Department of State Growth

Site Stabilisation and Landscaping Guideline

August 2018

Executive summary

The Department of State Growth (State Growth) undertakes construction and maintenance of the State Road network in Tasmania. This responsibility goes beyond management of essential road infrastructure, into the surrounding land within the road reserve. This includes the earth surfaces adjoining the road pavement, such as the verge, shoulder and batters.

Significant funds are directed toward stabilising these surfaces during construction, and providing continuing maintenance throughout the road's lifespan. It is important that adequate consideration is given to these 'green' assets during design and construction, to ensure that a quality, aesthetically pleasing product is provided for all road users. This quality will ensure continuing performance, along with simple and economical on-going maintenance, to ensure that maximum value is provided in State Growth's expenditure.

This Guideline provides direction on the design and construction of these 'green' assets, including consideration of the suitability of various surface stabilisation and landscaping techniques, with a focus on the use of vegetation in the final landform. The proposed framework provides the key factors necessary for a consistent approach to site stabilisation across road projects and considers requirements for, or at least is the best possible fit for, stabilisation, cost reduction, safety, maintenance, and visual amenity.

Batters are generally the largest and most visually significant areas in the road reserve, and connecting the road pavement to the adjoining land. Erosion control is a key consideration in the design and construction of batters during road projects. Batter slope vegetation provides structural stability to landform surfaces through root reinforcement, and is important to limit erosion. It can also provide habitat for flora and fauna species, and helps to make the roadside environment more attractive. Correctly implemented, the outcome will control invasive weeds and limit on-going maintenance costs.

This Guideline also outlines development of plans to control erosion in the project's highly disturbed Construction Phase. They also provide guidance on transitioning the initially stabilised surface into a robust road corridor throughout the Operational Phase of the project corridor. This includes the development of a compliant Erosion and Sediment Control Plan, as required under Standard Section 176 (Environmental Management) of State Roads' Road Construction Specification.

The document does not address geotechnical or civil engineering aspects of batter surface stabilisation. Road project teams should always undertake an assessment of geotechnical stability for all earthworks, including batters.

Site stabilisation

It is important to provide an integrated approach to site stabilisation, which works with design, to improve outcomes and reduce overall costs. Project scoping needs to provide meaningful costings for the works required. Simply allocating a proportion of the available budget to site stabilisation, without a proper consideration of the site's constraints and opportunities, or understanding the measures required, is not appropriate.

A focus on progressive stabilisation, during a project's development, will ensure whole-of-life cost savings through reduced construction timeframes, reduced re-work and reduced environmental risk. The key benefit to State Growth from this approach is reduced maintenance of roadsides.

Defined design process for earthworks

The approach contained in this Guideline outlines a process for design and construction of batters and associated earthworks. It focusses on planned management of soil and water during the Design Phase, and continuing into the Construction and Operational Phases.

Improved consideration of erosion and sediment control during design development will allow informed decisions to be made during construction. This should reduce unplanned rework during construction, such as erosion of newly formed batters and damage to recently completed and vegetated areas.

Low maintenance vegetation

Properly designed, low maintenance vegetation provides several opportunities to minimise maintenance over the asset lifespan. Correctly selected and properly cultivated vegetation make batter slopes more stable, through deep root systems, minimising erosion and subsequent maintenance of the batter. Suppression of environmental weeds can be achieved by correct selection of robust vegetation, also reducing ongoing costly maintenance.

Vegetation needs to be designed to minimise maintenance. It is critical that decision making to reduce project construction costs do not result in landscaping failure. Similarly, inappropriate landscaping treatments can be expensive to maintain. For example, increased focus on worker safety means that workers in high traffic volume locations will require traffic management. This makes maintenance more expensive, time consuming and can introduce avoidable hazards for maintenance operations.

Selection of plant species plays a large part in successful revegetation. In the short-term, this increases the risk of erosion on batters and allow growth of environmental weeds. For example, rapidly growing grasses can be a fire hazard, and therefore require constant mowing to reduce fuel loads and maintain visual amenity. In some cases, a better outcome can be accomplished by provision of a stable vegetation community.

Vegetation will always grow on soil faced road batters, whether planned or not. Establishment of appropriate species, that provide the ‘best fit’ for each situation, is essential to meet State Growth’s requirements for the safety of road users and maintenance workers, during the project’s Operational Phase.

Appealing roadside landscaping

The presence of vegetation enhances road infrastructure. It provides interest to the surroundings through character, colour, and texture. Vegetation provides shade, filters pollution from air and water, and enhances air by converting carbon dioxide to oxygen.

Roadside vegetation enhances road user amenity and provides interest along throughout their trip, and it can provide visual clues to upcoming changes to road alignment, or town entrances. Roadside vegetation can also help to reduce the impact of main roads on nearby residents, by minimising undesirable views of roads and traffic. Vegetation plays an important role in reducing erosion and filtering water run-off within roadside drains.

Landscaping does not have to be a complex and expensive investment to provide a good result. Through clever design, simple, neat and cheap vegetation can provide exceptional value to a project.

Contribution to road safety

Improved road safety is a constant focus for upgrades of the State Road network. Road design for new and upgraded roads aims to reduce crash severity by providing a greater clear zone free from hazards (such as trees). Carefully selected vegetation will increase the safety of road users by removing unnecessary obstructions from road batters and verge areas.

Poorly conceived landscaping can increase crash risk and consequence for road users. Large trees in the wrong place are a hazard for vehicles and planting of improper plants can obscure sight distance for drivers. Additionally, some batters may not offer sufficient soil depths to provide sufficient root support for trees resulting in a risk of tree-fall onto the road.

Stable batters and surfaces

This Guideline provide advice on design and construction of earth surfaces supporting the road formation including, but not limited to, batters.

Stable batters provide many advantages, including cost savings through reduced maintenance. Poorly designed and constructed batter slopes have the potential to become unstable, and rapidly erode. Batter erosion is a costly issue for State Growth, with significant funds spent each year in maintaining and repairing batters.

Batter stability is dependent upon many factors, such as batter material, degree of slope, length of slope, drainage, weather conditions, surface cover and vegetation type. These factors required careful consideration during project design and construction.

Vegetation cover is a key measure for erosion control and batter stability. It is imperative that effective re-establishment of vegetation is properly considered both in design and implementation.

Batter slope also has significant implications for surface stability. On slopes steeper than 3:1 access for maintenance is constrained, and this has consequences for potential revegetation options. Additionally, as the batter becomes steeper, rehabilitation becomes more difficult and expensive, and the availability of effective treatments is more restricted.

How to use the guidelines

This document provides guidance, to all staff (including contractors) working on State Growth's road projects, on the key considerations to make at each phase of the design and construction process.

This guideline has been written to be used alongside the International Erosion Control Association, Australasia (IECA) guideline for Best Practice Erosion and Sediment Control (IECA 2008). This document provides comprehensive guidance for erosion and sediment control in construction projects. This guideline is referenced frequently in this standard, and should be considered by everyone undertaking erosion and sediment control, and landscaping, for State Growth projects.

This Report is subject to, and must be read in conjunction with, the limitations set out in Section 1 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

The Department of State Growth (State Growth) manages a network of over 3700 km of State Roads across Tasmania. This includes maintenance of existing roads and roadsides, along with upgrades of the network to improve safety and transport efficiency, cater for traffic growth and meet community expectations.

Due to the nature of the terrain across Tasmania, significant earthworks are often required as part of upgrade works. This often involves construction of large batters. Batters are the side slopes that connect the road surface to the contour of the surrounding land. Depending on the underlying geology, batters may be constructed as rock cut faces or sloping earth surfaces. It is important that road design and construction considers a range of factors to ensure that batter slopes are stable and maintainable in the long-term.

1.1 Purpose of this Guideline

The purpose of this Guideline is to provide a batter stabilisation methodology that effectively addresses State Growth’s requirements for stabilisation, cost reduction, safety, maintenance and visual amenity.

This document defines the requirements for stabilisation and revegetation of disturbed sites within State Growth’s road construction projects. The methodology outlines an approach to establish batters, and associated roadside areas that provides:

- Consistency across projects
- Integration within the overall design process
- Cost-effective batter treatments
- Increased success of roadside vegetation
- Greater consideration of maintenance requirements
- Improved safety for constructors, road users and maintenance workers
- Appealing roadside environments, and
- Improved value to State Growth projects.

1.2 Scope and limitations

This report: has been prepared by GHD for Dept of State Growth and *may only be used and relied on by Dept of State Growth for the purpose agreed between GHD and the Dept of State Growth as set out in section 1.3 of this report.*

GHD otherwise disclaims responsibility to any person other than Dept of State Growth arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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2. Considerations for site stabilisation and landscaping

When planning road projects, the capital cost of the proposed works is often the primary consideration. However, this approach ignores potential for higher on-going costs over the lifetime of the road asset. It is important that whole-of-life costs (i.e. construction, operation, maintenance, renewal and stabilisation) of a road and its associated supporting assets are understood, so that this can be appropriately considered during project planning

One important consideration for minimising whole-of-life costs for road assets is batter design and construction. A focus of this Guideline is to outline the key considerations for design and construction of road batters.

2.1 Data required to inform batter design

Appropriate early investigation will enhance understanding of project sites and the key considerations for road design and construction. In many cases, the relatively minor cost of such investigation will benefit the Design and Construction Phases by better considering whole-of-life cost savings for the project.

Key information gathered and updated during project design includes:

- Geotechnical and soil investigation
- Local environmental constraints
- Meteorological data
- Property boundaries and easements, and
- Service utility location.

Early investigation will identify whether the project can be delivered within a realistic budget, or whether compromises need to be made during the Design Phase. This information will allow better consideration of site stabilisation and landscaping as the project moves through the Design and Construction Phases.

2.2 Batter stability and erosion

Batter stability is dependent upon the underlying material, slope gradient, surface and sub-surface drainage, uninterrupted length of slope and surface cover type. Surface erosion will always occur to some degree, but this significant surface erosion can occur if batter stability is not considered during the Design and Construction Phases of the project.

Road geometry requirements and site constraints may mean that some factors, such as batter slope, can be difficult to vary. Other factors, such as ground cover type and slope length, may be easier to tailor to each site. Reduced surface erosion and successful surface treatments will be realised with proper consideration of these factors.

Figure 1 below shows a steep rectilinear batter that does not match the surrounding landform, resulting in more complex drainage and increased erosion risk. Figure 2 shows with some of the key features of appropriate batters that match the natural surface, resulting in more simple drainage, better aesthetics and more stable batter slopes.

Figure 1 - Steep rectilinear batter inappropriate for landform

Steep and rectilinear batter slopes		
Steep gradients	Minimal surface area	Increased erosion risk
More complex drainage	Increased rehabilitation cost	Unnatural appearance

Figure 2 - Natural contour batter appropriate for local landform

Natural contour batter slopes		
Shallow gradients	Greater surface area	Decreased erosion risk
Simplified drainage	Reduced stabilisation cost	More aesthetic and natural appearance

2.2.1 Surface erosion

Uncontrolled erosion, with subsequent sedimentation resulting from construction sites or inappropriately constructed batters, is a contributor to land and water quality degradation in Tasmania.

Erosion affects earth-face batters, with soil-sized particles (nominally less than 2 mm), and can affect exposed rock. Rock fall onto roads are too common in Tasmania, and are often the result of the erosion/weathering process.

IECA 2008 provides the following definition of soil erosion:

'…the wearing away of earth surfaces by the action of external forces. This includes erosion caused by running water, rainfall, wind, ice and other geological agents. It includes such processes as detachment, entrainment, suspension, transportation and mass movement'.

'(It) does not only present detrimental environmental effects, it also impedes construction budgets and timeframes, and whole-of-life asset economy, through the difficulties involved in maintaining a surface that is constantly wearing away'.

Soil erosion also results in sedimentation. IECA 2008 provides the following definition of sedimentation:

'Sedimentation is the deposition of sediment displaced by the various erosion processes'.
'Sediment, in its natural location and natural concentration, is a natural part of the environment, but when found in un-natural quantities or concentrations, within natural and un-natural locations, it is considered a "pollutant" or "contaminant" that needs to be managed to the best of our abilities'.

Table 2.1 notes possible impacts of erosion and sedimentation on the built environment.

Table 2.1 Possible impacts of soil erosion and sedimentation on the built environment (IECA 2008)

Environment	Impact of soil erosion	Impact of sedimentation
Construction work site	• Loss of topsoil • Rework due to reinstatement of finished surfaces • Undermining roads and services • In-filled excavations and trenches • Decrease in water quality	• Down-time due to generation of mud • Cleaning blocked drainage systems • Increased down time and clean-up costs
Adjoining landscape	• Soil erosion within adjacent properties and receiving waters due to altered drainage conditions within the work site (such as culvert discharge points) • Costs associated with the stabilisation of off-site erosion	• Safety issues involved with sedimentation on roads • Damage to adjoining properties • Social and economic costs associated with increased drainage and flooding problems • Economic costs of desilting pipes and drains • Legal cost and public discontent associated with turbid water flow in downstream watercourses

Top: Rill erosion caused by excavation of sodic soils, Richmond Vineyard **Bottom Left:** Tasman Highway, Dunalley **Bottom Right:** Tunnel erosion following removal of topsoil

Figure 3 - Erosion due to removal of top soil during batter formation

Figure 4 - Sedimentation of drainage channel and dam downstream of construction

To better manage erosion and sedimentation during construction, State Growth Specification Section 176 (part D.1) requires that:

'The Contractor shall minimise the risk of soil erosion and sediment pollution of the site, adjacent land, and waterways, by defining and implementing erosion and sediment controls measures as part of its Environmental Management Plan'

In developing Environmental Management Plans for construction, a key principle should be the widely accepted philosophy that the best way to prevent impacts of sedimentation is to prevent erosion. IECA 2008 provides excellent advice on this subject and this Guideline, together with IECA's documentation, outlines an improved process for design and construction to reduce erosion and sedimentation associated with road construction projects.

Project designers should address surface erosion issues by careful consideration of design and documenting where compromises have been made and/or agreed. Following the easiest, cheapest solution will not necessarily provide the most economical whole-of-life solution for the proposed infrastructure. Well established vegetation will generally provide the best long-term option for erosion control on flat to moderate slopes. However, this may need to be combined with other more structural components until sufficiently established, or where steeper slopes exist.

Better management of erosion and sedimentation will benefit construction timelines and costs. This will also provide a better path to meeting the contractual requirements of State Growth projects.

2.2.2 Slope gradient and length

Slope gradient and length are key considerations for batter stability and erosion. The slope gradient[1] is generally the most significant factor when considering batter stabilisation.

Historically, steep slopes (1.5H:1V or more) have been adopted in Tasmania in an effort to reduce the size of batter, and contain the road formation within a dedicated reserve. While such slopes may be appropriate for some rock batters, soil surfaces will be difficult to stabilise and maintain on steep batters. Steeper batter gradients increase the risk of batter failure,

[1] Slope gradient can be defined in a number of ways, however the most common is as a ratio of horizontal run to vertical rise (for example 4 m of horizontal run with a rise of 1 m will be expressed as a 4H:1V slope). Batter slopes referenced in this document use this convention.

through erosion of soil media with subsequent loss of vegetation. The result of this failure is increased cost to State Growth, both in financial cost and public perception.

Batter surfaces should be as flat and short as possible to reduce the risk of surface erosion. Flatter slopes will provide:

- Reduced energy of stormwater surface flow
- Easier retention of topsoil, mulch and other surface cover
- A surface that is safer, and easier, to construct and maintain
- Reduced risk of failure following establishment, and
- Cost savings throughout the Operational Phase of the asset lifespan.

This may be unrealistic, in some cases, given the topography that the State Road network traverses across Tasmania and the design process will involve a range of compromises to achieve desired project outcomes.

As slopes get longer and steeper, flow energy increases, along with the potential for stormwater flow to transport eroded sediment from the slope. Steeper batters are also:

- More difficult to construct safely, and cost-effectively
- More likely to fail
- More challenging to place and contain growing media on the slope, and
- More difficult, and therefore costly, to maintain during the life of the batter.

Generally, the possibility of costly future maintenance, due to batter instability, increases with slope of the batter. Justification of steeper batter slopes, only to save on construction costs, should be considered over the lifespan of the project.

Table 2.2 notes some of the issues specific to key ranges of batter slopes.

Table 2.2 Batter slope advantages and disadvantages

Batter slope	Advantages	Disadvantages
Steeper than 1.5H:1V	• Can often be provided without property acquisition • Possibly suitable for rock faced batters (upon Geotechnical advice) • Reduced surface area exposed to erosion	• Stability issues for earth batters with risk of slumping • Higher construction cost for stabilisation and vegetation • Increased risk of future failure • Difficult maintenance with higher cost • Steeper batter face may inhibit traffic sight distance • Specialised maintenance may be required
Between 1.5H:1V and 3H:1V	• Reduced possibility of property acquisition • Increased likelihood of suitability for stable rock faced batters	• State Growth Specification requires soil application to batters 1.5H:1V or flatter • Earth batters may suffer future instability • Difficulty in maintaining growth media and vegetation • Increased maintenance costs
Flatter than 3H:1V	• Increased suitability for vegetated treatments • Easier and less costly to construct soil batters	• Property acquisition likely • Will expose a larger area of batter to erosion (unless

	• Easier and less costly to maintain vegetated treatments	adequately addressed by surface stabilisation.

2.2.3 Batter material

When designing and constructing road batters, the batter slope gradient must be appropriate for the geotechnical and erosion characteristics of the soil. Project planning and design should include sufficient geotechnical investigation to confirm that the proposed batter design will create stable batter slopes.

Road batters generally comprise of three categories: soil; mixed soil and rock; and rock. State Growth Specification Section 204 requires topsoiling and vegetation of any batter 1.5H:1V or flatter. However, some batters will not be suitable for stabilisation using standard topsoil and vegetation treatments. Vegetated batters may be unsuitable in a range of situations, including:

- slopes steeper than 1.5H:1V
- exposed rock or unstable soil batter material, and
- sites presenting difficult or hazardous maintenance (e.g. sites with access restrictions and/or adjacent to high traffic volumes).

Batter slopes that are difficult to stabilise using vegetation may require a flatter gradient, or a site specific vegetation treatment. Specific engineered treatments should be considered where vegetation is not practical, including:

- bare rock cut batters
- Rock (boulder) faced batters
- Gabions, or other retaining structure, and
- Artificial lining such as concrete.

Rock batters

Rock batters are generally more stable than soil batters, provided they are properly investigated, designed and constructed. Such batters may also require less maintenance in the long term, where they can be constructed as a bare rock surface. Generally, excavation in hard rock will be minimised where possible when designing and constructing a road, due to the difficulty and expense of excavation. Softer and/or fractured rock, may present stability issues with expensive solutions required during construction, to ensure that a batter can be provided securely to resist rock fall, and provide safety for road users.

Stability issues may also arise where mixed rock and soil batters are left bare, and vegetation self-establishes on the batter, with roots extending into cracks within the rock structure, exacerbating instability. Rock batters should always be the subject of geotechnical investigation and design, which is beyond the scope of this Guideline.

Soil batters

Soil batters require surface protection to provide adequate resistance to erosion, particularly as slopes steepen. Possible surface cover solutions, along with an indication of site suitability and cost, are noted in Appendix A.

Soil characterisation issues require consideration in design and construction of these batter slopes. These typically fall into three categories:

- Chemical - related to either an excess, or lack, of different chemicals in soils. For example:

    - Sodic soils contain high amounts of cations, which bind to clay particles, and cause the soil to swell excessively when wet. The clay particles move so far apart that they separate making the soil dispersible and very prone to erosion.

- Physical - related to soil structure, texture, surface crusting and wet or dry strength of the soil, or its ability to infiltrate or retain water. For example:
    - Sandy soils can be non-cohesive due to the poorly graded, uniform, particle sizes within the soil. These soils usually require flatter batter gradients to provide stability.
- Biological problems relate to diseases contained within the soil that may affect plant germination and growth. For example:
    - Nutrient imbalance is a common cause of poor plant growth, leading to failure of vegetated batters requiring excessive maintenance.

Adequate testing of soils, which may be exposed by construction, should be undertaken during the Project Inception and/or Concept Design Phases (refer to Section 3.1.7).

Dispersible Soils

Dispersible soils are found in many areas of Tasmania and are subject to a high risk of erosion. IECA 2008 (Appendix C, Exp- C22 Dispersive Soil) notes the following regarding dispersible soils:

'*Dispersive (dispersible) soils are structurally unstable in water, breaking down into their constituent particles (sand, silt and clay) and consequently allowing the dispersible clay fraction to disperse and cloud the water. This dispersion is caused by the high, negative, electro-static charge on the surface of particles typically less than 0.005 mm in diameter (i.e. clay and smaller silt-sized particles)*'.

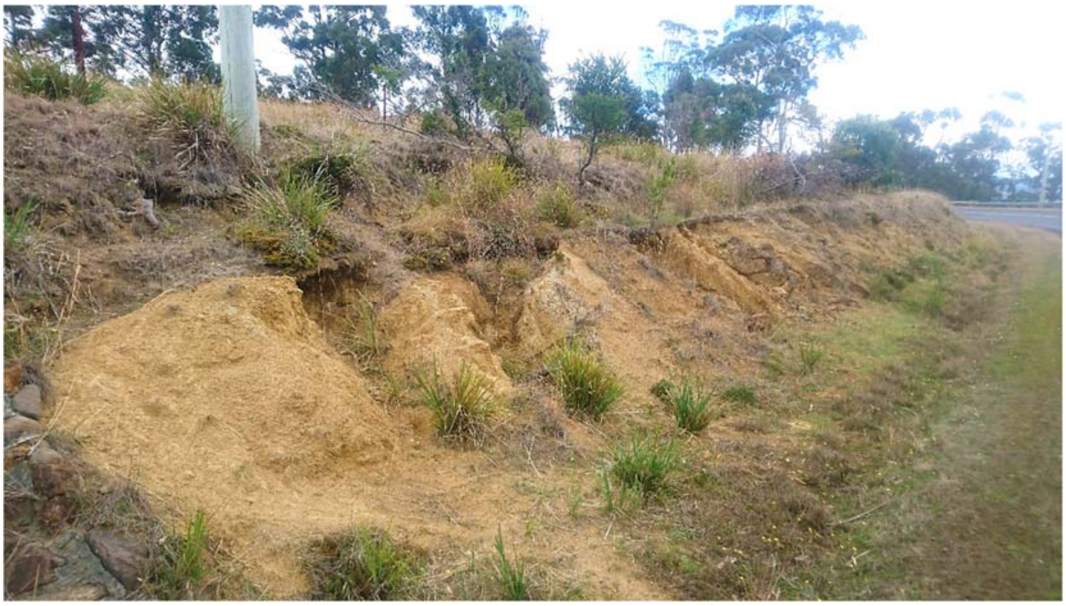

Figure 5 - Erosion of a batter constructed in dispersible soil

Soil dispersion is generally caused by high levels of exchangeable sodium in the soil and excessive mechanical disturbance, especially if the soil is wet. Dispersive soils are usually highly erodible and will require specific consideration in designing and constructing road batters. They are structurally unstable soils, which can result in the following problems:

- Severe rill erosion of unprotected earth batters
- Tunnel erosion of drainage berms and batters, and behind engineered structures such as retaining walls
- High levels of turbidity in stormwater runoff, and
- Transportation of nutrients attached to dispersed clay particles.

These soils must be appropriately treated, or buried under an appropriate layer of non-dispersive soil (usually 100 mm minimum), before undertaking any revegetation or erosion control measures. Batter slopes in dispersible soils may need to be reduced and/or specialised preparation of the sub-grade required. The standard requirements of the construction specifications are generally not adequate for stabilisation in dispersive soils.

Wherever possible, cutting catch drains into dispersive soils should be avoided. Instead, flow diversion banks or mulch berms should be used to temporarily divert stormwater across the site, until permanent drainage systems have been stabilised by vegetation. Permanent drainage systems in dispersive soils will require careful consideration.

Top: Tunnel erosion **Bottom Left:** Erosion of the batter and table drain, 18 months after construction. **Bottom Right:** Tunnel erosion in Brighton, a result of stormwater construction

Figure 6 - Erosion due to dispersible soils

2.2.4 Drainage

Stormwater drainage must be considered for all batters. Correctly designed drainage measures can:

- Redirect stormwater flow away from sensitive areas that may be prone to erosion
- Reduce the potential for erosion by decreasing runoff velocities
- Shorten effective slope lengths
- Increase stormwater infiltration into the soil, and
- Trap eroded sediments.

Drainage systems should be designed to complement the natural topography and existing drainage lines. It is important that catch drains are constructed in a continuous line close to the contour, and that appropriate drain linings are considered, to ensure that the gradient of the drain does not encourage flow velocities that will result in erosion of the structure.

Figure 7 - Erosion caused by water flow over the face of a batter

2.2.5 Cost-effectiveness

The design of batters should adopt appropriate measures to provide for cost-effective development and maintenance, throughout the Construction and Operational Phases of the project.

Historically, steep batter slopes have been adopted in Tasmania to reduce costs for earthworks in road construction. In many cases, soil surfaces are difficult to stabilise and maintain at steep gradients, meaning that expensive surface cover treatments may be required, with more maintenance provided to ensure the continuing stability of the batter surface.

Flatter batter slopes provide easier servicing, reduced work and decreased cost to maintain, and become more difficult to maintain as the surface gradient increases. In some cases, steep batters cannot be avoided, but in these cases, maintenance access and worker safety must be considered in design. Road-side surfaces, such as medians and road verge, may be subject to a traffic hazard during maintenance and therefore require traffic control, or lane closures, to undertake that work. In some situations, additional maintenance costs may outweigh the cost of adequate construction measures and property acquisition required to provide room for a flatter batter slope, which can be more easily constructed and maintained.

2.2.6 Staging of construction works

Before undertaking earthworks, construction staging should be considered by the contractor. Disturbed, newly formed earth surfaces should be completed as soon as practicable after the earthworks are complete, with the final surface cover and vegetation installed. All completed surfaces should then be delineated as 'no-go' areas to avoid damage by workers and machinery. This will allow a shorter period before vegetation is adequately established and reduce work required to reinstate completed earthworks.

2.3 Key success factors for vegetation establishment on batters

Given that the majority of road batters will be stabilised using vegetation, it is key to consider the key success factors for vegetation establishment on batters.

2.3.1 Minimise disturbance of existing vegetation

Established vegetation contributes to batter stability, and usually erosion protection. Minimising the extent and duration of disturbance to existing ground covers is one of the most effective forms of erosion control, for disturbed earth surfaces (including batters).

A fundamental principle of road construction is that existing vegetation should be preserved to the largest extent possible, on all surfaces not directly exposed to project earthworks.

Tree preservation may have high ecological value, but the preservation of ground covers (e.g. grasses, leaves and mulches) generally provides the greatest benefit to surface stabilisation. Trees provide their greatest erosion control benefit on steep slopes where their root system can help to anchor the slope, especially when the soils are saturated following prolonged rainfall.

Best practice land clearing includes the following options:

- Appropriate staging of works to minimise timing between clearing and grubbing, finalisation of earthworks and vegetation establishment
- Bulk tree clearing with minimal disturbance of existing ground covers (i.e. no removal of ground cover mulch and vegetation and no grubbing), followed by appropriate staging of works to delay final clearing and grubbing as long as possible
- Bulk tree clearing and grubbing of the site immediately followed by temporary stabilisation of all disturbed areas (e.g. temporary grassing or mulching) prior to commencement of staged construction works.

2.3.2 Choosing surface cover for vegetated batters

Surface erosion protection is required for all soil batters, even on flat or low gradient land. Surfaces exposed to low stormwater flow velocities can have significant erosion due to raindrop impact erosion.

Vegetation provides protection against erosion. Landscaped batters have improved structural soil strength, due to roots binding the soil, and improved soil infiltration along with reduced evaporation losses thereby decreasing stormwater runoff. Appropriate and correctly installed vegetation provides cost effective slope stabilisation and generally provides an attractive, economical alternative to engineered solutions.

It is critical to understand the environmental conditions of each surface. Surrounding vegetation type, elevation, aspect and localised soil type must be considered in plant selection. For example, in the Midlands, grassland vegetation may be most appropriate, while in coastal areas, an assemblage of native shrub may be more effective. Self-propagated vegetation needs to be considered as this can have a significant impact on whole-of-life costs and public safety. Vegetation should be selected to become a structural component of the overall design as well as a means to suppress unwanted plant growth and minimise maintenance costs.

It is accepted that vegetation coverage of around 40% cover is required to anchor the surface soil, however, such a light cover does not provide adequate protection against raindrop impact erosion. IECA 2008 notes that '*around 70 to 80% ground cover is considered necessary to provide a satisfactory level of erosion control in most urban areas*'. It is also noted that a minimum of 90 to 100% ground cover is required to adequately protect against erosion in highly erodible clayey soils.

Surfaces that are not directly exposed to stormwater flow from external sources may still be subject to significant weathering, and subsequent erosion, due to raindrop impact during storm events. For steeper, unstable slopes, hard armouring (such as concrete and rock) require consideration. These treatments should be the subject of specialist engineering advice and are not considered in detail in this document.

More natural means, such as organic mat and mulching, used in conjunction with landscaping, can also be used to provide a more aesthetic result where batter conditions permit.

Figure 8 - Batter Surface Vegetation

Appendix A notes possible surface cover solutions for landscaped batter stabilisation. The information presented in this table has been derived from the 'Guideline for Batter Surface Stabilisation Using Vegetation' (NSW Roads and Maritime Services, April 2015)

It should be noted that the product lifespan should be given careful consideration. These are often reliant on conditions that are not present on Tasmania. The best results will generally be achieved by following manufacturers' specifications, along with advice from revegetation contractors, landscape designers, soil scientists and/or ecologists.

2.3.3 Selection of appropriate landscaping

Revegetation planning for newly constructed batters should take cues from the landscape context. Consideration for species selection and vegetation character can be informed by the surrounding environment should it be farmland or forest.

Urban landscapes

The peri-urban highway environment can form gateways to cities and towns and more attractive (and expensive) landscaping treatments may be justified in some situations. There are wider opportunities and options for species selection in the urban environment where the focus may be on high standard of aesthetics. The use of strong colours may be desirable in some situations. Other considerations may be use of advanced trees, mass planting and incorporation of structural features.

Consideration of whole-of-life costs are important in the selection of urban landscaping, and there are specific constraints for landscaping in urban areas, including:

- Landscaping is frequently seen by the travelling public, and unattractive landscaping generally draws complaints
- High traffic volumes makes maintenance difficult and expensive, and has implications for worker safety
- Road reserves are more highly constrained with proximity to adjoining residential and other urban areas, and
- Cost to rectify poor implementation will be disproportionately higher than correct implementation during construction.

Appropriate landscaping treatments should be identified early in the project development process, with all requirements carried through into detailed design and construction methodologies. For example, if steep cut batters through unstable materials such as highly weathered dolerite are required, design considerations must include measures to ensure slope stability, and provision of access for maintenance workers and vehicles.

Figure 9 - Colourful vegetation can provide a visual gateway to towns

Rural landscapes

Roadside reserves within modified landscapes can support significant remnant native vegetation with a high concentration of threatened species. In Tasmania, roadside reserves are typically narrow, and decisions on batter angle are less likely to make a difference to outcome of impact. However, these values may require offsetting, especially where approval under threatened species legislation is required. Decisions on managing topsoil, and propagating species for use in revegetation works should be integrated into the design process.

Some roads also traverse significant rural cultural heritage landscapes. For example, the Midland Highway passes through significant cultural landscapes in the Tasmanian Midlands that include historic hedges and Pioneer Avenue plantings.

Natural landscapes

Tasmania's reserve estate is large, occupying over 40% of the land are of the State. Roads passing through these reserves, particularly the Tasmanian Wilderness World Heritage Area, need to be responsive to natural values, both in impact and reserve design and management. In such areas, retaining existing vegetation as far as practicable, becomes a more important consideration.

Landscaping of specific road features

Landscaping considerations for specific road infrastructures are discussed in Section 5 of this document.

Figure 10 - Natural landscape extended to the batter

2.3.4 Installation of landscaping

Seasonal variation in weather affects construction in many ways. This includes the success of plantings for landscaping. The same weather variations will also affect construction of earthworks, so construction staging needs to be considered carefully to give the best chance of success to new vegetation.

It is important that landscape design and specifications for each project give specific advice regarding the required season for planting, and maintenance requirements during establishment of new roadside vegetation. This plan should include other requirements for establishment of proposed vegetation, including:

- Retention of topsoil for use on newly constructed batters.
- Staged vegetation, such as the provision of early, short-lived, fast-growing, grasses that protect the surface from rain and provide a mulch for slower more permanent species to establish.
- Landscape design should be laid out in design plan including justification for treatment choice.

It should be noted that a single treatment type may not be suitable for the entire project site. Local constraints may restrict options for batter treatments, and advice should be sought from geotechnical engineers and specialist landscape contractors and /or consultants to determine the most practical treatment for each batter location.

State Growth's Specification Section 720, provides the general requirements for landscape works on road projects.

2.3.5 Local climate and site-specific conditions

The recommendations made in this Guideline will provide improved batter treatments for most locations in Tasmania. However, site-specific considerations should be made for all sites during design, such as those that are in areas more prone to erosion due to weather conditions, and/or soil type.

It is important that design and construction of road batters considers localised conditions in determining effective batter surface treatments. These conditions include monthly rainfall depth, land surface area, slope and soil type).

Soil type

Tasmania's geology is complex, with significant variation in soil fertility and structure across Tasmania. For example, low fertility quartzite soils and peats in western Tasmania are not capable of supporting grassed batters, requiring alternate revegetation or stabilisation options. Similarly, low fertility sedimentary substrates (sandstone and mudstone) or granite typically support very shallow or sandy soils, which limit revegetation options.

Figure 11 - Poor soils on a steep batter resulting in poor stability

Fertile soils derived from dolerite, basalt or alluvial valley flats present greater options for revegetation. These not only present erosion hazards and provide limited options for vegetation establishment.

Individual road projects may pass through more than one geology type, so that revegetation responses need to vary. It is important that the substrate types across the project site are identified early in project development, and available resources effectively utilised to achieve revegetation and stabilisation.

Batter slope

Shallower batters will help to limit post-completion maintenance cost and are generally easier to successfully rehabilitate. However, this needs to be considered in the context of additional land acquisition, earthworks and land clearing required to construct shallower batters.

Consideration should be given for not landscaping batters cut into sound rock during design, although State Growth's Specification Section 204 requires topsoiling of all batters up to 1.5H:1V. Topsoil will be difficult to retain on steep rock batters without the use of some additional treatment, which will add to the cost of establishing the batter. Maintenance costs, for such batters may also be higher. Batters cut into competent rock can be stable and resistant to erosion, without additional lining of the surface. These can be retained as a bare rock surface, allowing funds to be directed to stabilisation and vegetation of other more suitable earth batters.

Figure 12 - Rill erosion on steep batter with failed stabilisation

The 'Guide to Road Design Part 7: Geotechnical Investigation and Design' (Austroads 2008) notes that generally:

'…*for cuttings through soft, highly fractured or weathered rock and soil, the maximum batter slopes should be no steeper than 2H:1V so planting can be established on the face of the batter to prevent soil erosion and improve stability. Cuttings through stable rock formations where planting is not required to prevent soil erosion may typically be steepened to between 1.5H:1V and 1H:1V. Cuttings through monolithic and stable rock formations requiring excavation by use of explosives may be further steepened to minimise the amount of rock excavation and land acquisition required'*.

For embankments, Austroads 2008 notes that, from a geotechnical viewpoint:

'*All fill batters should be designed with:*

- *slopes no steeper than 2H:1V vertical if planting is required to stabilise the sides of the embankment and prevent soil erosion*
- *slopes considerably flatter than 2H:1V if the road reserve is not confined and there is surplus fill available, particularly if the project has significant surplus volumes of unsuitable low grade fill or rock that is too large to be used as common fill for the structural portion of the embankment.*

Embankments steeper than 2H:1V should not be grassed but planted and mulched as they cannot be mowed or maintained easily.

Road safety considerations generally suggest that much flatter batters will be required. The batter line defined by the 1.5H:1V fill profile is regarded as the structural portion of the embankment where a high standard of compaction is required for soil materials or in the case of rock fill, a strong inter-particle contact.

For erosion prone materials such as dune sand, batters may also need to be flatter than 2H:1V to enable more rapid establishment of vegetation and to lower the velocity of surface water flowing down the batter particularly after heavy rainfall.

For rock fill that does not require extensive planting for erosion protection, batter slopes may be up to 1.5H:1V. This also includes 'spill through' bridge abutments that are generally faced with rock beaching, slate or concrete blocks.

For embankments where steeper batter slopes than 1.5H:1V are required, some form of retaining or protection structure is likely to be required for at least part of the embankment near the toe.

Proper consideration of appropriate slope stability methods during the Design and Construction Phases will increase safety, amenity, and maintainability, while reducing the risk of batter failure.

Local climate

The climatic limitations imposed by the Tasmania's weather will influence opportunities for vegetation establishment. Species selection should respond to the surrounding habitats across Tasmania. The State Road network traverses a range of climate types, ranging from frost-prone subalpine at 1000 m above sea level, to coastal environments, subject to salt spray.

Figure 13 - Tasmania is subject to a wide range of climates

Rainfall across Tasmania ranges from annual 450 mm to over 3000 mm, which influences selection of stability measures and/or vegetation selection significantly.

Variation of climate within sites should also be considered in developing landscaping designs. For example, aspect has significant effect on growing conditions, with north-west slopes getting higher solar exposure through the warmer months and south-east aspects experience extended cooling and waterlogging of soils through winter that impact adversely on plant vigour.

2.4 Maintenance Requirements

Batter slopes become more expensive and time-consuming to maintain as the surface gradient increases. Flatter batter slopes generally require less work and are lower cost to maintain.

Roadside surfaces, such as medians and areas within the verge, may require traffic control or lane closures to undertake maintenance work safely. In some cases, it could be more effective (from a whole-of-life cost perspective) to provide with a hard surface treatment (e.g. rock or concrete) to reduce the ongoing maintenance cost.

Solutions for batter stabilisation should ensure that maintenance requirements are minimised. This is particularly important where significant constraints exist, such as:

- Steep batters (nominally steeper than 2H:1V)
- Locations adjacent to roads with high traffic volumes, and
- Where access to the roadside vegetation is difficult and/or restricted.

Maintenance requirements are dependent on the method of surface stabilisation. Therefore, maintenance should be determined by product supplier specifications, contract requirements and site-specific conditions (such as local weather conditions).

Table 2.3 notes particular criteria for landscape works as provided by State Growth Specification Section 720.

Table 2.3 Performance Requirements for Shrub and Groundcover Planting Areas (State Growth Specification Section 720)

12 months after Practical Completion	24 months after Practical Completion
• minimum 25% ground closure	• minimum 60% ground closure
• all plants showing healthy growth	• all plants showing healthy growth
• performance indicating probable 90% ground closure at 36 months after Practical Completion	• performance indicating probable 90% ground closure at 36 months after Practical Completion

2.5 Constructability

The design of batters should adopt appropriate measures to provide for cost-effective development and maintenance, throughout the Construction and Operational Phases of the project.

Appropriate construction staging can provide cost and time savings in construction of batters. Disturbed and newly formed earth surfaces should be completed (i.e. final surface cover and vegetation installed) without delay after the earthworks are complete. Completed surfaces should be delineated as ‘no-go’ areas, to avoid rework and allow vegetation to be established.

3. Batter and landscaping design process

During the design process, consideration of the key erosion risks and the range of design and construction solutions is key to achieving better landscaping and erosion management outcomes. The design process should aim to reduce whole-of-life cost by:

- Investigation of local constraints and opportunities early in the project development process;
- Allowing adequate room for construction of the preferred batter treatment;
- Consideration of surface stormwater drainage to direct water away from batter surfaces, and/or convey stormwater down slopes;
- Provision and proper installation of correctly selected batter surface treatments;
- Allowing for maintenance of constructed batters, including vegetation, until the slope is completely covered and resistant to erosion;
- Transition from initial stabilisation treatment (cereal cover-crop) to project life stabilisation treatment. (desired plant assemblage)
- Consideration of maintainability during batter design and construction (i.e. flatter slopes, construction access, vegetation selection); and
- Commitment to regular inspection and maintenance.

To guide consideration of erosion management and landscaping early in the road design process, the below provides a guide to define when different landscaping elements should be considered, at different design and construction phases including:

- Project inception
- Concept design
- Preliminary design
- Detailed design
- Construction, and
- Post-construction

Figure 14 indicates the key steps in the design and construction process for considering landscaping and erosion control measures along with the key outputs at different design phases.

A checklist for this process is included in Appendix B of this document. This is to be completed and passed onto each following phase of project development through inclusion in project briefs and design reporting.

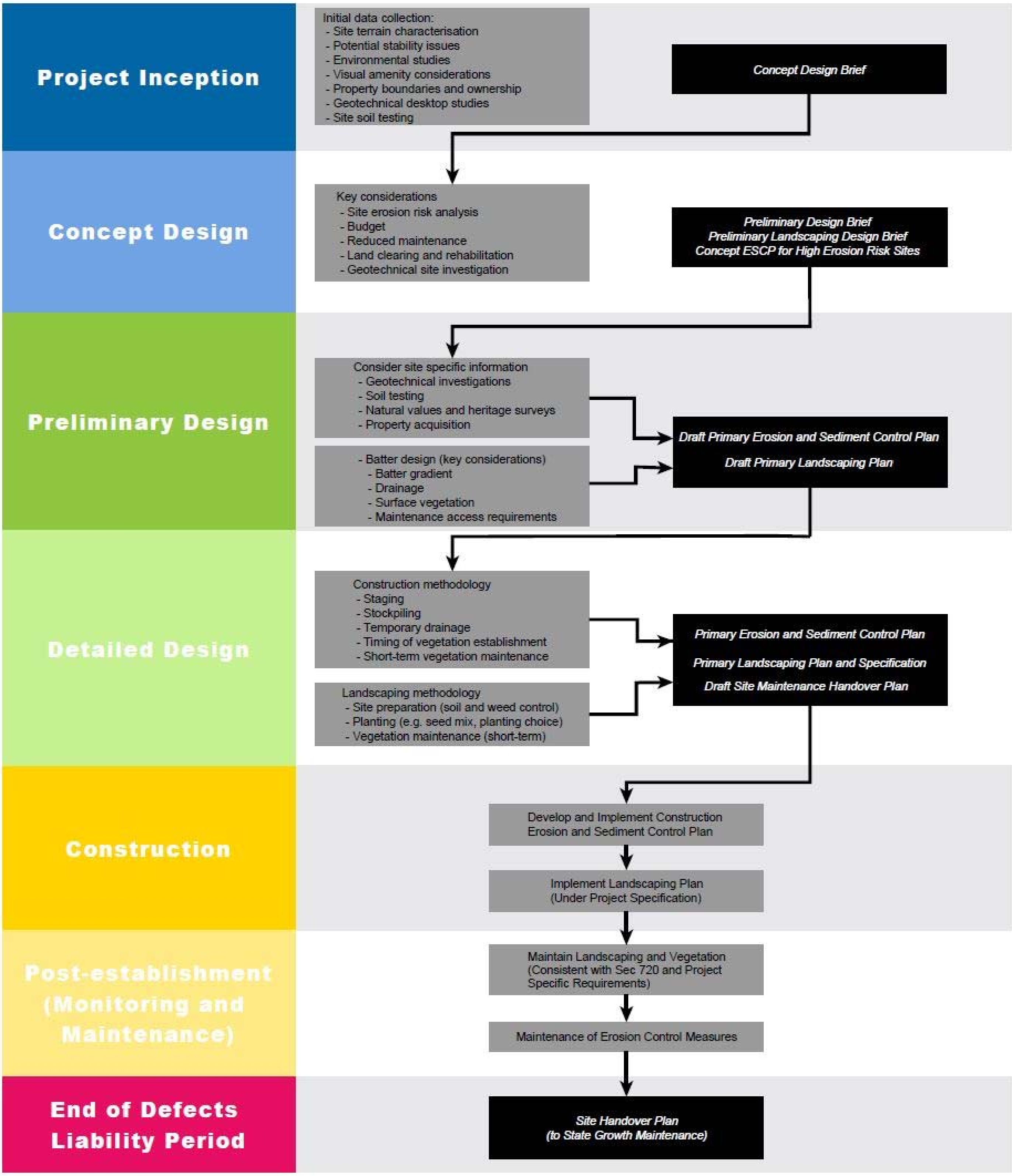

Figure 14 - Site stabilisation design and construction process

3.1 Project Inception Phase

Environmental and property constraints are two of the key considerations during the inception phase of a road project. These particularly need to be considered early, ideally when determining how the proposed works will fit into the final landform.

Information gathered and analysed at this Phase should include a geotechnical desktop assessment and site soil investigation, along with local environmental constraints, such as the location of native vegetation communities and species. These constraints may limit the opportunity to provide the ideal road infrastructure, requiring compromises to be made in how the new road and batters are designed and constructed.

Early investigation will identify whether the project can be delivered within a realistic budget, or whether compromises need to be made during the design development. This information will allow a more informed project and a better brief to the team as the project moves through the Design and Construction Phases.

3.1.1 Site terrain characterisation

An indication of the terrain through which the road passes can be gathered from contour data, such as that found in theList (www.thelist.tas.gov.au). There may be no option other than steep batters where the local terrain is steep, but a more gently sloping landform may allow flatter batter slopes to be considered.

The location of natural watercourses and existing drainage should also be noted. This will give an early insight to the local terrain that will influence the new arrangement of infrastructure.

3.1.2 Identify known land stability issues

Desktop analysis of the underlying site geology and soil type should be undertaken during the Project Inception Phase. This will assist early determination of any potential land stability issues, and form a basis for geotechnical and soil investigations required to inform the design.

A preliminary determination of local land stability can be made by examination of the Landslide Planning Map found in theList on-line mapping service (www.thelist.tas.gov.au). This layer has information on areas of unstable ground, as well as areas of active landslips. Appropriate advice should be sought in determining the accuracy of any data found which may give an early indication of land stability issues.

Existing geotechnical information can also be gained from Mineral Resources Tasmania's databases (www.mrt.tas.gov.au) and DPIPWE's Groundwater Information Access Portal (www.dpipwe.tas.gov.au/water/groundwater/groundwater-information-access-portal). Although the information currently contained is more related to mining, some has been obtained for engineering infrastructure purposes and provides a useful resource.

3.1.3 Key natural and environmental constraints

Environmental constraints can also be gained from sources such as theList (www.thelist.tas.gov.au) and the Natural Values Atlas (www.naturalvaluesatlas.tas.gov.au), which both contain useful information for inception phase investigation. These databases can identify key natural values, such as threatened ecological communities and/or species, which will warrant further investigation during subsequent design phases.

An early understanding of existing vegetation types and/or the endemic vegetation assemblage will provide a valuable insight into the most appropriate vegetation treatment to be considered in the design process.

3.1.4 Collection of site specific data

A site visit by appropriate specialists, during project inception will provide an opportunity to undertake reconnaissance and collect a valuable overview of existing soil types, site drainage vegetation and environmental conditions at the site.

Table 3.1 lists key components that should be investigated during a site visit in the Project Inception Phase ideally, although this can be done during the following Concept Design Phase. However, it is important to collect this data at the earliest opportunity, so that further detailed investigations can be better targeted and impractical concept designs avoided.

Table 3.1 Site investigation and data collection tasks

Component	Site investigation tasks	Site data collection tasks
Soil	Note existing eroded areas	Field mapping and sketches. Note depth and type of existing erosion
	Note existing fill and cuts	Are these natural (through previous erosion processes) or caused by previous construction (historic)
	Note existing soil type and depth	Collect soil samples to allow testing as recommended by IECA 2008 (including Particle Size Distribution to inform Universal Soil Classification System class and Emmerson test for dispersibility)
	Note existing topsoil and depth	Collect information, samples of existing topsoil for consideration of suitability for re-use, and any amelioration required Estimate availability of topsoil for re-use in site stabilisation
	Geomorphology assessment	Map expected geological types, from auger results and observations of exposed rock
Water	Identify rainfall frequency and depth/intensity	Is the site subject to high rainfall? Are large puddles and high water flows apparent in watercourses?

	Note path of water flows across the site, including points of run-on and run-off	Field mapping and sketches of flow paths
	Note flows as spread or concentrated	
Vegetation	Inspect and quantify existing vegetation. If possible inspect nearby previously disturbed sites	Note general type of vegetation - grasses, tree type, size etc. Prevalence of weedy species particularly trees Provide recommendations for pre-construction site preparation, such as weed control Assess proportion/areas of unusable soil due to weed content Assess and estimate volume of available biomass-for reuse as mulch Note areas where vegetation provides clues to local geology/hydrogeology. Such as sags/paperbarks/salinity indicators
Other considerations	Identify any potential environmentally sensitive areas	Collect observations, including location sketches

3.1.5 Adjacent land ownership

theList (www.thelist.tas.gov.au) provides existing cadastral boundaries and ownership information. The Project Inception Phase should include analysis of land constraints, opportunities for flatter batter slopes and determine where there is room between the road and property boundary to provide this. Where there is little available space for batters, an early decision can be made to pursue property acquisition, and funding set aside for this purpose.

3.1.6 Budget

In the right situation, considerable whole-of-life cost savings can be achieved by providing flatter batters, with subsequent stable surface treatment, compared with steep batters.

Batter treatments must be considered as ongoing cost for the Construction and Operational Phases of the project, including maintenance and safety in all activities. The whole-of-life cost of a batter needs to consider construction, vegetation establishment and longer-term maintenance costs. Reduced whole-of-life cost can be achieved by:

- Investigation of local constraints and opportunities
- Allowing adequate room for construction of the preferred batter treatment
- Correct consideration of surface stormwater drainage to direct water away from batter surfaces, and/or convey stormwater down slopes
- Provision and proper installation of batter surface treatments
- Maintenance of constructed batters, including vegetation, until the slope is completely covered and resistant to erosion
- Consideration of maintainability during batter design and construction (flatter slopes, construction access, correct vegetation selection), and
- A commitment to regular inspection and maintenance of the batter by the asset owner.

3.1.7 Geotechnical desktop investigation

When constructing road batters, it is important to ensure that the batter slope gradient is appropriate for the geological characteristics of the site. Further detailed investigations may be required to confirm that the proposed batter design will meet State Growth's requirements for stability, reduced maintenance and economy.

At the very least, site characterisation should be undertaken at this stage to inform investigation of batter slope stability. Useful information may include:

- Existing mapping of underlying geology
- Geotechnical investigation, and
- Soil characters (depth, pH, structure – clay/loam/sand, fertility from theList and other resources).

A number of free on-line resources are available when undertaking desktop geological and environmental investigations. These include:

- Department of Primary Industries, Parks, Water and Environment's (DPIPWE) groundwater portal (www.dpipwe.tas.gov.au/water/groundwater/groundwater-information-access-portal),
- theList (www.thelist.tas.gov.au), and
- Mineral Resources Tasmania's website (www.mrt.tas.gov.au)

3.1.8 Soil site investigation

It is important that site soil investigations provide sufficient information to the design process. Chapter 3 of IECA 2008 discusses site planning and notes a requirement for soil testing for linear site disturbance (in Note 1) which states that:

> '*Boreholes for such projects should be spaced at 50 to 75 m intervals along the entire length of the disturbance. A staggered pattern should be adopted if the disturbance width is greater than 10 m*'.

These recommendations should be considered for all State Growth projects as it is common for soil types to vary considerably within short distances, making specific batter treatments necessary, rather than a typical treatment throughout the project.

Soil testing should include, at least, Particle Size Distribution, and Emmerson Aggregate tests, which will assist in determining properties of soil types that need to be managed during earthworks and subsequent vegetation establishment.

Particle Size Distribution is the standard laboratory procedure for determination of particle size distribution in a soil. The results of this test can be used to classify types of soil in accordance with the Universal Soil Classification System (USCS), and therefore give some indication of typical soil properties.

The Emmerson Aggregate Test classifies the behaviour of soil aggregates on their coherence in water. Soils are classified into seven classes, with one further class being distinguished by the presence of calcium rich minerals. Class 1, 2 and 3 soils are considered highly dispersible. Earthworks involving these soils will require greater consideration, due to their dispersible nature, as noted in Section 2.2.3.

These tests will be useful in determining the erosion hazard for both earthworks during the Construction Phase, and ongoing batter stability in the Operational Phase of the project.

3.1.9 Develop brief for Concept Design Phase

Proper investigation of site constraints and opportunities, will allow for a more detailed brief for the Concept Design Phase. This brief should include requirements for the following items:

- Property acquisition
- Ecological constraints
- Preferred batter slopes, and
- An indication of requirements for vegetated batter treatments.

This early consideration will allow early determinations to be made, and the desired outcomes to be developed in the following design phases. These constraints may inform options for roadside batters, identify whether the project can be delivered within a realistic budget, and identify where compromises need to be made in the design process.

3.2 Concept Design Phase

To deliver better site stabilisation and landscaping outcomes, it is important that planning for landscaping and erosion control continues in the Concept Design Phase. Project Inception Phase investigations should be conducted during the Concept Design Phase where earlier consideration of those factors was not undertaken.

The key aim of any investigations at the Concept Design Phase will be to understand any key risks to be considered for site stabilisation and landscaping, in the context of other considerations, such as project budget, environmental issues and property constraints.

3.2.1 Erosion Risk Rating

At the Concept Design Phase, it is important to identify the erosion risk for the project site. Erosion Risk Rating is particularly relevant to Tasmania, due to the large differences in anticipated rainfall and soil type between localities. For example, measures that may be appropriate for a site on the east coast may not be appropriate for a site in western Tasmania.

Erosion Risk Rating links the average monthly rainfall depth to a required erosion control standard in accordance with the procedure outlined in IECA 2008. The standard of erosion control is particularly relevant during the project's Construction Phase where earthworks, including batters, may be unprotected and exposed to erosive agents such as water and wind. IECA 2008 provides important guidance for the control of erosion during construction of batters. Similarly, IECA states that:

> '*Best practice erosion control requires appropriate measures to be employed as soon as reasonable and practicable to limit soil erosion and, in particular, to protect any and all exposed areas of soil from raindrop impact erosion*' (IECA 2008, 4.4).

For simplicity, the Erosion Risk Rating in these Guidelines is linked to monthly rainfall depth, without consideration of other factors (such as surface area and slope), because the focus is primarily on raindrop impact erosion, rather than sheet and rill erosion. However, soil type and, to some extent rainfall intensity, should also be considered as contributors to erosion risk for a site.

Some soils exhibit characteristics that make them more prone to erosion, especially dispersible soils, which are distributed throughout Tasmania. Where soil testing discovers some extent of dispersible soil within the project site, the project is considered to have a high erosion risk.

Rainfall intensity increases erosion risk through more concentrated rainfall and therefore increased impact erosion. High intensity rainfall also produces higher peak run-off volumes, which subsequently increase the occurrence of concentrated stormwater flows and therefore a greater risk of rill erosion. Tasmania's east coast is subject to higher rainfall intensity than other regions. However, the intensity does not vary considerably between locations, in comparison to the mainland states of Australia, indicating that rainfall depth is likely more suitable to determine an erosion risk rating, than rainfall intensity.

Erosion Risk Rating allows the following:

- A comparative indication of the risk of erosion for each project site;
- A method by which erosion control planning can be focussed on erosion prone sites;
- Identification of sites that require a preliminary assessment of erosion and sediment control (ESC) issues during the Project Inception Phase; and,

- Identification of those developments that require a review of the project's Erosion and Sediment Control Plan (ESCP), including batter treatments, by a suitably qualified person, such as a Certified Professional in Erosion and Sediment Control (CPESC).

The following figures and table provide information to allow determination of an Erosion Risk Rating based upon monthly rainfall depth and soil dispersibility.

Figure 15 - Representative Locations in Tasmania

Table 3.2 Erosion Risk Rating (based on average monthly rainfall depth (adapted from IECA 2008))

Average monthly rainfall depth (mm)	Dispersible soil present	
	No	Yes
< 45	Low	Medium
45+ to 100	Medium	High
>100	High	High

Table 3.3 Indicative average monthly rainfall and Erosion Risk Rating for representative locations

Location	Average Monthly Rainfall (mm)	Dispersible soil on site	Erosion Risk Rating
Hobart	56.1	No	Moderate
		Yes	High
Adventure Bay	94.3	No	Moderate
		Yes	High
Huonville	61.8	No	Moderate
		Yes	High
Ouse	42.5	No	Low
		Yes	Moderate
Oatlands	45.5	No	Moderate
		Yes	High
Port Arthur	84.1	No	Moderate
		Yes	High
Triabunna	43.8	No	Low
		Yes	Moderate
Bicheno	56.1	No	Moderate
		Yes	High
Launceston	57.6	No	Moderate
		Yes	High
Georgetown	63.0	No	Moderate
		Yes	High
Scottsdale	81.5	No	Moderate
		Yes	High
Campbell Town	46.5	No	Moderate
		Yes	High
Flinders Island Airport	61.1	No	Moderate
		Yes	High

Burnie	78.9	No	Moderate
		Yes	High
Sheffield	88.0	No	Moderate
		Yes	High
Smithton	74.7	No	Moderate
		Yes	High
Currie	75.0	No	Moderate
		Yes	High
Waratah	179.8	No	High
		Yes	High
Granville Harbour	125.4	No	High
		Yes	High
Queenstown	207.4	No	High
		Yes	High

Note: The Erosion Risk Rating above is intended as a guide only. The information does not consider each environmental aspect of every site in Tasmania, and the project team should undertake consideration of specific issues relating to each site.

3.2.2 Design requirements based on Erosion Risk Rating

The following requirements for project design development apply to each erosion risk rating:

Erosion Risk Rating	Project requirements
Low erosion risk	The Project Designer should undertake the design of batters, and other earthworks, in accordance with the recommendations made in this document. The design process should identify and consider the soils found within the site, the proposed process to control the erosion of those soils during the Construction and Operational Phases. The Concept Design drawings, and an accompanying report, shall record findings for, and the methodology of, erosion and sediment control for the project.
Moderate erosion risk	The previous (low risk) process will be followed, with review of key documentation reviewed by a suitably qualified and/or experienced person at each design iteration.
High erosion risk	The Project Designer will prepare a specific Concept Erosion and Sediment Control Plan and accompanying report. This conceptual plan will consider the soils found within the site, the proposed process to control the erosion of those soils during the Construction and Operational Phases. A suitably qualified and/or experienced person will review the Concept ESCP and report.

Figure 16 presents the workflow for site stabilisation design development.

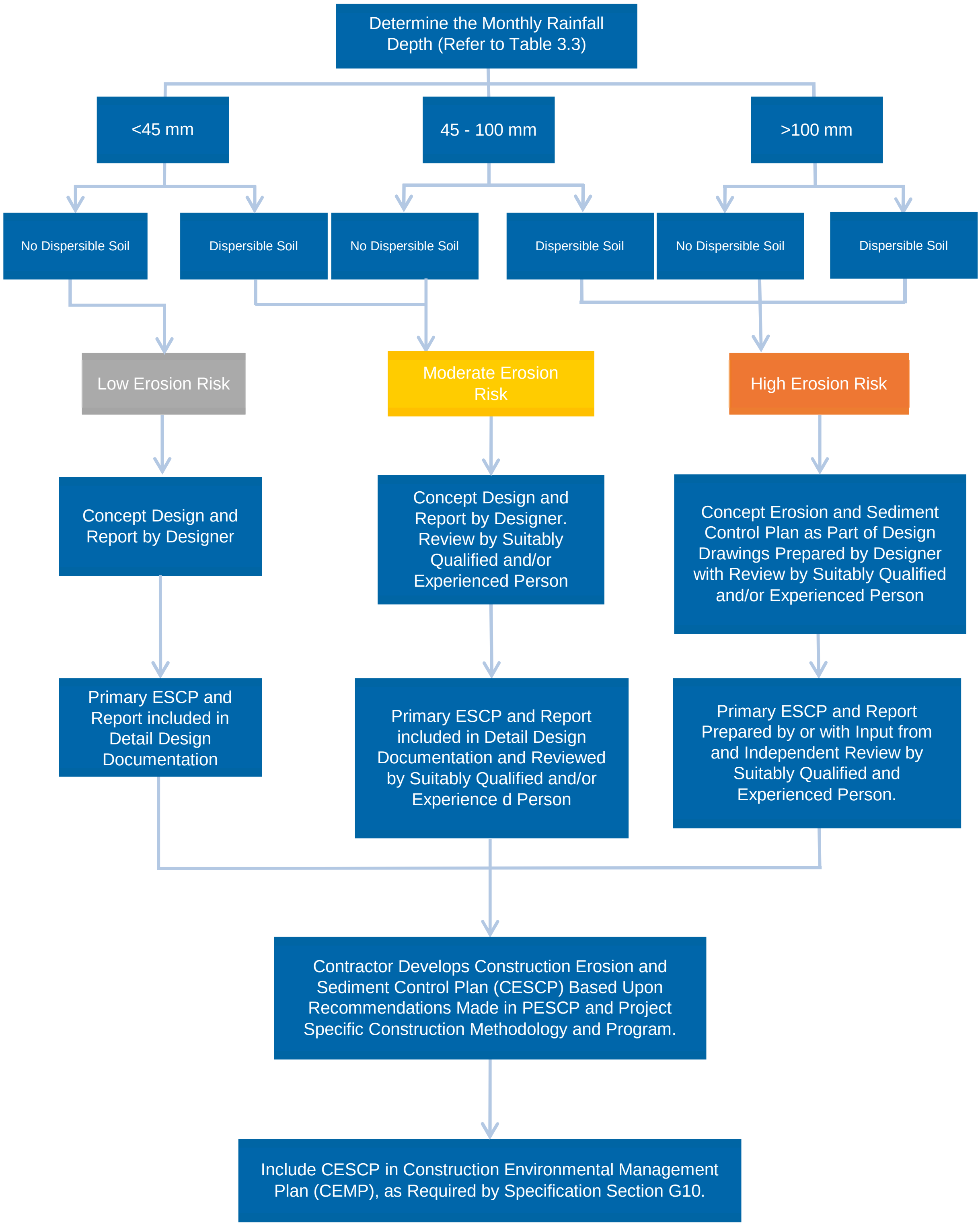

Figure 16 - Batter design and risk rating workflow

3.2.3 Concept design consideration of site stabilisation issues

Early consideration of batter formation and stabilisation should be made at the Concept Design Phase. The requirement for site stabilisation, during design development, is determined by the site's Erosion Risk Rating. Erosion control is a major component of site stabilisation.

State Growth's Standard Specification Section 176 part D requires that:

> *'The Contractor shall minimise the risk of soil erosion and sediment pollution of the site, adjacent land, and waterways, by defining and implementing erosion and sediment controls measures as part of its EMP'.*

IECA 2008 Chapter 5 provides appropriate advice on the requirements for Erosion and Sediment Control Plans. Specifications for further design phases should reference this document, with its recommendations adopted for planning and design of erosion control works for each project.

3.2.4 Geotechnical site investigations

Geotechnical investigations are key to determining whether the underlying geotechnical conditions are suitable for desired batter slopes. Most projects will involve geotechnical investigations for pavement designs, and it is good practice to extend these investigations to batter slopes. Given the significant potential for unstable material to be identified during earthworks, additional geotechnical investigations for batter treatments will assist in:

- Identifying key geotechnical constraints for batter design
- Better manage construction cost risks for earthworks and site stabilisation
- Designing more appropriate batters, and
- Determining appropriate treatments.

The Concept Design Phase should outline the requirement for geotechnical investigation during project development. For higher risk projects, a geotechnical investigation program should be determined by an experienced geotechnical engineer during the Concept Design or Preliminary Design Phases, with reference to Austroads 2008.

3.2.5 Land clearing and stabilisation requirements

It is widely accepted that the best way to prevent impacts of sedimentation is to prevent erosion. Minimising the extent and duration of disturbance to existing ground covers is one of the most effective forms of erosion control. Existing vegetation should be preserved to the largest extent possible, on all surfaces not directly exposed to project earthworks.

IECA 2008 provides advice on requirements for land clearing and stabilisation. Table 3.4 reflects these recommendations, which should be applied to Tasmanian project sites with the relevant erosion risk ratings.

Table 3.4 Best practice land clearing and rehabilitation requirements (IECA 2008)

Erosion Risk Rating	Best practice requirements
All cases	• All reasonable and practicable steps taken to apply best practice erosion control measures to completed earth works, or otherwise stabilise such works, prior to anticipated rainfall – including existing unstable, undisturbed, soil surfaces under the management or control of the building/construction works.
Low	• Land clearing limited to maximum 8 weeks of work. • Disturbed soil surfaces stabilised with minimum 70% cover within 30 days of completion of works within any area of a work site. • Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 30 days. • Appropriate protection of all planned garden beds is strongly recommended.
Moderate	• Land clearing limited to maximum 6 weeks of work. • Disturbed soil surfaces stabilised with minimum 70% cover within 20 days of completion of works within any area of a work site. • All planned garden beds protected with a minimum 75 mm layer of organic mulching, heavy erosion control blanket, rock mulching, or the equivalent. • Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3 m vertical increments wherever reasonable and practicable. • Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 20 days.
High	• Land clearing limited to maximum 4 weeks of work. • Disturbed soil surfaces stabilised with minimum 75% cover within 10 days of completion of works within any area of a work site. • All planned garden beds protected with a minimum 75 mm layer of organic mulching, heavy erosion control blanket, rock mulching, or the equivalent. • Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3 m vertical increments wherever reasonable and practicable. • The use of turf to form grassed surfaces given appropriate consideration. • Soil stockpiles and unfinished earthworks are suitably stabilised if disturbance is expected to be suspended for a period exceeding 10 days.

3.2.6 Develop Preliminary Design, Erosion and Sediment Control, and Landscaping Briefs

The Concept Design Phase should identify the key investigations required during the Preliminary Design Phase. Information gathered and decisions made during formulation of the Concept Design should be reported in the Preliminary Design Brief. This brief should provide as much guidance for initiation of the Preliminary Design Phase as possible. For example, in undulating terrain, a road engineering survey should be appropriately scoped to allow designers provide sufficient survey area coverage to allow batter slopes to be reduced, without having to undertake additional survey.

A specific Landscaping Brief should be prepared to inform the Draft Primary Landscaping Plan which will be developed during the Preliminary Design Phase. Landscape features requiring specific treatment should be identified along with any constraints on road design and batter treatment. The style of landscape design should be clearly prescribed and be used to inform species selection for replanting and batter treatments. Where available, other information that can be included in this brief, such as:

- Property acquisition
- Ecological constraints
- Batter slope, and
- Preferred batter treatments.

The Draft Primary Erosion and Sediment Control Plan, to be completed in the Preliminary Design Phase, will benefit from information contained within the Concept Design documentation, which should include facts regarding soil testing conducted, information gathered, and decisions made in regard to formation of batters and erosion control. This information will be included in the Concept Erosion and Sediment Control Plan, for sites determined to have a high erosion risk.

Early identification of additional investigations required to design landscaping and stabilisation works appropriately will ensure that minimal delays to project design and allow designers to more thoroughly specify required construction works through the Preliminary and Detailed Design Phases.

3.3 Preliminary Design Phase

The Preliminary Design Phase is fundamental in integrating broader project outcomes with batters design and landscaping treatments that meet the desired outcomes of this document.

The relevant key outcomes from the Preliminary Design process will:

- Meet State Growth's project specific outcomes for visual and environmental amenity,
- Develop a design that is deliverable within the project's budget, and
- Minimise whole-of life costs (e.g. vegetation establishment and maintenance).

In many cases, projects will include specific design features (such as roundabouts and/or grade-separated junctions, which require particular consideration. Some further information for these sites are included in Section 5.

3.3.1 Site-specific investigations

There are a range of site-specific surveys and investigations required for the Preliminary Design Phase. If requirements for further investigations are identified as the Preliminary Design progresses, these inputs should be included in the design as early as possible.

Soil testing

Additional soil testing may be required where determined in the Project Inception Phase investigations. Testing may also include determination of topsoil quality, and amelioration requirements, to improve use in site stabilisation landscaping.

Natural values surveys

State Growth will generally undertake natural values assessments for areas potentially impacted by road construction projects. Some of the information collected in these surveys is useful in developing landscaping options for construction works.

Characterisation of existing vegetation and appropriateness to replicate in revegetation program. Areas of native vegetation where topsoil should be reused as part of the revegetation program are to be identified. Particular consideration is to be given to retaining, storing and re-using topsoil that may support good condition native vegetation, threatened flora or high conservation value native grassland. Similarly, topsoil in areas with weed infestations should not be re-used to prevent future weed infestations developing on site.

Geotechnical investigations

Early geotechnical investigations are essential in understanding site opportunities and constraints, and should be undertaken as soon as practical to inform the design process during Preliminary Design. However, timing of these investigations needs to be balanced with the progress of design to a point where horizontal and vertical alignment is well understood, which would allow more focused investigation and reduce investigation costs.

There are also a range of geotechnical investigation methodologies that can be considered. For example, geophysical investigations can be used in conjunction with a smaller borehole program to estimate depth to rock to assist with batter design (see below for an example). In all cases, an appropriately qualified geotechnical engineer should be consulted on decision-making for geotechnical investigations, including methodology.

Midland Highway upgrade – St Peters Pass – York Plains Road

As part of the Preliminary Design for the upgrade of the Midland Highway near St Peters Pass, there were a number of large batters identified. As part of the design process, a project-specific geotechnical investigation programme was undertaken, including

- *Structural defect mapping of existing cuttings for kinematic feasibility assessment and determination of appropriate cut batter angles.*
- *Seismic refraction survey (geophysical investigation) to estimate depth to rock and determine seismic velocities to assist with excavation estimates.*

The survey traverses targeted behind existing cuttings, generally parallel to the road, in areas where proposed cuttings were typically in excess of 3 m height.

This allowed the design team to better understand geotechnical conditions at the site and identify potential geotechnical issues that may impact the proposed works, including:

- *Subsurface ground conditions, including groundwater.*
- *Assessment of excavation conditions at the site and safe batter angles for permanent excavations.*

Geotechnical investigations should include sufficient investigations to find shattered, fractured or jointed rock, along with degradable, weathered or low strength rock. The investigations should also aim to estimated quantities of different rock types for construction cost estimation.

3.3.2 Batter design and stability management

The Preliminary Design phase is where key project design parameters are developed and refined, such as cross section, vertical and horizontal alignment. These road design parameters will be key in determining the earthworks required as part of the project.

Consideration of batter slopes and stability management are a key input to this process. It is essential that appropriate measures are considered, to provide that batters are stable, low maintenance and are consistent with the existing visual landscape.

Any compromises in batter design during design should consider appropriate stabilisation treatments. The following provides some guidance on the key elements to be considered.

Batter Gradient

Reduced gradient of batters is the most desirable design outcome from an erosion control perspective. Shallower batter slopes have the following benefits:

- Reduced risk of failure through erosion
- Reduced cost of construction
- More flexibility in surface cover treatment, including the selection of species for landscaping
- Increased opportunity for stormwater infiltration, and
- Improved access for, and ease of, maintenance.

Shallow batter slopes also increase the broader project footprint, which may not be desirable when considering adjacent landowners or environmental constraints. Similarly, the amount of earthworks required to achieve reduced batter slopes can increase construction costs, although this should be balanced against whole-of-life costs.

Historically, steep batter slopes (1H:1V or more) have been adopted in Tasmania in an effort to contain the road formation within the existing road reserve. While such slopes may be appropriate for competent rock batters, soil surfaces will be difficult to stabilise and maintain at such gradients. For these slopes, expensive surface cover treatments may need to be adopted to ensure slope stability, with a reduced chance of success, and more extensive maintenance requirements. The cost of adequate construction measures, and increased ongoing maintenance, may outweigh the initial cost of property acquisition required to provide room for a flatter batter slope, which can be more easily constructed and maintained.

Batter slopes become more difficult to construct and maintain as the surface gradient increases. Flatter batter slopes provide easier servicing and therefore reduced work and decreased cost to maintain. In general:

- Topsoil should not be placed on slopes steeper than 2H:1V, without any additional means of stabilisation, as there is a high risk of the topsoil slipping from the slope.
- Slopes steeper than 2H:1V are unsafe for access without consideration of appropriate means to address safety of workers and the public.
- Grassed slopes steeper than 3H:1V cannot be mown using ride-on machinery, and must maintained by hand mowers.
- Slopes steeper than 3H:1V entail an increased health and safety hazard to maintenance workers due to the increased risk of ‘slips and trips’ during maintenance.

Long batter slopes can compound the erosion issues caused by batter gradient. Slope lengths can be reduced by introducing benches into the batter to reduce the length of slope, and therefore flow energy stormwater runoff down the batter (refer to IECA 2008).

Drainage

Stormwater drainage requires consideration during batter design. Correctly designed drainage measures can reduce the risk of erosion by:

- redirecting stormwater flow away from sensitive areas
- decreasing runoff velocities and shortening effective flow lengths
- increasing stormwater infiltration into the soil, and
- trapping eroded sediments.

Improved stormwater drainage will control water flow over batter slopes, reducing the amount and velocity of run-off over these areas. This will lead to reduced:

- potential for rill erosion
- damage to surface treatments and vegetation, and
- maintenance requirements during the life of the asset.

The layout of all batter drainage should be carefully conceived so that concentrated flow will not be directed to a single location where it could cause significant erosion.

Catch drains (refer to IECA 1998, drawings CD-01 to CD-05) should be installed at the top of every batter to capture and re-direct run-on stormwater flow before it reaches the slope.

Figure 17 - Batter erosion due to water flow over slope

It is important that catch drains are designed in a continuous line, close to the contour, to ensure that the gradient of the drain does not encourage flow velocities that will result in erosion of the structure. Appropriate drain linings should be selected to ensure that erosion of the drain does not occur.

Batter chutes should be provided to convey captured stormwater down batters without causing erosion of the slope (refer to IECA 2008, drawings CH-01 to CH-06).

Figure 18 - Batter chute to convey water down slope

Batter surface vegetation

The Preliminary Design should prescribe appropriate surface treatments (including vegetation) across the entire project site. Surface treatment will vary across the project site to best respond to site characteristics and desired outcomes, including:

- Reduced erosion
- Successful establishment of vegetation

- Reduced weed establishment
- Visual amenity, and
- Reduced maintenance requirements.

A single treatment type may not be suitable for the entire project site, especially for long sites or sites with significant variation in substrate. Local constraints may restrict options for batter treatments, and advice should be sought through geotechnical engineers and specialist landscape contractors to determine the most practical treatment for each batter location.

Some batters may not be suitable for stabilisation using vegetation treatments. Vegetated batters may be unsuitable in a range of situations, including:

- Steeper batter slopes
- Inappropriate batter material, such as exposed rock or unstable soils, and
- Areas where on-going maintenance will be difficult or hazardous (e.g. sites with difficult access and/or high traffic sites.

In those locations, alternative treatments may be selected, such as rock-faced batters, rock gabions or other artificial surface lining. This guideline does not deal with such treatments, and these should be selected and designed by appropriately qualified people on a project-specific basis.

The hierarchy of stability treatments should be laid out in design plans, and justification of various treatment choices should be included in design reports.

Vegetation treatments will generally include succession from fast-growing cover crops to more permanent ground covers and larger plants. Strategies such as early planting of short-lived fast-growing grasses, to protect the surface from erosion and provide a mulch for slower growing, longer-lived species to establish, should be considered.

Opportunities for stockpiling topsoil for re-use on newly constructed batters should be considered. The natural values survey should be used to identify any opportunities to utilise existing resources during re-vegetation work (e.g. retention of mulch or topsoil from the site).

Figure 19 – Tailored vegetated surface treatments

3.3.3 Draft Primary Erosion and Sediment Control Plan

The Primary Erosion and Sediment Control Plan should identify key erosion risks for projects, along with mitigation strategies to manage these risks. A draft of this plan should be developed in the Preliminary Design Phase, and will include the results of all previous investigations, and determinations made. Guidance on the detail that should be provided in this plan is provided in Section 3.4.1.

The following requirements, for project design development, apply to each erosion risk rating:

- **Low erosion risk**. The Project Designer may prepare the draft Primary Erosion and Sediment Control Plan (PESCP) and accompanying report. This PESCP will detail the soils found within the site, the proposed process to control the erosion of those soils during the Construction and Operational Phases, and the means by which eroded sediment will be contained within the site. The PESCP, and report, will be included in the Detailed Design documentation and subjected to review as part of that package.
- **Moderate erosion risk**. The Project Designer may prepare the draft Primary Erosion and Sediment Control Plan (PESCP) and accompanying report. This PESCP will detail the soils found within the site, the proposed process to control the erosion of those soils during the Construction and Operational Phases, and the means by which eroded sediment will be contained within the site. Assistance should be sought from a suitably qualified person where the Designer has little experience in the consideration, and design, of ESC requirements and/or the site is more difficult. A suitably qualified and/or experienced person will review the Primary ESCP and report.
- **High erosion risk**. A suitably qualified and/or experienced person will prepare, or provide direct input to, the draft PESCP and report. This plan will consider the soils found within the site, the proposed process to control the erosion of those soils during the Construction and Operational Phases, and the means by which eroded sediment will be contained within the site. An independent suitably qualified and/or experienced person will review the PESCP and report.

3.3.4 Draft Primary Landscaping Plan (including drawings)

For projects that do not have specific landscaping requirements, a Primary Landscaping Plan may not be required. Such projects can generally follow State Growth's existing Specifications – Standard Sections (especially Section 720).

Where project specific landscaping options are being considered (and/or are required), these should be presented as graphic plans for use in communication with stakeholders and general public. They should be included in web-based 3D drive-through designs. Early consultation on these landscaping treatments with key stakeholders will help to gain early acceptance of any changes, and enable final design to better consider stakeholder input.

Where project specific landscaping has been found to be useful, it would be advantageous to update the Standard Specification to include specification and performance measures for these treatments.

3.4 Detailed Design Phase

The Detailed Design Phase is key to progressing the Preliminary Design into Construction through the finalisation of the road design and development of construction specifications, including draft management plans.

The key outcomes from the Detailed Design Phase will be to transition the Preliminary Design into the Construction Phase, and set up the construction specification and management plans to ensure that the Construction Phase delivers effective landscape and erosion management outcomes.

Outputs from the Detailed Design Phase should include landscaping and erosion control plans to provide guidance to the construction contractor and contract administration team, including project specific actions.

These documents should reference State Growth's Standard Specification, and include the:

- Primary Erosion and Sediment Control Plan, and report
- Primary Landscaping Plan, specification and report, and
- Draft Site Handover Plan, including maintenance instructions.

Designers of projects within areas of <u>low erosion risk</u> should be undertaken in accordance with the recommendations made in this document. The drawings and report should identify the soils found within the site, and the proposed process to control the erosion of those soils during the Construction and Operational Phases and the means by which sediment will be contained within the site. The drawings and report should be subject to review as part of the design documentation.

Designers of projects within areas of <u>moderate erosion risk</u> should engage a suitably qualified person to undertake review of the design documentation prepared. Assistance should be sought from a suitably qualified, and/or experienced person where the designer has little experience in the consideration and design of erosion and sediment control requirements.

Designers of projects within areas of <u>high erosion risk</u> should provide a Primary Erosion and Sediment Control Plan as part of the Conceptual and Detail Design Drawing package. The drawings, and report, should be prepared with input from, and subject to independent review by, a suitably qualified and/or experienced person.

3.4.1 Primary Erosion and Sediment Control Plan

The Draft Primary Erosion and Sediment Control Plan (PESCP), prepared in the Preliminary Design Phase, must be developed during the Detailed Design Phase. The PESCP should include consideration of how batters are to be constructed, including:

- Staging of construction
- Stockpiling of materials, such as top soil
- Provision of temporary and permanent drainage
- Timing for vegetation of batter slopes and adjoining areas, and
- Maintenance of formed batters to ensure rapid stabilisation and establishment of vegetation.

The PESCP should be based on the investigations and recommendations made in the previous design phases, developed in consideration of the project's Detailed Design.

The PESCP should be presented on drawings to clearly demonstrate the arrangement and staging of controls required to ensure that construction of the project, including batters, can be undertaken with minimal erosion and loss of sediment from the site. A report should accompany the drawings to provide background information, and calculations, to construction contractors and maintenance staff through the project lifespan.

As noted previously, IECA 2008 provides the 'best practice' guidelines for this discipline. IECA 2008 - Chapter 5 provides appropriate advice on the requirement for, and issues to be considered in, erosion and sediment control plans.

The following information should be specified in the PESCP, which adhere to accepted drafting requirements (north point, title, scale etc.):

- site and easement boundaries
- construction access points (where appropriate)
- site office, and location of stockpiles
- proposed limits of disturbance
- retained vegetation, including protected trees, and critical environmental constraints
- site revegetation requirements (if not contained within separate plans)
- general soil information, and location of problem soils
- general layout and staging of proposed works
- existing, and final, site contours, including locations of cut and fill
- construction drainage plans for each stage of earthworks, including land contours for that stage of construction, sub-catchment boundaries and location of watercourses
- location of all drainage, erosion and sediment control measures
- full design and construction details for all temporary drainage, including diversion channels and sediment basins
- construction specifications for adopted ESC measures (as appropriate)
- notes relating to:
  - site monitoring and maintenance program
  - site preparation and land clearing
  - extent, timing and application of erosion control measures
  - temporary ESC measures installed at end of working day
  - temporary ESC measure in case of impending storms, or emergency situations;
  - installation sequence for ESC measures
  - site revegetation and stabilisation requirements
  - application rates (or at least the minimum application rates) for mulching and revegetation measures, and
  - legend of standard symbols used within the plans
- calculation sheets for the sizing of ESC measures, and
- any other relevant information the regulatory authority may require to properly assess the ESCP

This list is indicative only and may be amended, where appropriate, with reference to IECA 2008 and relevant State Growth Standard Specifications.

3.4.2 Primary Landscaping Plan and specification

The Primary Landscaping Plan should be developed during the Detailed Design Phase. This should include detailed landscaping plans for the project site, considering batter design, surface cover requirements and any other design elements. Where possible, the project specification should include quantities, and timeframes, to allow for accurate costing by construction contractors. This should include identification of appropriate species for planting, growing media requirements (based on soil sampling) and recommendations for site preparation.

This specification should consider opportunities for propagation from material on site (cuttings and seed collection) and time required to grow plants. Where possible, an indicative staging plan for earthworks and vegetation establishment should be developed, to assist adequate forward planning is followed to ensure availability of materials, along with the optimum time of year for planting. As a guide, specific treatments for site preparation should include:

- Sub-soil preparation, such as the need for ripping , rock removal, or retention of site structure where it is intended to retain vegetation
- Pre-planting weed control
- Soil treatment including depth and type of growing media
- Site preparation including ancillary products required (e.g. compost blanket or other options from Appendix A)
- Mulch options
- Seed mix and quantities, plant names, size and numbers, and
- Maintenance and audit schedule for the period up to 36 months after planting, including watering, weeding and replacement of plants (to account for losses).

Further guidance on key success factors for vegetation establishment are provided within Section 2.3.

3.4.3 Draft Site Handover Plan

A Draft Site Maintenance Handover Plan should be prepared as part of the Detailed Design Documentation. This plan should state the requirements for further establishment, and maintenance, of all site infrastructure including batter surface protection and landscaping for the project. The plan should be in accordance with the requirements of State Growth's Specification Section 720, and include:

- Landscaping performance criteria through the Defects Liability Period
- An auditing program schedule, to consider site preparation through to maintenance, to measure against the Specification at 12, 24 and 36 months, and
- Detail of ongoing monitoring for general plant health, to consider amongst other things competition for weeds, adequacy of watering, plant health need for fertilising, and herbivory (browsing animals or insects). A response plan should be prescribed where required.

Where project specific landscaping outcomes are defined in the construction specification, the maintenance plan should ensure that these are key growth goals are achieved and that future maintenance actions are handed over, where relevant.

A program of auditing should be scheduled to consider site preparation through to maintenance to measure against the standard at 12, 24 and 36 months, and consider the project's specific timing for defects liability period, and handover to State Growth's maintenance team.

Ongoing monitoring for general plant health, to consider amongst other things competition for weeds, adequacy of watering, fertilising requirements and herbivory management for browsing animals or insects.

IECA 2008 provides useful recommendations regarding requirements for establishment of erosion protection ground cover, along with other requirements for continuing operation of erosion and sediment control measures until such ground cover is established to a satisfactory level. Recommendations made in this regard may be considered by the project designer, and included in the plan, as required.

4. Construction

Careful management, planning and implementation in the Construction Phase is key to delivering key landscape and erosion management outcomes. IECA 2008 notes that:

> '*all reasonable and practicable measures must be taken to incorporate erosion control measures into each stage of site disturbance and rehabilitation. Erosion control should* ***not*** *be restricted to just the post-construction activities*'.

Standard Specification Sections 160 and 176 set out the requirements for preparation and implementation of a Construction Environmental Management Plan (CEMP) during construction. These specifications require that the Contractor shall demonstrate that both known and potential environmental effects are clearly understood and are effectively managed throughout the contract period (including the defects liability period). Section 176 requires that soil erosion and sediment pollution of the site, adjacent land, and waterways, is managed by defining and implementing erosion and sediment controls measures as part of the CEMP.

The Primary Erosion and Sediment Control Plan (PESCP) and Primary Landscaping Plan are two important contributors to a Contractor developing a pertinent and site specific CEMP in compliance with this specification. The contractor should adopt the decisions and recommendations made in these documents to inform their construction methodology, and develop the CEMP accordingly.

The Construction Phase should finalise and implement landscaping and erosion control plans, and the construction contractor and contract administration team should work together to ensure that these plans are implemented correctly, and that any issues are resolved prior to construction completion.

This stage should also require the construction contractor to prepare and implement a response plan to be prescribed where contracted works fail to meet the required specification.

4.1 Construction Erosion and Sediment Control Plan

The PESCP, developed during Detailed Design of the project will be a key document for managing erosion and sediment controls during the Construction Phase. The PESCP shall be updated and adopted by the Contractor as part of their construction management plans, prior to any earthworks starting on site.

The PESCP is intended to provide a base design and methodology for construction and a resource for the Contractor in developing their Construction Erosion and Sediment Control Plan (CESCP). It is important that the contract administration team works with the contractor to ensure that the CESCP meets the key erosion management outcomes outlined in the Detailed Design Phase.

The CESCP will provide a suitable methodology to allow the project to be constructed in accordance with the project specification and State Growth's Standard Specification. As a guide, the CESCP should consider:

- Appropriate staging of earthworks
- Stabilising and covering disturbed surfaces as soon as practicable after earthworks
- Marking completed surfaces as 'no-go zones' to prevent machinery from trafficking those areas, thereby resulting in erosion issues and cost of rework to the project

- Providing temporary erosion control measures to minimise damage to completed surfaces by due to rain events, to minimise erosion and rework, and

It should be noted that Section 176 of the Specification requires that any defects and/or deficiencies in control measures:

'*shall be rectified immediately and these control measures shall be cleaned, repaired and augmented as required to ensure effective control measures thereafter*'.

4.2 Implementation of landscaping plan

In the implementation of the landscaping design, during the Construction Phase, the contractor will develop a staging plan for implementation of landscaping works.

Disturbed and newly formed surfaces should be stabilised, soon after the earthworks are complete, with the final surface cover and vegetation installed. These completed surfaces should be delineated as 'no-go' areas to avoid damage by workers and machinery as adjoining works are undertaken. Any areas and/or control measures damaged after forming should be repaired immediately and stabilised to prevent erosion, as required by Section 176 of the Specification. This will reduce the time period before vegetation is adequately established, thereby reducing erosion of newly formed surfaces. A reduction in the amount of remediation work, required to reinstate completed earthworks, will provide cost savings to the Construction Phase Contractor.

Figure 20 - Batters under temporary stabilisation during construction

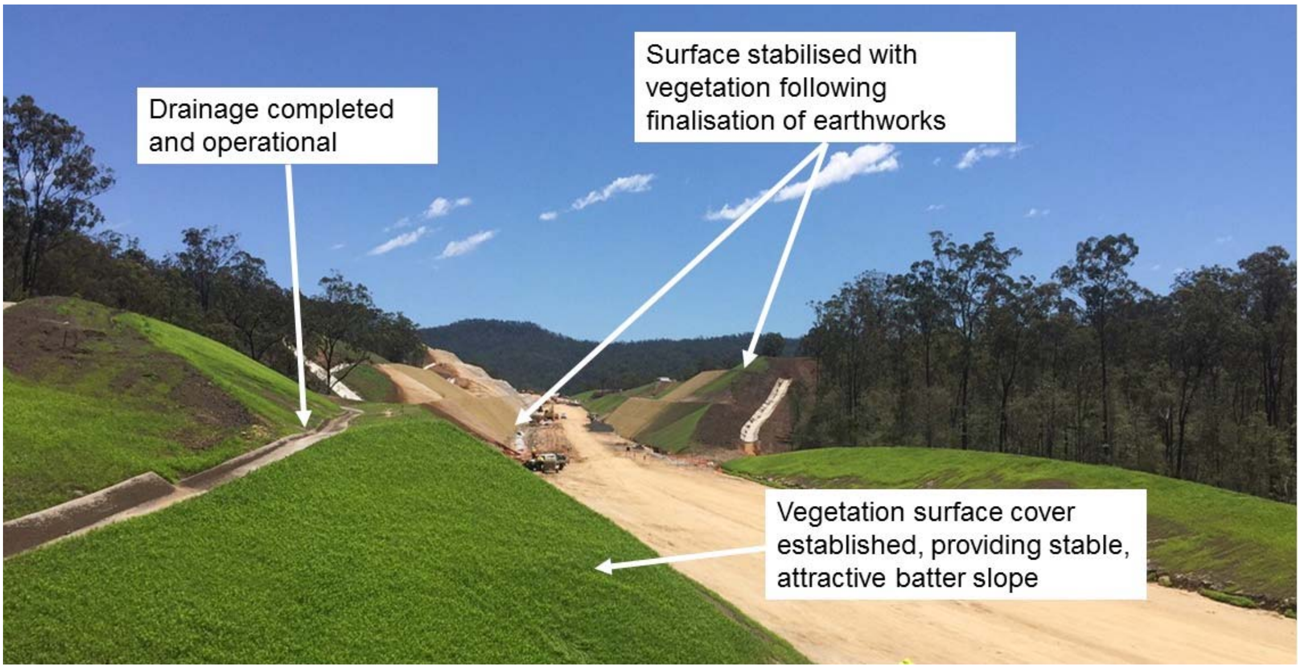

Figure 21 - Construction phase landscaping - staging

The Primary Landscaping Plan will also ensure adequate forward planning to ensure availability of plantings and other materials, along with the optimum time of year for planting to ensure successful establishment. The landscaping plan will also consider timing for specific treatments for site preparation, including:

- Prior to earthworks
  - pre-planting weed control
  - fencing for retention of vegetation, where required
- During earthworks
  - stockpiling and management of topsoil and mulch
  - sub-soil preparation, such as the need for ripping and rock removal
- Post-earthworks
  - soil treatment including depth and type of growing media
  - site preparation including ancillary products required (e.g. compost blanket)
  - mulch options
  - seed mix and quantities, plant names, size and numbers, and
- Post-establishment
  - maintenance schedule for the period up to 36 months after planting, including watering, weeding and replacement of plants (to account for losses).

Vegetation establishment should be staged to allow for approval of preparation before moving to next stage. The plan will also include relevant hold points and auditing during and after each of these stages:

- Site preparation – Ripping, topsoil application, cultivation and finish (refer to Section 720, part 7 of the Specification)
- Mulching (refer to Section 720, part 8 of the Specification), and

- Planting & Grassing (refer to Section 720, parts 9, and 10 of the Specification).

4.3 Post-establishment – monitoring and maintenance

The Post-establishment Stage aims to maintain vegetation and any longer-term erosion control measures, both during construction and the Defects Liability Period. The key elements of this stage will be ensuring that vegetation establishment meets the specifications of the construction contract, and that all erosion control measures are functioning as specified.

In this stage, it is essential that the construction contractor and contract administration team work together to ensure that site monitoring is completed in a timely manner, and any defects are rectified as quickly as possible.

4.3.1 Vegetation maintenance

State Growth's Standard Specification Section 720 requires annual audits to ensure performance requirements are achieved at 12, 24 and 36 months. It also requires periodic audits to ensure plant health is not being compromised by weed competition, inadequate watering, or herbivory from browsing animals and insects.

Maintenance should include a program of routine checks and activities, but also include reactive checks and activities following rainfall. Occasional maintenance should be done to slash dead temporary crops, remove standing dead vegetation from cut slopes, repair rolled products or target noxious weeds.

Selective herbicides should be used for weed management to target the correct form or species of weed for each particular site. If too much spraying or inaccurate spraying is done, then the long-term vegetative cover can be damaged and impaired.

Maintenance mowing of all road shoulders, table drains, batters and other surfaces likely to experience accelerated soil erosion must aim to leave the grass length no shorter than 50 mm where reasonable and practicable. Maintenance mowing should done in a manner that will not damage the profile of formed, soft edges, such as the crest of earth embankments.

4.3.2 Maintenance of other erosion control measures

It is critical to attend to minor maintenance issues (e.g. loose erosion control blanket) promptly, as they can quickly result in major issues or even complete batter failures if not fixed prior to rainfall.

All erosion and sediment control measures, including stormwater drainage, should be fully operational and maintained in proper working order, until the downstream surfaces have achieved substantial establishment of ground cover vegetation. Sediment removed from sediment traps and places of sediment deposition should be disposed of in a lawful manner that does not cause ongoing soil erosion or environmental harm.

4.3.3 Site handover plan

The Defects Liability Period is not completed until final approval at the timing defined in each construction contract. If targets have not been met then this can be extended on a 12 monthly basis (according to Standard Specification 720).

After the Defects Liability Period, management of the vegetation transfers to State Growth's Maintenance program. Where specific landscape features form part of the landscaping works, these may still warrant a site-specific regime of monitoring and management by qualified horticulturist/ecologist.

The Draft Site Maintenance Handover Plan should be updated by the Construction Contractor, for handover to State Growth's Maintenance team. This plan should include revised requirements for further maintenance of all site infrastructure, where the arrangement and/or type of infrastructure was amended during construction of the project.

5. Landscaping considerations for specific sites

Guidance for landscaping of specific types of road infrastructure is outlined in the following sections. This provides a general overview only, and a project-specific solution should be developed for each project.

General requirements for each project site should include:

- Vegetation communities that are as self-reliant as possible
- Adequate sight distance for all road users
- Consideration of 'hard' landscape treatments for infrastructure in high volume traffic sites, and
- Adequate provisions for maintenance, including consideration of reduced maintenance tasks, safety for workers, and adequate access to road infrastructure (vegetated or otherwise).

5.1 Urban road landscaping

Traffic management requirements for working on roadsides in urban environments will direct landscape design to low maintenance options. Hard landscaping (such as concrete walls) with higher up-front cost, can prove beneficial in the longer term. The urban character is better suited to non-vegetated options, which can provide alternative aesthetic opportunities through artistic design.

The peri-urban highway environment is also key in presenting gateways to cities. More expensive options may be justified in some situations. Accessibility for maintenance is a key factor for consideration. There are wider opportunities and options for species selection in the urban environment where focus may be on high standard of aesthetics. The use of strong colours may be desirable in some situations. Other considerations may be use of advanced trees, mass planting, incorporation of structural features etc.

Figure 22 - Landscaping provides character to an urban location

5.2 Roundabouts

Roundabouts are separated from the surrounding area by road lanes, and offer no pedestrian access. They can be difficult to maintain as workplace safety requirements for maintenance workers require a clear separation between workers and traffic. This can mean that the circulating carriageway needs to be partially closed to vehicles.

Landscaping of roundabouts should aim to require minimal ongoing maintenance. A simple paved, or robust grass (or groundcover) surface might be more appropriate on smaller roundabouts. A paved outer surface is recommended ease maintenance difficulties on busy roundabouts, with a low concrete edge provided to protect planting. Mass planting of shrubs should be dense low groundcovers and native grasses, planted into weed mat overlaid with mulch. Adequate drainage should be provided.

Figure 23 - Landscaped roundabout

5.3 Medians

For road medians, it is important that landscaping strongly considers future maintenance requirements in designing appropriate landscaping for the site. This does vary between urban and rural areas, and some further context is provided below.

5.3.1 Urban medians

Similar to roundabouts, urban medians are usually located directly adjoining traffic lanes. They can be difficult to maintain as workplace safety requirements for maintenance workers require a clear separation between workers and traffic, which may result in the adjoining road lane being partially closed to vehicles. As such, careful consideration should be given to planting a median, and a sealed surface (concrete or similar) may provide a more acceptable solution.

Typically, median widths and landscaping arrangements should be:

- Less than 2 m wide – these medians should be ‘hard’ landscaped to avoid/reduce maintenance.
- 2 to 4 m wide - these medians may be suitable for groundcovers and mulch, but hard landscaping should be strongly considered, especially in higher traffic environments. If vegetation is chosen, then a long term management plan will be required. Safety for maintenance workers must be considered as part of the design.
- Greater than 4 m – Multiple solutions are possible for such wide medians. However, safety for maintenance workers should be considered as part of the design.

Any vegetation should be neat and structured with lower groundcovers next to the road followed by taller species. Planting within road clear-zones must be frangible unless behind a barrier installed as part of the engineering design. Planting must not restrict road user sight lines on the approach to intersections or pedestrian crossings.

There should be a concrete margin along the edge of the median to provide a neat, easy to maintain edge. Planting should be set back from the road edge to avoid overhang of the carriageway from limbs and foliage. Any grassed areas should be turfed using low maintenance turf.

Figure 24 - Planted (top) and concrete (bottom) urban medians

5.3.2 Rural medians

The rural median is generally located within higher speed zones than the urban median. These separate high speed traffic, and assist in screening headlight glare from approaching traffic. As with urban medians, these can be difficult to maintain as Occupational Health and Safety requirements for maintenance workers may require a clear separation between workers and traffic which may result in the adjoining road lane being partially closed to vehicles. As such, careful consideration should be given to planting a median, and a hard surface (concrete or similar) may provide a more acceptable long-term solution.

All median landscape areas should be revegetated with a native seed mix using frangible species. Where planting is required for medians, an average planting density of 1 plant per 2 m^2 should be adopted. Planting should only be used as an additional measure to ensure that a well vegetated corridor is provided and the design objectives are achieved. Ensure that all sight distance requirements are satisfied and maintained at the approaches to intersections.

Generally, the ratio of shrubs to groundcovers should be in the order of 50% shrubs to 50% groundcovers within rural medians. To allow for maintenance of planted urban medians, these should be provided with a minimum width of 2 m for lower speed roads, and 4 m for higher speed roads. A 2 m wide mowing strip should be provided at the edge of the median where the median is wider than 6 m.

Figure 25 - Planted (left) and typical (right) rural medians

5.4 Grade separated junctions

Grade separated intersections have similar constraints to roundabouts, as they often have small areas of road reserve surrounded by road lanes and offer no pedestrian access.

They can be difficult to maintain as workplace safety requirements for maintenance workers may require a clear separation between workers and traffic, which may result in the circulating carriageway being partially closed to vehicles.

Many of these intersections have batter slopes that are steep, which presents some difficulty in ongoing maintenance of grass and other vegetation.

Small and/or steep areas of road reserves within grade separated junctions should be designed for minimal maintenance. Paving, or concrete, may be appropriate on smaller reserves.

For larger, steep reserves, providing lower maintenance shrubs is an option, which would negate the need for regular mowing. Mass planting of shrubs should be dense low groundcovers and native grasses, planted into weed mat overlaid with mulch, with adequate drainage.

Figure 26 - Grade separated junction

5.5 Heritage landscaping

There are a number of places across Tasmania where heritage landscaping occurs within (and adjacent to) the road corridor. In project planning, it is recommended that heritage investigations be undertaken to map and identify trees and other planting of heritage significance.

This information should be used during road design to avoid direct and indirect impact avoid heritage plantings, where practical and feasible. As part of construction works, all heritage landscaping should protected through exclusion zones or other measures.

Where it is unavoidable to remove heritage plantings, re-establishment of heritage landscaping should be considered through plantings outside the road reserve and outside the potential envelope for future upgrades. Any plantings should be consistent with the pre-existing heritage values (including species selected), and be undertaken in close consultation with landholders.

Figure 27 - Heritage landscaping in Ross

6. Key reference material

- Department of State Growth Specification for Construction
- Best Practice Erosion and Sediment Control – International Erosion Control Association, Australasia, (IECA 2008)
- Guide to Road Design Part 7: Geotechnical Investigation and Design (Austroads 2008)
- Guidelines for Cut Road Batters in Areas of High Erodibility Soils (Forest Practices Authority, 2011)
- Dispersive Soils and Their Management (Department of Primary Industries and Water 2009)

Appendices

Appendix A – Possible surface cover solutions

The information presented in this table has been adapted from the ‘Guideline for Batter Surface Stabilisation Using Vegetation’ (NSW Roads and Maritime Services, April 2015).

Table 6.1 Possible Surface Cover Solutions

Stabilisation Technique	Suitable Batter Slope	Comparative Cost	Time Until Protection	Erosion Risk Suitability
Broadcast Seeding	△	$	●	Low
Hyrdoseeding	△	$	●	Low
Soil Binder – Bitumen Emulsion	△	$	◐	Low
Turf	△	$$	○	Low
Hydromulch	△	$	○	Moderate
Mulch/Topsoil Mixes	△	$	○	Moderate
Soil Binder – Tackifier	◭	$	◐	Moderate
Straw Mulching	◭	$	○	Moderate
Cellular Confinement Systems	▲	$$$	○	Moderate
Erosion Control Blanket – Organic Fibre	▲	$$	○	Moderate
2D Turf Reinforcement Mat	△	$$$	●	High
3D Turf Reinforcement Mat	△	$$$	○	High
Compost Blanket	◭	$$$	◐	High
Erosion Control Blanket – Synthetic	▲	$$$	○	High
Hydromulch - Bonded Fibre Matrix	▲	$	○	High
Hydromulch - Hydrocompost	▲	$$	◐	High
Rock Faced Batter (No Vegetation)	▲	$	○	High

Key

Suitability for Slope	
△	Not likely suitable for slopes steeper than 3H:1V
◭	May be suitable for slopes between 3H:1V – 1.5H:1V
▲	Likely suitable for slopes steeper than 1.5H:1V

Indicative Cost	
\$	Low $\leq\$5/m^2$
\$\$	Moderate $\$5\text{-}\$10/m^2$
\$\$\$	High $\geq\$10/m^2$

Period Until Surface Protection is Achieved	
●	Slow -Relies on Establishment of Vegetation
◐	Rapid – Erosion protection will be enhanced with vegetation establishment
○	Immediate – Effective as soon as installation is complete

Appendix B – Site Stabilisation / Batter Design Checklist

Table 1.2 Site Stabilisation / Batter Design Checklist

	Completed		Comments
	Yes	No	
Project Inception Phase			
Site Visit Conducted			Notes: Endemic plant assemblage, Amenity requirements, Weed risk, Availability of site materials, natural drainage routes, Environment, Property boundary etc.
Soil Investigation			Notes: Soil types encountered e.g. USCS and Emerson Class
Geotechnical Investigation			Notes:
Property Boundaries			Notes: Reserve width, Potential impacts, Potential acquisition
Concept Design Brief	Yes	No	Notes:

	Completed		Comments
	Yes	No	
Concept Design Phase			
Site Erosion Risk Rating			Notes: Low, Moderate, High
Proposed Batter Slopes			Notes: Slopes 2H:1V etc.
Proposed Batter Surface Treatments			Notes: Proposed treatments
Property Acquisition Required	Yes	No	Notes:
Preliminary Design Brief	Yes	No	Notes:
Preliminary Landscaping Design Brief	Yes	No	Notes:
Draft ESCP Required?	Yes	No	Notes:

	Completed		Comments
	Yes	No	
Preliminary Design Phase			
Proposed Batter Slopes	Yes	No	Notes: Slopes 2H:1V etc.
Proposed Batter Surface Treatments	Yes	No	Notes: Proposed treatments
Property Acquisition Required	Yes	No	Notes:
Primary Landscape Design	Yes	No	Notes:
Primary ESCP Required?	Yes	No	Notes:

	Completed		Comments
	Yes	No	
Detailed Design Phase			
Proposed Batter Slopes	Yes	No	Notes: Slopes 2H:1V etc
Proposed Batter Surface Treatments	Yes	No	Notes: Proposed treatments
Property Acquisition Required	Yes	No	Notes:
Primary ESCP	Yes	No	Notes:
Landscape Design and Specification	Yes	No	Notes:
Draft Site Maintenance Handover Plan	Yes	No	Notes:

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3218695-33280/https://projects.ghd.com/oc/Tasmania/sitestabilisationan/Delivery/Documents/Site Rehab and Landscaping Standard report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	I. Millar/ M. Davis	M. Davis		Simon Lukies		
1	I. Millar	M. Davis		Simon Lukies		15/5/18
2	I. Millar	M. Davis		Matt Davis		26/7/18
3	I. Millar	M. Davis		Matt Davis		22/8/18

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