

Engineering Design Specification D11 Control of Erosion and Sedimentation (Design)

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Control of Erosion and Sedimentation (Design)

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1 General

1.1 Introduction

1.1.1 Worksection application

This worksection is applicable to the design and documentation requirements of control measures for mitigating the effects of erosion and sedimentation from construction activities and stormwater run-off, as required for the development erosion and/or sediment risk level. It includes both temporary and permanent control measures.

1.2 Responsibilities

1.2.1 General

Requirement: Provide design and documentation for temporary and permanent erosion and sedimentation control measures to minimise short and long term soil erosion and the impact of erosion.

1.3 Interpretation

1.3.1 Abbreviations

General: For the purposes of this worksection the following abbreviations apply:

- ARI: Average recurrence interval.
- ESC: Erosion and sediment control
- ESCP: Erosion and sediment control plan.
- GPT: Gross pollutant trap.

1.3.2 Definitions

General: For the purposes of this worksection the following definitions apply:

- Average recurrence interval: The average or expected value of the period between exceedances of a given discharge, it is generally expressed in years.
- Catchment (area): A topographically defined area drained by a stream, river or reservoir of water (into a groundwater system).
- Clean water: Water conforming to one of the following:
 - Water that enters the development site from an external source and has not been further contaminated by sediment within the site.
 - Water originating from the site and does not require treatment to reach the required water quality level.
 - Water that would not be further improved if it was to pass through the sediment trap for the site.
- Erosion control measures: Measures to prevent or reduce soil movement from wind, rain or flowing water from a construction site resulting from both natural processes and human activity.
- Low gradient flow diversion (drainage) technique: A flow diversion drain, channel or bank with a gradient sufficiently low to maintain subcritical flow along its length.
- Permanent control measures: Measures/works implemented to control run-off water quality beyond the construction and maintenance stages.
- Rainfall erosivity: The R-factor is a measure of rainfall erosivity and is defined as the mean annual sum of individual storm erosion index values, EI30, where E is the total storm kinetic

energy and I30 is the maximum 30-min rainfall intensity. It is measured as (MJmm/ha/hr). When factors other than rainfall are held constant, soil losses are directly proportional to the magnitude of rainfall erosivity. The R-factor represents the climatic influence on water-related soil erosion, and can be used to quantify broad-scale, climate-driven, soil erosion potential.

- Sediment control measures: Measures to reduce the impact of erosion by trapping and retaining sediment before it is discharged into the surrounding environment. Flowing sediment is captured and held in place long enough for it to settle.
- Steep gradient flow diversion technique: A flow diversion drain, channel or chute with gradient sufficiently steep to cause supercritical flow within its length.
- Sub-catchment: A topographically defined area drained by a tributary or branch drain of a primary stream, river or main draining catchment.
- Temporary control measures: Measures required to control and filter the run-off from areas disturbed by the contractor's activities.
- Unsealed road: A road surface that comprises of either natural parent material or gravel added and is not surfaced by bitumen or concrete.

1.3.3 Qualifications

Expertise: Use suitably qualified or experienced personnel to assess the erosion risk level of the development site and prepare the ESCP.

2 Pre-design planning

2.1 Planning

2.1.1 Key characteristics

General: The principles of erosion and sediment control for urban development equally apply for unsealed roads, but some key differences relating to planning, design, construction and maintenance for unsealed roads include:

- They are linear and produce large amounts of sediments in stormwater runoff and can cause serious environmental damage on reaching waterways.
- Cross multiple catchments and have various discharge points making effective sediment control measures difficult to implement.
- Control of erosion and sedimentation are required at all stages of construction and ongoing maintenance to minimise erosion, sediment and pollutant transport.
- Specific works like bridges, culverts, causeways and borrow pits, road safety and constructability may influence the selection and location of erosion and sediment control measures.
- Management of roadside drainage in controlling sediment runoff, with an emphasis on slowing drainage flows and dispersing them more frequently.
- Roadside vegetation in maintaining good stormwater quality by slowing and filtering stormwater runoff.

2.1.2 Data collection

Requirement: Collect data required for assessing the development site erosion risk level and for preparing the erosion and sedimentation management strategies for the development.

Erosion risk assessment: Collect site data required to inform the risk assessment, including the following:

- Geotechnical investigation: To AS 1726.

- Soil data: From soil maps or, if this is not available, from soil sampling and testing. Identify soil properties such as soil type, erodibility, dispersion potential, salinity, shrink swell capacity, texture and drainage characteristics. If required by a regulatory authority or if the development involves varied and complex land use where changes are expected, prepare a soil survey to identify the existence of problematic soils.
- Site constraints and attributes: Including the following:
 - Topography and landform: Slope, gradient and aspect.
 - Lithology: Rock outcrops and substrate material.
 - Climate and hydrology: Rainfall, flood liability, groundwater level and rainfall erosivity.
 - Vegetation.
- Area of disturbance or prone to mass land movement.
- Distance of site to existing drains/watercourses.
- Areas with drainage problems.

Erosion and sedimentation strategies: Collect site data to assist in preparing management strategies, including the following:

- Site properties/constraints and development impact data to assist in the selection and design of drainage, erosion and sediment control measures, including identification of the following:
 - Site contour.
 - Off-site and on-site hazards.
 - Potential impacts of the development.
 - Potential site constraints, including soils, topography, water supply and vegetation.
 - On-site natural watercourses and receiving water such as creeks, ponds, lakes, wetlands, waterways, swamps, springs and artesian features.
 - Potential flood prone land.
 - Critical environmental habitats.
- Nature of land disturbance resulting from the proposed development.
- Site and development data to assist in the design of site revegetation.
- Soil treatments required to facilitate site revegetation.
- Natural drainage paths on the site.
- On-site water quality levels/values and discharge standard.
- Non-erodible areas and potential diversion routes.
- Locations of potential dispersive soils.
- Areas of potential landslip/mass movement.
- High and extreme erosion risk areas requiring protection.
- Areas with soils of extreme pH and/or requiring amelioration.

2.1.3 Site erosion risk assessment

Risk level assessment: Determine the development site erosion risk level by calculating the predicted total soil loss from the site over the total period the site will be disturbed, e.g. 6 months. Use the Council's risk class or scale criteria to determine the site erosion risk level.

Higher risk areas on site: Identify areas with higher risk so that management measures can be addressed at the planning stage. These areas include the following:

- Areas with high potential for soil loss.

- Areas with high potential to cause environmental harm.
- Areas located within or within close proximity to critical habitats such as wetlands, creeks and waterways.
- Areas with monthly rainfall erosivity (R factor) more than 285.
- Areas affected by high risk construction activities, including the following activities:
 - Which disturb natural wetlands or flowing streams.
 - Which disturb threatened species and habitats.
 - Which disturb protected vegetation.
 - With the potential to cause significantly more soil loss and/or environmental harm.
 - Which run longer than 6 months.

2.1.4 Site sediment risk assessment

Risk level assessment: Determine the development site sediment risk level based on predicted soil loss from the site over the total period the site will be disturbed for determining sediment control methods required for the site.

2.1.5 Land capability assessment and site actions required

Requirement: Determine site/land/urban capability based on extent of land disturbance required by the development, and water erosion and water pollution risk.

Areas requiring remedial action: Identify existing areas subject to erosion, where remedial measures are required.

Severe rainfall: If severe rainfall events are expected, prepare a contingency plan.

2.2 Consultation

2.2.1 Council and other authorities

Council consultation: Liaise with the Council's Development Control officer(s) for the following:

- Soil and contour mapping.
- Vegetation mapping.
- Tree/vegetation subject to statutory protection.
- Flood prone areas.
- Council's policy and Development control plans for ESCP requirements for erosion and sediment control, and stormwater drainage.

Procure approvals as required:

An erosion and sedimentation control concept plan for all stages of the project shall be prepared and submitted to Council for approval. The approved concept design shall be included in the Drawings for the project.

Other authorities: Consult with and seek approval for the scheme development from the state government authorities responsible for the following:

- Bushland areas.
- Wetlands.
- Waterways and developments in coastal areas.
- Catchment water quality.

2.2.2 Other project development team members

Other development project design team members: Identify high risk areas as early as possible in the project development and liaise with other members of the design team to address the control measures in the project concept design so that risks and hazards can be mitigated or eliminated.

Integrated development planning: In particular, liaise with members of the development design team preparing the design of the following:

- Works in or close to a watercourse.
- Layouts of lots, roads, cycleways and pedestrian pathways.
- Recreational facilities, open spaces or natural heritage reservations.
- Stormwater drainage systems.
- Services installations.
- Site rehabilitation.

3 Design criteria

3.1 General

3.1.1 Classification of unsealed roads

General: To Austroads AGRD02 Table 2.2.

3.1.2 Design objective

Requirement: Design erosion and sediment control measures for the proposed development with the following objectives:

Integration of measures with the site and construction planning.

Compatibility with the anticipated soil, weather and construction conditions.

Minimisation of the extent and duration of soil disturbance, with limitations on the time surfaces are exposed.

Control water movement through the site.

Minimisation of soil erosion.

Prompt stabilisation of disturbed areas.

Maximisation of sediment retention on the site.

Measures are functional at all times.

With monitoring measures to maintain the required performance standard.

ESC measures are appropriate for the environmental risk; type, cost and scope of proposed development.

Ensure that maintenance considerations are included as an essential design element

Design considerations: Address all aspects of site disturbance, stormwater management, erosion and sediment control, and site rehabilitation for the duration of the construction from initial clearing to project completion.

3.1.3 Location of unsealed roads

For new unsealed roads: Select the location considering the following factors:

Locate the road along a ridge or as high as possible on side slopes to reduce the catchment area above the road or track.

Minimise disturbance to soil and vegetation.

Minimise the number of watercourse and drainage line crossings.

Avoid steep cross-slopes (greater than 18 degrees).

Avoid high erosion hazard soils (e.g. dispersive soils, soil loss classes 5, 6 and 7).

Avoid areas of riparian vegetation and maintain buffer strips between the road and any watercourse.

Avoid areas where there are perched water tables, swamps, or areas of poor drainage.

Avoid areas prone to mass movement or slope stability problems.

Avoid soil types having poor construction quality.

3.2 Development planning considerations

3.2.1 Construction and site planning

Control measures and staging of works: Design type, location, and timing of measures and actions in relation to the disturbance activities for each phase of work, including clearing, earthworks, civil construction, services installation and landscaping/rehabilitation. Design the measure/action to minimise erosion, manage flow and capture sediment in relation to the construction and access areas at each phase of work.

Protection measures: Provide measures based on the following requirements:

Existing buffer zones protecting the site.

Sensitive natural and indigenous features requiring protection.

Fencing and isolation measures required to protect features including habitats.

Temporary drainage works required to divert water and sediment through works in progress.

Site conditions: Apply the appropriate site conditions for designing run-off control measures to withstand storm event.

3.2.2 Development planning

Integrated development planning: Review proposed development layout and coordinate soil and water management with engineering requirements. If required, modify development layout to:

Minimise land clearing and land shaping.

Minimise the risk of erosion within downstream waterways.

Minimise changes to the volume, frequency, duration and velocity of stormwater run-off affecting the natural water cycle.

Minimise earthworks and construction activities along property boundaries.

Allow disturbance areas to be permanently stabilised.

So that non-disturbance areas can act as sediment control buffer zones.

Allow for early installation and operation of permanent stormwater drainage system.

Avoid placing critical structures or buildings in regions with the lowest land elevation.

To integrate identified site constraints.

Risks that cannot be eliminated as part of the design: Develop measures to control/ reduce or eliminate the risks.

3.2.3 State legislation

Comply with the following:

NSW Gov Act No. 26 - Dams Safety Act 2015

NSW Gov Act No. 30 - Local Government Act 1993

NSW Gov Act No. 156 - Protection of the Environment Operations Act 1997

NSW Gov Act No. 10 - Soil Conservation Act 1938

3.2.4 State guidelines

Refer to the following:

Landcom "Blue Book". Landcom Publication; *Managing Urban Stormwater: Soils and Construction Vol 1, Landcom 2004-Latest Edition*

3.2.5 Site evaluation tools

Requirement: If required for the development, an appropriate mapping tool to determine the suitability of the proposed development for the site as follows:

Site/land/urban capability mapping: To assess land use (for the development) through soil investigation.

Erosion risk mapping: Include mapping of site constraints that directly relate to soil erosion and zones of various erosion risks. Base the selection/design of control measures on the assessed risk.

Erosion hazard assessment: Use a system appropriate for the development, to assess all the erosion hazard items affecting the erosion risk level of the proposed development, e.g. average slope of disturbance area, duration of soil disturbance, climate, topography, geology, drainage and surface hydrology.

Available contour mapping.

3.2.6 Site constraints

Requirement: Design development layout and erosion control measures to reflect known site constraints and regional factors.

Soil limitations: From the soil data collected, assess the potential and limitations of soils for the proposed development and soil management measures required for the site. If a soil survey has been prepared, use the survey to assess the appropriateness of land use proposed by the development; plan, design grading and erosion control measures for the development; make recommendations for soil treatments and allow for soil management technique such as vegetation selection.

Topographic limitations: Minimise land reshaping, utilise the existing topography where practicable and where appropriate, address the following topography regions in the development design and layout:

Drainage problem areas.

Areas with existing erosion problems.

Flood prone land.

Land prone to mass movement erosion.

Land prone to storm surges.

Rock outcrops.

Steep slopes.

Wetlands.

Water limitations: Determine the expected seasonal water quality, quantity and supply cost. If required, allow for sediment basins as a temporary water supply for dust control and plant irrigation.

Vegetation limitations: Consider the following in the development design and layout:

Retention or rehabilitation of critical areas such as watercourses, floodplains, steep slopes or wetlands with natural vegetation cover for soil stabilisation.

Selecting trees for preservation before locating roads, buildings and open works.

Locate roadways, construction storage areas and parking bays away from the drip zone of trees (Tree Protection Zone) selected for preservation.

Avoid excavation, traversing, filling, trenching within the drip zones of trees selected for preservation.

Retain existing ground cover on slopes steeper than 10% and deep rooted vegetation on slopes steeper than 20%.

Ecological limitations: Consider any adverse effect the erosion and sediment control measure selected may have on the natural ecology of the site. For example, reinforcing mesh applied in bushland areas may cause native fauna (birds or ground dwelling reptiles) to become entangled.

3.3 Drainage control

3.3.1 Design standards

Permanent drainage design: To *D09 Stormwater Drainage (Design)*.

Anticipated design life of temporary drainage works:

3.3.2 Drainage design standard for temporary drainage works table

Drainage structure	ARI based on the anticipated design life		
	< 12 months	12 to 24 months	> 24 months
Temporary drainage structures ¹ : NSW, Victoria, Tasmania, South Australia, and southern Western Australia	1 in 5 year	1 in 10 year	1 in 10 year
Temporary drainage structures ^{1,2} : Located immediately upslope of an occupied property that may be adversely affected by the failure of the structure (e.g. catch drain, flow diversion bank)	1 in 10 year	1 in 10 year	1 in 10 year
Temporary culvert crossing	Minimum 1 in 1 year hydraulic capacity wherever reasonable and practicable.		
¹ Design capacity excludes minimum 150 mm freeboard.			
² Design flow rate based on upslope drainage structures, excluding freeboard.			

3.3.3 Drainage for unsealed roads

Requirement: Design road drainage to divert the stormwater away from the road by minimising the sediment load by slowing the drainage flows and dispersing them more frequently. Drainage design for unsealed roads applications include:

Pavement surface drainage.

Table drains.

Catch drains and batter slopes.

Culverts and pipes.

Creeks and drainage line crossings.

Road drainage in areas with high water tables.

Road drainage in semi-arid and arid areas.

Road drainage in wet tropics.

3.3.4 Maximum distance of water flow along road surfaces and table drains prior to diversion into under road culverts table

Road grade (degrees)	Maximum distance (metres)	Road grade (degrees)	Maximum distance (metres)
1	250	8	70
2	200	9	65
3	150	10	60
4	125	11	55
5	100	12	50
6	90	13	45
7	80	14 and 15	40

(Source: NSW State Office of Environment and Heritage).

3.3.5 Drainage control measures

Requirement: Allow for control measure to suit the site drainage gradient/slope, drainage surface and function required.

Low gradient drainage technique: Select from the following measures:

- Catch drain.
- Compost berm.
- Diversion channel.
- Flow diversion bank – earth, sandbags.
- Straw bale flow diversion bank.

Drainage down slopes, steep gradient flow diversion technique: Select from the following measures:

- Chute.
- Level spreader.
- Slope drain.

Outlet structures for temporary drainage systems: Select from the following measures:

- Level spreader.
- Outlet structure.

Velocity control structures for channels and drains: Design drainage channels so that the maximum flow velocity does not exceed that allowed for the surface material to minimise channel erosion, including along the invert. If channel width, depth or gradient cannot be altered, control invert erosion through the following options:

- Reducing flow velocity through check dam placement.
- Increasing effective scour resistance of the drain by incorporating channel liners such as erosion mats or rocks.

Check dam techniques: Select from the following measures:

- Fibre roll.
- Rock check dam.
- Recessed rock check dam.
- Sandbag check dam.
- Triangular ditch check.

Channel/chute lining techniques: Select from the following measures:

- Cellular confinement system.
- Erosion control mats.
- Geosynthetic lining.
- Grass lining.
- Grass pavers.
- Hard armouring.
- Reinforced grass.
- Rock lining.
- Rock mattresses.
- Turfing.
- Turf reinforcement mats.

Drainage control on unsealed roads: Select from the following measures:

- Discharge of water as sheet flow:
 - Level spreader.
- Drainage from unsealed access roads:
 - In-fall drainage.
 - Out-fall drainage.
 - Crowned.

Temporary watercourse crossings: Select from the following measures:

- Bridge.
- Culvert.
- Ford.

3.3.6 Control measure selection considerations

Sandbag check dams: Allow in drains shallower than 500 mm.

Rock check dams: Allow in drains deeper than 500 mm.

Track drainage: Refer to NSW Rural Fire Service – Fire Trail Design, Construction and Maintenance Manual

Stripped topsoil: Where possible re-use stripped topsoil to form flow diversion banks upslope of the soil disturbance.

Watercourse crossings: Design watercourses to filter run-off through surrounding grass or bushland before it enters streams.

Temporary culvert crossings: Design crossing so that head loss across the structure is limited to 300 mm maximum at the point when overtopping first begins to occur.

Long unstable slopes: Subdivide into manageable areas to prevent rill erosion.

3.4 Erosion control

3.4.1 Risk assessment

General: Develop and adopt local risk assessment procedure. Alternatively adopt the erosion risk rating based on average monthly erosivity, or average monthly rainfall depth or on the estimated soil loss rate as appropriate.

3.4.2 Erosion risk rating table

Erosion risk rating ¹	Average monthly erosivity (R-factor)	Average monthly rainfall (mm)	Soil loss (t/ha/yr)
Very low	0-60	0-30	0-150
Low	60-100	30-45	150-225
Moderate	100-285	45-100	225-500
High	285-1500	100-225	500-1500
Extreme	> 1500	> 225	> 1500

¹ Risk rating categories are defined in IECA Book 1 Table 4.4.7 *Best practice land clearing and rehabilitation requirements*.

3.4.3 Erosion control measures

Soil stabilisation techniques: Select from the following measures, as appropriate for the site erosion risk assessment:

- Bonded fibre matrix.
- Cellular confinement system.
- Compost blanket.
- Erosion control blanket.
- Gravelling.
- Heavy mulching.
- Light mulching.
- Revegetation.
- Rock mulching.
- Soil binders.

3.4.4 Mulching

Requirement: Select light or heavy mulching for soil stabilisation and to prevent soil crusting of non-vegetated areas or areas where garden beds are proposed on flat or mild slope.

Light mulching: Select from the following measures:

- Bonded fibre matrix.
- Brush mulch.
- Dead or dormant grass cover (temporary seeding).
- Hydromulch.
- Straw mulching including sugarcane mulch.

Heavy mulching: Select from the following measures:

- Brush, bark, woodchip mulch.
- Compost blanket.
- Rock mulching.
- Straw mulching including sugarcane mulch.

Grass seeded areas: Allow for protection from raindrop impact erosion with light mulch immediately after seeding.

3.4.5 Erosion control blankets

Requirement: In areas of strong winds or overland flows, allow for erosion control blankets as an alternative to loose mulching or for stabilising mulch from washing or blowing away. Select from the following measures:

- Hydraulically applied blankets.
- 100% biodegradable jute and coir blankets.
- Jute and coir mesh.
- Short-term synthetic reinforced composite blankets.
- Permanent turf reinforcement mats.

3.4.6 Control of soil erosion on slopes

Requirement: Consider the following practices when designing erosion control measures for soil areas that are sloped:

- Establishing non-erosive drainage conditions for periods when rainfall may occur.
- Establishing 70% of soil surface for periods when rainfall may occur.
- Establishing complete and continuous vegetation cover.
- Slopes that are likely to be vegetated: Allow for slope to be as flat as possible to reduce the shear stress of the slope from stormwater run-off.
- Slopes that are unlikely to be vegetated: Allow for slope to be as steep as possible to reduce exposure of slope effective surface area to raindrop impact erosion.
- Steep grass seeded slopes: Allow for turf strips to be pinned along the contour in maximum 2 m spacing to maintain sheet flow down the slope and reduce the risk of rill erosion.

3.4.7 Application of erosion control measures to soil slopes table

Flat land (flatter than 1V:10H)	Mild slopes (1V:10H to 1V:4H)	Steep slopes (steeper than 1V:4H)
Erosion control blankets	Bonded fibre matrix	Bonded fibre matrix
Gravelling	Compost blankets	Cellular confinement systems
Mulching	Erosion control blankets, mats and mesh	Erosion control blankets, mats and mesh
Revegetation	Mulching well anchored	Compost blankets
Rock mulching	Revegetation	Revegetation
Soil binder	Rock mulching	Rock armouring
Turfing	Turfing	Turfing

3.4.8 Dust control

General: Dust control treatments vary with site conditions. Select the appropriate treatment from the **Dust control practices table**.

Wind erosion: To prevent wind erosion, incorporate the following measure(s):

- Revegetation.
- Maintaining moist soil conditions.
- Chemical sealants (soil binders) placed over the soil surface.
- Surface roughening.
- Wind breaks.

3.4.9 Dust control practices table

Site conditions	Treatment options						
	Permanent vegetation	Mulching	Watering	Soil binders	Gravel road	Stabilised entry/exit pad	Minimise site disturbance
Areas not subject to traffic	✓	✓	✓	✓	✓		✓
Areas subject to traffic			✓	✓	✓	✓	✓
Material stockpiles			✓	✓			✓
Clearing and excavation			✓	✓			✓
Unpaved roads			✓	✓	✓	✓	
Earth transport					✓	✓	

3.4.10 Major drainage channels and watercourse stabilisation

Stabilisation of disturbed areas: Allow for disturbed areas to be revegetated to the water's edge, to link aquatic and riparian habitats. Stabilise by rock protection during plant establishment.

3.4.11 Vegetation management

Vegetation management planning: Where site clearing is required, minimise soil disturbance to the development site; and allow for site revegetation to provide short or long term erosion protection to suit the following site properties:

- Natural slope (gradient) of the site.
- Site topography.
- Current and future land use within and adjacent to the site.
- Existing native flora.
- Soil condition, including structure, water holding capacity, nutrient content and dispersion potential.

Vegetation clearing: Plan land clearing operations in conformance with the following:

- So that vegetation clearing does not start before a vegetation management plan is prepared and sedimentation control measures and drainage have been installed.
- Clearing is staged to minimise the extent and duration of soil exposure to wind, rain and running water.
- Clearing is limited to 5 m from the edge of proposed construction works.

Plant selection: Select plants suited to the site erosion likely to occur at the development site. For example, where sheet erosion is likely, ground cover grasses are suitable to provide continuous cover; where wave erosion is likely, reeds and mangroves are suitable for coastlines, rivers and lakes. Management of problematic soils: Allow for soil protection measures or soil adjustments so that vegetation can establish. If required, allow for erosion control blanket, mat or mesh to protect the soil from short-term erosion during the plant establishment period.

3.5 Sediment control

3.5.1 Design standards

Sediment control standard: Design sediment control measures based on the allowable soil loss rate limit (t/ha/yr) or the monthly erosivity (R-factor) and average monthly rainfall for the development site.

Design discharge for sediment traps: Allow for design storm of 0.5 times the 1 in 1 year ARI peak discharge.

3.5.2 Design objectives

Design criteria: Design sediment control measures in conformance with the following:

- Sediment laden run-off: So that sediment is collected and retained wholly within the development work site and trapped before the run-off moves onto road surfaces.
- Sediment laden run-off originating from the road surface: So that sediment is prevented from entering sealed (e.g. hard lined) drainage systems or permanent drainage systems (e.g. piped or open channel drain).
- Sediment controls within or adjacent to roadside stormwater outlets: Allow for gully bags in preference to road-surface sediment traps.
- Kerb inlet sediment traps: So that inlet traps do not replace sediment traps up-slope of stormwater inlets, as required by the relevant regulatory authority or to suit the current version of Council's Drainage Design Handbook
- Sediment traps at outlets of stormwater pipes: If required, locate downstream of the influence of outlet jetting, 10 to 13 x pipe diameters downstream of the outlet.

Development site environmental protection: Do not rely solely on sediment control measures, consider more efficient and economical means of protection, such as drainage and erosion control measures.

Sediment trap locations: Locate sediment traps in conformance with the following:

- Trap efficiency: So that clean water is diverted around the sediment trap to maximise sediment trap efficiency.
- Protection of surrounding environments: So that adjacent properties and downstream environments are protected from the adverse effects of sediment and sediment laden water discharged from the site.

Sediment trap properties: Allow for traps with the following features:

- Able to pond water.
- Adequate retention time so that suspended particles can settle.
- The capacity to collect the required volume of sediment.
- Adequate hydraulic capacity required before start of flow bypassing.
- The maximum depth pooling limits required for public safety.

Straw bales as sediment traps: Do not include in the design unless site conditions prevent the use of other more appropriate sediment control systems.

3.5.3 Sediment control measures

In areas of sheet flow: Select from the following measures:

- Buffer zones.
- Compost berm.
- Fibre roll.

- Filter fence.
- Filter sock.
- Filter tube dam.
- Grass filter strip.
- Modular sediment trap.
- Mulch berm.
- Sediment fence.
- Stiff grass barrier.

At kerb inlets: Select from the following measures:

- Gully bag sediment trap.
- On-grade kerb inlet sediment trap.
- Sag inlet sediment trap.

At field (drop) inlets: Select from the following measures:

- Block and aggregate drop inlet protection.
- Excavated drop inlet protection.
- Fabric drop inlet protection.
- Filter sock drop inlet trap.
- Mesh and aggregate drop inlet protection.
- Rock and aggregate drop inlet protection.

Areas of minor concentrated flow: Select from the following measures:

- Check dam sediment trap.
- Coarse sediment trap.
- Filter tube dam.
- Modular sediment trap.
- Stiff grass barrier.
- U-shaped sediment trap.

In areas of concentrated or instream flow and sediment control techniques: Select from the following measures:

- Cofferdam.
- Filter tube barrier.
- Floating silt curtain.
- Geo lot.
- Isolation barrier.
- Modular sediment barrier.
- Rock filter dam: Filter cloth used as the primary filter medium or aggregate used as the primary filter medium.
- Sediment fence isolation barrier.
- Sediment filter cage.
- Sediment weir.

At entrances to culverts and open stormwater pipes: Select from the following measures:

- Block and aggregate sediment trap.

- Excavated sediment trap.
- Filter sock sediment trap.
- Mesh and aggregate sediment trap.
- Sediment fence (woven or non-woven).
- Sediment weir.

At outlets of stormwater pipes: Select from the following measures:

- Excavated sediment trap.
- Filter tube dam.
- Sediment weir.
- Straw bale barrier.

Dewatering measures: Select from the following measures based on expected flow level:

- Low flow:
 - Sump pit.
 - Filter bag.
 - Filter tube.
 - Grass filter bed.
 - Compost berm.
 - Filter fence.
 - Sediment fence.
- Moderate flow:
 - Filter tube dam.
 - Filter sock.
 - Filter pond.
 - Portable sediment tank.
 - Settling pond or stilling pond.
 - Hydro-cyclone (centrifuge).
- High flow:
 - Sediment basin.

At development site entry and exit points: Select from the following measures:

- Rock pad.
- Vibration grid.
- Wash bay.

3.6 Stockpile management

3.6.1 General

Location: Locate stockpiles in conformance with the following:

- Clear of existing or proposed drainage works.
- Clear of areas likely to be disturbed during construction.
- Clear of the drip zone of trees.
- On reasonably flat areas.
- At least 5 m from concentrated water flows and at least 10 m from waterways.

- At least 2 m from hazardous areas, retained vegetation and overland paths, especially for stockpiles of fine non-cohesive material.
- Up-slope of an appropriate sediment control system.

Topsoil stockpiles: Isolate topsoil from subsoil material in separate stockpiles.

3.6.2 Erosion control measures

Up-slope stormwater: Design control measures so that stormwater is diverted around stockpiles if the following conditions exist:

- Periods when rainfall is possible.
- Up-slope catchment area: > 1500 m².
- Average monthly rainfall: > 45 mm.

Stockpile protection: Allow for stockpile protection from wind and rain, especially those of clayey soils which are more susceptible to raindrop impact erosion than sand stockpiles.

3.6.3 Sediment control measures

Down-slope of stockpiles: Allow for woven sediment fencing or other control measures to suit the stockpile material, for example, sand, gravel, topsoil or subsoil.

4 Documentation

4.1 Submissions process

4.1.1 Document submission and approval process

Requirement: Submit ESCP and supporting documentation at the following development design phases:

- Functional layout submission: Include the following as part of the development functional layout submission for approval before detailed design work:
 - Site risk and hazard assessment.
 - Conceptual ESCP for high risk sites.
 - Layout of drainage and roads within and affecting the development.
- Detailed design submission: Include the following as part of the development application/approval submission:
 - ESCP and supporting information including soil data, site constraints, erosion risk/hazard assessment, sediment risk assessment and site capability.
 - A catchment map defining sub-catchment boundaries.
 - Documentation showing the preferred location and area requirements of major sediment traps (such as sediment basins) and whether they can be permanently incorporated into the stormwater management system, e.g. detention basins or wetlands.
- Final design submission: After detailed design is approved, submit final design documentation with the following as part of the submission:
 - Final ESCP with supporting information for the construction and operational phase.
 - ESCP specification.
 - Water management plans.
 - Construction details and drainage plans.
 - Certification documents.
 - Remedial Action Plan (RAP): If remedial action is identified, submit details.

4.1.2 Conceptual erosion and sedimentation control plan (ESCP)

Requirement: Prepare a concept ESCP if any of the following conditions apply to the development site:

- Average slope of proposed land disturbance: > 10%.
- Site erosion risk: High risk, including for construction.
- Emerson class 1 or 2 soils.
- Expected soil disturbance: > 6 months and > 1 ha.
- Earthworks or construction within a natural watercourse.

4.2 Statutory documentation requirements

4.2.1 Approvals

Requirement: Document the conditions, advised by the appropriate authority, required to obtain approval of the development for the following:

- Council for:
 - Functional layout and concept ESCP.
 - Tree clearing or relocation.
 - Stormwater drainage design and water management plans.
- Planning and water resources department for general land use and problematic soil management measures.
- The EPA for other general environmental impact requirements.
- Utilities authority for any public or private utility affected by the development.

4.2.2 Approvals

Conditions: Document the approval conditions advised by the appropriate authority which contribute to the basis for the design of erosion control measures.

4.2.3 Calculations

Requirement: Provide a design report incorporating the criteria, computer studies, calculations and references supporting the design and maintenance requirements.

4.2.4 Program

Recurrence interval storms: Provide drawings and/or computer output defining the works and the sequential program to minimise exposure to erosion from ARI storms.

4.2.5 Specifications

Requirement: Refer to Council's Engineering Construction Specifications.

4.2.6 Design certification

Requirement: Provide a signed and dated design certificate. Refer D02-Annexure A-Sect 3.1.1

4.3 Drawings

4.3.1 Conceptual erosion and sedimentation control plan (ESCP)

Conceptual ESCP drawing content: Include the following on the drawing(s):

- Control measures required based on soil data collected.
- Control measures required based on site constraints.
- Means of feasibly constructing the development whilst protecting the environment.

- Requirements for sediment basins on site.
- Adequate space for the construction and operation of major sediment traps and essential flow diversion systems.
- Location of problem soil areas including dispersive soils, acid sulphate soils, areas of potential mass movement.
- Environmental features requiring protection such as vegetation.

Conceptual ESCP scale: < 1:1000.

4.3.2 ESCP

Drawing content: Prepare separate ESCPs for the construction and operational phase for the development incorporating the following:

- North point and plan scale.
- Legend of standard symbols used within the plans.
- Proposed development layout, taking into consideration local issues, concerns, site constraints and development approval conditions.
- Site and easement boundaries and adjoining roadways.
- Existing site contours (unless the provision of these contours adversely impacts the clarity of the ESCP).
- Final site contours including locations of cut and fill.
- Limits of disturbance.
- Retained vegetation including protected trees. Location and description of existing vegetation.
- Soil information and location of problematic soils. If required, prepare soil maps for the site to identify problematic soils including dispersive and acid sulphate soils, sandy soils and clayey soils.
- Location of all drainage, erosion and sediment control measures.
- Full design and construction details (e.g. cross sections, minimum channel grades, channel linings) for all drainage and sediment control devices, including diversion channels and sediment basins.
- Site revegetation requirements (if not shown on a separate plan).
- Location of potential areas of non-disturbance and critical areas (vegetated buffer strips, drainage lines and structures, water bodies, unstable slopes, flood plains and seasonally wet areas).
- The final limits of disturbance.

Construction phase ESCP: Incorporate the following in the construction phase ESCP for the development:

- General layout and staging of proposed works.
- Construction access points.
- Site office, carpark and location of material stockpiles.
- Location and stabilisation measures for temporary construction roads and watercourse crossing.
- Location of access haulage tracks and borrow pits.
- Location of all earthworks including roads, areas of cut and fill and regrading.
- Location of major sediment traps (including truck cleaning facilities where required).

- Controls for clean water run-off, including type and location of diversion works that direct uncontaminated run-off around areas of future disturbance.
- Controls for flow velocities in drains.
- Controls for dirty water run-off.
- Protection of channels and outfall zones.
- Divide the site into hydraulically manageable drainage areas and coordinate this with the construction drainage plans.
- Erosion control measures on disturbed boundary.
- Proposed vegetated buffer strips and no access areas.
- Revegetation program.

4.3.3 Construction phase drainage plans

Disturbances greater than 1500 m²: Prepare construction drainage plans for each stage of the earth works, this can either be part of the ESCP or separate drawings showing the following:

- Flow entry and exit points.
- Areas of sheet flow and lines of concentrate flow (including all drainage channels).
- Sub-catchment boundaries.
- All permanent and temporary roads.
- Site contours.
- Location of watercourses.

4.4 Supporting design documents

4.4.1 Calculations

Requirement: Provide a design report incorporating the criteria, computer studies, calculations and references supporting the design and maintenance requirements.

4.4.2 Program

Recurrence interval storms: Provide drawings and/or computer output defining the works and the sequential program required to minimise erosion risk from ARI storms.

4.4.3 ESCP specifications

Construction documentation: Refer to Council's Engineering Construction Specifications.

ESCP specification content: Include the following information:

- Basis of design: Development description, estimate of soil loss, erosion and sediment risk assessment.
- Principles to minimise sediment discharge from the site, including:
 - Land clearing.
 - Site management and temporary ESC measures installed at the end of the working day.
 - Watercourse management.
 - Site rehabilitation.
 - Vegetation management, including application rates (or minimum application rates) for mulching and revegetation measures.
 - Soil management including earthworks, topsoil and problematic soils.
 - Dust control.

- Detailed design information of ESC measures: Include information of the ESC measures required for each catchment, such as contributing catchment size for each measure, holding capacity, dimensions, supporting calculations, associated components of the measure (e.g. outlets and emergency spillways). Other requirements such as revegetation techniques, time frame and methods of achieving stabilisation.
- Site monitoring and maintenance program, including the location of proposed water quality monitoring stations.
- Emergency ESC measure (including drainage) and heavy rainfall response and contingency measure.
 - Temporary ESC measures in case of impending storms, or emergency situations.
- Inspection and test plans, and procedures for review and/or amendment to the ESCP.
- Identification of site responsibilities.
- Construction program and installation sequence for ESC measures.

4.4.4 Design certification

Certificate: Provide a signed and dated design certificate as evidence that a Professional Engineer has reviewed all the design documents, including erosion and sediment program and plans for the development, and can verify that the designed measures will effectively mitigate sediment migration from the development site. Refer D02-Annexure A-Sect 3.1.1

4.4.5 Additional certification

Sites with a soil disturbance greater than 2500 m²: Provide certification by a Professional Engineer that the ESCP conforms to the following:

- Satisfies the intent and design/performance standards established by all relevant local, state and federal policies relating to erosion and sediment control.
- Has been reviewed and approved for construction, soil science, hydrology/hydraulics and site revegetation/rehabilitation.

Certification by a hydrology and hydraulics Professional Engineer: Required for sites greater than 1 ha or where the ESCP incorporates a sediment basin.

Certification by a geotechnical specialist: Required if ESCP incorporates a sediment basin with a constructed earth embankment with a height greater than 1 m.

4.5 Work-as-executed

4.5.1 Work-as-executed documents

Work-as-executed drawings: Provide an additional set of final construction drawings for the purpose of recording the work completed by the Contractor.

Provide all required data and electronic files as outlined in WSC “Work as Executed plans specification and attribute requirements” located on council’s website.

4.5.2 Final certification of completed works

Requirement: Council requires the designer or its representative to carry out sufficient site inspections to validate the final certification of the proposed works.

Completed works: The designer to provide evidence that the site inspections were undertaken during construction works and provide final certification that the completed work is consistent with the approved design.

4.6 Referenced documents

The following documents are incorporated into this worksection by reference:

AS 1726	2017	Geotechnical site investigations
Austrroads AGRD		Guide to road design
Austrroads AGRD02	2019	Design Considerations
NSW OEH	2012	Erosion and sediment control on unsealed Roads Field Guide
NSW LANDCOM	2004	Managing Urban Stormwater: Soils and Construction Vol 1 (The Blue Book).
NSW SOIL CONSERVATION SERVICE	2017	Fire Trail Design, Construction and Maintenance Manual