Table Drains
Erosion Control Guideline
January 2001
FORWARD:

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City Design facilitated consultation with key Council staff from Local Asset Services, Brisbane City Works, Development and Regulatory Services, Asset Support Group and Waterways Program. Special thanks to Tony King of Soilcon Pty. Ltd. for assisting in the completion of the draft guideline.

This guideline forms part of the Urban Management infrastructure maintenance series and will remain in draft for 12 months. Users of this guideline should provide specific comments and recommendations to Asset Support Group or Waterways Program to assist in the documents revision early in 2002.
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1.0 INTRODUCTION TO THIS GUIDELINE

Background and Aims

Brisbane City Council is responsible for the maintenance of approximately 300km (>1,000,000 m^2) of unsealed road shoulder and associated open roadside drainage across the City. This includes unsealed shoulders and machine formed drainage systems such as spoon drains, v drains, swales and table drains.

In most areas of Brisbane at any time there is evidence of minor erosion in table drains. Minor scour results in the loss of 5 – 30 kg of soil per linear metre of drain. Major erosion / scour problems are less common, but can result in the loss of 1000 kg of soil per linear metre of drain in one or more storm events. Invert erosion in roadside drains ultimately results in the deposition of soil in waterways reducing the health of aquatic ecosystems and increasing flood potential as hydraulic capacities in natural watercourses are reduced. Unattended erosion problems lead to community safety issues and high remediation costs.

This guideline aims to deliver improvements in the quality of runoff leaving open roadside drainage systems by providing technical direction in the assessment an repair of common erosion problems. The guideline will assist in the planning and costing of maintenance activities and should promote organisational consistency in table drain erosion repair. Recommendations are generally applicable to any of the drainage profiles mentioned above, where they are associated with the conveyance of stormwater away from Council roads.

Document Layout

This guideline presents a stepwise process that will lead the user from identification of the erosion problem in table drains and its causes, through to selection of the most appropriate remedial works as indicated in this simple diagram:

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The Fact Sheets in Section 6 include a range product information, installation techniques and supporting information to assist the user in identifying and applying the most appropriate erosion control measure.
2.0 THE EROSION PROCESS

The general “erosion process” consists of three main stages. These are:

- **Soil Detachment** – Water falling as raindrops dislodge soil particles through kinetic energy and hydraulic action. The impact of a single raindrop on a wet soil surface is like a small bomb blast as soil aggregates are broken up and scattered by the force of the impact.

  Soil detachment also occurs when the tractive forces (shear stress) of flowing water exceed the soil’s inherent resistance to erosion. This typically occurs in areas of concentrated flows such as table drains and channels.

  In the context of a road and its margins, soil particles may also be detached from each other (pulverised) by the movement of traffic over the shoulder and possibly the drain. The finer soil particles are the easier they are transported (lost) by wind or water.

- **Soil Transportation** – Soil transportation is the entrainment and movement of those dislodged soil particles (now called sediment) from their original location. Dislodged soil particles can be transported by either raindrop splash, flowing water or wind.

- **Soil Deposition** – Soil deposition, or sedimentation, occurs when the soil particles that have been detached and transported by the mechanisms described above, finally come to rest. Sedimentation occurs when the water, or wind in which the soil particles are carried is sufficiently slowed for the particles to settle out due to gravity.

  Heavy coarse particles will settle out relatively quickly. Smaller fine particles, typically clays and silts take much longer to settle out and in the case of dispersive soils may not settle out at all.

On-site erosion and sedimentation may cause costly site damage and create a public safety hazard. Off-site impacts, particularly those caused by sedimentation and turbidity, have the potential to also affect the community and the environment, and “serious environmental harm” (as defined in the *Environmental Protection Act 1994*) may result.

Our first priority therefore, must be to control erosion, as sediment is only generated once erosion (soil detachment) has occurred. Erosion control will not only protect the drainage asset but will also help to protect downstream environmental values.
Photo 1: Uncontrolled erosion will not only cause damage to the site, but the resulting sedimentation will require costly and time consuming clean up works.

Photo 2: Turbid water (contaminated with fine suspended sediments) has the potential to cause “serious environmental harm” to waterways and aquatic ecosystems. (South Stradbroke Island on right, North Stradbroke Island on left).
3.0 EROSION ASSESSMENT

When is Action Required?

Unacceptable erosion is an actively eroding drain. Eroding enough to plainly see evidence of soil loss. The asset is disappearing from one storm event to the next or from one year to the next.

When standard maintenance practice fails to arrest such problems, specialised erosion control measures are required. This guideline provides detail on a suite of erosion control practices and products designed to halt erosion in roadside drains.

Figure 2, Section 4 provides triggers for seeking specialist engineering and environmental advice as required to undertake major erosion repair projects resulting from highly erosive stormwater flow.

Determine the Likely Cause(s)

In many cases the initiating cause of erosion is significantly different from the processes causing the erosion to continue. Table drain scour around Brisbane is primarily initiated and perpetuated by:

- Poor drain shape and/or hydraulic capacity;
- Steepness of slopes (high flow velocities);
- Insufficient soil surface cover;
- Influence of adjacent land use (principally urban development resulting in large impervious catchment areas).

Other contributing factors may also include:

- Soil type;
- Trickle flows;
- Damage to the invert or channel lining material.

Drain Shape and/or Hydraulic Capacity

Table drains often have a “V” shaped profile because they are quick and easy to construct and maintain with a grader. However, V-shaped drains are extremely prone to erosion along the invert as all the tractive forces generated by the flowing water are concentrated along a narrow corridor. Accordingly, V drains are very hard to stabilise without some form of hard armour such as rock or concrete.

Wherever practicable, table drains should be constructed with either a parabolic or trapezoidal cross-section. These profiles allow the flow of water to spread over a broader invert, with a shallower depth of flow and are therefore much less prone to erosion.

Although both trapezoidal and parabolic profiles are preferred, parabolic profiles are usually easier to construct and maintain with a backhoe or excavator. Most
trapezoidal channels end up with a parabolic profile over time due to maintenance procedures, accumulation of vegetative material and sediments.

This guideline aims to address this issue through:

- The adoption of a “standard” parabolic table drain profile for use in the BCC area where the length of drain does not exceed 500 metres. Wherever practicable the “standard” drain should be 1.2 metres wide x 400 millimetres deep. Channel treatment will then be dependent upon catchment area and slope gradient.

The methodology and procedure used to determine the dimensions of the “standard” drain are detailed in Appendix A.

The ideal ratio for dimensions of a parabolic shaped drain is where the depth of the drain is between 25% - 30% of the top width. Where it is expected that a good grass cover will be maintained along the invert of the drain a figure of 30% should be adopted. This will provide an allowance for the retarding effect that vegetation will have on the flows within the drain and will minimise the incidence of “out of channel” flows.

For example, the depth of the “standard” drain is 400 mm which is 30% of the top width of 1,200 mm (this will generally provide the ideal side slopes for a parabolic profile of around 1:3 (v:h), refer to Figure 1 below).

In many areas it will be impractical to construct a table drain with a top width of 1.2 metres or depth to top width ratio of 25% - 30%. In this case the drain must maintain a minimum cross sectional area (hydraulic capacity) of 0.32 m² to ensure it has sufficient capacity to convey the Q2 (design) storm event.

The methodology and procedure used to determine table drain cross sectional area is detailed in Appendix A.

It must be noted however, that as the top width decreases, the depth must increase accordingly to maintain the required cross sectional area in the drain. The drain is now moving away from a parabolic profile (a spoon shaped or “rounded” invert with ideal side slopes of around 1:3) and is becoming a V-shaped profile. Refer to comments regarding a V-shaped profile above and in Fact Sheet 8.

For example, the geometry of a drain with a top width of 1.0 metre and depth of 500 millimetres and 1:1 side slopes becomes a “V” drain. The resulting cross sectional area would be 0.25 m², insufficient to safely convey all the runoff from a Q2 storm.
**Figure 1:** Parabolic and trapezoidal profiles are more “erosion friendly” than the traditional “V” shaped drain which is prone to erosion along the invert.

**Photo 3:** Parabolic (or spoon shaped) profiles are generally more desirable from an erosion control perspective. They are also easy to construct and maintain with either a backhoe or excavator working along side the drain.
**Steepness of Slopes – High Flow Velocities**

Long, steep slopes increase both the velocity and volume of water flowing into and along table drains. These drains also convert sheet flow from the pavement surface into potentially more erosive concentrated flows. When high velocity, concentrated flow exceed the soils inherent resistance to erosion, soil particles detach (scour) and the erosion process begins.

High velocity flows and subsequent erosion, may also occur where there is a rapid change in grade in the drain (eg. dropping down into a culvert) or where high velocity flows enter the table drain from a stormwater pipe or culvert outlet.

This guideline aims to address this issue through the use of:

- Channel lining material to protect the invert where gradients are greater than 1%;
- Chutes or drop inlet structures where there is a rapid change in grade (ie. entering a culvert or watercourse);
- Check dams as short term, temporary velocity control structures during the construction / maintenance phase of a project.

*Photo 4: High velocity flows, and subsequently erosion, may occur where there is a rapid change in grade of the drain.*
Steepness or the slope gradient can be quickly measured using either a hand held clinometer or by using basic survey equipment such as a dumpy or automatic level. For example, if a slope length is 100 metres and there is 7.0 metres fall along its length, there is an average 7% grade (0.07 m/m).

In the event that flow velocities need to be determined or confirmed, the easiest and quickest technique is to measure actual velocity (in metres per second) in the drain during a runoff producing rainfall event. For example, measure out a section of drain 10 metres in length; at the upstream end of this section put a twig, leaf or some other “floatable” item into the flowing water. With a watch, time how long this item takes to travel through the measured section. Divide 10 (metres) by the time taken (seconds) to give the average velocity in metres per second (eg. 10 metres / 5 seconds = 2 metres per second).

Alternatively, Manning’s Formula can be used to calculate the average velocity. Refer Appendix A.

Soil Surface Cover

The velocity at which erosion will start in a table drain is known as its “maximum permissible velocity (MPV)”. The MPV will vary according to a number of factors, however the most significant of these is the type of channel lining material used (soil surface cover) and its ability to resist scour.

For example, where velocities are kept below 0.5 metres per second a bare earth channel can be used with reasonable success (providing the soils are not...
dispersive). However, as velocities increase the MPV of bare soil is exceeded and other forms of channel lining material must be incorporated (eg. the establishment of mature vegetation with or without supplementary reinforcement, rock or concrete).

This guideline aims to address this issue through the use of:

- Bare earth channels where flow velocities are below 0.5 metres per second;
- Turf or grass with temporary erosion control mats where velocities are between 0.5 – 2.0 metres per second;
- Reinforced turf, grass with permanent erosion control mats or hard armour (eg. rock, concrete) where velocities are in excess of 2.0 metres per second.

Manning’s Formula has been used to calculate velocity of flow in the “standard” table drain and these velocities have subsequently been converted into the slope gradient classes contained in Figure 2, Section 4. (Appendix A details the procedure used.)

For example, bare earth channels should only be used with channel slopes less than 1% to ensure the velocity remains below 0.5 metres per second. A grassed “standard” drain channel on slopes up to 7% will generally result in velocities around 2 metres per second, whilst slopes greater than 7% will result in flows exceeding 2 metres per second.

Accordingly, channel stabilisation must be completed as soon as the drain has been constructed to avoid possible scouring of the invert (unless slope along the table drain is less than 1%).

Detailed velocity calculations and corresponding slope classes are only applicable to BCC’s “standard” parabolic drain and are not necessarily applicable to areas outside Brisbane.

Influence of Adjacent Landuse

Concentrated flow delivered by a concrete pipe for example can result in severe scouring in table drains and adverse impacts downslope. Additional volumes of water entering roadside table drains from new up-slope urban or commercial development can have a severe impact on the stability of a table drain. Drains which were initially constructed to convey road runoff only can be overloaded and badly damaged by additional runoff from increasingly urbanised up-slope catchments.

Although not a cause of erosion, the proximity of eroding drains to areas of environmental significance (eg. bushland reserve, waterways, wetlands) should be considered an important trigger for maintenance activities and restoration of eroded table drains.

This guideline aims to address this issue through the use of:

- Professional engineering and environmental advice where factors external to the site diminish the potential for successful erosion repair using basic control measures as recommended in this guideline.
Soil Type

The relationship between soil type and soil erosion rate is fairly straightforward. The more erodible the soil is, the easier the soil particles detach and the quicker it is eroded. In the Brisbane context, brown and red soils have a low to moderate erodibility, whilst light coloured yellow, grey and white soils have a high to extremely high erodibility.

Clay soils, providing they are not dispersive, are generally stable and not prone to rapid rates of erosion, whereas silty and fine sandy soils are the most likely to erode.

The worst case scenario around Brisbane is a fine sandy-clay soil (yellow to white in colour) with a high percentage of dispersive clays. These soils will erode very easily, damaging the drain and other assets. They will also generate turbid run-off water (contaminated with fine clay sized soil particles in colloidal suspension) which has the potential to cause “serious environmental harm” to waterways and aquatic ecosystems.

A simple field procedure to test whether a soil is dispersive or not requires a ped (or clod) of dry soil approximately 25 mm in diameter to be placed (fully immersed) in a dish of distilled water and allowed to stand for at least 30 minutes. One of the following outcomes is probable:

- The ped left undisturbed does not lose its shape. From an erosion perspective this is considered to be a stable soil;

- The ped loses its shape but the water remains clear. This soil is referred to as a “slaking soil” but is not dispersive. These soils have a moderate to high erodibility.

- The ped disintegrates quickly leaving the water very cloudy. This is a dispersive soil. These soils have extremely high erodibility, and are unfortunately quite common in surface and sub-surface profiles around Brisbane. An exposed surface condition is not a suitable treatment for dispersive soils.
Photo 6: The worst case scenario around Brisbane is a fine sandy-clay soil (yellow to white in colour) with a high percentage of dispersive clays. These soils will erode very easily, damaging the drain and other assets. In this case, what was once a table drain has been severely eroded by concentrated stormwater flow entering the top of the drain from an upslope development.

Trickle Flows

Continuous trickle flows, springs and other seepage along a table drain will keep the soil along the invert wet, thereby loosening the bonds between the soil particles and making them prone to detachment when higher velocity flows pass through during a storm event.

Damage to the Invert or Channel Lining

Erosion can also be initiated where the invert or channel lining material has either deteriorated or has been damaged due to errant vehicle movements, maintenance activities such as slashing or grading, bush fire, herbicides or even loss of vegetative cover caused by extended wet weather. Tyre tracks left by tractors and slashers up the centre of a wet drain for example can initiate ongoing erosion problems.
4.0 PRIORITY OF REMEDIAL WORKS

Determine the Appropriate Course of Action

Figure 2 below offers a simple flow chart procedure to assist the user in identifying the cause and severity of an erosion problem, and to determine an appropriate course of action.

The following questions must also be answered before making decisions about an appropriate control measure:

**QUESTION:** Does the erosion problem present an immediate risk to:

i. Public Safety?

ii. A Public Asset (eg. road formation, pavement, utilities)?

iii. A creek, watercourse or wetland area downstream?

If the answer is yes to any of these questions, the erosion problem will require:

- **Immediate treatment** – this may require installation of interim works to temporarily stabilise an area or to make the area safe, in which case installation of final permanent works may be delayed slightly. Alternatively, permanent remedial works may need to be “fast tracked” and completed as soon as practicable.

If the answer is no in all cases, the treatment of the erosion may be prioritised to receive:

- **Delayed treatment** – this will allow time to monitor the rate of erosion, assess potential impacts and make an informed “cost-benefit” decision. This will also allow time to schedule and allocate appropriate funds and resources.

Delaying treatment may allow remedial works to be completed in conjunction with other scheduled activities (eg. pavement rehabilitation or maintenance, maintenance or widening of shoulders etc), thereby reducing mobilisation and establishment costs.

Delaying treatment where there is no immediate risk may also allow Council to require that works are completed by, or in association with an adjoining development.

- **No treatment** – in situations where erosion is no longer active (eg. invert has eroded to bedrock) and where there are no public safety or aesthetic issues, a nil treatment alternative may be an acceptable option.
Photo 7: In situations where the invert has eroded to bedrock and where there are no public safety issues, a nil treatment alternative may be an acceptable option.

Photo 8: Immediate works will be required in situations where the erosion poses a significant risk to natural waterways downstream and/or community safety.
Is the drain currently under construction or is only temporary protection (less than 4 months) required?

No

Is the drain only eroding due to a rapid change in grade (i.e. where drain drops into a culvert)?

Yes

Construct a chute or drop inlet into culvert

No

Has the eroded invert reached bedrock or a stable grade?

Yes

Are the sides of the invert and/or shoulders actively eroding?

No

Do nothing

Yes

Seek expert environmental or hydrologic assistance for direction and advice

No

Is the drain immediately upstream of a significant environmental area or watercourse?

Yes

Reconstruct the drain with a parabolic profile; finished dimensions of 1.2m wide x 400mm deep. Line drain with either:
- reinforced turf
- permanent (synthetic) erosion control mat
- loose rock
- asphalt
- concrete

No

Does the drain carry water from:
- new developments up-slope?
- large catchments outside the road reserve?

Yes

Seek expert environmental or hydrologic assistance for direction and advice

No

Is the drain longer than 500m?

No

Is the scour due to an obvious deterioration or damage to a particular section(s) of the drain?

Yes

Repair and reinstate the damaged section of the drain

No

Is the channel lined with either vegetation or rock?

Yes

Minimise or prevent trickle flows

No

Is the channel lined with either vegetation or rock?

Yes

Repair and reinstate the damaged section of the drain

No

Is the drain longer than 100m?

Yes

Repair and reinstate the damaged section of the drain

No

Is the slope of the drain less than 1%?

Yes

Repair and reinstate the damaged section of the drain

No

Is the drain on highly erodible fine sandy yellow, white or grey soils (including dispersive of soils)?

Yes

Reconstruct the drain with a parabolic shaped bare earth channel; finished dimensions of 1.2m wide x 400mm deep

No

Is the drain subject to constant trickle flow?

Yes

Reconstruct the drain with a parabolic profile; finished dimensions of 1.2m wide x 400mm deep

No

Figure 2: Flow chart procedure to help determine an appropriate course of action.
5.0 SELECT THE MOST SUITABLE CONTROL MEASURE

Selection Criteria

There are a number of products or control measures which can be used, either in isolation or in combination, to solve any given erosion problem. The selection process and ultimately the final decision will be based upon a series of value judgements made by the user but should include consideration of:

- Environmental sensitivity, especially of receiving environments;
- Hydraulic performance requirements;
- Aesthetic compatibility with the surrounding environment;
- Cost; initial and ongoing maintenance costs;
- Expected life (and subsequently whole-of-life cost / benefit analysis);
- Constructability, including availability of materials or products;
- Availability of equipment or skilled personnel to construct;
- Institutional acceptability.

Water Sensitive Urban Design

Water sensitive urban design has now been widely accepted as a cost effective means of enhancing urban stormwater quality. Water sensitive urban design employs fairly basis principles and techniques to control stormwater runoff quantity and quality at its source.

Some roadside drainage systems are now being engineered to detain runoff, promote stormwater infiltration and assist in sediment, nutrient and pollutant removal by taking advantage of both the physical attributes of site (eg. inherent soil permeability) and biological systems (eg. grasses and soil biota).

Grass lined table drains offer significant additional benefits over hard armour channels in terms of water quality improvement. Opportunities should always be sought to incorporate (where practical) erosion control measures that promote improvements in stormwater quality and reflect an understanding of the benefits of water sensitive urban design.

Fact Sheets

The following section contains erosion treatment fact sheets have been prepared to assist in this last stage of the selection process and should also provide general guidance to assist with budgeting and scheduling of resources. The fact sheets present the following information:

1. Description of the control measure or product group;
2. Possible alternative / variations;
3. General selection criteria;
4. Limitations and common problems;
5. Indicative cost and life span;
6. Installation procedure; and
7. Maintenance requirements.
6.0 EROSION TREATMENT FACT SHEETS

Fact Sheet 1: CHECK DAMS

Fact Sheet 2: TEMPORARY CHANNEL LINERS

Fact Sheet 3: GRADE STABILISING (DROP) STRUCTURES

Fact Sheet 4: TURF LINED DRAINS

Fact Sheet 5: TEMPORARY EROSION CONTROL MATS (biodegradable)

Fact Sheet 6: REINFORCED TURF LINED DRAINS

Fact Sheet 7: PERMANENT EROSION CONTROL MATS (synthetic)

Fact Sheet 8: HARD ARMOUR CHANNELS
Fact Sheet 1: CHECK DAMS

Photo 9: Sandbag check dam.

Description of the Control Measure or Product Group

Check dams are small temporary hydraulic control structures placed in series along a table drain or channel. Their purpose is to reduce erosion of the invert by slowing the velocity of flow (a well used analogy is dabbing the brakes on a car as it coasts down a hill in order to keep it at a “safe” speed). These structures may also trap sediment, although this is a secondary function.

Possible Alternative / Variations

- Temporary channel liners such as builders plastic or geotextile.

General Selection Criteria

- This control measure should not be used in large watercourses or “live” (wet) streams;
- Check dams are usually constructed from stacked loose rock (D_{50} = approx. 50 mm) or aggregate filled UV stabilised “sand bags”. The material used must contain sufficient mass to withstand the energy of a concentrated flow.

Limitations

- Small catchment areas - check dams should not be used where total length of drain exceeds 250 metres;
- Effectiveness of this procedure is significantly reduced on slopes exceeding 5%;
• Short life span, temporary control measure only;
• Potential public safety problems;
• Potential damage by motor vehicles;
• Potential for loose rocks to be missiled by children.

Indicative Cost and Life Span

• A typical stacked rock check dam in a roadside table drain will cost in the vicinity of $80.00 each (fully installed);
• A typical sand bag structure in a roadside table drain will cost in the vicinity of $90.00 each (fully installed);
• Life span: 3 – 4 months.

Installation Procedure

• Excavate a small “cut off” trench beneath structure so that rock or “sand bags” are keyed into the natural surface. Water must not be allowed to pass under the structures;
• Needle punched geofabric on downstream spillway protection;
• Place rock or “sand bags” to construct a small weir across the table drain;
• The centre of the structure should be a minimum 150mm lower than the outer edges, to form a spillway. Water must not be allowed to pass around the outside edges of the structure;
• Structures should be placed so that the spillway level of the downstream structure approximates the level of the toe of the structure immediately upstream.

Figure 3: Typical installation of temporary sandbag check dam.
Common Installation Problems

- Insufficient turn up at edges of the structure, water scouring around corners and damaging road formation and embankments;
- Water flowing under rather than through or over the centre of the structure.

Maintenance Requirements

- Check for scour damage over centre of structure or around the edges;
- Check for movement of, or damage to structures;
- Remove accumulated sediments and place on a stabilised area (ie. well grassed area);
- Check scour pattern of upstream invert to ensure check dam/s is correctly positioned along drainage line. Close up spacing of structures if scour is occurring.
**Fact Sheet 2: TEMPORARY CHANNEL LINERS**

![Photo 10](image)

*Photo 10: Temporary channel liner fabricated from builder’s plastic. Builders plastic should only be used as a short term temporary control measure in the appropriate circumstances.*

**Description of the Control Measure or Product Group**

Temporary channel liners can be used as a short term stop gap measure to stabilise small areas of drain or channel. They are best used where the drain is conveying water rather than collecting it.

**Possible Alternative / Variations**

- Check dams fabricated from stacked rock or aggregate filled UV stabilised “sand bags” (See Fact Sheet 1).

**General Selection Criteria**

- Temporary channel liners are usually fabricated from 200 μm thick black builders plastic or from a needle punched geotextile (approximately 140 g/m²).

**Limitations**

- Small catchment areas – temporary channel liners should only be used in drains no longer than 100 metres;
- Possible slipping hazard for workers and pedestrians, and potential appeal to children as a play area;
- Short life span, relatively high cost, suited to small areas only;
• Possible UV degradation and/or physical damage to builders plastic.

**Indicative Cost and Life Span**

• Builders plastic: approximately $4.00 – 4.50/m² installed;
• Geotextile: approximately $4.70 - $5.00/m² installed;
• Life span: 4–6 weeks. Geotextile material will generally last longer as it is more UV resistant, however the “installation” is usually damaged beyond repair by traffic, wind or high flows within a 4–6 week period.

**Installation Procedure**

• Shape, or reshape drain along proposed line and grade;
• Remove rock and clods that may puncture the liner or hold it off the ground surface;
• Excavate “cut off” trench across the drain 300 mm deep along the upstream or leading edge of liner. Fold the liner down into the trench, peg in place at 400 mm intervals, backfill and compact;
• Roll out liner in the direction of flow and peg at 1.0 metre intervals along both outside edges all the way down its length. Timber, polythene or U shaped steel pegs 150 – 300 mm can all be used in this application (See Section 7). Plastic and steel pegs generally have the advantage of being able to be pushed down flush with ground surface level and can be left to degrade naturally;
• Overlap joints shingle style, with a minimum 300 mm overlap.

**Common Installation Problems**

• Upstream or leading edge of material not keyed into ground; water flows under the liner;
• Material must be kept taught and pegged closely along edge nearest to the pavement.

**Maintenance Requirements**

• Inspect weekly and after each rainfall event to check for damage and water flows under the liner.
Fact Sheet 3: GRADE STABILISING (DROP) STRUCTURES

Photo 11: Grade stabilising structure made from sandbags filled with 10:1, sand to cement mix.

Description of the Control Measure or Product Group

Grade stabilising structures (ie. drop structures or chutes) are vertical or near vertical structures designed to reduce erosion caused by excessive channel grade or to stabilise areas where there is a rapid change in grade.

A grade stabilising structure provides a stable point for water to safely move from one level to another. By elevating the relief level (RL) at the outlet end of the table drain, the overall grade along the length of the drain is reduced.

Possible Alternative / Variations

- Drop inlet pits (gully pits) above culverts can also be used to elevate the RL of the invert at the outlet end of a table drain. Slope gradient is then reduced as the grade change is made as the water falls into the pit.

General Selection Criteria

- Grade stabilising structures can be either chutes or straight drop structures constructed from concrete, gabions, reno mattresses, stacked rock or sand and cement filled sandbags;
- It is recommended that professional engineering advice be sought before designing or constructing grade stabilising structures (ie. consult with City Design, Water and Environment Group).
Photo 12: High velocity flows, and subsequently erosion occurs where there is a rapid change in grade of the invert as it approaches a culvert headwall.

Photo 13: Drop inlet pits (gully pits) above culverts can also be used to elevate the relief level (RL) of the invert at the outlet end of a table drain. Slope gradient is then reduced as the grade change is made as the water falls into the pit.
Limitations

- Lowering bed grade will reduce flow velocity and increase the depth of flow, thereby potentially reducing the capacity of channel to convey its original volume, for example:

\[ Q = V \times A \]

where:
- \( Q \) = Quantity of water conveyed (m\(^3\)/s)
- \( V \) = Velocity of flow in channel (m/s)
- \( A \) = Cross sectional area of channel (m\(^2\))

- Accordingly, increased incidence of out of channel flows may result unless channel cross sectional area is adjusted accordingly;
- Structure may be overtopped, outflanked or overturned in large rainfall events;
- Energy dissipation may be required at the bottom of drop structures to avoid scouring of the receiving channel.

Indicative Cost and Life Span

- Cost will vary according to construction materials and dimensions;
- Life span: 10 years plus.

Installation Procedure

- It is recommended that professional engineering advice be sought before constructing grade stabilising structures. Each structure will be different and will require individual consideration of a range of issues. (ie. consult with City Design, Water and Environment Group).
Fact Sheet 4: TURF LINED DRAINS

Description of the Control Measure or Product Group

Turf lined drains carry concentrated runoff to a stable outlet without damage from erosion, deposition or flooding. This practice applies to table drains where a un-reinforced vegetative lining can provide sufficient stability for the channel cross section and grade.

Turf lined channels will slow down runoff and allow pollutants and nutrients to be filtered out through the grass. They will also allow a reasonable degree of infiltration.

When correctly installed, turf lined drains provide instant erosion protection.

Possible Alternative / Variations

- Temporary (biodegradable) Erosion Control Mats

General Selection Criteria

- Select low growing, stoloniferous (mat forming), warm season grass species which are tolerant of drought and low nutrient conditions (eg. couch);
- Use wide rolls (>1 m) where ever available, to avoid joins;
- The use of un-reinforced turf should be limited to drains of 500 metres or less, with slopes of less than 7% (flow velocities of less than 2 m/s).
Limitations

- Requires a consistent, uniform and complete grass cover to be effective;
- Requires regular post installation watering until new roots are well established;
- High sediment loads may smother and kill the grass;
- Prolonged drought, errant vehicles or maintenance operations may damage and kill the grass.

Indicative Cost and Life Span

- $3.00 - $5.00/m\textsuperscript{2} supplied and laid, plus cost of excavation of drain, supply and placement of sandy loam “topsoil” material and watering;
- Life span: 10 years plus.

Installation Procedure

- Excavate drain along proposed line and grade, allow a 75 mm overcut to compensate for the placement of 50 mm of consolidated sandy loam “topsoil” material under the turf and for 25 mm depth of turf. Top of turf must be at, or slightly below, natural surface level;
- Place and lightly compact sandy loam “topsoil” material, rake off rocks and clods so that turf can sit flush on the prepared surface;
- Roll out turf and peg as required to prevent the turf being lifted or moved by high flow velocities. Timber, polythene or U shaped steel pegs 150 – 300 mm can all be used in this application (See Section 7). Plastic and steel pegs generally have the advantage of being able to be pushed down flush with ground surface level and can be left to degrade naturally;
- Fertilise with 25g/m\textsuperscript{2} of fertiliser with an N,P,K analysis of 14:4:11 (eg. Growforce 301, 303 or equivalent) and immediately water to field capacity avoiding runoff from the treated area.

Common Installation Problems

- Sides of turf strip are not “countersunk” and turf lip sits proud of soil surface allowing water to run along the edge of the turf, resulting in scour;
- Sandy loam “topsoil” material not sufficiently compacted thus creating subsidence and voids under the turf (roots not in contact with the soil);
- Avoid applying fertiliser or herbicides / pesticides when storms are likely to wash this material into adjacent watercourses.

Maintenance Requirements

- Immediately following installation, water every day for 7 days, then water 3 times a week for 3 weeks (although this will ultimately be dependent upon site conditions and season);
- Depending upon grass species selected, turf lined drains will require mowing, up to 8 times per year. Grass should be mowed to a height not less than 35 mm to avoid “scalping” or damage to the crown of the plant;
• Avoid mowing with heavy tractor based mower / slasher when invert is boggy. Preferably mow with boom type mower.

Photo 15: If the sides of turf strip are not “countersunk”, a lip of turf sits up proud of soil surface and water cannot flow into the drain. Scour then occurs as water runs parallel to the turf lined invert.
**Fact Sheet 5: TEMPORARY EROSION CONTROL MATS**
*(biodegradable)*

*Photo 16: Temporary erosion control mats are made from natural, biodegradable materials, such as this open weave jute mesh.*

**Description of the Control Measure or Product Group**

Erosion Control Mats are proprietary products, which are used as channel liners in concentrated flow situations. They are available as either a natural (mostly biodegradable) or synthetic (non-biodegradable) product (See Fact Sheet 7).

The biodegradable mats offer temporary protection to newly constructed table drains, allowing sufficient protection until the grasses have time to establish.

Over time, the products biodegrade and offer no further protection. By this time vegetation in the drain should be sufficiently established to provide the long term protection required.

**Possible Alternative / Variations**

- Open weave jute mesh “Soil Saver”;
- Jute Master “Fine Mat (FM)”;  
- Aspenwall “AGL 101”;
- Biomac “T300”;
- Turf lined drains.
General Selection Criteria

- The use of Temporary Erosion Control Mats should be limited to drains of 500 metres or less, with slopes of less than 7% (flow velocities less than 2 m/s).
- Seed species selected for sowing under the mats should be low growing, stoloniferous (mat forming), warm season grasses which are tolerant of drought and low nutrient conditions (ie. couch and fine leaf carpet grass mix).

![Photo 17: Low growing grasses should be planted in table drains to reduce both maintenance and interference with runoff.](image)

Limitations

- Possible tripping hazard for workers and pedestrians;
- Some temporary mats may be manufactured with a synthetic reinforcing mesh or net on the outside of the product. Small animals and birds can occasionally get caught in the mesh;
- Prolonged drought, errant vehicles or maintenance operations such as mowing or slashing may damage vegetation and the erosion control mat;
- Requires a consistent, uniform and complete grass cover to be effective;
- Will require some post installation watering until plants have established;
- High sediment loads may smother and kill the grass.

Indicative Cost and Life Span

- $0.80/m² for jute mesh - $4.00/m² for the coir (coconut) fibre material, ex-store for erosion control mat only, plus drain excavation, supply and placement of sandy loam “topsoil” material, seed, fertiliser and installation (indicative supply and install price: $5.00/m² for jute mesh up to $8.00/m² for coir products);
- Life span of Temporary Erosion Control Mat: 12 – 18 months;
- Life span of subsequent vegetative cover: 10 years plus.
Installation Procedure

- Suppliers and distributors of Temporary Erosion Control Mats will provide manufacturers recommendations for the installation of their products.

In general terms however, the following procedure is fairly typical:

- Excavate drain along proposed line and grade, allow a 50 mm overcut to compensate for the placement of 50 mm of consolidated sandy loam “topsoil” material under the mat. Top of mat must be at, or slightly below, natural surface level;
- Place and lightly compact sandy loam “topsoil” material, rake off rocks and clods so that mat can sit flush and evenly over the prepared surface and is not “tenting”;
- Spread seed (couch / fine leaf carpet grass) and fertilise with 25g/m² of fertiliser with an N,P,K analysis of 14:4:11 (eg. Growforce 301, 303 or equivalent);
- Excavate “cut off” trench across the drain 300 mm deep along upstream or leading edge of the mat. Fold the mat down into the trench, peg in place at 400 mm intervals, backfill and compact;
- Roll out mat in the direction of flow and peg at 1.0 metre intervals along both outside edges all the way down its length. Polythene or U shaped steel pegs 150 – 300 mm can be used in this application (See Section 7). Plastic and steel pegs generally have the advantage of being able to be pushed down flush with ground surface level and can be left to degrade naturally;
- Overlap joints shingle style, with a minimum 300 mm overlap;
- Water “topsoil” material up to field capacity if conditions are very dry. Avoid runoff from the treated area.

Common Installation Problems

- Poor soil surface preparation or poor establishment of a consistent vegetative cover;
- Poor “topsoil” quality and lack of soil testing to determine deficiencies / requirements, lack of suitable ameliorants or fertilisers;
- Unsuitable selection / nomination of species mix;
- Incorrectly installed (ie. insufficient number of pegs used to locate mats);
- Ground surface must be smooth and even so that mats can be pegged in close contact with the ground;
- Avoid applying fertiliser or herbicides / pesticides when storms are likely to wash this material into adjacent watercourses.

Maintenance Requirements

- Inspect after heavy rains or large flow events and repair (ie. remove, re-prepare, reseed and replace mat) in damaged sections;
- Depending upon grass species selected, grass lined drains will require mowing, up to 8 times per year. Grass should be mowed to a height not less than 35 mm to avoid “scalping” or damage to the crown of the plant.
Fact Sheet 6: REINFORCED TURF LINED DRAINS

Photo 18: Reinforced turf lined drains can provide stability to table drains on steeper grades (>7%).

Description of the Control Measure or Product Group

Reinforced turf lined drains carry high velocity concentrated runoff to a stable outlet without damage from erosion, deposition or flooding. This practice applies to table drains where a reinforced vegetative lining can provide sufficient stability for the channel cross section and grades steeper than for standard turf lined drains (ie. >7%).

Reinforced turf lined channels can slow down runoff and allow some pollutants and nutrients to be filtered out through the grass, they will also allow a reasonable degree of stormwater infiltration.

When correctly installed, reinforced turf lined drains provide instant erosion protection.

Possible Alternative / Variations

- "STAYturf";
- Permanent (synthetic) Erosion Control Mats.

General Selection Criteria

- Select low growing, stoloniferous (mat forming), warm season grass species which are tolerant of drought and low nutrient conditions (eg. couch);
- Use wide rolls (up to 4 m) where available, to avoid joins;
- The use of reinforced turf should be limited to drains of 500 metres or less, with slopes of greater than 7% (flow velocities between 2 - 4 m/s).
Limitations

- Vegetation and the reinforcing matrix may be damaged by prolonged drought, errant vehicles;
- Should only be used in, shallow parabolic drain cross sections to avoid damage by maintenance operations such as mowing or slashing;
- Requires a consistent, uniform and complete grass cover to be effective;
- Requires regular post installation watering until new roots are well established;
- High sediment loads may smother and kill the grass.

Indicative Cost and Life Span

- $14.00 - $16.00/m² supplied and laid, plus cost of excavation of drain, supply and placement of sandy loam “topsoil” material and watering;
- Life span: 10 years plus.

Installation Procedure

- Excavate drain along proposed line and grade, allow a 75 mm overcut to compensate for the placement of 50 mm of consolidated sandy loam “topsoil” material under the turf and for 25 mm depth of turf. Top of turf must be at, or slightly below, natural surface level.
- Place and lightly compact sandy loam “topsoil” material, rake off rocks and clods so that turf can sit flush on the prepared surface and will not “tent”;
- Excavate “cut off” trench across the drain 300 mm deep along upstream or leading edge of the reinforced turf lining. Fold the turf down into the trench, peg in place at 400 mm intervals, backfill and compact;
- Roll out the reinforced turf in the direction of flow and overlap joints shingle style, with a minimum 200 mm overlap and secure overlap with pegs to prevent the turf being lifted or moved by high flow velocities. Timber, polythene or U shaped steel pegs 150 – 300 mm can all be used in this application (See Section 7). Plastic and steel pegs generally have the advantage of being able to be pushed down flush with ground surface level and can be left to degrade naturally;
- Where velocities of greater than 3.0 m/s are expected (ie. perhaps on slopes greater than 12%) “checkslots” (buried edges) must be placed at each joint. Checkslots are similar to cutoff trenches at the top of the drain, except that both pieces of turf should be securely pinned or pegged into the trench prior to backfilling and compacting. An extra row of pegs should secure the turf immediately above and below the checkslot. Pegs should be at 0.5 m spacing across the full width of the reinforced turf;
- Fertilise with 25g/m² of fertiliser with an N,P,K analysis of 14:4:11 (eg. Growforce 301, 303 or equivalent) and immediately water to field capacity avoiding runoff from the treated area.

Common Installation Problems

- Sides of turf strip are not “countersunk” and turf lip sits proud of soil surface allowing water to run along the edge of the turf, resulting in scour;
• Sandy loam “topsoil” material not sufficiently compacted thus creating subsidence and voids under the turf (roots not in contact with the soil);
• Avoid applying fertiliser or herbicides / pesticides when storms are likely to wash this material into adjacent watercourses.

Maintenance Requirements

• Immediately following installation water every day for 7 days, then water 3 times a week for 3 weeks (although this will ultimately be dependent upon site conditions and season);
• Depending upon grass species selected, turf lined drains will require mowing, up to 8 times per year. Grass should mowed to a height not less than 35 mm to avoid “scalping” or damage to the crown of the plant;
• Avoid mowing with heavy tractor based mower / slasher when invert is boggy. Preferably mow with boom type mower.
Description of the Control Measure or Product Group

Erosion Control Mats are proprietary products, which are used as channel liners in concentrated flow situations. They are available as either a natural biodegradable (See Fact Sheet 5) or synthetic non-biodegradable products.

Synthetic mats offer permanent protection to newly constructed table drains, allowing sufficient protection until the grasses have time to establish. Unlike the temporary mats, permanent erosion control mats will last for years and subsequently enhance the performance limits of the vegetative lining (ie. ability to safely convey flows greater than 2 m/s).

Possible Alternative / Variations

- “Grassroots 1”;
- North American Green “P 300”;
- Synthetic Industries “Landlok TRM 450”;
- Reinforced turf lined drains.
General Selection Criteria

- The use of Permanent Erosion Control Mats should be limited to drains of 500 metres or less, with slopes of greater than 7% (flow velocities between 2 - 4 m/s);
- Seed species selected for sowing under the mats should be low growing, stoloniferous (mat forming), warm season grasses which are tolerant of drought and low nutrient conditions (ie. couch and fine leaf carpet grass mix).

Limitations

- Possible tripping hazard for workers and pedestrians;
- As permanent mats are manufactured with a synthetic reinforcing mesh or net on the outside of the product some small animals and birds can occasionally get caught in the mesh;
- Vegetation and the synthetic erosion control mat may be damaged by prolonged drought, errant vehicles;
- Should only be used in, shallow parabolic drain cross sections to avoid damage by maintenance operations such as mowing or slashing;
- Requires a consistent, uniform and complete grass cover to be fully effective, although the mats themselves provide good erosion protection;
- Will require some post installation watering until plants have established.
- High sediment loads may smother and kill the grass.

Indicative Cost and Life Span

- $6.00 - $12.00/m² ex-store for erosion control mat only, plus drain excavation, supply and placement of sandy loam “topsoil” material, seed, fertiliser and installation (indicative supply and install price: $10.00 - $16.00/m²);
- Life span of Permanent Erosion Control Mat: 10 years plus;
- Life span of subsequent vegetative cover: 10 years plus.

Installation Procedure

- Suppliers and distributors of Permanent Erosion Control Mats will provide manufacturers recommendations for the installation of their product.

In general terms however, the following procedure is fairly typical:

- Excavate drain along proposed line and grade, allow a 50 mm overcut to compensate for the placement of 50 mm of consolidated sandy loam “topsoil” material under the mat. Top of mat must be at, or slightly below, natural surface level;
- Place and lightly compact sandy loam “topsoil” material, rake off rocks and clods so that mat can sit flush and evenly over the prepared surface and is not “tenting”;
- Spread seed (couch / fine leaf carpet grass) and fertilise with 25g/m² of fertiliser with an N,P,K analysis of 14:4:11 (eg. Growforce 301, 303 or equivalent);
Excavate “cut off” trench across the drain 300 mm deep along upstream or leading edge of the mat. Fold the mat down into the trench, peg in place at 400 mm intervals, backfill and compact;

Roll out mat in the direction of flow and peg at 1.0 metre intervals along both outside edges all the way down its length. Polythene or U shaped steel pegs 150 – 300 mm can be used in this application (See Section 7). Plastic and steel pegs generally have the advantage of being able to be pushed down flush with ground surface level and can be left to degrade naturally;

Overlap joints shingle style, with a minimum 300 mm overlap;

Where velocities of greater than 3.0 m/s are expected (ie. perhaps on slopes greater than 12%) “checkslots” (buried edges) must be placed at each joint. Checkslots are similar to cutoff trenches at the top of the drain, except that both pieces of mat should be securely pegged into the trench prior to backfilling and compacting. An extra row of pegs should secure the mats immediately above and below the checkslot. Pegs should be at 0.5 m spacing across the full width of the mat;

Water “topsoil” material up to field capacity if conditions are very dry. Avoid runoff from the treated area.

Common Installation Problems

- Poor soil surface preparation and/or poor establishment of a consistent vegetative cover;
- Poor “topsoil” quality and lack of soil testing to determine deficiencies / requirements, lack of suitable ameliorants or fertilisers;
- Unsuitable selection / nomination of species mix;
- Incorrectly installed - insufficient number of pegs used to locate mats;
- Ground surface must be smooth and even so that mats can be pegged in close contact with the ground;
- Avoid applying fertiliser or herbicides / pesticides when storms are likely to wash this material into adjacent watercourses.

Maintenance Requirements

- Inspect after heavy rains or large flow events and repair (ie. remove, re-prepare, reseed and replace mat) in damaged sections;
- Depending upon grass species selected, grass lined drains will require mowing, up to 8 times per year. Grass should be mowed to a height not less than 35 mm to avoid “scalping” or damage to the crown of the plant.
Figure 5: Installation procedure for erosion control matting. Note “Checkslot” procedure for securing the leading edge of the mat below surface level.
Fact Sheet 8: HARD ARMOUR CHANNELS

Photo 19: Rock or rip-rap lined drains are useful where a permanent grasses cannot be established or maintained.

Photos 20: Asphalt can be used to protect both the shoulder and the invert of the drain, but should generally be used on slopes less than 7% as it can scour with high velocities, and lead to scour at exits points.
Description of the Control Measure or Product Group

Hard armour channels are channels with erosion resistant linings of rip-rap, reno mattresses, concrete or other structural material, designed for the conveyance of concentrated flows. Hard armour is used when the design flow velocity exceeds that applicable to a vegetative lining, or where vegetation is not applicable.

Possible Alternative / Variations

- Loose rock or rip-rap;
- Formless concrete cast in-situ;
- Asphalitic Concrete;
- Slip formed concrete (kerb and channel);
- “Reno” rock filled mattresses.

General Selection Criteria

- Rip-rap or reno mattresses will allow some foundation settlement and movement, thus applicable to landfill, mines or use on dispersible soils;
- Both can be topsoiled and revegetated for a “softer”, more aesthetic appearance;
- Choice of lining depends on cost benefit or longevity required of project.

Basic design criteria for rock lined channels is provided here to assist site supervisors and operations managers to make quick decisions in the field regarding suitable stone size and thickness for use on small roadside drains:

- **Drain geometry** - preferably parabolic profile, the ideal ratio for dimensions of a rock lined parabolic shaped drain is where the depth of the drain is approximately 25% of the top width (refer Photo 21), side slopes preferably 1:3 (v:h), not to exceed 1:2. Overcut channel to allow for placement of rock at design thickness;
- **Rock type** - Crushed rock is more suitable than rounded river stone. The rock should be heavy, hard and resistant to weathering;
- **Rock size** - Minimum average rock size should be 150 mm diameter. Alternatively, rock size can be determined by $D_{50} = 40(v)^2$, where $D_{50}$ is average rock size (mm) and V is average channel velocity (m/sec). Maximum rock size should be no larger than $1.5 \times D_{50}$ (ie. 225 mm);
- **Rock depth** - should be 1.5 times the maximum rock size (ie. approx. 350 mm). Rock must be placed over a geotextile filter cloth membrane.

Limitations

- Rigid linings such as concrete or grout filled mattress are more expensive and less forgiving of foundation conditions;
- Concrete lined drains also introduce high energies (flow velocities) that may need to be dissipated at the end of the drain. Unless drains discharge directly into field inlet pits or grade stabilisation (drop) structures, dissipation structures such as loose rock aprons, reno-mattresses or stilling ponds should be incorporated;
• Hard armour drains don’t allow for infiltration or nutrient removal;
• Not aesthetically pleasing in a “natural” environment;
• Potential for loose rocks to be missiled by children;
• Sediment may “fall out” in rock lined drain and partially reduce the design hydraulic capacity;
• Weeds may grow up between rocks and in accumulated sediments.

Indicative Cost and Life Span

• Loose rock lined drains with similar dimensions to the “standard” parabolic shaped drain should cost in the vicinity of $35.00 - $50.00/m supplied and installed, plus excavation;
• Formless cast in-situ concrete lined drains with similar dimensions to the “standard” parabolic shaped drain should cost in the vicinity of $40.00 - $60.00/m supplied and installed, plus excavation;
• “Reno” rock filled mattress drain with similar dimensions to the “standard” parabolic shaped drain should cost in the vicinity of $100.00 - $120.00/m supplied and installed, plus excavation;
• Respective life spans: 10 years plus.

Installation Procedure for Rock Lined Drains

• Excavate drain along proposed line and grade, allow sufficient overcut to compensate for the thickness of the rock lining (refer to notes above);
• Place and secure a 180g/m² needle punched geotextile filter fabric (eg. Bidim A24 grade or equivalent) prior to placing the rock on top;
• Well graded rock must be placed and consolidated to form a dense mass with few voids;
• Top of rock must be at, or slightly below, natural surface level so that lateral flows off the shoulder can flow down, into and along the drain.

Common Installation Problems

• Stone size in rip-rap liners not correctly sized or graded;
• Channel not overcut to allow for sufficient depth of stone, top surface of stone protrudes above adjacent ground level;
• Geotextile fabric not included under rock or reno mattresses; soil material is stripped from beneath lining;
• Rigid linings subside and crack due to insufficient foundation preparation, or lack of adequate expansion and/or contraction joints;
• Scour at end of channel due to higher velocities.

Maintenance Requirements

• Inspect channels after major storm events;
• Remove accumulated sediments and other debris;
• Check for scour along the edge of the drain, around outlet of channels and on outside of bends and make repairs as necessary;
• Spray out weeds and other volunteer species if they are likely to invade the drain.
Figure 6: Rock lining may be the preferred treatment to stabilise the invert where top width limitations force the profile of the table drain to assume a potentially more erodible “V” shape.
# 7.0 SUPPLIER DETAILS

*Table 1*: Listing of Erosion control products and their suppliers in the Brisbane Area.

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Purpose</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute Mesh “Soil Saver”</td>
<td>Temporary Erosion Control Mat made from open weave unbleached jute yarn.</td>
<td>Temporary erosion control and to assist seed germination.</td>
<td>Maccaferri</td>
</tr>
<tr>
<td>Jute Master “FM”</td>
<td>Temporary Erosion Control Mat made from recycled jute products.</td>
<td>Temporary erosion control and to assist seed germination. Also provides a mulch layer.</td>
<td>Landplan Engineering Supplies, Maccaferri, Geofabrics, Soil Filters Aust.</td>
</tr>
<tr>
<td>Aspenwall &quot;AG 101&quot;</td>
<td>Temporary Erosion Control Mat made from coir (coconut fibre). Available with either biodegradable or synthetic stitching.</td>
<td>Temporary erosion control and to assist seed germination. Also provides a mulch layer.</td>
<td>Erosion Solutions International</td>
</tr>
<tr>
<td>Biomac “T 300”</td>
<td>Temporary Erosion Control Mat made from coir (coconut fibre). Held together with a clear, fine polypropylene netting, stitched with a synthetic thread.</td>
<td>Temporary erosion control and to assist seed germination. Also provides a mulch layer.</td>
<td>Maccaferri</td>
</tr>
<tr>
<td>Wide rolls of standard turf (un-reinforced)</td>
<td>Thick vegetative matrix cut and transplanted.</td>
<td>Instant and permanent erosion protection.</td>
<td>BCC Business Unit preferred supplier Check local Yellow Pages under “Lawn and Turf Supplies”</td>
</tr>
<tr>
<td>“Grassroots 1”</td>
<td>Permanent Erosion Control Mat made from synthetic fibre with a polypropylene backing.</td>
<td>Permanent erosion protection and to assist seed germination. Also provides a “mulch” layer and permanently extends the performance of natural vegetation.</td>
<td>Soil Filters Australia (manufacturer), Geofabrics</td>
</tr>
<tr>
<td>North American Green “P300”</td>
<td>Permanent Erosion Control Mat made from 100% UV stabilised polypropylene fibres sewn between two nets.</td>
<td>Permanent erosion protection and to assist seed germination. Also provides a “mulch” layer and permanently extends the performance of natural vegetation.</td>
<td>Maccaferri</td>
</tr>
<tr>
<td>Synthetic Industries “Landlok TRM 450”</td>
<td>Permanent Erosion Control Mat made from dense three dimensional web of green polyolefin fibre bonded between two nets.</td>
<td>Permanent erosion protection and to assist seed germination. Also provides a “mulch” layer and permanently enhances the performance of natural vegetation.</td>
<td>Landplan Engineering Supplies</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>“STAYturf”</td>
<td>Reinforced turf</td>
<td>Instant and permanent erosion protection; extended performance over standard (un-reinforced) turf.</td>
<td>Jimboomba Turf Group (manufacturers)</td>
</tr>
<tr>
<td>“Terrafix”</td>
<td>Non-woven, staple fibre, needle punched geotextile filter fabric.</td>
<td>Restrict migration of fine soil particles while remaining permeable to water.</td>
<td>Soil Filters Australia (manufacturers)</td>
</tr>
<tr>
<td>“Bidim”</td>
<td>Non-woven, needle punched, continuous filament, polyester geotextile.</td>
<td>Restrict migration of fine soil particles while remaining permeable to water.</td>
<td>• Geofabrics (manufacturer) • Soil Filters Australia</td>
</tr>
<tr>
<td>“Mirafi”</td>
<td>Non-woven, needle punched geotextile.</td>
<td>Restrict migration of fine soil particles while remaining permeable to water.</td>
<td>Macciferri</td>
</tr>
<tr>
<td>Non-woven, needle punched geotextile</td>
<td>Non-woven, needle punched geotextile.</td>
<td>Restrict migration of fine soil particles while remaining permeable to water.</td>
<td>Landplan Engineering Supplies</td>
</tr>
<tr>
<td>Steel Pegs</td>
<td>U shaped black steel peg. Standard length 150mm.</td>
<td>Fixing for temporary or permanent channel liners and turf.</td>
<td>• Smorgon ARC • Gislers Wire Products (batch orders)</td>
</tr>
<tr>
<td>Polythene Pegs</td>
<td>Plastic pegs 200mm or 300mm.</td>
<td>Fixing for temporary or permanent channel liners and turf.</td>
<td>Soil Filters Australia (manufacturers)</td>
</tr>
</tbody>
</table>

Table 3 below provides company details and contacts for the products listed above. Suppliers should be contacted to accurately determine the price and availability of any products under consideration.
### Table 2: Suppliers and manufacturers contact details.

<table>
<thead>
<tr>
<th>Company name</th>
<th>Address, phone and fax</th>
<th>Contact person (2001)</th>
</tr>
</thead>
</table>
| Erosion Solutions International Pty. Ltd.         | PO Box 6005 Acacia Ridge DC  4110  
**Phone:** 3273 6124  
Fax: 3273 3763 | John Powell                                                  |
| Geofabrics Australasia Pty. Ltd.                  | 39 Noen St Sumner Park 4074  
**Phone:** 3279 1588  
Fax: 3279 1589 | Gary Tonks                                                   |
| Jimboomba Turf Group                              | 224 Paradise Rd Acacia Ridge 4110  
**Phone:** 3273 1166  
Fax: 3273 3763 | John Powell                                                  |
| Landplan Engineering Supplies Pty. Ltd.          | 5 Glasgow St St Johns Wood 4060  
**Phone:** 3366 6101  
Fax: 3366 1019 | Grant Sigston                                                |
| Maccaferri Pty. Ltd.                              | 31 Container St Tingalpa 4173  
**Phone:** 3890 3820  
Fax: 3890 3393 | Jason Crase                                                  |
| Soil Filters Australia Pty. Ltd.                  | 31 Activity Crs Southport 4215  
**Phone:** 5539 3600  
Fax: 5539 4027 | Simon Restall                                                |
| Total Erosion and Pollution Control (Aust) Co.    | 36 Avalon Rd Sheldon 4157  
**Phone:** 3206 2408  
Fax: 3206 2408 | Piya Wijemunige                                              |
| Smorgon ARC                                       | Ellison Road Geebung (Cnr. Bilsen Road)  
**Phone:** 13 1557  
Fax: 3265 2222 | Sales                                                        |
| Gisler Wire Products                              | 84 Ingleston Road Wakerley 4154  
**Phone:** 3890 2000  
Fax: 3890 4000 | Brad Udowika                                                 |
APPENDIX A

Design Methodology and Procedure

1. Calculation of table drain catchment area.

Assumption: the average table drain will have a catchment width of 30 metres for every 1 metre in drain length. For example:

Catchment area for table drain 100 m long = 100 metres x 30 m (assumed) = 3,000 m² = 0.3 ha

For ease of use within these guidelines, catchment areas for table drains have been related directly back to the length of the drain:

- 200 metre drain = 0.6 ha
- 300 metre drain = 0.9 ha
- 400 metre drain = 1.2 ha
- 500 metre drain = 1.5 ha

Assumption: maximum practical length of drain is 500 metres.

2. Calculation of peak discharge from 2 year, time of concentration storm event (Q₂) using Rational Method for each of the catchments.

Table A: Calculated peak discharge from 2 year, time of concentration storm event (Q₂) using Rational Method for each of the catchments

<table>
<thead>
<tr>
<th>Catchment Area (ha)</th>
<th>Corresponding Drain Length (m)</th>
<th>Time of Concentration (minutes)</th>
<th>Run-off Coefficient (worst case)</th>
<th>2 yr. tₜ Rainfall Intensity (mm/hr)</th>
<th>Q₂ Peak Discharge (m³/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>100</td>
<td>5</td>
<td>0.81</td>
<td>151</td>
<td>0.10</td>
</tr>
<tr>
<td>0.6</td>
<td>200</td>
<td>7</td>
<td>0.81</td>
<td>134</td>
<td>0.18</td>
</tr>
<tr>
<td>0.9</td>
<td>300</td>
<td>8</td>
<td>0.81</td>
<td>127</td>
<td>0.26</td>
</tr>
<tr>
<td>1.2</td>
<td>400</td>
<td>9</td>
<td>0.81</td>
<td>121</td>
<td>0.37</td>
</tr>
<tr>
<td>1.5</td>
<td>500</td>
<td>10</td>
<td>0.81</td>
<td>116</td>
<td>0.39 *</td>
</tr>
</tbody>
</table>

- maximum Q₂ value, used in calculations (See # 3 below)

3. Calculate cross sectional area (hydraulic capacity) required to pass Q₂ discharge from maximum catchment of 1.5 ha (drain length of 500 metres).

Cross section area required is calculated by:

\[
A = \frac{Q}{V}
\]
where:  
Q = Quantity (volume) of water to be conveyed (m³ per second)  
V = Velocity of flow in drain (m per second)  
A = Cross sectional area of drain (m²)  

**Table B:** Cross sectional area (hydraulic capacity) required to pass maximum Q₂ discharge from catchment of 1.5 ha (drain length of 500 metres)

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Maximum quantity of water to be conveyed (m³/s)</th>
<th>Calculated velocity of flow in “standard” table drain – See # 5 below (m/s)</th>
<th>Cross sectional area required (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.39</td>
<td>2.29</td>
<td>0.170</td>
</tr>
<tr>
<td>9</td>
<td>0.39</td>
<td>2.18</td>
<td>0.179</td>
</tr>
<tr>
<td>8</td>
<td>0.39</td>
<td>2.05</td>
<td>0.190</td>
</tr>
<tr>
<td>7</td>
<td>0.39</td>
<td>1.92 *</td>
<td>0.203</td>
</tr>
<tr>
<td>6</td>
<td>0.39</td>
<td>1.78</td>
<td>0.219</td>
</tr>
<tr>
<td>5</td>
<td>0.39</td>
<td>1.62</td>
<td>0.241</td>
</tr>
<tr>
<td>4</td>
<td>0.39</td>
<td>1.45</td>
<td>0.269</td>
</tr>
<tr>
<td>3</td>
<td>0.39</td>
<td>1.26</td>
<td>0.310</td>
</tr>
<tr>
<td>2</td>
<td>0.39</td>
<td>1.03</td>
<td>0.379 **</td>
</tr>
<tr>
<td>1</td>
<td>0.39</td>
<td>0.53</td>
<td>0.534 **</td>
</tr>
</tbody>
</table>

* 2.0 m/sec (7% slope) = maximum permissible velocity for unreinforced turf or grass with temporary erosion control mats.  
** Capacity of “standard” table drain (0.32 m²) may be exceeded on very low slopes (See # 4 below)

4. **Calculate cross sectional area (hydraulic capacity) of “standard” table drain.**

The adoption of a “standard” parabolic table drain profile has been proposed for use in the BCC area where length of drain does not exceed 500 metres. The “standard” drain should be 1.2 metres wide x 400 mm deep.

Cross sectional area of a parabolic shaped drain can be calculated using:

\[ A = 0.66 \, d \times T \]

where:-  
A = Cross sectional area (m²)  
d = Depth of drain (m)  
T = Top width of drain (m)

Accordingly, cross sectional area of “standard” table drain is:

\[ A = 0.66 \times 0.4 \times 1.2 \]
\[ A = 0.32 \, m² \]
This “standard” table drain has been designed with a cross sectional of 0.32 m² which should generally convey all of the runoff from a 2 year ARI storm event (Q2) on slopes 3% or greater.

However, as the capacity of the “standard” table drain is ultimately dependent upon the velocity of flow within the drain (ie. \( Q = V \times A \)), the capacity of this drain may be exceeded where low flow velocities exist or where large volumes of runoff are produced. For example:

- where drain lengths exceed 400m on slopes of less than 2%;
- where drain lengths exceed 300 m on slopes of less than 1%; or
- where the runoff exceeds that of a Q2 event).

The cross sectional area of many existing table drains within the BCC area is currently well below this nominated standard. Accordingly, it has been assumed that the risk associated with table drains overtopping or outflanking is generally acceptable. Construction of a “standard” table drain with larger dimensions than proposed in this guideline was also assumed to be generally unfeasible.

5. **Calculate velocity of flow in “standard” table drain.**

Manning’s Formula was used to determine average velocity of flow in Table B, above. Manning’s Formula is:

\[
V = \frac{1}{n} R^{0.66} S^{0.5}
\]

where:
- \( V \) = velocity of flow (m/s)
- \( R \) = Hydraulic radius (m)
- \( S \) = Slope (m/m)
- \( n \) = Roughness coefficient (assumed as 0.040 for this project, see also Table C below)

Hydraulic radius for a parabolic shaped channel can be calculated using:

\[
R = \frac{2d \cdot T^2}{3T^2 + 8d^2}
\]

where:-
- \( R \) = Hydraulic radius (m)
- \( d \) = Depth of drain (m)
- \( T \) = Top width of drain (m)
Table C: Manning’s Roughness Coefficient (n) for various channel linings. (Design Manual for Soil Conservation Works, Technical Handbook No. 5, Soil Conservation Service of NSW, 1982).

<table>
<thead>
<tr>
<th>Channel lining</th>
<th>Recommended “n” value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalitic concrete</td>
<td>0.014</td>
</tr>
<tr>
<td>Concrete - steel trowelled</td>
<td>0.012</td>
</tr>
<tr>
<td>Concrete – unfinished</td>
<td>0.015</td>
</tr>
<tr>
<td>Shotcrete – unfinished</td>
<td>0.017</td>
</tr>
<tr>
<td>Metal – corrugated</td>
<td>0.024</td>
</tr>
<tr>
<td>Plastic</td>
<td>0.013</td>
</tr>
<tr>
<td>Gabion</td>
<td>0.030</td>
</tr>
<tr>
<td>Earth - smooth, no weeds</td>
<td>0.020</td>
</tr>
<tr>
<td>Earth - some stones and weeds</td>
<td>0.025</td>
</tr>
<tr>
<td>Earth - good grass growth</td>
<td>0.040</td>
</tr>
<tr>
<td>Earth - thick grass growth</td>
<td>0.050</td>
</tr>
</tbody>
</table>