ENVIRONMENT DESIGN GUIDE

EROSION AND SEDIMENT CONTROL

Grant Witheridge

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Urban erosion and sediment control has been based on well-established principles of soil conservation; however, the building and construction industries still experience significant problems in both understanding and applying these principles.
- A number of commonly accepted sediment control practices, such as straw bale barriers, are now considered inappropriate.
- Attention should be focused on the *impacts* of sediment and turbidity on the environment, rather than the impacts of soil loss from a property.
- Priority MUST be given to those measures that minimise environmental harm, rather than those measures that maximise the capture of sediment.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:

- Investigate site constraints and appropriately integrate the development into the site in a manner that minimises both short and long-term environmental harm.
- Prepare and implement an Erosion and Sediment Control Plan based on these investigations.
- Minimise the number of site entry points and establish stabilised site entry/exit conditions.
- Expose the smallest possible area of land for the shortest possible time.
- Save and promptly replace topsoil.
- Divert up-slope stormwater run-off around any soil disturbances.
- Permanently or temporarily connect roof water downpipes to the permanent drainage system immediately the roof and guttering are installed.
- Actively control wind, rain and velocity-induced soil erosion.
- Firmly compact and stabilise all backfilled service trenches.
- Minimise sediment released from the property.
- Place all long-term stockpiles of erodible material within the sediment control envelope.
- Fully contain all wash-water from concreting, ceramic cutting and cleaning operations within an area of grassed or open soil.
- Promptly revegetate or otherwise stabilise disturbed areas.
- Maintain all control measures in good working order.

Cutting EDGe Strategies

- Avoid the use of exposed aggregate concrete surfaces unless ALL cement wash-off can be contained within an excavated pit.
- Avoid the use of straw bales in the formation of a sediment control barrier.
- Avoid the reliance on sediment control barriers installed within the road reserve.
- Actively promote the incorporation of land stabilisation/revegetation works into the building works as a continuous and coordinated process that minimises both short and long-term soil erosion, especially during periods of high rainfall.

Synergies and References

- Consider the benefits of introducing a risk ranking system to the building approval process.
- Actively promote the incorporation of a dedicated Erosion and Sediment Control Officer into local governments.
- Brisbane City Council's Best Practice Guidelines for the Control of Stormwater Pollution from Building Sites.
- *BDP Environment Design Guide* DES 18.

ENVIRONMENT DESIGN GUIDE

EROSION AND SEDIMENT CONTROL

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The principles of erosion and sediment control are said to be at the cutting edge of common sense. These principles have been around for decades, but in many areas current practices fall well short of the proper application of these common sense principles. This EDG note does not represent a guideline on erosion and sediment control, rather a discussion on the philosophy of erosion and sediment control and the deficiencies of a number of practices currently being used.

1.0 INTRODUCTION

Erosion control and sediment control are two different, but strongly related topics.

The science of erosion and sediment control has generally developed from the fields of soil science and agricultural engineering, and many of the early principles remain unchanged.

Some refer to it as erosion control while others prefer the term sediment control, but the better and more widely accepted terminology is erosion and sediment control (ESC). The importance of getting the terminology right is that erosion control measures consist of completely different techniques to those commonly used in sediment control.

Erosion control measures concentrate on preventing or at least minimising soil erosion, while sediment control measures concentrate on the trapping of displaced sediment.

Terminology and titles can bear an important influence over the actions and attitudes of people. For example, if we were to give an inspector the title *Erosion Control Officer*, then we should not be surprised to find them concentrating on soil erosion issues. Alternatively, the title *Sediment Control Officer* normally results in an inspector obsessed with the installation of sediment fences!

Unfortunately, all the titles and terms fail to identify the real aim of the exercise, that being *environmental protection*. This is because the principles of ESC originated from agricultural activities where, initially at least, the aim was to prevent soil loss and damage to the farm, rather than damage to the environment.

So what has this to do with a paper on erosion and sediment control? The first and most important step should be to clearly define the currently accepted aims of ESC so our attention can be focused on these aims rather than past ideals and assumptions.

2.0 PURPOSE OF EROSION AND SEDIMENT CONTROL

It is not the amount of pollution that matters, but the amount of harm it causes.

In the 70's and early 80's the talk was all about pollution control, pollution control Acts and pollution control authorities. Fortunately this has now changed and today we refer to environmental values, environmental protection Acts and environmental protection authorities.

Ultimately, we are not judged on how much pollution we stop, but on the health and sustainability of downstream ecosystems. If we were to spend thousands of dollars placing sediment fences around every building site, only to find that our waterways continued to be damaged by sediment and turbidity, then we would have failed in our basic aim.

Environmental protection, however, is not just about maintaining biodiversity and ecological health. Human life is a part of the environment and thus environmental protection also means protecting human interests and values.

So what is the aim or purpose of erosion and sediment control and what can be gained from the process?

This question is possibly best answered by reviewing some of the problems caused by soil erosion and off-site sedimentation, such as:

- loss of topsoil from building sites;
- traffic safety problems caused by sediment deposition upon roadways;
- local drainage problems caused by sediment deposition within stormwater pipes;
- increased residential flooding caused by sediment deposition within creeks;
- waterway instability problems;
- increased mosquito problems;
- reduced recreational and commercial fishing;
- impacts on the recreational use of our waterways;
- reduced biodiversity and poor ecological health within our waterways.

Of course the aims of erosion and sediment control are to prevent, or at least minimise, all of these problems.

As can be seen from the above, not all the benefits of ESC are ecologically based: most relate to human benefits and value systems.

Soil erosion generally results in two forms of pollution, *turbidity*—consisting of the finer clay-sized particles, and *coarse sediment or bed-load sediment*—consisting of the heavier silts and sand-sized particles. It is generally the coarse sediment that causes human-related problems such as traffic safety issues, drainage and flooding concerns, and creek instability problems, while turbidity is known to be a major cause of ecological health problems.

Turbid run-off generally results from raindrops impacting on exposed clayey soils. Without the benefits of a protective coverage of vegetation, clay-sized particles are easily washed from the soil surface by the impacting force of raindrops. Importantly, it is noted that the compaction of the soil generally has only a minor influence on rain-induced turbidity levels.

On the other hand, coarse sediment is most commonly displaced by water flowing at high velocity across the soil surface. In such cases soil compaction can have a major influence on erosion rates.

Of course the above description ignores the effects of wind erosion which can readily displace both coarse and fine sediments.

To adequately control soil erosion, the adopted erosion control measures must deal with both raindrop impact and velocity-induced surface erosion. It is noted that velocity-induced soil erosion can either result from thin *sheet* flow (sheet erosion) or concentrated flow (rill and gully erosion—rills being minor gullies that are less than 300 mm deep).

Erosion control may be divided into two fields, *drainage control* and *erosion control*. Drainage control measures are used to control soil erosion caused by concentrated flow, while erosion control measures are used to control raindrop impact, sheet and wind erosion.

Thus we have three main processes and three sets of management tools: drainage control, erosion control and sediment control.

On building and civil construction sites, it is the *sediment control measures* that concentrate on trapping the coarse sediment and the *erosion control measures* that concentrate on reducing turbidity. Drainage control measures aim to prevent rill and gully erosion, while bypassing *'clean'* water around soil disturbances, and prevent storm damage to the various erosion and sediment control measures.

Thus sediment control measures generally aim to minimise human-related problems, while erosion control measures mostly aim to minimise ecological harm.

Therefore, if we concentrated solely on sediment control practices, such as the installation of sediment fences, then we would likely fail in our overall aim of minimising environmental harm.

Thus, to satisfy our aim of minimising environmental harm, most building and construction sites require a combination of drainage, erosion and sediment control measures. The trick is being able to combine these separate ESC activities into an effective and cost-efficient working arrangement while not hindering building activities.

3.0 PRINCIPLES OF EROSION AND SEDIMENT CONTROL

Erosion and sediment control is at the cutting edge of common sense!

The basic principles of erosion and sediment control consist of:

- minimising site disturbance;
- controlling drainage;
- minimising soil erosion;
- promptly stabilising/revegetating disturbed areas;
- minimising the release of sediment;
- maintaining all control measures in good working order; and
- preparing ESC plans before commencing soil disturbance.

On small building sites these management principles translate into the following activities:

- Investigate site constraints and appropriately integrate the development into the site in a manner that minimises both short and long-term environmental harm.
- Prepare and implement an ESC plan based on these investigations.
- Minimise the number of site entry points and establish stabilised site entry/exit conditions.
- Expose the smallest possible area of land for the shortest possible time.
- Save and promptly replace topsoil.
- Divert up-slope stormwater run-off around any soil disturbances.
- Permanently or temporarily connect roof water downpipes to the permanent drainage system immediately the roof and guttering are installed.
- Actively control wind, rain and velocity-induced soil erosion.
- Firmly compact and stabilise all backfilled service trenches.
- Minimise sediment released from the property.
- Place all long-term stockpiles of erodible material within the sediment control envelope.
- Fully contain all wash-water from concreting, ceramic cutting and cleaning operations within an area of grassed or open soil.
- Promptly revegetate or otherwise stabilise disturbed areas.
- Maintain all control measures in good working order.

The cost of applying these principles to small building sites varies from location to location, depending mainly on the layout of building and the size and topography of the site. Typical costs are around $300–$500 per building lot.

4.0 DESIGNING TO MINIMISE SOIL EROSION AND SEDIMENTATION PROBLEMS

It is not the duration of the disturbance that matters, but the duration and severity of the ongoing impacts.

An individual building activity or environmental disturbance should not be considered in isolation, but must be considered in association with all other disturbances that are likely to impact environmental values.

Building activities on an individual site may only occur for three months over the 50 to 100 year life span of the structure, but within any waterway catchment there is generally always some form of building or construction activity occurring. Thus the environmental impacts of turbidity and sedimentation on an urban waterway are usually ongoing.

Therefore, all reasonable and practicable measures should be taken to design and construct buildings in a manner that minimises both short and long-term environmental harm while still achieving the desired aims and purpose of the structure.

A case in point would be slab-on-ground construction. While it may be impractical to ban slab-on-ground construction from heavily sloping blocks, such a proposal would likely reduce the overall environmental harm caused by urban development. Thus if slab-on-ground construction is specified on a steep block, then these works should be associated with more intense landscaping and ESC measures.

Designers must accept the challenge of demonstrating that their designs can be built without causing unnecessary environmental harm. In addition, building and planning regulators must be given the power to reject those designs that do not allow the installation, maintenance and operation of all necessary erosion and sediment control measures.

Where appropriate, designs should incorporate the following principles:

- Allow enough readily accessible room on the site to store all building materials, especially stockpiles of erodible material.
- Allow enough space to install all necessary sediment control measures, especially along the lower property boundary.
- Avoid specifying extensive earthworks at or around the lowest point in the property.
- Consider the use of elevated pole homes on steep blocks.
- Minimise the extent and duration of soil disturbance.
- Allow the early stabilisation of all disturbed areas located outside the immediate work area.
- Do not specify exposed aggregate concrete surfaces in areas where the cement wash-off cannot be fully contained within an excavated pit.

5.0 DRAINAGE CONTROL

Without good drainage control during construction, you're probably just wasting your time.

Temporary drainage controls during the building or construction phase perform a number of functions including:

- Reducing site wetness, thus reducing the generation of mud and reducing site clean-up costs.
- Reducing soil erosion.
- Reducing the maintenance requirements of down-slope sediment control measures.
- Reducing the volume of *'dirty'* water leaving the site.
- Reducing construction times.

Simple perimeter banks or excavated catch drains can be used to divert up-slope stormwater run-off around building activities and excavated trenches.

One of the most financially beneficial drainage control measures is the early installation of the underground stormwater system and the early connection of roof water downpipes to this drainage system (Figure 1).

These temporary downpipes are reusable, can readily be removed to allow building activities to be performed, can significantly reduce site wetness and can prevent the contamination of large quantities of stormwater run-off.

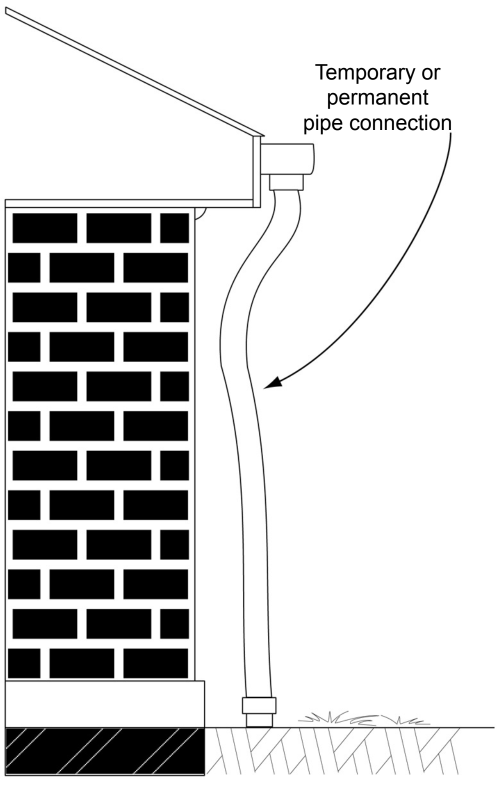

Figure 1. Temporary downpipe connection
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6.0 EROSION CONTROL

The higher the clay content, the greater the need for erosion control measures.

Erosion control is difficult during the earthworks phase and is thus often forgotten during the building phase; however, its importance cannot be understated. On small building sites, erosion control measures are often the only feasible means of minimising run-off turbidity.

The need for erosion control generally increases with the increasing clay content of the soil. In cities like Brisbane, this puts erosion control as a top priority. On the other hand, erosion control would have a lower priority (though is still important) in a city such as Perth where sandy soils predominate.

Erosion control measures include:

- In windy areas, covering stockpiles of sandy soils.
- Covering stockpiles of clayey material when rain is imminent or occurring.
- Locating all stockpiles away from concentrated flowing water.
- Protecting exposed earth batters with mulch, jute blankets or turf as soon as possible.

7.0 SEDIMENT CONTROL

Sediment control is not just the widespread application of sediment fences.

On small building sites it is not uncommon to see only sediment control practices being utilised. Very few homes or buildings should be constructed these days without some type of sediment fence; however, on large civil construction sites, a well-prepared ESC plan often incorporates very few sediment fences. So why the difference?

Basically, on small sites there is usually only limited space and funding for sediment control and thus the sediment fence is employed as one of the most compact, cost-effective and efficient forms of coarse sediment control.

Unfortunately, the humble sediment fence is unlikely to have a significant impact on turbidity levels. Thus on larger construction sites, significantly more effort must be taken to control soil erosion and turbidity levels.

Given their wide use in the industry, it is unfortunate that the sediment fence is so widely misused. A common misconception is that sediment fence fabric is supposed to 'filter' sediment from stormwater run-off. A sediment fence should *not* be looked upon as a filter. It is simply there to act as a porous dam wall aiming to temporarily pond dirty water up-slope of the fence thereby allowing coarse sediment particles to settle under gravity.

This is why *shade cloth* should *not* be used as sediment fence—it neither filters sediment nor provides enough flow resistance to create sufficient up-slope ponding to settle sediment.

However, it should be noted that most non-woven sediment fence fabrics (not filter cloth) do act as filters as well as performing the task of creating up-slope ponding. Thus these fabrics have the potential to provide better stormwater treatment; although, they are also likely to require more frequent maintenance in order to maintain them in proper working order.

Typical layouts for the use of sediment fences on building sites can be seen in Figure 3. Figure 3 also shows the use of drainage controls and site entry/exit pads (Figure 4).

It would be wrong to proceed much further without making special mention of one of the worst sediment control devices ever invented—straw bales. As a general rule, the wide use of straw bale sediment traps on building and construction sites should be taken as the first sign that the operator probably does not know what they are doing.

Straw bales quickly begin to lose their strength once wet. Thus if used at all, the straw bales need to be replaced after each storm event. Unfortunately these traps are rarely installed properly and almost always poorly maintained.

Having said this, I should also mention that straw bales can be an effective means of establishing *temporary* flow diversion barriers just prior to storm events, or as a means of bringing mulch onto a work site. Thus they can be used for drainage control and erosion control purposes.

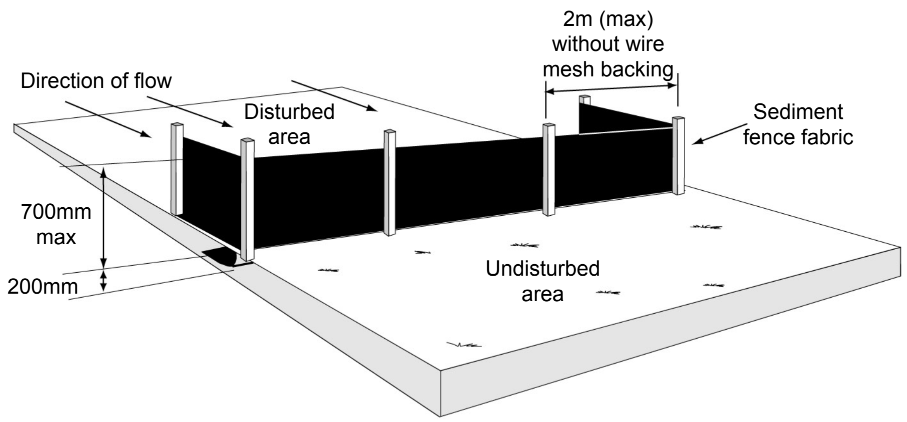

Figure 2. Sediment fence

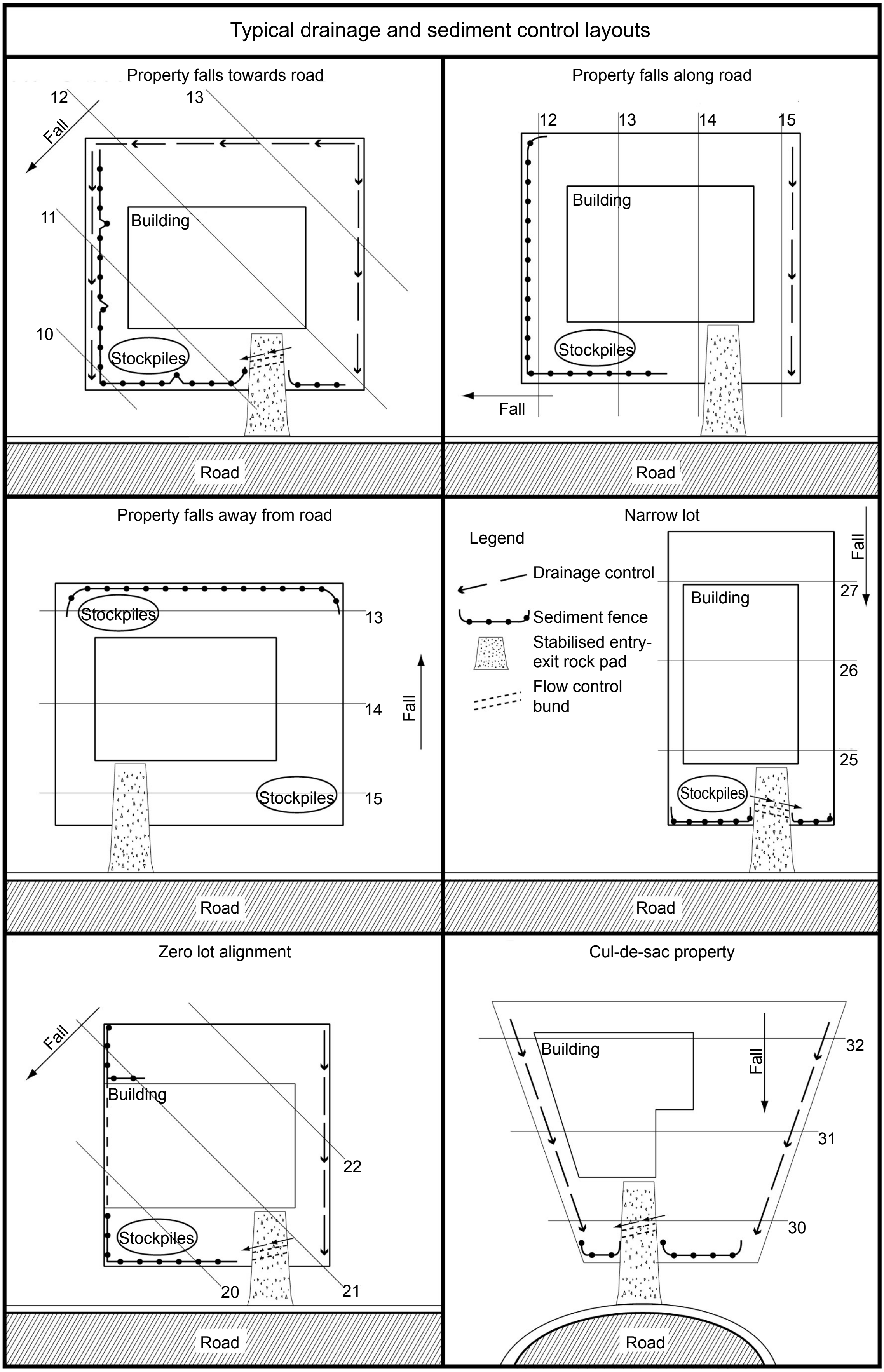

Figure 3. Typical building site ESC layouts

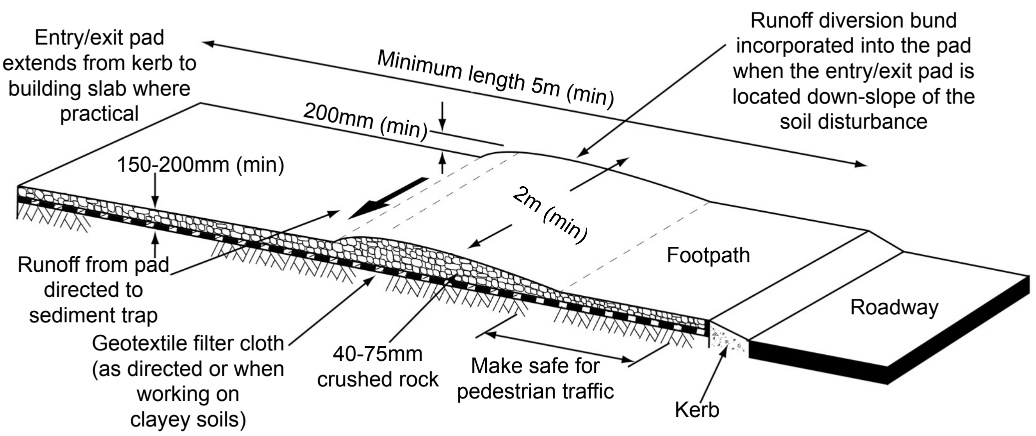

Figure 4. Stabilised entry/exit pad – building sites
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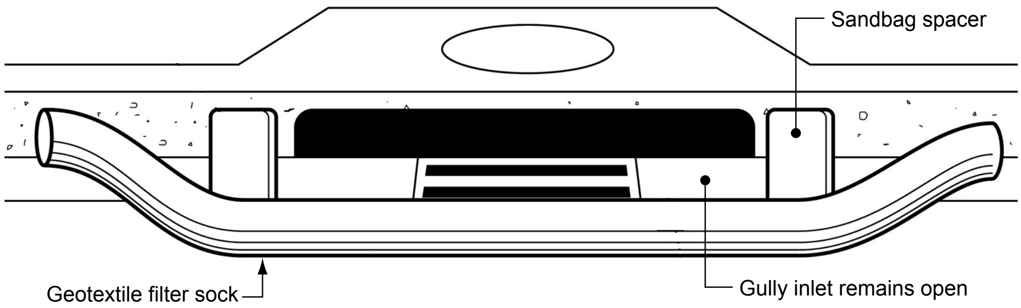

Figure 5. Sag gully inlet sediment trap
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Of course the overall winner of the most misused sediment control device would have to be the gully inlet sediment control filter sock or sediment control barrier. These devices are often rigorously specified by regulating authorities and are listed in most ESC guidelines. However, in ten years of being involved in the ESC industry I have rarely seen these devices installed properly.

There are two types of roadside gully inlets: sag inlets and on-grade inlets. Sag inlets are located at the bottom of a valley or road sag and thus stormwater enters a sag inlet from both directions. These inlets usually have a grate located in the centre of the gully opening (Figure 5).

On-grade gully inlets are located on the slope of a road and thus stormwater only approaches the inlet from one direction. In on-grade gully inlets the grate is normally located at the downstream end of the gully opening (Figure 6).

If the aim of the exercise was to simply prevent sediment entering the *first* gully inlet, then maybe these filter socks could do a half-decent job. However, the real aim is to prevent sediment from entering the stormwater system at any point down-slope of the work site.

When designing or installing any sediment control device it is essential to ask yourself two important questions: where is the water going to flow, and where is the sediment going to end up? Obviously, at some point the water and sediment have to go their separate ways in order for a sediment trap to work.

If a sediment barrier is placed across the face of an on-grade gully inlet, then all it is likely to do is deflect the water around the barrier and send it down the road to the next available gully inlet. If the sediment trap is designed so that it does not pond water (something that is hard to do on the side of a hill), then there is also no reason for the sediment to settle-out and leave the water.

The bottom line is that sediment should be trapped before it is allowed onto a roadway.

If a sediment trap must be constructed within a road reserve to protect an on-grade gully inlet, then it must be located well up-slope of the inlet and must take the shape of a dam that allows a pond to form up-slope of the sediment barrier as shown in Figure 6.

Unfortunately, if the road is open to vehicular traffic, then these devices can become a traffic safety hazard or simply targets for random destruction by aggressive motorists.

At sag inlets, the sediment barrier needs to completely surround the inlet (Figure 5), but MUST NOT block the inlet unless an adjacent overland flow path exists.

Possibly the only construction teams that can successfully use gully inlet sediment traps are councils and subdivision developers that own the road reserve and thus are able to control both road traffic and all gully inlets down to the sag point of the road.

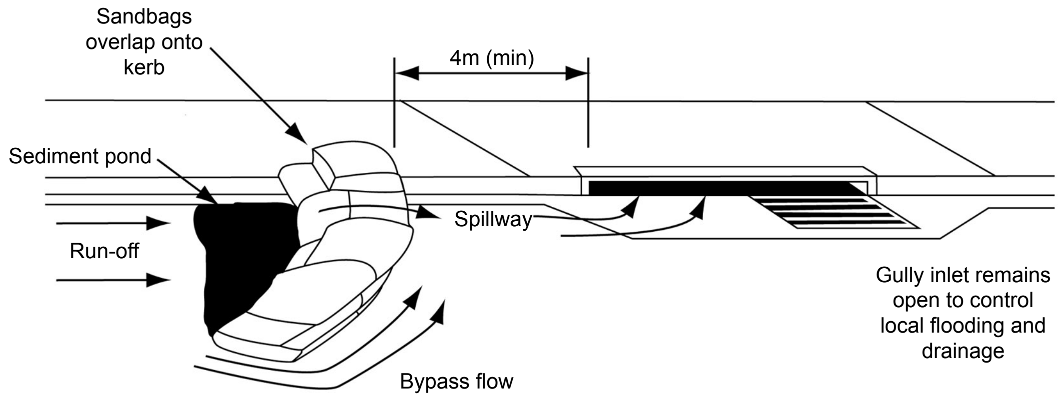

Figure 6. On-grade gully inlet sediment trap suitable for use on a closed road
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8.0 SEDIMENT CONTROL ON LARGER CONSTRUCTION SITES

Large construction sites usually incorporate a wider range of sediment control measures

While the principles of erosion and sediment control have basically remained unchanged for many years, the way erosion and sediment control measures are applied to various building and construction activities varies significantly.

As previously discussed, due to space and financial constraints, sediment controls on small building sites typically consist of just a sediment fence and stabilised rock entry/exit pad. On the other hand, sediment controls on large civil construction sites may also include sediment basins, stilling ponds, rock filter dams, sediment weirs, buffer zones, a grass filter bed, and field inlet and gully inlet sediment barriers.

Sediment basins are usually adopted as the primary sediment control system and they are one of the few sediment control devices that can significantly reduce turbidity levels. Stilling ponds are used to settle sediment from contaminated water pumped from pits and excavations.

Rock filter dams are used as coarse sediment traps in minor gullies. Sediment weirs are used in similar circumstances, but are much narrower than rock filter dams. Buffer zones and grass filter beds are mainly used in rural areas where sediment-laden stormwater run-off can be maintained as sheet flow.

Field inlet and gully inlet sediment barriers are used to reduce the discharge of sediment into underground stormwater systems. Sediment fences are used to minimise the quantity of sediment entering the road reserve or to treat water that cannot be directed to a sediment basin.

Entry/exit rock pads, wash bays and vibration grids are used to minimise the vehicular transport of sediment onto public roads. These are one of the few sediment control devices that perform their task during both wet and dry weather, and thus are always required on building and construction sites even when rain is unlikely to occur.

9.0 REVEGETATION AND LAND STABILISATION

Long-term erosion control is achieved by covering the soil, not just compacting it.

If a service trench is excavated, the services installed and the trench backfilled in just one day, some may claim that the duration of soil disturbance was minimised. However, if the backfilled trench is not immediately stabilised (ie turfed), the exposed soil remains a source of pollution for weeks or months until a full coverage of grass is established over the soil.

If the disturbed soil is simply grass seeded, then it may take a month or two before the soil surface develops enough grass coverage to control raindrop impact erosion. The fact that the grass may look thick and green from a distance is no indication that it can adequately control soil erosion. Newly seeded grasses generally grow vertically and thus provide very little protection from raindrop impact.

If when looking directly down on the grassed area you can still see the soil, then the rain will also find it and continue to wash it away. Compacting the soil hard does not help matters, it just delays the revegetation process.

The best way to obtain instant erosion control is to place turf. Turf consists of mature mat-forming grasses that totally cover and protect the soil from erosion. If grass is to be developed from seed, then a thin coverage of mulch should be applied. Alternatively, thin biodegradable erosion control blankets may be used. Mulching the surface reduces erosion, aids seed germination and reduces water evaporation.

In some locations straw mulching can introduce problems of nut grass infestation. An alternative erosion control method involves the application of a light covering of finely graded pine mulch, or similar product.

10.0 POST-BUILDING CONTROLS

Currently the ESC industry is struggling to figure out how best to control soil erosion and sediment run-off once the landowner takes control of the property.

On civil sites this is less of a problem because these developments are usually fully landscaped and heavily mulched prior to handover. However, on residential building sites problems can exist for weeks if not months after final handover.

It is not just the lack of landscaping that is a problem, unsealed driveways can cause sediment problems for years. On rural residential properties, a minimum council regulation should be the formation of a cross drain or 'speed bump' at the lower end of unsealed driveways. Raised cross drains force sediment-laden run-off to be deflected from the driveway onto an adjacent grassed area where the sediment can be filtered from the water.

11.0 INDUSTRY REGULATION

Regulations and procedures vary significantly around the country and thus it is not feasible to summarise the various regulatory approaches within this note.

However, generally the main issue is that it should be made more expensive for people to do the wrong thing rather than the right thing. Rules and design guidelines should be based on techniques and procedures that can be inspected, and these inspections and regulations should aim to penalise only those who do the wrong thing.

The cost of ESC must be passed onto the future landowner and not carried by the builder. The only way this can happen is for ESC rules to be written and enforced in a manner that applies equally to all.

To be effective, ESC regulations should not be carried out by the same building inspectors that inspect the plumbing or framework, but by dedicated ESC Officers. These officers regulate both building and development approvals as well as council's own building and construction works.

Councils such as Brisbane City Council have adopted ranking systems that require applicants to submit a standard site assessment form for all Building and Development Applications. These systems rank the environmental risk based on site factors such as soil type, land slope and the extent and duration of the soil disturbance. Proposals that attract a 'High' ranking should be reviewed by specialist ESC officers, while lower ranked proposals may be assessed solely by the normal development assessment teams.

The benefit of these ranking systems is that developers begin to design their proposals to minimise their risk ranking, which in effect indirectly introduces environmentally sensitive aspects into their designs. However, it should be noted that a 'Low' rating does not mean ESC measures are not required.

12.0 CONCLUSION

Throughout this Note an emphasis has been placed on the application of both erosion control and sediment control measures, with the aim of controlling the run-off of both turbidity and coarse sediment. However, the Note also recognised that appropriate building planning and design is required to allow the installation and operation of all necessary ESC measures.

FURTHER READING

Brisbane City Council 2002, *Best Practice Guidelines for the Control of Stormwater Pollution from Building Sites* – Guidelines and Fact Sheets. Brisbane City Council, Queensland.

NSW Department of Land and Water Conservation, (undated), *Urban Soil Erosion and Sediment Control – Sitewise*. NSW Department of Land and Water Conservation.

NSW Department of Housing, 1998, *Managing Urban Stormwater – Soils and Construction*. NSW Department of Housing.

Witheridge, G and Walker, R, 1996, *Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites*, The Institution of Engineers, Australia, Brisbane.

ACKNOWLEDGMENT

All diagrams are owned and supplied by Catchments and Creeks Pty Ltd.

BIOGRAPHY

Grant Witheridge is a civil engineer with 21 years experience in the design of hydraulic structures, erosion and sediment control, and creek engineering. Grant has worked for The University of NSW, Brisbane City Council and Griffith University. He currently works through his own consultancy, Catchments and Creeks Pty Ltd.

Grant is the principle author of publications such as *Institution of Engineers' Soil Erosion and Sediment Control Guidelines* and Brisbane City Council's *Sediment Basin Design Guidelines*, *Instream Sediment Control Guidelines*, *Creek Erosion Guidelines and Natural Channel Design Guidelines*, as well as being heavily involved in the development of the Council's risk ranking system for development and building sites, and their ESC guidelines for building sites.