

northern expressway

environmental report

geology, soils and site contamination

technical paper



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Energy and Infrastructure



Northern Expressway

Geology, Soils and Site Contamination Technical Paper

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Prepared by:

**Sinclair Knight Merz Pty Ltd, Department for Transport, Energy
and Infrastructure**

Level 5
33 King William Street
Adelaide SA 5000

Telephone: + 61 8 8424 3800
Facsimile: + 61 8 8424 3810

Prepared for:

Department for Transport, Energy and Infrastructure

33-37 Warwick Street
Walkerville SA 5081

PO Box 1
Walkerville SA 5081

Telephone: 1300 658 621
Facsimile: + 61 8 8343 2005
Email: northernexpressway@saugov.sa.gov.au

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List of abbreviations

AHD	Australian Height Datum
CEMP	construction environmental management plan
DTEI	Department for Transport, Energy and Infrastructure
EPA	Environment Protection Authority
FeS ₂	iron sulphide
ha	hectare
MSDS	material safety data sheet
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
SEDMP	soil erosion and drainage management plan

Glossary

Word	Definition
Acid sulphate soil	soils containing chemicals (generally sulphates) which have the potential to generate acid on oxidation
Alluvial fan	a fan-shaped accumulation of alluvium deposited at the mouth of a river or at the junction of a tributary stream with the main stream
Alluvium	any stream-laid sediment deposit found in a stream channel and in low parts of a stream valley subject to flooding
Anthropogenic	related to human activity
Aquifer	an underground bed or layer of earth, gravel, or porous rock that yields groundwater
Batter	the uniform side slopes of walls, banks, cuttings etc.
Bearing capacity	the load per unit area that a supporting medium can carry without failure or unacceptably large settlement
Borehole	the hole produced in the ground by drilling or driving
Clay	a natural earthy material possessing plastic properties and consisting of fine particles of complex hydrous silicate matter of less than 2 μm
Compaction	reduction in volume of a material by inducing closer packing of its particles by rolling, tamping, vibrating or other processes to reduce the air voids content
Consolidation	the process by which soil reduces in volume under load over a period of time due to drainage of water from the voids
Confined aquifers	porous layers of earth, gravel or rock in which water is stored under pressure
Gravel	a mixture of mineral particles in natural deposits, usually passing a 75 mm sieve and with substantial portion retained on a 4.75 mm sieve
Groundwater	water below the surface held in spaces between soil sediment or rock particles
Interfluvium	the region of higher land between two rivers that are in the same drainage system
Oxidise	combining of an element with oxygen
Permeability	the capacity of a porous rock, sediment or soil to transmit fluid; a measure of the relative ease of fluid flow under unequal pressure
Plasticity	a condition of a material when it can be easily remoulded e.g. moist to

	wet clay soils
Qra	Gawler River alluvium: grey fluviatile silts, sands and gravels of the modern drainage channels
Qrk	St Kilda Formation: light grey Shelley stranded beach ridge deposits and Shelley silts and sands overlain in places by modern intertidal and swamp deposits
Qpp	Pooraka Formation: pale red-brown sandy clay containing carbonate of the Loveday soil; gravel lenses near ranges (small outcrops of older calcrete and veneers of younger soils are not differentiated)
Quaternary sediments	sediments deposited during the geological period of time from the present to two million years ago.
Sand	natural mineral particles that pass through a defined sieve (normally 4.75 mm or 2.36 mm) and are free of appreciable quantities of clay and silt
Scour	the erosion of material by the action of flowing water
Settlement	a downward movement of the soil or of the structure it supports
Silt	all alluvial material intermediate in particle size between sand and clay; usually non-plastic
Slaking	the breaking down of soil aggregates when immersed in water into smaller sized micro-aggregates which may subsequently disperse
Soil profile	the profile of soil encountered below the natural ground surface
Subgrade	the trimmed or prepared portion of the formation on which the pavement is constructed
Tertiary sediments	sediments deposited during the geological period of time between 2 million and 65 million years ago (prior to the Quaternary sediments)
Topsoil	the top layer of soil that supports vegetation
T1 aquifer	on the Northern Adelaide Plains, a deep aquifer (below the Quaternary aquifers) consisting of sandstone and limestone averaging 100 m in thickness
T2 aquifer	on the Northern Adelaide Plains, the limestone and sand aquifer below the T1 aquifer, and separated by a layer of clay; the depth is approximately 100 m
Watertable	the natural level at which water stands in a borehole, well or other depression, under conditions of equilibrium

1 Introduction

1.1 Introduction

The Northern Expressway and Port Wakefield Road Upgrade Project was developed from a planning and concept design process that considered a number of options. The final configuration of the Northern Expressway, its construction method, and its environmental management during construction and operation may vary from the project described, but the project constraints, design principles and standards described in the Environmental Report would remain largely the same.

1.2 Project description

The Northern Expressway and Port Wakefield Road Upgrade will form part of the AusLink National Network, replacing the increasingly congested Main North Road thereby providing road safety and amenity benefits. In the Port Wakefield Road component the existing National Network road link, which connects the Northern Expressway and the Port River Expressway, will be upgraded.

The Northern Expressway will provide significant State and regional benefits. It is primarily aimed at improving access to Adelaide for freight transport via the Sturt Highway, including freight for export from key areas such as the Barossa Valley wine producing area and the Riverland wine and citrus producing area. Together with the Port River Expressway, it will provide a high standard link between the Sturt Highway at Gawler and the Port of Adelaide, South Australia's main shipping port.

It will maximise the opportunity for freight transport to gain access to producers, transport hubs, freight gateways and markets, achieve better delivery times and increase cost efficiency to gain a competitive edge, while improving safety significantly. It will also improve the transport link to the regions north of Adelaide, such as Gawler and the Barossa, and fringe rural communities will be more accessible to business, industry, tourists and commuters.

The Northern Expressway corridor crosses the northern Adelaide plains on the north-west edge of the Adelaide metropolitan area. The expressway links with the Gawler Bypass, south of Redbanks Road in the north, to Port Wakefield Road, approximately 500 m north of Taylor Road in the south. Port Wakefield Road would be upgraded between this southern terminal junction with the expressway and the Salisbury Highway–Port River Expressway intersection.

The route passes through mainly rural and horticultural land, bypassing the township of Angle Vale on its eastern side and passing north of the RAAF Base Edinburgh and the land with potential for an intermodal facility at Waterloo Corner.

The Northern Expressway is 23 km long and upgrades to Port Wakefield Road extend over 12 km.

The Expressway will be constructed to rural freeway standard in a new road corridor, providing dual carriageways, grade separation of access/connecting roads and restricted road access. The horizontal alignment of the new road has been designed for a posted speed limit of 110 km/h. The road would have a wide corridor, typically about 70 m, but may vary at some locations.

Interchanges are proposed at the Gawler Bypass (partial), Curtis Road (partial), Heaslip–Womma roads and at Port Wakefield Road (signalised junction).

The Northern Expressway will have hard shoulders along both sides for emergency vehicles and breakdowns, space for services and drainage, and a 15 m wide median.

The Port Wakefield Road works will upgrade the existing divided road at a number of intersections along the project length – at Waterloo Corner Road, Bolivar Road, Ryans Road, Martins Road and the Salisbury Highway – as well as changes to service roads, traffic controls and access to properties at other locations. In most locations, Port Wakefield Road will be widened along the outside edge of the road. The proposed posted speed limit on Port Wakefield Road typically of 90 km/h may vary at certain times to better manage safe traffic operations.

Landscaping treatment and potential noise management measures will be developed where required following detailed design development.

The proposed route of the Northern Expressway and Port Wakefield Road Upgrade is shown on Figure 1.1.

1.3 Topic explanation

This technical paper describes the physical ground conditions of the study area and details contaminated land, potential for acid sulphate soils and impacts associated with local soils. Existing conditions were established through a combination of desktop analyses, preliminary assessments and limited subsurface exploration. Further detailed investigations will be part of the planning and design process of the Northern Expressway and Port Wakefield Road Upgrade

1.4 Legislative requirements, policies and definitions

The South Australian *Environment Protection Act 1993* is the primary pollution control legislation in South Australia. In general terms, the Act seeks to ensure that appropriate measures are taken to protect, restore and enhance the quality of the environment. Potential breaches of the Act include:

- non-compliance with the general environmental duty
- non-compliance with an environmental protection order or clean-up order
- causing serious or material environmental harm or an environmental nuisance by polluting the environment
- failing to inform the Environment Protection Authority (EPA) of an incident that has caused, or threatens to cause, serious or material environmental harm as soon as reasonably practicable.



500m investigation corridor Study area

Figure 1.1 Study Area

1.4.1 Site contamination

The Environment Protection Act does not include specific provisions on site contamination. The *National Environment Protection (Assessment of Site Contamination) Measure* (NEPM) was subsequently developed by the National Environment Protection Council in 1999 to establish a nationally consistent approach to the assessment of site contamination.

The NEPM contains two schedules:

- Schedule A: identifies the recommended process for the assessment of site contamination
- Schedule B: identifies 10 general guidelines for the assessment of site contamination.

The NEPM does not address management of site contamination (except for a preferred hierarchy for remediation), which remains the responsibility of each jurisdiction. It does, however, recommend a process for the assessment of site contamination.

The *Environment Protection (Site Contamination) Amendment Bill 2005* (SA) has been proposed as an amendment to the Environment Protection Act to provide a statutory framework for the effective assessment and management of contaminated sites in South Australia. The Bill uses as a basis, and builds upon, the Assessment of Site Contamination NEPM.

The Bill is intended to form part of a site contamination package, a holistic framework for managing site contamination, and also regulate appropriate amendments to planning processes under the *Development Act 1993*, amendments to other South Australian legislation (particularly the Regulations under the *Land and Business (Sale and Conveyancing) Act 1994*), and a series of EPA guidelines and/or codes of practice.

The aim of the package is to provide the legislative framework to protect human health and the environment, whether the site was contaminated before or after the commencement of the Environment Protection Act on 1 May 1995

1.4.2 Acid sulphate soils

A strategy developed by the National Working Party on Acid Sulphate Soils in 1998 was the first step in the national recognition, coordination and management of resources to ensure that coastal acid sulphate soils are assessed and managed in a responsible manner. Inland acid sulphate soils conditions have not been adequately assessed nationally because of the poor state of knowledge of potential areas and their relation to rising watertables and salinity.

In recognition of the disturbance caused by coastal acid sulphate soils, the South Australian Coast Protection Board has developed policies, an implementation strategy and development guidelines on coastal acid sulphate soils.

1.4.3 Soil and erosion management

The *Stormwater Pollution Prevention Code of Practice for local, state and federal government* (EPA 1997) is intended to inform government agencies and their contractors of their 'general environmental duty' with respect to stormwater under the Environment Protection Act. The code provides for the preparation of a soil erosion and drainage management plan (SEDMP) where there is a risk of significant sediment pollution to adjoining lands or receiving waters.

2 Existing/current conditions

2.1 Description of existing conditions within corridor

This may occur across the entire corridor or may be broken down into segments or precincts. Use of maps and graphics and annotations on maps is appropriate. Base plans will be supplied at different scales for regionally related issues, and for specific aspects within the corridor.

2.1.1 Physical environment

The Northern Expressway and Port Wakefield Road Upgrade are located north of the city on the Northern Adelaide Plains between Gulf St Vincent and the Mount Lofty Ranges. The land rises gently from the gulf with slopes varying from less than 0.2% close to the coast to about 2% below the footslopes of the ranges. Originally almost featureless, the plain today exhibits a wide variety of land use with extensive urban development in the south and close to the ranges, and an intensive horticultural industry mainly in the north and west.

The area is most easily described in terms of its physiography. The four main land units are, eastwards from the coast: the estuarine plain adjacent to Gulf St. Vincent, the lower outwash plain, the foothills outwash apron or upper outwash plain, and the Para Fault Block. Each unit has characteristic surface slope range, soil types, and internal and external drainage features. Superimposed on these units is the drainage system from the ranges and, in the north, the remnants of a series of north-westerly trending dunes.

The Northern Expressway and Port Wakefield Road Upgrade extend from about 13 km to 40 km north of Adelaide and are confined to the two western units of the plain. At the southern end of the Port Wakefield Road Upgrade, a small section is located on land reclaimed and filled from the original swamps that used to fringe the gulf. Some remnants of these swamps remain and recent works have extended and reinstated some of the wetlands in this area.

Further to the north, around Taylor Road, the corridor strikes to the north-east across the lower outwash plain towards the town of Gawler which is located on the fault scarp of the ranges at an elevation of about 60 m. The corridor remains on the plain, crossing the Gawler River about 5 km west of the town and joining the existing Gawler Bypass towards its northern end, close to the western boundary of the upper outwash plain.

The surface sediments of the plain consist of outwash deposits from the ranges laid down during erosion of the softer Tertiary materials on the Para Fault Block into the St Vincent Basin during Quaternary times. Subsequent sea level changes and minor isostatic uplift have left the upper eastern margin of the plain at about 60 m above sea level. Sediment is still moving in the major drainage lines from the ranges to the gulf which are still active during the winter with an history of flooding around the Gawler River in the north and the Little Para River and Dry Creek towards the south. In addition, a number of other minor drainage lines have been realigned in many areas into open channels on the flatter parts of the plain. Many major roads in the area, and the Northern Expressway corridor, cut across this drainage; thus surface water movements can be retarded due to the low ground slopes and may take place only slowly along the road table drains into the main drainage lines. These issues are discussed in more detail in the Surface Water and Groundwater Technical Paper.

Between the drainage lines close to the ranges on the upper outwash plain, the terrain is characterised by broadly rounded and gently sloping interfluvies. These features become less distinct on the lower outwash plain with the slopes reducing and the land surface becoming almost flat; the only features are the drainage channels and some low, windblown sandy rises. Towards the Gawler River these rises become more pronounced and may be elevated to about 2 m above the plain. The vegetation on them has been mainly removed and the rises appear as loose sandy deposits within the agricultural areas. North of the river, where the rises are more pronounced and up to 5 m high, some vegetation remains and they form a series of linear north-westerly trending dunes.

2.1.2 Regional soils and geology

Along the preferred route for the expressway on the lower outwash plain, Quaternary clays of the Pooraka Formation (Qpp) form the main geological unit (Figure 2.1). The clays are a relatively uniform layer below the surface soil profile and boreholes penetrating below about 2 m reveal them to be brown, silty and sandy, and of low or medium plasticity. Although noted as clays in the geological descriptions, the Quaternary sediments are known to contain significant sand and clayey sand lenses. Close to the surface such coarser grained materials are mainly associated with old drainage lines which may have been infilled during later erosional events. Close to the ranges on the upper outwash plain, older, coarser grained alluvial fan deposits may also occur under more recent depositions of finer grained materials. More uniform sand and gravel deposits within the clays form aquifers which have been a valuable source of irrigation water for the northern plains agricultural industry. Towards the base of the Quaternary clays there is a thick layer of relatively uniform clay of high plasticity known locally as the Hindmarsh clay.

More recent deposits overlying the Quaternary sequence have been mapped in the north and south of the area. In the north, the series of linear north-westerly trending dunes becomes more pronounced north of the Gawler River. These dunes consist of pale red brown fine grained sands with a trace of clay which assists in binding the grains. North of the river the dunes have been mainly retained in the agricultural areas and are generally well vegetated.

In the south adjacent to the coastline, recent marine deposits of the St Kilda Formation (Qrk), overlie the Quaternary clays north of Port Adelaide (Figure 2.1). East of the salt pans these deposits are generally less than about 2 m thick although isolated deposits may be thicker in old drainage channels.

Along the major stream channels of Dry Creek, Little Para River and Gawler River, meander belts have formed due to the low slopes and erodable nature of the soils of the plain. Old, in-filled watercourses can be easily seen on air photos of the area, and these channels and the adjacent terraces are a major source of coarser grained soils (Qra) including the well known Gawler River loam (Figure 2.1).

The Mount Lofty Ranges form the eastern backdrop to northern plains, the boundary between the upper outwash plain and the Para Fault Block being the Para Fault. The bedrock exposed in the uplifted Para Fault Block consists of Precambrian slates and phyllites of the Adelaide System. These rocks also lie to the west of the fault below the Quaternary sediments of the plains but at great depth.

The soil profile which has developed on the Quaternary clays as parent material generally consists of a sandy topsoil horizon overlying brown and red brown silty and sandy clays of medium and high plasticity. With depth, the clays often become calcareous, with silty pockets and fine gravelly bands of calcrete. The plasticity of the clays generally decreases in the calcareous horizons and their texture may be a clayey sand or silt. The parent material is encountered below the calcareous horizon and generally before 2 m. This soil profile is known locally as Loveday soil.

Changes in the soil profile characteristics are more pronounced along an east–west section as they are affected mainly by elevation and drainage. Close to the coast, where more moist conditions prevail for much of the year towards the western margin of the lower outwash plain, the soils have a gradational profile with duller colours; closer to the ranges on the upper outwash plain there is more pronounced profile formation with duplex soils with calcareous horizons. Local variations can be influenced by the topography and drainage or where there are depositional environments with windblown sands or riverine deposits.

The soils of the area can be broadly described in terms of their location in the landscape.

Soils of the estuarine plain

The soils of the estuarine plain are located adjacent to the coast in the area of St Kilda formation (Qrk on Figure 2.1). The soils are mainly reworked sediments from the drainage lines (deltaic deposits) and are a mix of sands, silts and clays with some shell beds. On the more elevated areas near the eastern boundary some weak profile formation may be seen with a thin clayey sand topsoil horizon overlying grey mottled brown sandy clays of high plasticity. Below about 0.5 m, marine/estuarine sediments, often sands with seaweed or shells, are present.

Soils of the lower outwash plain

These soils cover most of the area between the estuarine soils in the west and the 80 m contour close to the lower footslopes of the Mount Lofty Ranges. In the western zone, over which most of the expressway will be built, they are weakly developed red brown earths with varying amounts of calcareous silt and sand (lime) in the profile. A typical profile consists of a silty sand topsoil horizon overlying reddish brown sandy clays of medium plasticity. With depth the sand content increases and lime may be present as silty and/or sandy pockets. At 1–1.5 m from the surface the parent clayey sand/sandy clay is present.

In the eastern part of the plain above about the 40 m contour good drainage has led to the development of stronger duplex soils with pronounced B horizon red brown clays of high plasticity. As for the weaker red brown earths, lime is present in the lower parts of the profile. The parent Quaternary sediments are generally found below about 1.5–2 m. The topsoil horizon in these clays is often deeper, grading from slightly silty sand to more clayey sand above the clays.

Variations to these standard soil types occur where riverine or aeolian materials have been deposited more recently. Close to the Gawler and Little Para rivers there are areas where natural levee banks have formed over older soil profiles. Pedogenic soil formation has led to a two storey profile on the underlying sediments. In other areas where there are low rises, much deeper surface sands may occur. These are remnants of the dune system which once covered this northern plains area and is still present north of the Gawler River.

Soils of the drainage lines

The Gawler River, Little Para River and Dry Creek all have recent alluvial terraces next to their current drainage channels. They are only mapped for the Gawler River (Qra), where they can be over 500 m wide between the old river escarpments. Alluvial terraces in the other drainage lines are not as wide and are not mapped.

The soils in these terraces are generally deposits of sands and silts which can be clayey in parts. As most are of relatively recent origin, soil profile formation is not advanced and the B horizon if present, is only weakly developed. In the Gawler River meander zone the alluvium is over 10 m deep which is about the current depth of the river channel.

As with most river deposits, those in the Gawler River region can be extremely variable. In the quieter sedimentation zones, finer grained silty clays and clayey silts have been found. Below old obvious river channels which are often depressed about 1 m below the surface of the terrace, the soils are coarse-grained with sand and fine gravel. Between these zones the sediments are mainly silty or clayey sands with cleaner sands towards the bed level of the river.

2.1.3 Geotechnical conditions

Within relatively small areas having the same geology, and particularly where the processes of sedimentation and soil formation has been allowed to occur within a relatively stable climatic environment, correlation is often found between the geotechnical properties of the surface soils and the different soil types. This has been confirmed for the Northern Adelaide Plains during the five geotechnical investigations carried out to date and reported by DTEI:

- Sturt Highway Extension, Preliminary Geotechnical Report, (2005)
- Northern Expressway (Northern Section), Geotechnical Report (2006)
- Northern Expressway (Southern Section), Preliminary Geotechnical Investigation (2006)
- Northern Expressway (Northern Section) and Sturt Highway Duplication, Materials Search (2006)
- Northern Expressway (Northern Section), Wingate Road Borrow Area, Materials Evaluation (2006).

These reports contain detailed but mainly preliminary information on the soil types and the geotechnical properties of the soils encountered in the area. At this stage, investigations along the corridor, with the exception of the Wingate Road investigations, have been restricted to existing road reserves. Early in 2007 more detailed, site specific investigations will be carried out for all structures at interchanges and bridges. The pavement subgrade will also be sampled at regular intervals along the route.

The geotechnical properties determined from these preliminary investigations are broadly summarised below for the previously described terrain features.

Soils of the estuarine plain

The surface soils within this region are mainly reworked marine and estuarine fine grained deposits which are still at high moisture content and relatively unconsolidated. Silty and clayey layers within these deposits are soft and of low strength. Although sand and shell beds occur below about 1 m in these deposits, and they can be of medium density, they often contain softer beds of seaweed. Groundwater is often located within 1.5 m of the ground surface.

The high moisture content of the soils means that they consolidate when loaded; embankments and shallow surface footings can undergo appreciable settlement. This can be alleviated by preloading the soils before construction, as for the Port River Expressway. Alternatively footings for structures can be piled to the underlying stronger Hindmarsh clay found at a depth of about 10 m and extending to depths of about 70 m.

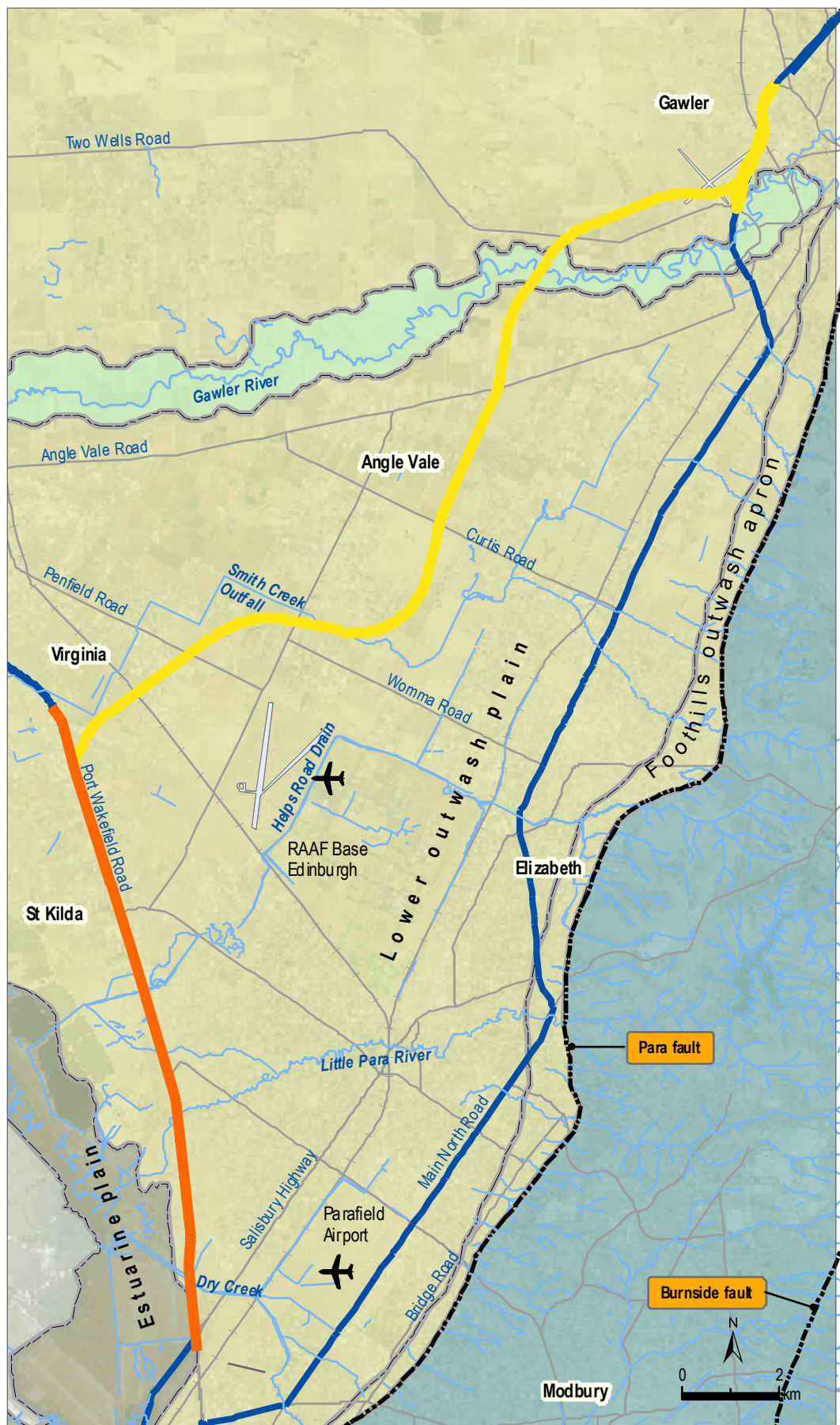


Figure 2.1 **Geology of the Adelaide Plains**

— Watercourse	Para fault block
Gawler River alluvium (Qra)	St Kilda formation (Qrk)
Pooraka formation (Qpp)	

Soils of the lower outwash plain

Within the Pooraka Formation the soils are much stronger although they can show some reduction in strength with wetting. When dry, the surface clay horizons can have very high strength and closer to the ranges, where stronger duplex profiles have formed, shrinkage cracking can be pronounced. The calcareous horizons below the B horizon clays can show appreciable loss of strength on wetting, the amount being dependent on the calcareous content. Collapse of these calcareous soils, a problem sometimes experienced on the Para Fault Block to the south, is unlikely to occur in this area as the lime is generally disseminated within a more clayey matrix.

The Quaternary clays on which the calcareous soil profiles have formed are strong and of high bearing capacity. These clays have undergone cyclic wetting and drying and are now over-consolidated. These clays generally move due to moisture changes rather than by consolidation. Thus vertical movements can take place in either direction, depending on whether they are shrinking or swelling.

The soils over most of this area have been classified as having low to moderate reactivity to moisture content changes. This indicates that between the normal extremes of wetting and drying, surface soil movements are likely to be within the range of 20–40 mm. Closer to the ranges, where the stronger clay profiles are found, movements may reach up to 60 mm. Towards the boundary with the estuarine sediments the soils are less reactive with surface soil movements towards the lower end of the range.

Where moisture reactive clays form the subgrade of road pavements, long term moisture changes can lead to deformations in the road surface. Where clays have only low to moderate reactivity, pavement distortions are not likely providing care is taken with the roadside drainage and landscaping to ensure stable moisture conditions.

Footings for structures on the clays can generally be founded at about 0.5–1.0 m from the ground surface where the soils have high bearing capacity. If horizons are present with a high percentage of calcareous silt or sand then footings can be founded at a greater depth to take advantage of the higher allowable bearing pressures in the underlying clays.

Close to the western boundary with the estuarine soils, where moist and even saturated conditions occur, the near surface clays can be of lower strength. Footings in this region can also be founded in the clays below about 1.5 m in the stronger Quaternary sediments.

River alluvium

The mainly sandy sediments in the Gawler River meander zone have a range of densities and strengths. Generally the cleaner sands and gravels at about current bed level or in old river channels at higher elevations are dense and have high bearing capacity for spread footings. Where the sediments are more clayey and silty they are not as dense and have lower bearing capacity. Extensive investigation of these sediments will be required for the new Gawler River crossing. As the river has its own dynamics, and movements north or south could occur with time, it is most likely that piled footings will be used for the abutments to avoid any problems should the sediments scour.

Sources of filling materials

Sources of filling materials for the pavements and in the embankments have been examined by the Pavements and Structures Section, DTEI. The major sources are:

- quarry overburden from the Angaston marble quarry which contains large boulders that will require crushing

- sandstone and quartzite from quarries in the western Mount Lofty Ranges
- recycled products including by-products from the sulphuric acid plant at Port Adelaide and crushed building products from Wingfield.

Groundwater

Groundwater levels in the estuarine/marine sediments is shallow at about -0.5 m AHD. Flows into shallow pits in this area often come through the sandy and shelly bands which lie below the more clayey surface layers in the upper 0.5–1 m.

On the lower outwash plain the groundwater table is deep, being present in a number of sand and gravel aquifers in the Quaternary clays. This water has been extensively used by the agricultural industry in the area and controls are now in place to ensure that it is not overused. This groundwater was not intercepted during any of the geotechnical investigations.

Shallow groundwater can be expected in the river alluvium of the main drainage channels for some time after flows. The gravel and sand beds in the Gawler River alluvium are known to be linked to the more shallow aquifers in the Quaternary sediments.

2.1.4 Erosion potential

Most local soils of the area are prone to erosion by running water, although existing channels and drains show that erosion processes are slow. Generally the more vertical the face in any cutting the more susceptible it will be to erosion due to the shrinkage cracking and slaking processes in the clay horizons below the topsoil. Battered faces with low slopes are less likely to erode but will still result in a gradual accumulation of mainly clays and silts in the bottom of any drainage features.

The surface sands, which may be the remnants of earlier dune deposits, are loose and prone to wind erosion when bare. Such soils occur mainly north of Womma Road to Gawler River. North of the river the dunes are more pronounced but mainly vegetated. Minor erosion and drifts were noted in road cuttings and in agricultural areas where some ploughing had left bare, disturbed soil.

2.1.5 Site contamination

A preliminary assessment of the broader study area aimed to identify significant contamination issues that might present a risk to the project or pose a liability to DTEI (PB 2005). At the time of the investigation, eight alternative route alignments were proposed in a study area of approximately 13,246 ha. The preliminary investigation was broken down into 11 sub-areas, of which the preferred route traverses 10.

The investigation comprised:

- a review of zoning and permitted land uses from local development plans
- a review of historical aerial photographs
- limited drive-by inspections of the broader study area
- a review of the regional geology and hydrogeology
- review of in-house archives to identify known or suspected sources of contamination in the study area

- identification of historical or current potentially contaminating land uses in the broader study area.

The study identified sites of potential contamination based on their current and past land uses. The potential contaminated sites were divided into two sections: general and specific areas. Those general areas identified as applying to most of the study area included:

- potential storage and use of agricultural chemicals associated with the extensive horticultural activities carried out within the study area
- unknown status of fill material imported in the study area
- use of pesticides beneath former and existing structures
- minor fuel storage on agricultural properties
- stockpiling of wastes on numerous properties throughout the study area.

Specific localised activities that may have caused contamination were also identified in the preliminary investigation. Potential contamination categories include potential fuel leakage at sites with fuel storage, biological issues associated with several cemeteries, use of weedicide along railway lines, landfill operations, and the operations of an explosives magazine, a firing range and wrecking yards and other light industrial premises.

Sites identified as having potentially hosting contaminating activities are shown on Figure 2.2.

2.1.6 Acid sulphate soils

Acid sulphate soils are widespread around low-lying areas of coastal Australia, especially associated with mangrove swamps and where landform elevations are less than 5 m AHD. Acid sulphate soils are naturally occurring soils or sediments that contain iron sulphides, most commonly pyritic (FeS_2) material that is a product of the natural interaction between iron rich sediments, organic matter and sulphate rich seawater present in low energy estuarine environments.

Undisturbed acid sulphate soils within the subsurface profile (called potential acid sulphate soils) are generally present in an anaerobic state and have a pH of neutral or slightly alkaline. Actual acid sulphate soils are the oxidised form, which may result from disturbance such as changes in groundwater levels and/or when potential acid sulphate soils are exposed to air.

Under oxygen-depleted, undisturbed conditions, the iron present within the soils or sediments combines with sulphur from sulphate to form iron sulphides, in particular pyrite. When these sulphides are disturbed and exposed to air, they oxidise and produce sulphuric acid.

Much of the acid produced either drains into waterways or reacts with carbonates and clay minerals in soils or sediments to liberate dissolved aluminium, iron, manganese, heavy metals such as copper and arsenic, and other metal ions. If acid or dissolved ions then build up, they can be extremely toxic to plants and animals. The effect of acid sulphate production and distribution can be the decrease in plant community diversity and plant communities may become dominated by acid-tolerant plants. Harmful algal blooms can also be triggered by acidic water containing dissolved iron and silica. Acid sulphate soils may also be very corrosive to artificial structures such as pipes and concrete.

Acid sulphate soils have been identified in the Port Adelaide–Gillman region of South Australia (approximately 10 km to the west of the western extent of the Northern Expressway Project area). The coastal areas at risk of acid sulphate soils have been mapped and are viewable as intertidal/marine maps of the South Australian Atlas (www.atlas.sa.gov.au). Acid sulphate soils also occur to an



Figure 2.2 Potentially contaminated sites

unknown extent in higher elevation inland areas. The soils within the study corridor are inland and have yet to be classified in relation to risk of acid sulphate soils or potential acid sulphate soils.

2.2 Summary of existing conditions

The land surface along which the expressway will be constructed slopes gradually from about 40 m AHD at the Gawler interchange to about 3 m AHD where it will connect with Port Wakefield Road. The soils along the route vary only slightly with mainly well drained, high strength, reddish brown clays for most of its length. Towards the southern end, adjacent to the coastline and at the lowest elevation, the soils are of marine/estuarine origin. They are poorly drained, often saturated and of lower strength. If acid sulphate soils occur they will be in this low-lying area.

The proposed route crosses a number of drainage channels and rivers which flow from the ranges to the coast. The flows are intermittent and erosion and sedimentation is an ongoing dynamic process. Between the drainage lines the land is almost flat meaning that surface runoff will drain slowly and may have implications for soil behaviour.

3 Effects of project upon existing conditions

3.1 Construction effects

3.1.1 Soils

To assess the effect of any form of development on the existing land surface it is necessary to consider a number of characteristics. For road construction in arid and semi-arid environments it is recognised that loss of vegetation, surface soil disturbance, cutting and filling along the route and alteration to the natural drainage pattern are the most likely effects at the time of construction. The characteristics that determine how the landscape will react to these effects are closely linked to the soil profile characteristics, the surface cover and the internal and external drainage.

The materials covering or forming the upper surface layer of the land are of particular importance when considering the consequences of construction and the long term stability of the area. Along the proposed route these materials are all fine grained sands, silts and clays. Table 3.1 broadly describes the effects of construction.

Table 3.1 Construction considerations

Surface cover	Construction considerations
Sand	<p>Loose sand deposits in parts of the drainage lines indicate that they are flood-prone and subject to scour during periods of streamflow. Windblown sand deposits are generally of low density and can settle or collapse on wetting and loading.</p> <p>On the low sandy rises and dunes, loss of vegetation and breakdown of the weak silt and clay bonds easily occurs.</p> <p>The red brown earths, which are the main pedological soil type widespread over the area, have a topsoil horizon of silty, fine-medium grained sand which becomes clayey with depth close to the B horizon clays. When moist the clays and silts act as a binder of the sand particles; when dry the bonds are easily broken and the surface soils can be prone to erosion by wind and water.</p>
Silts	<p>Silts may occur on parts of the estuarine plain and low lying areas near drainage. Even when some clay is present the soils are very weak when dry and easily broken down under traffic, creating a dust nuisance that is not easily controlled even by occasional wetting.</p>
Clays	<p>Clays along the corridor range from sandy and silty clays to clays of high plasticity. All are strong when dry but lose strength on wetting. For all weather access, sheeting is generally necessary. Footings need to be protected against saturation to avoid loss of strength and problems associated with shrinking and swelling. On exposed faces of cuttings, wetting and drying results in fine cracking, making the soils prone to erosion by running water resulting in slaking into the drainage system. More stable surface layers can also be undercut leading to more massive instability in near vertical faces.</p>

Possible effects of the construction of the expressway on these soils are:

- loss of topsoil due to disturbance followed by erosion by wind and water, which could lead to dust nuisance and siltation of drainage lines
- erosion of soils from cut faces and, due to the potential for accumulation of sands and silts in the bottom of drainage features, retardation of flows along drainage lines is also possible in the long term
- saturation of areas where water is allowed to pond in drains or basins for long periods
- erosion of soil from embankment batters with the accumulations having the potential to retard flows in drainage structures
- settlement of buildings on low density soils due to construction work by heavy equipment and pile driving
- settlement of buildings on low density soils due to traffic vibrations.
- heave and settlement of footings founded on reactive clays due to alterations in the drainage regime.

3.1.2 Site contamination

There is potential for contaminated soil to be encountered on the land excavated during construction of the road corridor but the extent is not known at present. Contaminated soil that may be discovered in the course of the earthworks for the road construction may either be anthropogenic in origin such as those identified in PB (2005), or naturally occurring such as acid sulphate soils or potential acid sulphate soils. The potential risks of acid sulphate soils and potential acid sulphate soils are discussed in Section 3.1.3.

Key areas of risk for site contamination are:

- exposure of pre-existing contaminants directly to construction workers
- exposure of pre-existing contaminants to other (e.g. off-site) human or environmental receptors as a result of construction activities (e.g. from mobilisation or disposal practices)
- introduction of new contaminants during construction (e.g. construction-related chemical spills).

The disturbance of contaminated soil during construction of the road corridor may have a number of impacts. If present, contaminants in the soil may be released to the environment through contact with stormwater either in situ or at a disposal location. If spoil is to be removed from the site for disposal elsewhere, there is potential to create a new broader geographical health or environmental hazard. There is also a risk to construction workers if direct contact is made with contaminated material encountered on site. These impacts can be minimised through appropriate management.

All reasonable steps will be taken to avoid land contamination from project activities; however, during construction there is the potential for small quantities of hydrocarbons to be released through:

- accidental spillage of fuels
- leakage during plant operation, storage and transport of materials.

If soil is locally contaminated as a result of project activities, remediation will need to be undertaken as required. Contaminated soils will be remediated on-site or removed and disposed of off-site as appropriate.

3.1.3 Acid sulphate soils (naturally occurring)

Various construction activities have the potential to disturb and activate acid sulphate soils:

- construction of embankments for the elevated roads
- construction of stormwater collection, treatment and control measures
- construction of piers and footings for overpasses
- construction of noise barriers
- stockpiling, removal and replacement of spoil material at the worksite and at disposal points.

Potential impacts associated with disturbance of acid sulphate soils include:

- changes to water chemistry of the groundwater resources
- degradation of steel and concrete pipes and structures
- exposure of acid sulphate soils at the disturbed areas to runoff thus causing the release of acid into the environment in the short and long term
- leaching of acid into the environment at the disposal site
- exposing potential acid sulphate soils along the route to air, surface runoff and water flows, thus causing increased oxidation and release of acid
- uneven settlement or displacement of footings or earthworks.

The severity of acid sulphate soils impacts depend upon soil characteristics (e.g. texture, pyritic concentration, presence of natural neutralising material), the depth of occurrence, and thus period and frequency of acid sulphate soils exposure. Although not yet formally classified, the risk of acid sulphate soils being present along the new expressway route is considered very low due to the natural surface elevations being well above 5 m AHD, and the lack of excavation activities required at significant depth.

3.2 Operational effects

Potential contamination effects associated with ongoing operations will be mainly related to contamination through accidental spills (addressed in the Surface Water and Groundwater Technical Paper). The risk of traffic accidents that may lead to spills is discussed in the Traffic and Transportation Technical Paper.

Ongoing effects associated with soils and erosion should be minimal following establishment of vegetation throughout the corridor. Further details of the landscape concept are provided in the Urban Design, Landscape and Visual Assessment Technical Paper.

4 Safeguards and mitigation measures

4.1 Principles adopted to minimise effects

Mitigation measures for the project will implement management and monitoring practices from the planning and design phase and throughout the construction phase that align with accepted industry practice. Appropriate management of site contamination and acid sulphate soil issues will rely on early identification during the planning and design process.

4.2 Specific actions to minimise effects during planning and design

A construction environmental management plan (CEMP) will be prepared which will document the environmental controls and measures to be implemented throughout the construction phase of the project to mitigate risks associated with:

- subgrade moisture changes
- soil erosion
- topsoil management
- low density soils
- moisture reactive clays
- accidental spills and leaks
- spill response
- excavation of potentially contaminated land
- disturbance of acid sulphate soils.

4.2.1 Soil management and geotechnical issues

During the design stage the following procedures will be adopted:

- Footings for structures will be designed to ensure that differential movements between structures and embankments are kept to within acceptable limits.
- Long-term embankment settlements will be minimised by preloading the softer subgrade soils where necessary.
- Long-term pavement distortion will be minimised by keeping subgrade moisture conditions stable, possibly by lining drainage channels in areas of moisture reactive clays to minimise infiltration of surface runoff and restricting tree planting to the edges of the road reserves.

- Batter slopes on embankments will be designed to be stable. If sandy soils are used as the main embankment fill the exposed surfaces will be covered with more stable soils to ensure that erosion does not occur and that the slopes can be revegetated.
- Selection of fill materials for the road pavement and embankments will be made after consideration of all available sources. The use of borrow materials from areas adjacent to the expressway will be investigated to ensure there are no detrimental environmental effects.

4.2.2 Site contamination

A site contamination investigation as early as possible in the design phase – and certainly before or during the development of the CEMP – will focus on locations where earthworks may encounter contaminated soils. The *Preliminary site contamination assessment – Sturt Highway Extension Study Area* (PB 2005) will provide a basis for scoping the environmental site assessments.

Site contamination investigations will begin with a detailed site history to identify:

- historical and current owners of the site
- previous land uses
- previous industries supported
- site geology and hydrogeology
- wastes produced
- chemical storage and transfer areas
- disposal locations
- product spills and losses
- discharges to land and water
- previous contaminated land investigations.

Following the site history investigations, a soil sampling and analysis regime will be adopted at the project site targeting:

- potential sources of contamination identified during the site history review
- locations that have previously shown visual or olfactory evidence of contamination but have not yet been sufficiently analysed.

Laboratory analysis of the site contamination investigations, by a NATA accredited laboratory, will be designed and conducted in accordance with:

- AS4482.1-2005 Guideline to the investigation and Sampling of Sites with Potentially Contaminated Soil – Non-volatile and Semi-volatile Compounds
- Assessment of Site Contamination NEPM, 1999.

Site contamination management and remediation strategies will be incorporated into the CEMP. After the contaminated land has been assessed, appropriate remediation strategies will be designed and implemented to remove or contain the contamination, possibly including:

- on-site material treatment

- off-site material disposal at an EPA certified disposal location
- on-site containment of contamination by bunding and/or covering with impervious materials.

Each site of contamination will be assessed individually to determine the most appropriate remediation approach and ensure compliance with the Environment Protection Act. Any contaminated materials required to be taken off site will be waste tracked and taken to an EPA certified disposal/ treatment location in accordance with EPA requirements.

4.2.3 Acid sulphate soils (naturally occurring)

The risk of encountering acid sulphate soils or potential sulphate soils on the Northern Expressway and Part Wakefield Road Upgrade route is considered low.

If encountered, mitigation and management measures for controlling impacts associated with acid sulphate soils will be developed in accordance with the *Acid sulphate soil manual* (Stone et al. 1998).

Management measures for the acid sulphate soils will include best management and monitoring practices (starting at the design phase and extending through to the preconstruction and construction phases) to ensure the potential environmental impacts of the soils are minimised and controlled.

An on-ground site survey along the road corridor will map areas with indicative acid sulphate soils and potential acid sulphate soils characteristics, for example ground elevation (acid sulphate soils and potential acid sulphate soils generally occur in areas of low relief, less than 5 m) and flora stress (as a result of the acidic environment).

The areas identified from the mapping assessment will then be investigated further with a drilling and shallow excavation study. Material from these soil investigations will be tested at a NATA accredited laboratory to determine if they are acid sulphate soils or potential acid sulphate soils.

The *Queensland acid sulphate soil technical manual, soil management guidelines* (version 3.8) (Dear et. al. 2002) and the *Coastal acid sulfate soil management guidelines, Barker Inlet, SA* (Thomas et. al. 2003), provide management options which include:

- avoidance
- minimisation of disturbance
- neutralisation
- hydraulic separation
- strategic reburial.

In particular, acid sulphate soils mitigation measures should specifically ensure:

- changes in natural groundwater levels are minimised; the acid generating potential of material to be excavated is adequately treated and managed throughout the construction phase
- where acid sulphate soils must be disturbed, soil treatment with lime or other neutralising agents, in accordance with the treatment rates prescribed in management guidelines (e.g. Thomas et. al. 2003; Dear et. al. 2002), must be used on site to prevent the downstream or offsite impacts from acid water drainage

- acid sulphate soils material treatment pads and stockpiling areas are constructed, bunded and prepared before construction begins and located in areas where overland flow can be adequately controlled and diverted
- all leachate and runoff from areas excavated below 5 m AHD, known acid sulphate soils areas, acid sulphate soils treatment pads and stockpile areas should be adequately captured, contained, analysed and treated (if necessary) before being discharged off site
- all fill to be used on site (e.g. for elevating roadways) must be acid sulphate soils-free or first evaluated for the presence of acid sulphate soils; if acid sulphate soils are found they must first be treated with lime or other acid neutralising agents, according to treatment rates prescribed in management guidelines (e.g. Thomas et. al. 2003; Dear et. al. 2002).

Careful planning will be required during the design stage and implementation of suitable management and mitigation measures during construction to minimise and adequately manage the potential effects from disturbance of acid sulphate soils. It will also be essential to maintain and monitor the condition and performance of permanent mitigation measures that are installed during construction and for the duration of the operational stage in order to prevent or minimise potential delayed effects some time in the future.

Water management is one of the key elements for the management and mitigation of potential effects resulting from the disturbance of acid sulphate soils affected material. Therefore, it is essential to identify runoff and drainage control points within and leaving the construction site and design suitable control measures and structures to be installed during construction that will divert or contain runoff from specific areas.

4.3 Specific actions to minimise effects during construction

4.3.1 Topsoil management and erosion control

The suitability of erosion and sediment controls depends on the soil, landform and hydrological characteristics of the site. As these characteristics vary across the extent of the proposed route, a range of control measures will be implemented during construction.

Topsoils along the proposed route are generally weakly bonded when dry and easily disturbed by construction traffic. Periodic wetting of areas will help reduce dust but care is required to ensure that excessive amounts of water are not applied and thus create additional problems.

Sheeting of access roads and staging areas will help control dust and erosion. Removal of the upper 150–200 mm of the topsoil may also assist as it will expose the stronger clayey soils below but the clays may also be problematic during wet periods.

Dust creation by construction vehicles will be less problematic in sandy topsoils, which are instead prone to rutting and wind erosion. In this case, construction traffic should be restricted wherever possible to prepared access tracks and staging areas which have been paved.

Topsoil removed will be stockpiled at temporary locations along the route. All stockpiles would be protected by temporary seeding if necessary, together with other erosion and sediment control measures as required. The location of stockpiles and procedures required for management will be included as a component of the CEMP.

Erosion and sediment control measures may include:

- ponding basins and silt traps in new drainage lines to capture construction site runoff
- revegetation of embankments and noise mounds
- protection of cut faces in drainage lines with geo-textiles or topsoil placed over clay lining of low permeability.

4.3.2 Effects on existing structures

The location of all buildings close to the Northern Expressway and Port Wakefield Road Upgrade will be noted and foundation conditions assessed. If it is considered that alterations to the existing drainage system, planting of roadside vegetation or the effects of construction traffic have the potential to cause building movements, appropriate measures will be taken to minimise any damage. Dilapidation surveys on these buildings will establish their condition before construction activities begin.

4.3.3 Site contamination

All potentially contaminating materials used on the project that have the potential to cause land contamination will be listed in a hazardous materials register, which will include details on storage location and requirements, proper usage, safe handling procedures and appropriate disposal procedures. Much of this information will be available in the material safety data sheets (MSDS) which will be kept for all materials and chemicals maintained within the register.

All chemical and fuel storage areas and bund facilities will be designed to comply with the relevant Australian Standards, including *AS1940-2004: The Storage and Handling of Flammable and Combustible Liquids*, and *AS3780-1994: The Storage and Handling of Corrosive Substances*.

Fuels or other chemicals used during construction will be stored and handled in accordance with Australian Standards, South Australian legislation and accepted industry practice so as to minimise the risk of spills to the environment. This may include temporary containment of storage tanks, visual and inventory monitoring of storage tanks to verify containment, as well as procedures for manual handling.

Emergency response procedures will incorporate spill response procedures. Appropriate spill response and spill containment equipment will be kept at the site in close proximity to storage and handling areas. Spills and leaks will be cleaned up and remediated promptly.

Induction and training for all construction staff will address contaminated land issues.

In the event that contaminated soil needs to be removed and disposed of at an appropriately licensed facility, waste tracking will be undertaken and documented in accordance with EPA requirements.

4.3.4 Acid sulphate soils

If acid sulphate soils or potential acid sulphate soils are identified during the next stages of the investigations, appropriate steps will be taken at the design stage to ensure they do not have a long term detrimental effect on structures. Disturbance of the soils will be kept to a minimum and alterations to local drainage carefully assessed to ensure minimal effect on local vegetation.

4.4 Specific actions to minimise effects during operations

Saturation of the road subgrade for prolonged periods can lead to softening of the underlying soils and consequent pavement distortions and possible pavement failures. Good drainage along the road must be maintained to avoid these problems. Where ground slopes are very low and surface water drainage is retarded, the possibility of allowing surface waters to flow into ponding basins away from the road will be examined.

Moisture conditions in the subgrade will be stabilised by using sealed shoulders and linings of low permeability clay in drainage channels. Planting of roadside vegetation along the boundaries of the corridor will assist in keeping the soils drier in those areas and maximise infiltration into soils at the edge of the road reserve.

The potential for soil contamination following construction is considered further in the Surface Water and Groundwater Technical Papers, and the Traffic and Transportation Technical Paper. Australian Standards and good practice guidelines will be adopted to minimise risk of chemical spills and to ensure containment in the event of a spill or leak.

In the event of soil contamination, it will be cleaned up and an incident investigation undertaken to identify any measures necessary to prevent a reoccurrence.

5 Conclusion

Soil and geological conditions along the proposed Northern Expressway corridor vary, but generally consist of fine-grained materials prone to a number of issues including erosion, dust, loss of strength when saturated, and shrinking and swelling with changes in moisture content. All are readily managed through effective planning, design and the implementation of environmental management procedures during construction and operation.

No detailed site contamination investigations have been undertaken to date, but a preliminary assessment of the study area in 2005 identified significant contamination issues which might present a risk. Further investigations into site contamination are required during design. In order to manage any potential contaminated land issues, a number of systems would be implemented during the planning, design and construction phases.

Mitigation and management measures for controlling effects associated with acid sulphate soils will be developed in accordance with the *Acid sulphate soil manual* (Stone et al. 1998) should any issues be encountered.

Storage and handling of hazardous substances and dangerous goods associated with project construction will comply with the relevant Australian Standards. The risk of encountering acid sulphate soils or potential acid sulphate soils on the Northern Expressway route is considered to be low.

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