SA Water

Engineering

Technical Guideline TG0631

General Technical Information for Geotechnical Design - Earthworks

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Only the current revision of this Guideline should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

This is the first issue of this Technical Guideline under the new numbering format. The original version of the document was last published in 2007 with the name of General Technical Information for Geotechnical Design Part C – Earthworks (TG 10c). A full version history of this document is given in Document Controls. The major changes in this revision include the following items:

- Addition of Section 3, as an overarching section related to the safe works practices in earthworks
- Major revision of Section 4 (formerly Section 2 in TG 10c)
- Minor revision of Section 5 (formerly Section 3 in TG 10c)
- Major revision of Appendix A (formerly Section 4 in TG 10c)

Document Controls

Revision History

Revision	Date	Author	Comments
0	2004	Ed Collingham	First Issue of TG 10c
1	10/1/2007		Nil
2	15/8/2019	Moji Kan	Major Revision, Reformatting to TG 0631

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Contents

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1 Introduction

SA Water is responsible for operation and maintenance of an extensive amount of engineering infrastructure.

This guideline has been developed to assist in the design, maintenance, construction, and management of this infrastructure.

1.1 Purpose

The purpose of this guideline is to detail minimum requirements to ensure that assets covered by the scope of this guideline are constructed and maintained to consistent standards and attain the required asset life.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
PCBU	Person Conducting a Business or Undertaking
SA Water	South Australian Water Corporation
SWMS	Safe Work Method Statement
TG	SA Water Technical Guideline
TS	SA Water Technical Guideline

1.3 References

1.3.1 Australian and International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
NA	

1.3.2 SA Water Documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Number	Title
NA	

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g. AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Responsible Discipline Lead	The engineering discipline expert responsible for TG 0631 defined on page 3 (via SA Water's Representative)

2 Scope

The scope of this document is to provide guidelines for the geotechnical design of earthworks for SA Water infrastructure.

3 Excavation Work

Excavation work refers to any work involving the removal of soil or rock from a site to form an open face, hole or cavity using tools, machinery or explosives. Any excavation work designed or constructed for SA Water infrastructures shall be undertaken in accordance with the Work Health and Safety Act 2012 and also comply with local and national legislations, including, but not limited to:

- South Australian Development Act and Regulation
- Excavation Work Code of Practice - Safe Work Australia.

The earthworks shall be performed according to the specified technical specifications. A typical Technical Specification of the past SA Water projects is given in Appendix A. The appointed Consultants or the Designer of the project is responsible to prepare the technical specifications of the earthworks.

A person conducting a business or undertaking (PCBU) must manage risks associated with all kinds of excavations (no matter how deep) at the workplace.

3.1 Risk management

A PCBU must manage risks to health and safety associated with a person:

- falling into an excavation
- being trapped by the collapse of an excavation
- being struck by a falling thing while working in an excavation
- being exposed to an airborne contaminant while working in an excavation.

A PCBU must also have regard to all relevant matters, including the following:

- the nature of the excavation
- the nature of the excavation work, including the range of possible methods of carrying out the work
- the means of entry into and exit from the excavation, if applicable.

Any construction work, including any work connected with an excavation, that is carried out in or near a shaft or trench with an excavated depth of greater than 1.5 metres, or a tunnel, is considered to be 'high risk construction work' for which a Safe Work Method Statement (SWMS) must be prepared.

3.2 Safe Work Method Statements

A high-risk construction work SWMS is a document that is prepared in consultation with relevant persons that accounts for the workplace-specific circumstances that may affect the way in which the high-risk construction work is done. A SWMS must:

- identify the high-risk construction work,
- specify hazards relating to the work and risks to health and safety associated with those hazards,
- describe how the control measures are to be implemented, monitored and reviewed,

- consider all relevant matters, including circumstances at the workplace that may affect the way in which the work is carried out,
- consider the Work Health and Safety Management Plan that has been prepared for the workplace.

3.3 Additional controls with excavations

A PCBU who proposes to excavate a trench at least 1.5 metres deep must ensure, so far as is reasonably practicable, that the work area is secured from unauthorised access, including inadvertent entry, having regard to risks to health and safety arising from unauthorised access and the likelihood of unauthorised access occurring to the work area.

The PCBU must also minimise the risk to any person arising from the collapse of the trench by ensuring that all sides of the trench are adequately supported, by doing one or more of the following:

- shoring by shielding or other comparable means
- benching
- battering
- receiving written advice from an authorized geotechnical engineer that all sides of the trench are safe from collapse. The advice may be subject to a condition that specified natural occurrences may create a risk of collapse and must state the period of time to which the advice applies.

3.4 Underground essential services

A PCBU who has management or control of a workplace where excavation work is being carried out must take all reasonable steps to obtain current underground essential services information relating to the part of the workplace where the excavation work is being carried out, and areas adjacent to it, before directing or allowing the excavation to commence. This information must be provided to any person engaged to carry out excavation work.

'Underground essential services information' means the following information about underground essential services that may be affected by the excavation:

- the essential services that may be affected
- the location, including the depth, of any pipes, cables or other plant associated with the affected essential services
- any conditions on the proposed excavation work.

3.5 Dial Before You Dig

Dial Before You Dig is the national referral service for information on underground infrastructure. It puts those who intend to excavate in touch with underground asset owners who are members of the Dial Before You Dig service.

The asset owners respond by providing information (generally plans) on the location of any underground pipes and cables, along with information on how to work safely and carefully while excavating in the vicinity of underground plant (online at www.1100.com.au or by telephone through the national call centre on 1100).

4 Cuts and Fills at Boundaries

4.1 Regulation and inferences regarding the design

The South Australian Development Regulations (2008) in Section 75(2), requires a professional engineer who has "appropriate experience and competence in the field of civil and geotechnical engineering" to specify appropriate requirements "to shore up any excavation … that affects the stability of other land ..." in following cases:

a. an excavation which intersects a notional plane extending downwards at a slope of 1V:2H (vertical to horizontal) from a point 600 millimetres below natural ground level at a boundary with an adjoining site (as depicted by an example shown in Figure 1);

b. an excavation which intersects any notional plane extending downwards at a slope of 1V:2H (vertical to horizontal) from a point at natural ground level at any boundary between 2 sites (not being a boundary with the site of the excavation), where the boundary is within a distance equal to twice the depth of the excavation (as depicted by an example shown in Figure 2);

c. any fill which is within 600 millimetres of an adjoining site, other than where the fill is not greater than 200 millimetres in depth (or height) and is for landscaping, gardening or other similar purposes.

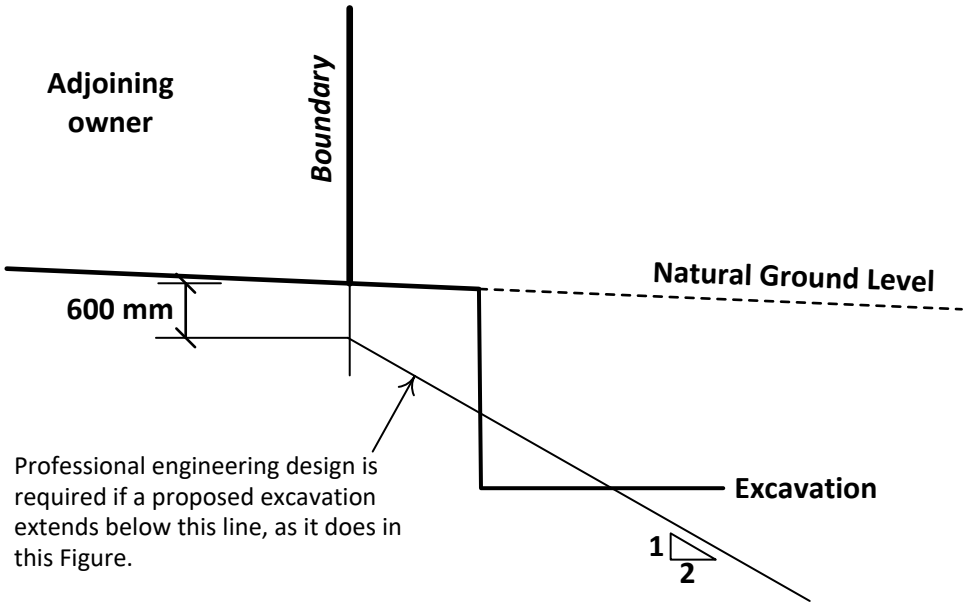

Figure 1: Geometry of the excavation adjacent to other land in case (a) above (extracted from Figure 1 of Schedule 15 in South Australian Development Regulations, 2008)

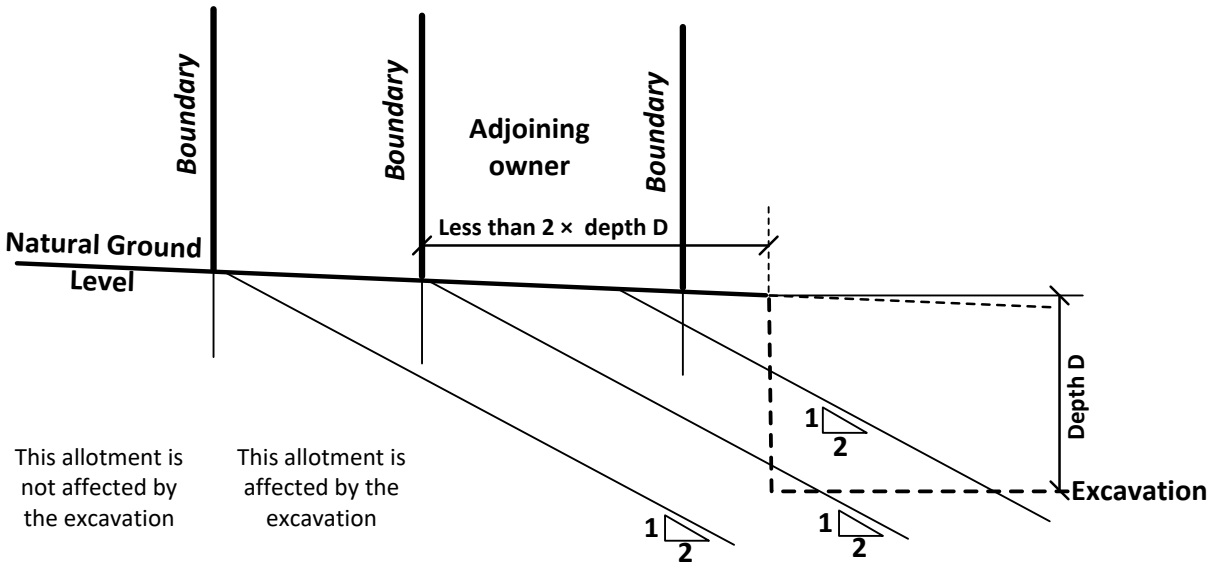

Figure 2: Geometry of the excavation adjacent to other land in case (b) above (extracted from Figure 2 of Schedule 15 in South Australian Development Regulations, 2008)

5 Erosion Control for Earthfills

The top of embankments shall be finished with a definite crown (or at the very least a one-way crossfall) so that runoff makes its way off the top by the shortest possible route. This will prevent rainwater ponding and seeping into the embankment (risking tunnelling erosion) or running off in concentrated rivulets (causing rill erosion).

To be effective, the crossfall on the top of the embankment must be significantly steeper than the longitudinal gradient - this usually means at least 1V:20H crossfall even for a "horizontal" length of embankment. Embankments with a longitudinal slope need special consideration.

If a one-way crossfall is used it is better to direct it to the (usually) well grassed and/or flatter outer slope of the embankment.

Very wide embankments or elevated plant areas would probably benefit from having "internal" drainage to sumps or paved spoon drains.

Tops of embankments should be topsoiled and grassed as a minimum, or "sealed" with a quarry rubble topping.

Ensure that no "windrows" of topping material are left along the edges of the crest - a definite "chamfer" is preferable.

Using open graded toppings such as screenings shall be avoided. These materials will not seal the top of the embankment but will simply disguise any poor shaping in the embankment beneath and make it difficult to see whether tunnelling erosion is occurring (crabholes).

Specify low angle side slopes where possible to ease maintenance and minimise risk of erosion. 1V:2H slope can barely be stood on. 1V:3H slope can just be walked up. 1V:5H slope can be topsoiled, grassed and mown with ease and is visually pleasing.

Compact the whole embankment well in order to:

a. Ensure that the design shape of the top is not lost by differential settlement or rutting,

b. Ensure that the design elevation of the top is not lost by settlement

c. Reduce permeability and therefore the risk of tunnelling erosion.

Appendix A – Example of Earthworks Technical Specifications

This sample Technical Specifications was prepared by Ed Collingham on 07/11/1997 for Earthworks of EL 423 – 2.4 ML Tank. This example is provided here only for illustrative purposes and the appointed Consultants or the Designer of the project is responsible to prepare the required technical specifications for the earthworks.

A1 Stripping and storage of topsoil

The topsoil shall be stripped from all areas to be excavated (including tracks and pipe trenches) and stockpiled for use in the reinstatement of areas which have been filled or disturbed.

For the purposes of this contract, topsoil is defined as all friable organic soil (i.e. soil rich in humus and usually dark in colour), including the surface vegetation (grass etc), but excluding noxious weeds (blackberries etc).

The topsoil shall be stockpiled in a manner which prevents contamination by any other excavated material.

A2 Excavation for the tank foundation

The excavation for the tank foundation shall be taken down to a minimum level of 150 mm below the underside of the floor/footing as shown on the drawing, and additionally until "rock" is encountered.

"Rock" will be defined as well-interlocked jointed weathered rock or better.

Rock of appropriate quality will be indicated on site by the Superintendent's Representative in trial pits dug at the commencement of excavation work.

The Contractor shall allow for the excavation to be inspected and approved by the Superintendent's Representative before compacting the surface as detailed in Section 4 below.

A3 Excavation for the access road

The access road alignment shown on the drawing shall be boxed-out to a nominal minimum depth of 150 mm below the natural surface to give a smooth grade to the formation.

Any pockets or zones of soft clay, silt or other unsuitable soils exposed at formation level shall be removed until suitable soils are encountered or for a nominal maximum depth of 300 mm below formation level as approved by the Superintendent's Representative.

All excavation below road formation level shall be backfilled with readily compacted, low-reactivity fill material, won from the site or imported, and approved by the Superintendent's Representative.

The backfill material shall be placed in layers not exceeding 150 mm compacted thickness, and each layer shall be compacted to not less than 98% of the standard maximum dry density of the material (AS 1289.5.1.1).

A4 Compaction for tank excavation and road formation

The surface of both the tank excavation and the access road formation shall be compacted by not less than six passes of a 10-tonne vibrating smooth drum roller, and additional passes as required until (i) no observable settlement occurs on additional passes, (ii) the onset of "bouncing" occurs, and (iii) the rolled surface achieves a relatively smooth finish.

Any areas on which any of these criteria cannot be met shall be referred to the Superintendent's Representative for evaluation.

A5 Tank excavation backfill

The tank excavation shall be backfilled with 3% cement treated 20 mm quarry rubble (CTQR) in accordance with Department of Transport Standard Specification PM 21, C3.

The quarry rubble shall be compacted to not less than 98% of its modified maximum dry density (AS 1289.5.2.1).

The finished level of the top of the CTQR shall be the proposed underside of tank floor level to within a tolerance of + 0 mm and - 20 mm.

The Contractor shall be responsible for arranging for in-situ density testing to be carried out to demonstrate that CTQR backfill has been compacted to the required minimum density, and for presenting the results to the Superintendent's Representative.

The in-situ density testing of the CTQR backfill shall consist of not less than five sand replacement or nuclear densometer tests per 300 mm thickness.

A6 Access road pavement construction

The access road pavement shall consist of a 150 mm compacted thickness of 3% cement treated 20 mm quarry rubble in accordance with Department of Transport Standard Specification PM 21, C3.

The quarry rubble shall be compacted to not less than 98% of its modified maximum dry density (AS 1289.5.2.1).

A7 Testing of the CTQR access road pavement

The Contractor shall be responsible for arranging for in-situ density testing to be carried out to demonstrate that CTQR access road pavement has been compacted to the required minimum density, and for presenting the results to the Superintendent's Representative.

The in-situ density testing of the access road pavement shall consist of sand replacement or nuclear densometer tests, extending from the finished surface to a depth of 150 mm, at not less than five randomly selected locations evenly spaced over the area of the access road pavement.

A8 General fill

Any general fill or landscape fill required on the site shall consist of readily compacted, low-reactivity fill material, won from the site or imported, and approved by the Superintendent's Representative.

The general fill material shall be placed in layers not exceeding 150 mm compacted thickness, and each layer shall be compacted to not less than 95% of the standard maximum dry density of the material (AS 1289.5.1.1).

A9 Topsoiling

All cut faces and disturbed areas shall be reinstated with a layer of topsoil not less than 150 mm thick to the satisfaction of the Superintendent's Representative.

All topsoiled areas shall be revegetated by applying, in accordance with the supplier's recommendations, a balanced trace-element fertiliser and a "hills pasture seed" mix.

A10 Disposal of surplus material

Surplus excavated material shall be removed and disposed of off-site. It shall be the Contractor's responsibility to arrange for disposal and pay all associated fees.

A11 Excavation of pipe trenches

The Contractor shall inform all relevant authorities and install signs in accordance with AS 1742 prior to commencing excavation.

The Contractor shall excavate the trench evenly to achieve the required grading.

The trench width shall be as narrow as practicable, consistent with the need to ensure proper laying of pipe and the proper placement and compaction of the pipe embedment and trench fill materials in accordance with this specification.

There will be no payment for any over excavation. If the trench floor is over excavated it shall be backfilled in accordance with this specification.

The Contractor shall be responsible for ensuring all the excavation work is carried out in accordance with the specified safety requirements.

It shall be the Contractor's responsibility to determine whether shoring or battering of the pipe trench is required.

Surplus excavated material shall be removed and disposed of off-site. The Contractor shall submit details of the proposed disposal of surplus excavated material as it shall be the Contractor's responsibility to locate a suitable dump and arrange the payment of all associated fees.

No claims for extensions of time or cost will be considered by the Principal for the disposal of surplus excavated material as the tendered rates for the laying of the pipeline will be deemed to allow for the disposal of all surplus material from the excavation site.

A12 Rock excavation

Whenever the Contractor consider that the material to be excavated is rock, they shall immediately notify the Superintendent's Representative for approval of the rock classification.

Rock shall be defined as material which cannot be effectively excavated with a 20-tonne hydraulic excavator in first class operating order equipped with the appropriate rock teeth, and hence requires the use of a single ripper or a hydraulic rock breaker.

All quantities of excavated rock material shall be measured and recorded by the Contractor. The quantities recorded, in a format as approved by the Superintendent's Representative, shall be submitted (at the completion of that section of rock excavation) to the Superintendent's Representative for verification and approval.

Measurement for payment of rock excavation shall be on the thickness of the layer of rock encountered in the trench and the minimum width and depth of trench required for efficient laying of the pipe.

Where sheet rock is encountered in the trench excavation, materials above and below the sheet rock shall be excluded from the measurement for payment of rock excavation.

No claims for extension of time for rock excavation will be considered by the Superintendent's Representative unless the volume allowed for in the Schedule of Rates is exceeded.

A13 Groundwater control and dewatering of excavation

The Contractor shall be responsible for obtaining, prior to commencing construction, geotechnical or groundwater information necessary for the design of any groundwater control or dewatering systems.

The water table shall be lowered to below the level of the floor of the excavation or trench (e.g. by well pointing) BEFORE beginning to excavate:

a. Where there is a possibility that there may be heave of, or loss of density in, the material comprising the floor of the excavation or trench

b. Where there may be a threat to the stability of the walls of the excavation or trench

c. Where it may otherwise not be possible to maintain "dry" working conditions in the excavation or trench.

Observation wells shall be installed to verify and monitor the lowering of the water table.

The water table shall be maintained below the level of the floor of the excavation or trench until the excavation or trench has been backfilled, or until such time as there is no danger of flotation of the newly installed structure or pipes.

The Contractor shall remove any water which may enter or be found in excavations or trenches while the pipes are being laid and while any other works under the Contract are being constructed. The Contractor shall have available at all times sufficient pumping units for this purpose, ready for immediate use.

Provided that there is no possibility that there may be heave of, or loss of density in, the material comprising the floor of the excavation or trench, or a threat to the stability of the walls of the excavation or trench, the Contractor may use permeable screenings laid on the floor of the trench to convey water away from the immediate workplace to temporary pump sumps. Where permeable screenings are used, they shall be covered by an approved geotextile prior to placing the pipe bedding.

Water from groundwater control systems, excavations or trenches shall be disposed of in such a manner that it shall not cause injury to persons or property, to the work completed or in progress, to the surface of the streets, or cause any interference with the use of the streets by the public or be a public nuisance.

The Contractor shall be responsible for and bear the costs and consequences of any damage to property or personal injury or death of any person, caused by the dewatering operations and/or water disposal, and also for dealing with and settling any claims arising there from.