Diversion Channels

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] The design of permanent diversion channels requires consideration of issues not discussed within this fact sheet, such as safety and maintenance requirements.

Symbol → DC →

Photo 1 – Temporary diversion channel collecting "dirty" water down-slope of a soil disturbance

Photo 2 – Permanent diversion channel collecting stormwater runoff up-slope of a subdivision

Key Principles

1. Diversion channels are sized for a specific design flow rate based on the catchment area, topography, soil and hydrologic conditions.
2. Critical design parameters are the choice of surface lining, hydraulic capacity and stability of the discharge point.
3. Critical operation issues are usually related to controlling sediment, vegetation and debris collection within the channel, and maintaining a stable outlet.

Design Information

Diversion channels are usually major hydraulic structures requiring design input from an experienced hydraulics specialist. This fact sheet does **not** provide sufficient information to allow diversion channels to be designed by inexperienced persons.

The design of permanent drainage channels requires consideration of issues not discussed within this fact sheet, such as safety and maintenance requirements.

The design discharge (Q) must reflect the specified drainage control standard of the site. Refer to the relevant regulating authority for relevant design standards.

Typical design standards are presented in Table 1.

Refer to *Channel Linings* Fact Sheets for velocity calculations and guidelines on the design of rock, grass or mat lining of the channel.

Recommended maximum bank slopes are provided in Table 2.

Table 1 – Typical design standards for temporary diversion channels

Parameter	Design standard
Design discharge	• Refer to regional guidelines
Channel depth	• Minimum channel depth of 300mm
Freeboard	• Minimum freeboard being the greater of 150mm, 10% of channel depth, or the velocity head ($V^2/2g$) • Allow embankment settlement of 10% of fill height (in addition to freeboard) if the embankment's design life exceeds 1 year
Embankment	• Optional embankment formed down-slope of the channel (Figure 1). • Minimum crest width of 600mm, and down-slope bank gradient of 2:1 for reasons of stability against overtopping flows
Safety	• Safety requirements, such as the depth*velocity product (d.V), generally do not apply to drainage channels • Safety considerations generally focus on allowing good egress from the channel, and ensuring safety risks are obvious
Maintenance berm	• Desirable 1.5m wide (min) maintenance berm on at least one side of the channel (not always practicable in short-term projects)

Table 2 – Typical maximum bank slopes [1]

Site conditions	Max bank slope (H:V)
Highly compacted clay (hard, pick required)	1:1 to 1.25:1
Medium compact sandy clay	1.2:1 to 1.5:1
Slightly compact silty clay or sandy clay (soft, spade required)	1.5:1 to 2:1
Non-cohesive fine sandy soil or soils with humus or peat content	2:1 to 3:1
Non mowable vegetated slopes	3:1
Permanent, mowable, grass slopes (maximum grade)	4:1
Permanent, mowable grass slopes (recommended grade)	6:1
Rock lined channels	1.5:1 [2]

[1] Bank slopes provided as a guide only. Actual bank slope should be based on geotechnical and landscaping advice wherever practicable.

[2] Desirable maximum bank slope is 2:1 for dumped rock; however, with increased placement effort and skills, rock may be placed on bank slopes up to 1.5:1 in low velocity channels.

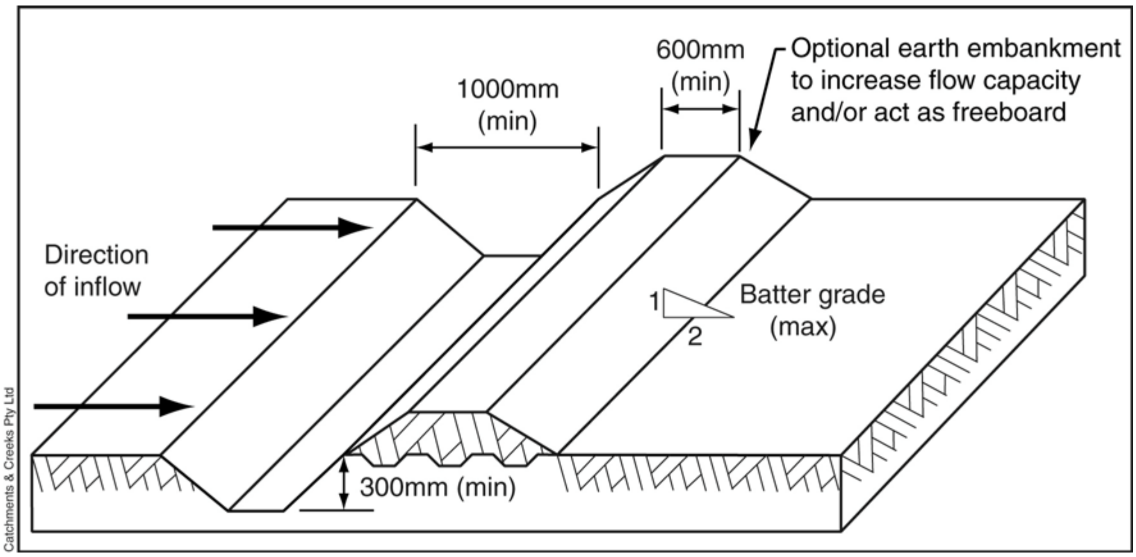

Figure 1 – Typical profile of temporary diversion channels

Hydraulic design of diversion channels:

Step 1 Determine the required design discharge (Q).

If the channel gradient varies significantly along its length, then it may be desirable to split the channel into individual sections and determine an appropriate design discharge at the downstream end of each of these sections.

Step 2 Nominate the channel profile: parabolic or triangular (V-drain). Parabolic channel are generally less susceptible to invert erosion.

Step 3 Choose the preferred surface condition of the channel (e.g. earth, grass, rock).

The design information provided in the *Catch Drain* fact sheets can be used as a guide in selecting a surface lining and trial channel size.

Step 4 Select a bank slope (m) using Table 2 as a guide. Do **not** necessarily select the maximum bank slope, but consider such issues as safety and maintenance access.

Step 5 Determine the Manning's roughness (n) and allowable flow velocity (V_{allow}) using the relevant fact sheet (refer to channel linings) or Tables A17 to A20, and Tables A23 to A28 in Appendix A – *Construction site hydrology and hydraulics*.

For grass and rock-lined channels it may be necessary to estimate a channel depth, and hydraulic radius (Steps 6 to 8) before determining Manning's roughness.

Step 6 Determine the minimum required flow area ($A = Q/V_{allow}$).

The design flow area does not have to be equal to this minimum flow area, but of course it must not be less than this area. It depends on how confident the designer is in the determination of the design discharge and the allowable flow velocity.

Step 7 Choose a trial channel size (depth, y; bed width, b; and flow top width, T) and the required freeboard (refer to Table 1).

Ultimately this may require an iterative process where various channel profiles are tested for hydraulic capacity.

Step 8 Determine the hydraulic radius (R) of the channel (based on flow area, **not** the overall channel dimension, which would include freeboard). Refer to Table A30 in Appendix A.

Step 9a **If the channel gradient is <u>not</u> set by site conditions, then:**

Determine the channel gradient (S) using Manning's equation.

$$S = (n\,.V)^{2}/(R)^{4/3} \qquad \text{(S has units of m/m)}$$

Step 9b **If the channel gradient is set by site conditions, then:**

Determine the actual flow velocity (V) and compare this with the allowable flow velocity (V_{allow}).

$$V = (1/n)\, R^{2/3}\, S^{1/2}$$

If $V < V_{allow}$, then accept the design, or repeat Steps 7 & 9 for a smaller channel.

If $V > V_{allow}$, then repeat Steps 7 & 9 selecting a larger channel.

Step 10 Confirm final freeboard requirements given final depth and velocity head (Table 1).

Step 11 Ensure suitable conditions exist (e.g. machinery access) to construct and maintain the channel, otherwise a narrower channel width may be required.

Step 12 Given the final channel depth and velocity, check the required freeboard.

Specify the overall dimensions of the diversion channel, including freeboard.

Step 13 Ensure appropriate, non-erosive, flow conditions exist at the points of flow entry into the channel.

Step 14 Ensure the channel discharges to an appropriate, stable outlet structure.

Step 15 Appropriately consider all likely safety issues, and modify the channel design and/or surrounding environment where required.

Design example:

Design an earth-lined channel of trapezoidal cross-section to carry $0.5m^3/s$ located within a moderately erodible soil.

Step 1 The required design discharge is given as, $Q = 0.5m^3/s$.

Step 2 The question specifies a trapezoidal channel profile.

Step 3 The surface condition has been specified as earth-lined.

Step 4 For a slightly compacted soil (typical for a temporary drain), the maximum bank slope is likely to be around 1.5:1 or 2:1 (from Table 2).

If the drain was going to be deep (say, $y > 0.5m$) a flatter slope of 3:1 would be desirable for reasons of safety; however, this drain is likely to be relatively shallow, so choose a bank slope of 2:1 (i.e. $m = 2$).

Warning: "m" is the term used for both bank slope, and the metric unit of metres!

Step 5 Select a Manning's "n" for an earth lined channel, n = 0.02 from Table A17 of Appendix A – *Construction site hydrology and hydraulics*.

For a moderately erodible soil, choose a maximum allowable velocity, $V_{allow} = 0.6m/s$ from Table A23 of Appendix A.

Step 6 The minimum required flow area, $A_{min} = Q/V_{allow} = 0.5/0.6 = 0.833m^2$.

Step 7 For this example it will be assumed that the designer has confidence in the determination of the design discharge and the selection of an allowable flow velocity for the given soil conditions. Therefore, a design flow area of $0.84m^2$ is chosen (only slightly greater than the minimum value determined in Step 6).

Choose: $A = 0.84m^2$

Trial flow depth and bed width: Given that maximum depth of the excavated channel may be limited by existing site conditions, a first guess of the channel dimensions may be obtained by adopting one of the following options:

(i) try a flow depth, y = maximum allowable channel depth - 150mm; or

(ii) try a bed width, $b = (A/(1 + m))^{1/2}$

If we choose the latter option, then: $b = \sqrt{\frac{A}{(1+m)}} = \sqrt{\frac{0.84}{(1+2)}} = 0.53m$

For small channels it is good practice to select a bed width equal to the width of a typical excavator bucket. The most common bucket widths are 450, 600 and 900mm. So, for this example a bed width, b = 0.6m will be chosen.

If a flow depth (y) is chosen, then $b = \frac{A}{y} - y(m)$

If a bed width (b) is chosen, then: $y = \frac{\sqrt{(b^2 + 4(m)A)} - b}{2m}$

Thus for this example: $y = \frac{\sqrt{(0.6^2 + 4(2)0.84)} - 0.6}{2(2)} = 0.515m$

Step 8 From Table A30 of Appendix A, the hydraulic radius (R) is given by:

$$R = \frac{y(b + my)}{b + 2y\sqrt{(1+m^2)}} = \frac{0.515(0.6 + (2)0.515)}{0.6 + 2(0.515)\sqrt{(1+2^2)}} = 0.289m$$

Step 9a If its assumed that the channel slope is not governed by existing site conditions (i.e. the designer is free to determine a preferred channel slope), then the desired channel slope can be determined from Manning's equation:

Desired channel slope: $$S = \frac{n^2.V^2}{R^{4/3}} = \frac{(0.02)^2.(0.6)^2}{(0.289)^{4/3}} = 0.00075$$

The above equation provides slope in units or [m/m], thus the channel slope is equivalent to, S = 0.075%.

Step 10 Freeboard requirements will be defined by the greater of:

(i) 150mm

(ii) 10% of channel depth, = 0.1(0.515 + 0.15) = 0.067m, or

(iii) the velocity head ($V^2/2g$) = $(0.6)^2/19.6$ = 0.018m

Therefore, choose a freeboard of 150mm.

Final channel dimension:

Discharge, Q = 0.5m^3/s

Channel slope, S = 0.075%

Bank slope, m = 2 or (2:1) (H:V)

Maximum design flow depth, y = 0.515m

Freeboard = 0.15m

Excavated channel depth = 0.515 + 0.15 = 0.665m

Bed width, b = 0.6m

Top width of excavated channel = 0.6 + 2(2)(0.515 + 0.15) = 3.26m

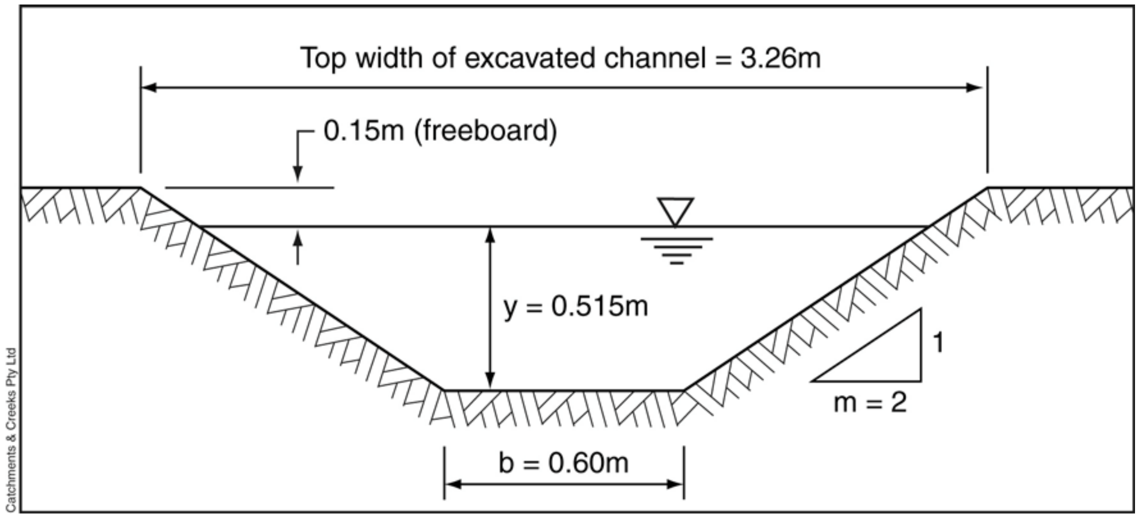

Figure 2 – Final channel dimensions

Description

Diversion channels are formally designed temporary or permanent excavated drainage channels usually with well-defined bed and banks.

Diversion channels are normally stabilised with a healthy and complete coverage of vegetation, primarily consisting of grasses. However, this should not prevent the use of alternative channel lining as appropriate for the site conditions.

Diversion channels can be formed with or without an associated down-slope flow diversion bank. The inclusion of a down-slope bank can significantly increase the hydraulic capacity of the channel.

Purpose

Diversion channels are used to:

- collect and transport stormwater runoff around or through a work site;
- collect sediment laden runoff down-slope of a disturbance and direct it to a sediment trap;
- temporarily divert a existing drainage channel while construction activities are occurring.

Limitations

Channel size and gradient are governed by the allowable flow velocity of the surface material.

Advantages

Low maintenance requirements.

On larger catchments, the cost savings resulting from the diversion of uncontaminated "clean" flow around a soil disturbance and/or sediment trap can be significant.

Disadvantages

May restrict vehicular movements around the site, possibly requiring the construction of *Temporary Watercourse Crossings* over the channel.

Can cause significant erosion problems and flow concentration if overtopped during heavy storms.

Common Problems

The low channel gradient can cause long-term ponding and mosquito breeding.

Soil erosion at points of water inflow and at the channel outlet.

Special Requirements

The erosion-resistance of the local subsoils should be investigated before planning or designing any drainage channels.

Diversion channels should be vegetated if the expected working life exceeds 30 days. Exception may apply in arid and semi-arid regions.

If the channel is to be vegetated using grass seeding, then the channel should be established well before high flows are expected within the channel.

All diversion channels **must** have a stable outlet.

The channel must have positive gradient along its full length to allow free drainage.

Sufficient space must be provided to allow construction and maintenance access.

Site Inspection

Check that the drain has a stable, positive grade along its length.

Check for a stable drain outlet.

Check if the associated embankment is free of damage (e.g, damage caused by construction traffic).

Check that the drain has adequate hydraulic capacity given the catchment area (general observations based on past experience).

Check for sediment accumulation within the channel.

Check for excessive settlement of any associated fill embankments.

Check the channel lining (if any) for damage or displacement. If *Erosion Control Mats* have been used, check that they are correctly overlapped in direction of flow.

If the channel is lined with rock, check that the rock is not reducing the channel's required hydraulic capacity.

Installation

1. Refer to approved plans for location, extent, and construction details. If there are questions or problems with the location, extent, or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Ensure all necessary soil testing (e.g. soil pH, nutrient levels) and analysis has been completed, and required soil adjustments performed prior to planting.
3. Clear the location for the channel, clearing only what is needed to provide access for personnel and construction equipment.
4. Remove roots, stumps, and other debris and dispose of them properly. Do not use debris to build any associated embankments.
5. Excavate the diversion channel to the specified shape, elevation and gradient. The sides of the channel should be no steeper than a 2:1 (H:V) if constructed in earth, unless specifically directed within the approved plans.
6. Stabilise the channel and banks immediately unless it will operate for less than 30 days. In either case, temporary erosion protection (matting, rock, etc.) will be required as specified within the approved plans or as directed.
7. Ensure the channel discharges to a stable area.

Additional requirements for turf placement:

1. Turf should be used within 12 hours of delivery, otherwise ensure the turf is stored in conditions appropriate for the weather conditions (e.g. a shaded area).
2. Moistening the turf after it is unrolled will help maintain its viability.
3. Turf should be laid on a minimum 75mm bed of adequately fertilised topsoil. Rake the soil surface to break the crust just before laying the turf.
4. During the warmer months, lightly irrigate the soil immediately before laying the turf.
5. Ensure the turf is not laid on gravel, heavily compacted soils, or soils that have been recently treated with herbicides.
6. Ensure the turf extends up the sides of the drain at least 100mm above the elevation of the channel invert, or at least to a sufficient elevation to fully contain expected channel flow.
7. On channel gradients of 3:1(H:V) or steeper, or in situations where high flow velocities (i.e. velocity >1.5m/s) are likely within the first two week following placement, secure the individual turf strips with wooden or plastic pegs.
8. Ensure that intimate contact is achieved and maintained between the turf and the soil such that seepage flow beneath the turf is avoided.
9. Water until the soil is wet 100mm below the turf. Thereafter, watering should be sufficient to maintain and promote healthy growth

Maintenance

1. During the site's construction period, inspect the diversion channel weekly and after any increase in flows within the channel. Repair any slumps, wheel track damage or loss of freeboard.
2. Ensure fill material or sediment is not partially blocking the channel. Where necessary, remove any deposited material to allow free drainage.
3. Dispose of any collected sediment or fill in a manner that will not create an erosion or pollution hazard.

Removal

1. When the construction work above a temporary diversion channel is finished and the area is stabilised, the area should be appropriately rehabilitated.
2. Dispose of any collected sediment or fill in a manner that will not create an erosion or pollution hazard.
3. Grade the area and smooth it out in preparation for stabilisation.
4. Stabilise the area as specified in the approved plan.