4. Topography, Geology, Soils and Geomorphology

4.1 Topography

4.1.1 Existing Environment

The proposed Emu Swamp Dam will be located 5 km north of Ballandean and 15 km southwest of Stanthorpe.

The proposed Emu Swamp Dam is located on the Severn River. There are mountains on either side of the Severn River at the proposed dam location with mountain peaks greater than 900 m AHD. The topography of the Project area is presented in **Figure 4-1**.

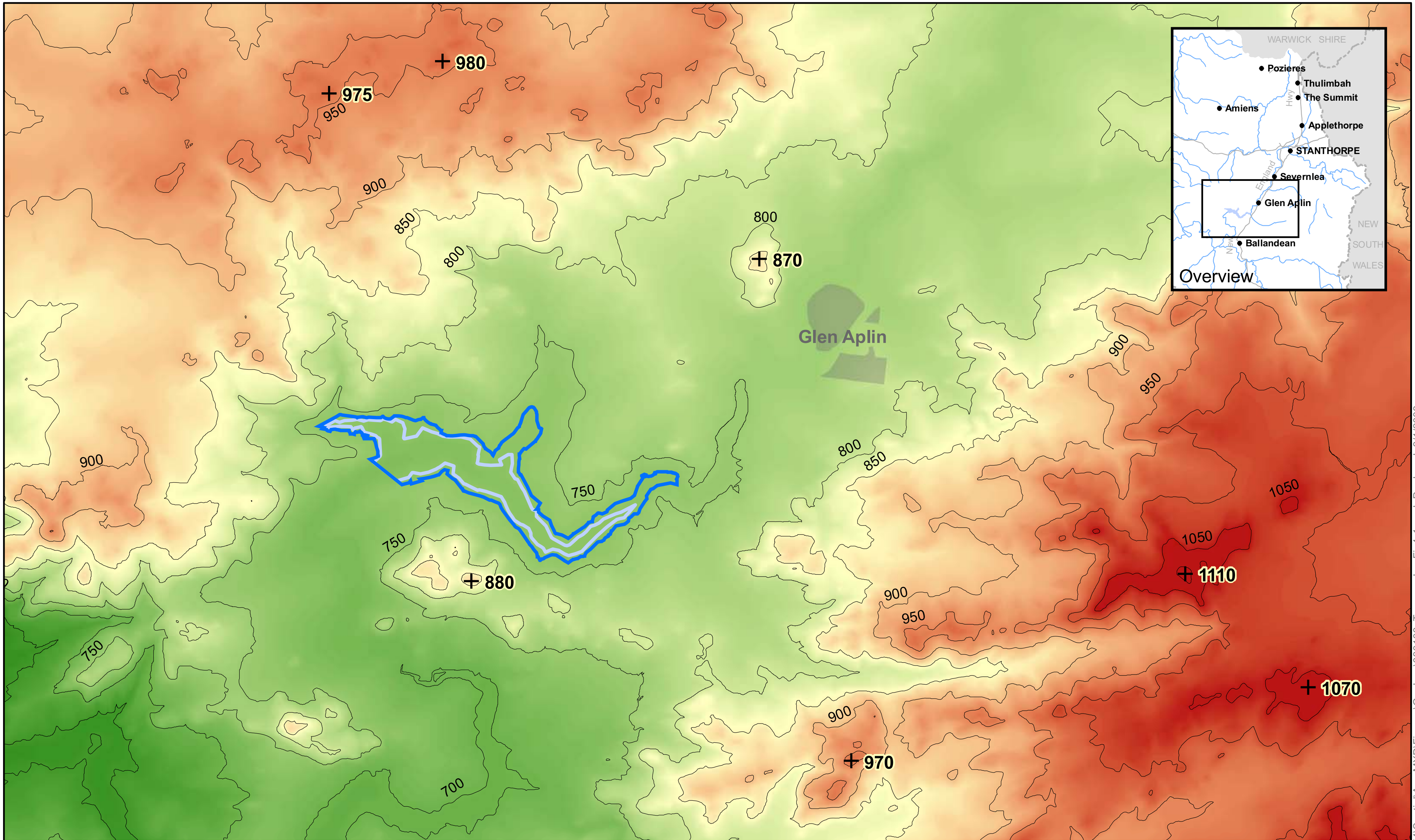
4.1.2 Potential Impacts

The major modification to the topographical features will be associated with excavation activities for the quarry, sand extraction, the recreational area and construction of Stalling Lane Access.

The quarry and sand extraction areas are both within the inundation of the proposed dam. The final quarry excavation walls will be shaped to eliminate steep unsafe faces.

The recreational area will be constructed to the eastern side of the proposed Emu Swamp Dam. There may be some shaping of the landscape associated with the recreational area but these will be in keeping with the natural landscape.

Stalling Lane Access will be constructed to follow the natural terrain as closely as possible. However, some excavation may be required so the gradients of the road are not too steep.



Legend

- Full Supply Level 734.5m AHD
- Full Supply Level 738m AHD
- Height (m AHD)
- 50m Contours
- Glen Aplin Township

N
W
E
S

0 0.5 1 2
Kilometres
Scale - 1:60,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Emu Swamp Dam Site

Figure 4-1
Topography of Inundation Area and Surrounds

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4.2 Geology

4.2.1 Existing Environment

A description of the geological history of the Stanthorpe area is provided using the outcomes of a number of previous studies, to assist in understanding the structure and composition of the geology within the Project area.

4.2.1.1 Geological History

The Project area is located in a reasonably young and historically active tectonic setting. Regionally, the Palaeozoic volcanic and sedimentary assemblages of the Warwick – Stanthorpe – Texas area form the southern section of the New England Orogen which extends from Southern Queensland to Northern New South Wales. These features form the southern section of the New England Orogen which extends from Northern New South Wales into Southern Queensland and the Project area. As a result of subduction-related activity occurring in the Devonian to Triassic periods, the New England Orogen is the easternmost and youngest portion of the Australian continent (Bryant *et al* 2004).

The Upper Palaeozoic New England Fold Belt consists of the New England Batholith (Shaw 1981). The Batholith extends for approximately 400 km in length and 110 km in width from Stanthorpe in Queensland to Tamworth in New South Wales (Hunter and Clarke 1998). The Batholith was emplaced in two major periods of volcanic activity, the first during the Upper Carboniferous and the second during the Upper Permian and Triassic.

The regional composition of the New England Batholith includes Tertiary Basalts, Permian Volcanics, Serpentinites and Plutonic Supersuites (I-type and S-type).

The tectonic evolution of the area has been described by Spencely (2001) and is listed chronologically below:

- During the mid-late Permian and Early Triassic a series of compressional events occurred terminating during the late Middle Triassic following the main compressional event, the Hunter-Bowen Orogeny;
- During the latest Permian to Middle Triassic, rapid uplift along the Panthalassan/Pacific margin of eastern Australia occurred creating an Andean style landscape;
- Permian to Lower Triassic granitic rocks intrude the strata of the New England Fold Belt;
- Late Carboniferous to Early Permian was a period of extensional tectonics with the development of a volcanic arc extending, and of rifting and development of half grabens.

The Juvenile nature of the crustal materials in this region is reflected in the composition of the intruded granites which dominates the local geology of the Project area and influences soil types found (refer **Section 4.3**). The geological setting is comprised of I-type Moonbi Supersuite (primarily Late Permian to Early Triassic) which was emplaced when Australia was part of a convergent plate-margin system (Spenceley, 2001).

4.2.1.2 Geology Within the Inundation Area

Regional (1:100,000) geological mapping records published by Department of Natural Resource and Water (DNRW) and the Geological Survey of Queensland (DNRW 2005) were used to describe the geological setting within the Inundation area.

The dominant geological formation underlying the inundation area and foundations of the proposed dam wall is the Stanthorpe Adamellite, as shown in **Figure 4-2**. The Stanthorpe Adamellite is typically comprised of high-potassium hornblende-biotite granites (Bryant 2004). The Stanthorpe Adamellite has been interpreted to be relatively competent, resistant to weathering and reasonably tectonically stable. Geological cross sections in the inundation area are presented in **Figure 4-3**.

Ruby Creek granites are limited in aerial extent within the Project area, however a minor outcrop exists in the south west section of the Inundation area, as shown on **Figure 4-2**. The Ruby Creek granites were among the last to be emplaced during the Triassic Period and appears to be the most resistant to erosion relative to the Stanthorpe

Adamellite (Wills (1976). The Ruby Creek Granite is typically comprised of a fine to coarse grained biotite leucogranite.

Localised Alluvium along the Severn River has been regionally identified, however have not been observed to occur within the Inundation area based on regional (1:100,000) geological mapping records (DNRW 2005). Further detail on surface sediments is provided in **Section 4.3**.

4.2.1.3 Geology near the Proposed Pipeline

The dominant geological formations underlying the pipeline route are Stanthorpe Adamellite and a minor section of Ruby Creek Granites underlying the Irrigation Pipeline within the north of Stanthorpe (refer **Figure 4-2**). The pipeline runs parallel to, and occasionally intersects, Quaternary Alluvium associated with the Severn River between Glen Aplin and Severnlea and sections near Applethorpe, Stanthorpe and between Amiens and Applethorpe. The Quaternary Alluvium is generally comprised of clay, silt, sand, gravel and flood plain alluvium.

A small section of the Irrigation Pipeline north of Stanthorpe intersects the Marburg Subgroup (Jurassic in Age) between Poziers and Thulimbah. This unit is comprised of lithofeldspathic sandstone, siltstone, shale, and contains minor coal deposits.

The majority of the pipeline will be constructed within slightly weathered granites which have been described as being relatively stable and competent and generally resistant to weathering.

A discussion of the susceptibility of sedimentary units to weathering is provided in **Section 4.3**.

4.2.1.4 Faults

The presence of two approximate faults inferred within the Stanthorpe Adamellite and Ruby Creek Granites running through the inundation area are shown on **Figure 4-2**. Other than these inferred faults, no other geologic structure having potential to impact the Project have been identified within the inundation area.

As part of the geotechnical investigations for the feasibility and engineering design of the dam, no known geologic structures or faults have been reported to run through the proposed Emu Swam Dam (URS 2006).

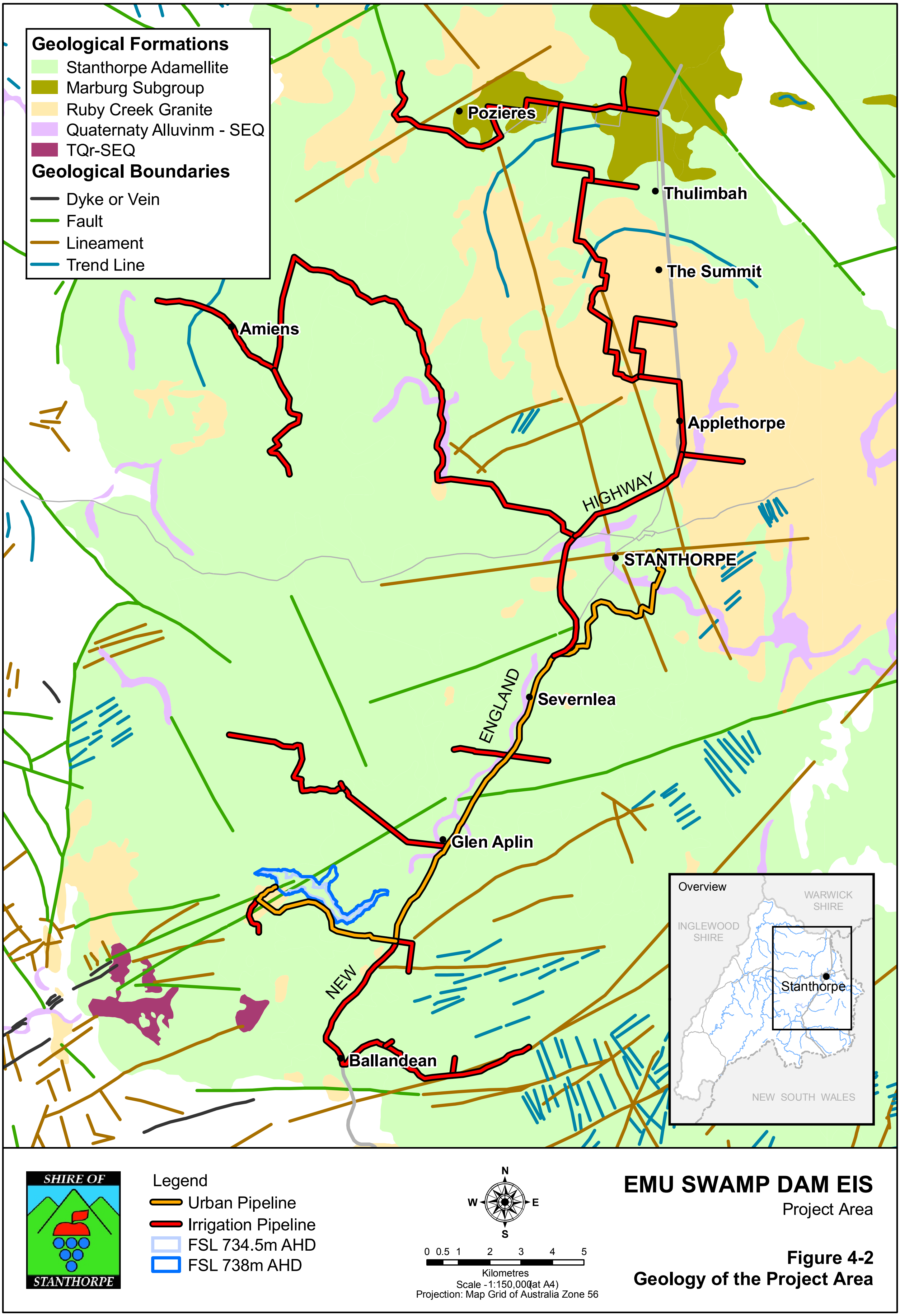
An approximate fault just north of the township of Glen Aplin has been inferred to run across the proposed pipeline within the Stanthorpe Adamellite.

Further geotechnical investigations would be undertaken during the detailed design of the dam. The likely presence (or otherwise) of faults would be determined as part of these investigations.

4.2.1.5 Fossils

The presence of any significant fossil specimens generally occurs within sedimentary formations. Given the geology of the Project area, the likelihood of fossils occurring within the Stanthorpe Adamellite and the Ruby Creek Granite is negligible.

At the depth of excavation for pipeline construction, the geology is weathered material. Fossils are unlikely to occur in this material. If fossils are uncovered during construction of the pipeline the Queensland Museum will be notified and a strategy will be developed to protect these specimens.

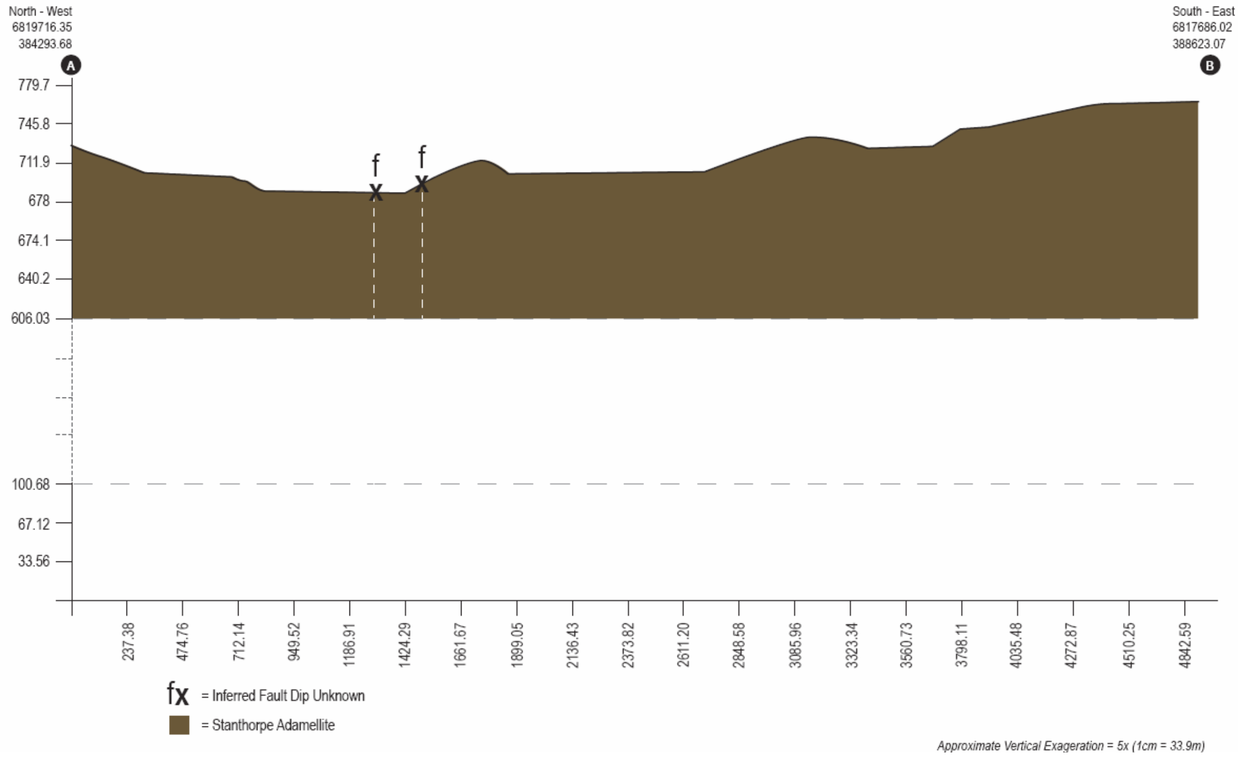


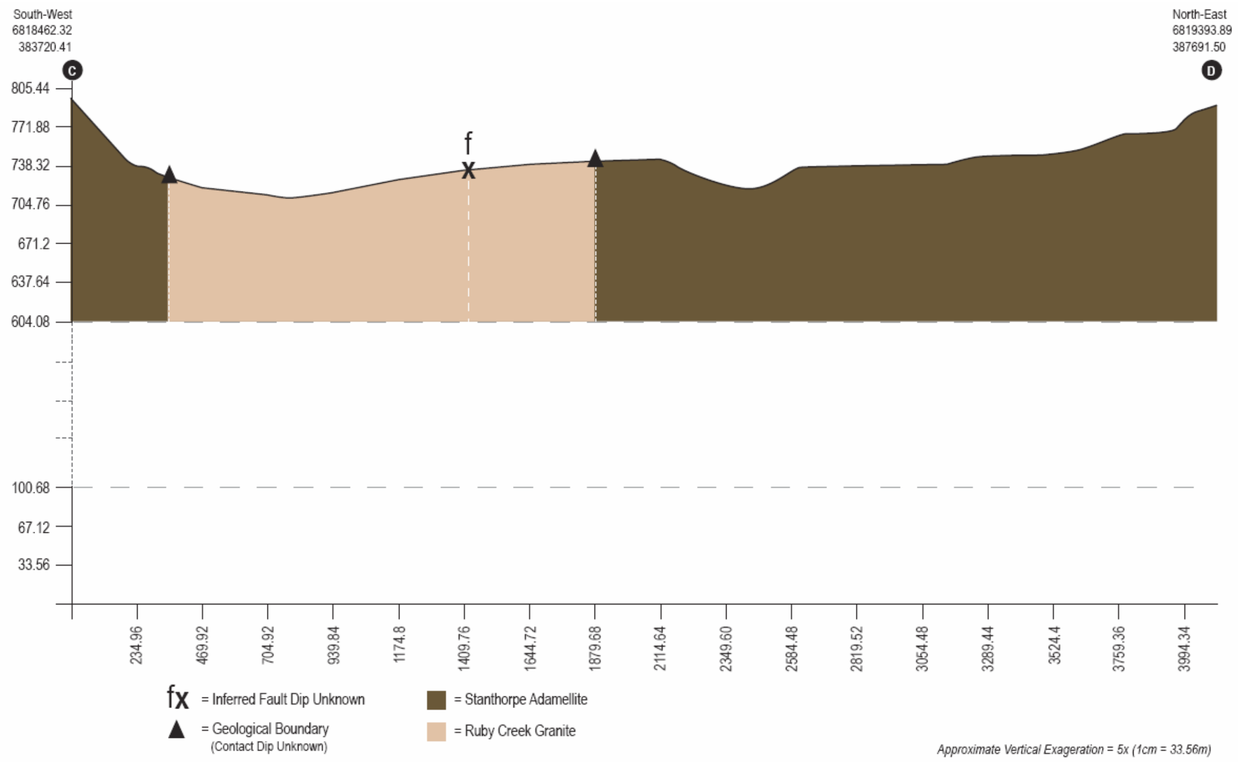
EMU SWAMP DAM EIS

Project Area

Figure 4-2
Geology of the Project Area

▪ Figure 4-3 Geological Cross Sections within the Inundation Area





4.3 Soils

The description of soils within the Project area is based on detailed survey and reporting undertaken by GT Environmental Services. Further detail on the findings of the soil survey is provided in the Supporting Technical Document – *Emu Swamp Dam Soil and Land Suitability* (GT Environmental Services 2007).

4.3.1 Soils in the Project Area

Soil surveys were undertaken within the Project area to confirm the broadscale mapping of soil types and boundaries (Powell 1975) and to assist with the characterisation of soil erodibility and suitability for construction, cropping and other landuses. The regional soil associations within the Project area, as identified by Powell (1975), are shown in **Figure 4-4**.

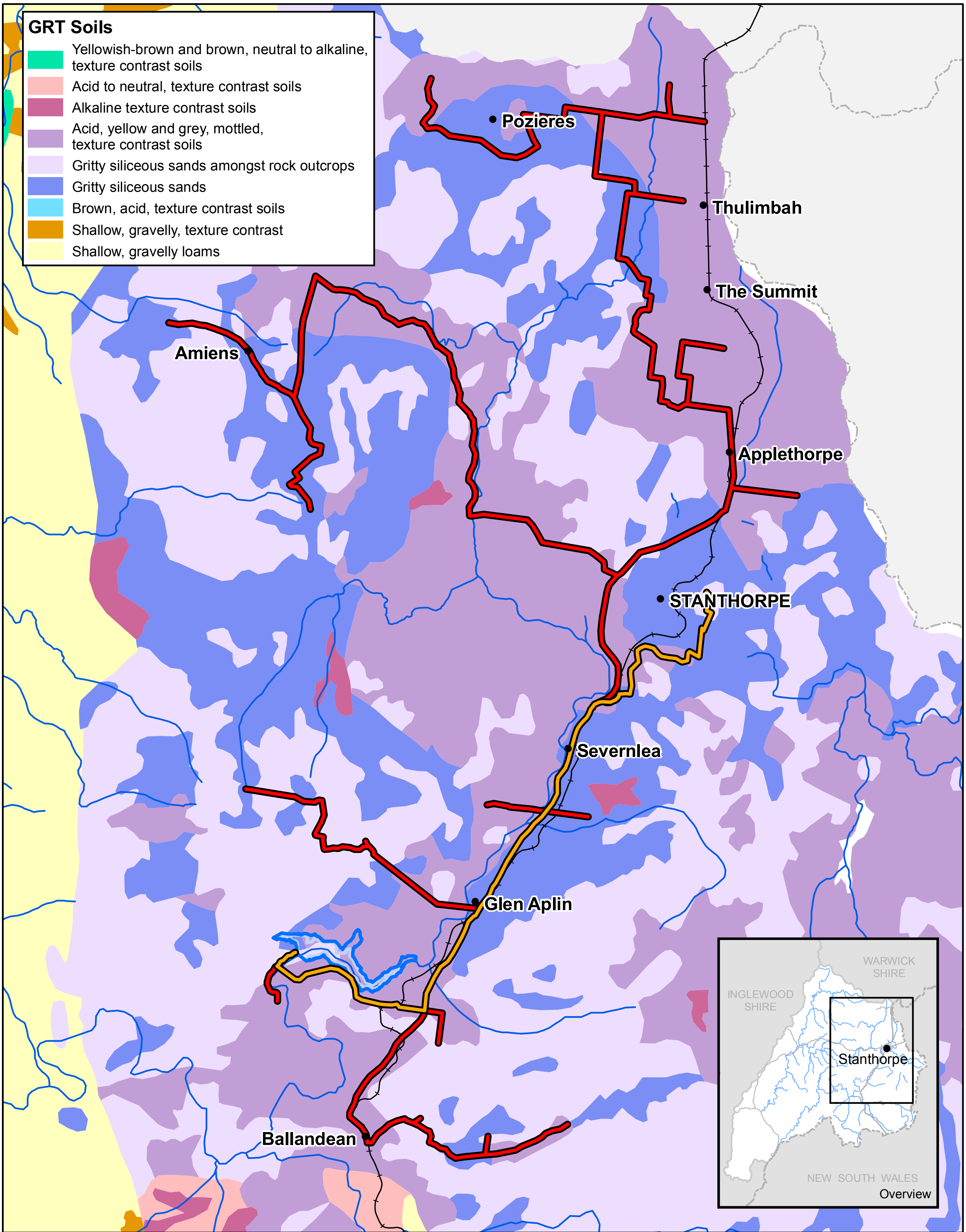
The survey area is wholly contained in the upper catchment area of the Severn River where underlying geology is exclusively granite. The principal soil type within the Project Area is uniform coarse gritty silicious sands of variable depth to weathered bedrock (granite).

The soils within the Project area were mapped at an approximate scale of 1:10,000 in line with recommendations of Gunn *et al* (1988) using outcomes of field investigations and previous geology, geomorphology, land types, land use and soil type studies, including:

- Maher (1996) - all areas along the pipeline route were included in a 1:250,000 scale map of 'Land Types' with major soil types described for each land type;
- Wills (1976) described soils and geomorphology across the region, also at a 1:250,000 scale;
- Powell (1977) mapped the soil types which were included in Wills (1976); and
- Wills (1980) identified issues and aspects in areas of existing and proposed cultivation.

Soil surveys were undertaken using free survey techniques (Gunn *et al* 1988) to check and refine soil types and boundaries described in Maher (1996). The sampling survey included 31 detailed site observations within the Inundation area and Pipeline route, supported by other non-detailed sites involving review of surface soil and vegetation type and topographical form to confirm soil type and map boundaries. Representative sites were sampled for detailed chemical analysis to determine chemical limiting factors and assist in agricultural suitability assessments for cropping and grazing.

Soil map units within the Project area have been developed primarily on the basis of similarity in morphology, laboratory data, soil depth, percentage of granite outcropping and topographic position. The following sections provide an outline of soils within the inundation area (**Section 4.3.1.1**) and within the Pipeline route (**Section 4.3.1.2**).



SHIRE OF STANTHORPE

Legend

- Urban Pipeline
- Irrigation Pipeline
- Full Supply Level 734.5m AHD
- Full Supply Level 738m AHD

N W E S

0 0.5 1 2 3 4 5
Kilometres
Scale - 1:150,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Project Area

Figure 4-4
Regional Soil Associations

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- **Table 4-1 Soil Map units and Sampling Site Details**

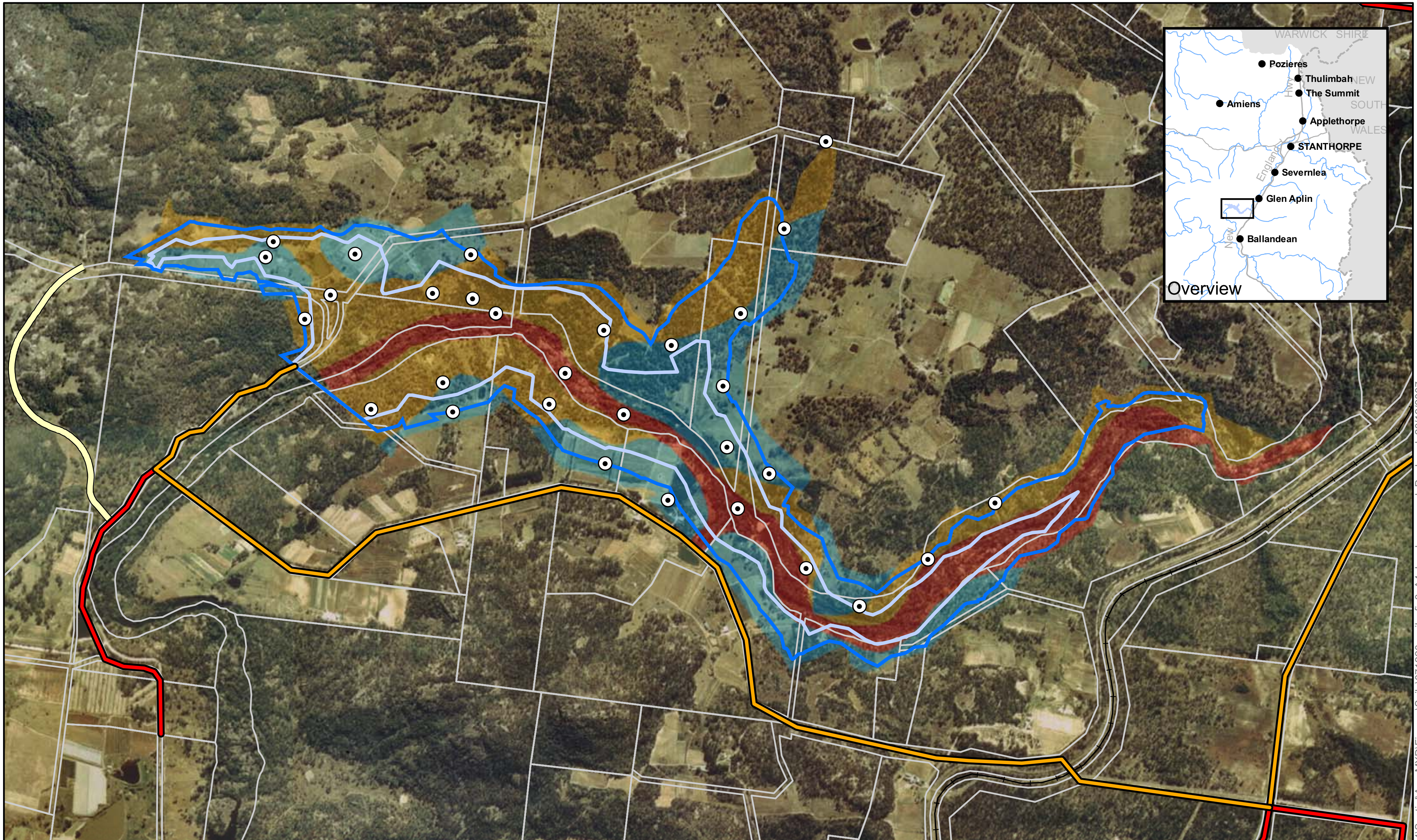
Map Unit	Soil Description and Distinguishing Land Features	Australian Soil Classification	Comparable soils from other surveys		
			Powell (1977)	Wills (1976)	Maher (1996)
A	▪ Loamy coarse sands associated with active creek or river channels (alluvial plains and embankments). ▪ Typified by variable soil depth, slope and surface topography. ▪ Often extensive (>50%) granite outcropping, stones and boulders. ▪ Slope <1% ▪ Vegetation is mostly uncleared remnant open forest with isolated areas of clearing ▪ Surface condition when dry is highly variable, with granite common and other areas typically firm silty loam and loose coarse sand	Orthic Tenosol	Ucc	GUC1	Banca
B	▪ Undulating with uniform siliceous coarse to loamy sands, possible bleach often with moderate granite outcropping. ▪ Soil depth generally in a range from 30 to 60 cm (average 40cm). ▪ Gently undulating plain with slopes generally 2-6%. ▪ Surface condition when dry is sandy and loose ▪ Vegetation is mostly uncleared remnant open forest with new England Blackbutt	Grey Kurosol	Uca	GUC2	Pozieres and Banca
C	▪ Very gently undulating uniform sandy soils often with yellow / red mottled subsoil extending past 50cm to weathered or fresh granite bedrock. ▪ Soil depth generally deeper than A and B, in a range 40 to 100 cm (average 55cm). ▪ Mostly cleared for cultivation (forage), pasture or grape vines and stone fruit. ▪ Granite outcropping < 20%. ▪ Slopes generally < 2%	Leptic Tenosol and Grey Kurosol	Ucb	GUC2 and G Dy-Dg	Pozieres

4.3.1.1 Soils of the Inundation Area

Three main soil types are described within the Dam Inundation Area:

- Map unit A – Uniform loamy sands associated with alluvial channels;
- Map unit B – Uniform coarse loamy sands with moderate slope and granite outcropping
- Map unit C – Uniform coarse loamy sands on low slopes

The extent of these soil map units within the inundation area is presented in **Figure 4-5**. Typical soil profiles are shown and described in **Figure 4-6**.



SHIRE OF STANTHORPE

Legend

- Urban
- Irrigation
- Full Supply Level 734.5m AHD
- Full Supply Level 738m AHD
- Stalling Lane Access
- Cadastral Boundaries

Soil Unit

- Alluvial
- Shallow to Mid Depth Sands
- Mid to Deep Sands
- Soil Sampling Site

N W E S

0 100 200 400 600 800 1,000
Metres

Scale - 1:20,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Emu Swamp Dam Site

Figure 4-5
Soils of the Inundation Area

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Figure 4-6 Photographs showing typical Soil Map unit Landform Elements

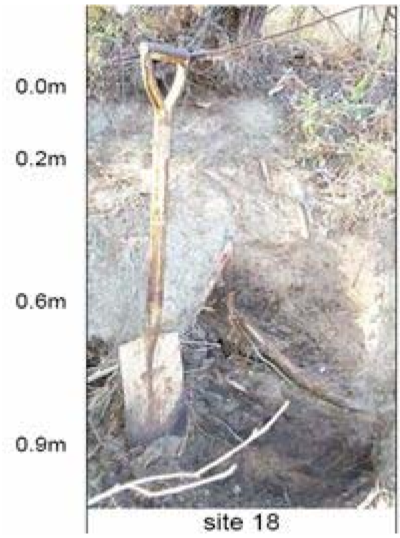
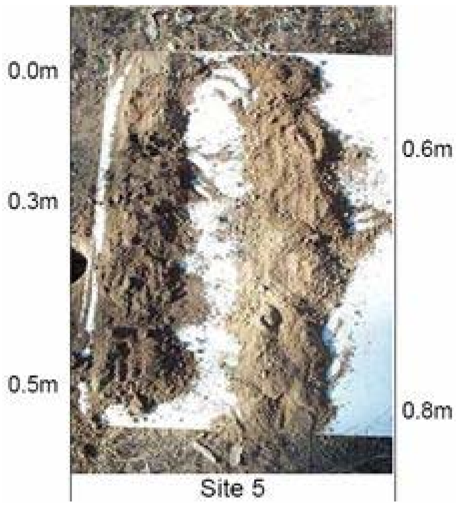
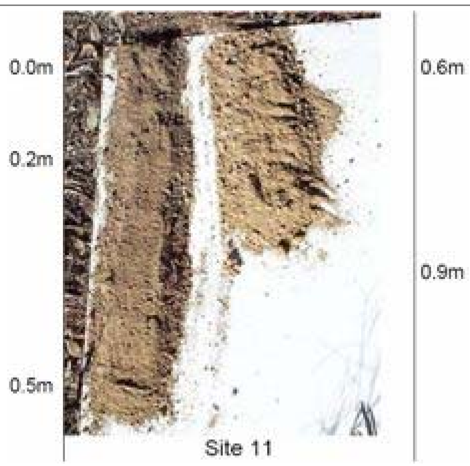
Soil Map Unit	Soil Profile		
	Photograph	Depth	Description
A – Deep sand		0 -60 cm	Pale brown 10YR5/3, silty sandy loam, firm, field pH 5.5 clear change to
		60-120+ cm	dark brown 10YR 3/1, loamy coarse sand, massive, field pH 5,
		Runoff	Quite good infiltration but rapid over exposed rock.
		Permeability	High
		Drainage	may be impeded by bedrock or hardpans
B – coarse sands		0 -20 cm	Brown 10YR3/2, coarse sand, massive , field pH 5.5 clear change to
		20-55 cm	greyish brown 7.5YR 5/2, coarse sand, no segregations massive, field pH 4.5, red mottling below 30 cm depth increasing
		55+ cm	parent material
		Runoff	Rapid over rock exposure areas otherwise slow
		Permeability	High
		Drainage	restricted by bedrock or hard pans
C - coarse loamy sands		0-20 cm	Dark brown 10YR4/3, coarse gritty sand, massive , field pH 5.0 clear change to
		20-50 cm	greyish brown 10YR 5/3, coarse sandy loam, no segregations, massive, field pH 5.0
		50-100+ cm	loamy coarse sand , greyish brown 10YR5/3 with yellowish red staining (mottles), no segregations field pH 4.5
		Runoff	Slow
		Permeability	High
		Drainage	Possibly restricted by bedrock or hard pans

Table 4-2 provides a summary of the particle size distribution for these soil samples and **Table 4-3** provides a summary of the laboratory analysis of soils sampled within the inundation area and. This soil analysis characterisation has been used to assist with determining the fertility and erodibility of soils and is discussed below.

Soil Map unit A

Soil map unit A is characterised by a surface comprising 80% sand with equal proportions of fine and coarse sand. (refer **Table 4-2**, Site 1). This sandy composition suggests that the surface may tend to seal and set hard. The laboratory analysis for Site 1 indicates that the soil has very low fertility with levels of nitrogen, phosphorus, sulphur and boron being very low (refer **Table 4-3**). Most trace elements are adequate. Cation exchange capacity is very low and pH trend is acid which continues to the bedrock. Little potential for dispersion is indicated above 30 cm depth. The subsoil below the bleached layer at 30cm is not saline. The soil bleach indicates a tendency to waterlog as rapidly infiltrating water is held up by the hard, impervious subsoil layer.

Soil Map Unit B

Soil map unit B is characterized by sand with moderate fractions of fine sand included (refer **Table 4-2**, Site 5). The laboratory analysis for site 5 indicates that soil fertility within this map unit is lower than the alluvial soils described in map unit A. Specifically, nitrogen, phosphorus, copper, potassium, sulphur and boron are very low while most other trace elements are adequate (refer **Table 4-3**). Cation exchange capacity is very low and pH trend is strongly acid which continues to the bedrock. Organic matter is high in the surface as is the calcium to magnesium ratio. Electrical conductivity is very low throughout as is cation exchange. As for map unit A the subsoil is non-sodic or saline. The site was freely drained with no sign of impeded drainage. Dispersive tendency is very low

Soil Map unit C

Particle size distribution is dominated by coarse sand in both sites which differs from soils A and B which had considerably more fine sand fraction (refer **Table 4-2**, Site 11, 21). Laboratory analysis for Sites 11 and 21 indicate reasonable fertility. Site 21 may have had fertiliser applied however 11 probably has not. Phosphorus, magnesium. Sulphur and boron were low in both sites however most other indicators of fertility were reasonable (refer **Table 4-3**). Cation exchange capacity is very low and pH trend is mildly acid to strong acid at depth. Organic matter is high in the surface as is the calcium to magnesium ratio.

Electrical conductivity is very low throughout as is cation exchange capacity. As with soil map units A and B the subsoil below the A horizon is non-sodic or saline. The sites had impeded drainage with red mottling evident below 50 cm depth. Dispersive tendency in soils at both sites 11 and 21 is low.

Table 4-2 Particle size distribution of the sampled soils

Soil Map Unit	Sample	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Dispersivity
A	Site 1	42	40	7	12	0.40 (low)
B	Site 5	40	34	14	12	0.63 (low)
C	Site 11	64	21	8	8	0.60 (low)
	Site 21	62	26	7	6	0.49 (low)

Table 4-3 Inundation Area Soil Laboratory Analysis

Analyte	Map Unit A			Map Unit B		Map Unit C				
	Site 1			Site 5		Site 11			Site 21	
Depth (cm)	0-10	30-40	100-110	0-10	30-40	0-10	40-50	60-70	0-10	50-60
pH(H_2O)	4.9	4.8	4.6	5.3	4.7	5.5	5.9	5.4	6.5	4.0
pH ($CaCl_2$)	4.2			4.8		4.9			5.8	
Organic matter (%)	1.9			3.3		2.1			1.9	
CEC (meq/100g)	5.7	6.2	5.5	10.9	5.1	7.3	4.2	3.6	9.4	8.7
EC (dS/m)	0.05	0.09	0.05	0.05	0.02	0.04	0.03	0.02	0.11	0.05
NO_3-N ppm	1.7			3.5		1.9			29.3	
Phosphorus (Olsen)ppm	6			8		21			15	
Potassium (meq/100g)	0.24	0.24	0.22	0.24	0.10	0.29	0.16	0.14	0.70	0.25
Calcium (meq/100g)	3.3	2.88	2.72	8.76	3.05	4.93	2.17	1.85	7.16	1.92
Magnesium (meq/100g)	1.78	2.3	1.94	1.49	1.48	1.68	1.55	1.27	1.11	3.60
Sulphur (ppm)	5			8		6			9	
Boron (ppm)	<0.1			0.3		0.2			0.4	
Copper (ppm)	0.6			0.2		3.0			3.3	
Iron (ppm)	84			45		57			34	
Manganese (ppm)	21.1			52.2		23.9			31.5	
Zinc (ppm)	0.8			0.6		1.5			2.0	
Aluminium (meq/100g)	0.14	0.19	0.21	0.12	0.18	0.15	0.15	0.12	0.17	
Sodium (meq/100g)	0.3	0.6	0.4	0.3	0.3	0.3	0.2	0.3	0.3	0.7
Chloride (ppm)	12			7		7			6	
Calcium/ Magnesium ratio	2.4	1.3		1.1	3.6	2.1	3.5	3.3	1.8	25.6

4.3.1.2 Soils of the Pipeline Route

The main soil types along the Urban and Irrigation Pipeline are described in **Table 4-4** and the extent of these soil map units is presented in **Figure 4-7**.

Table 4-4 Summary of Mapped Soil Types within the Pipeline Route

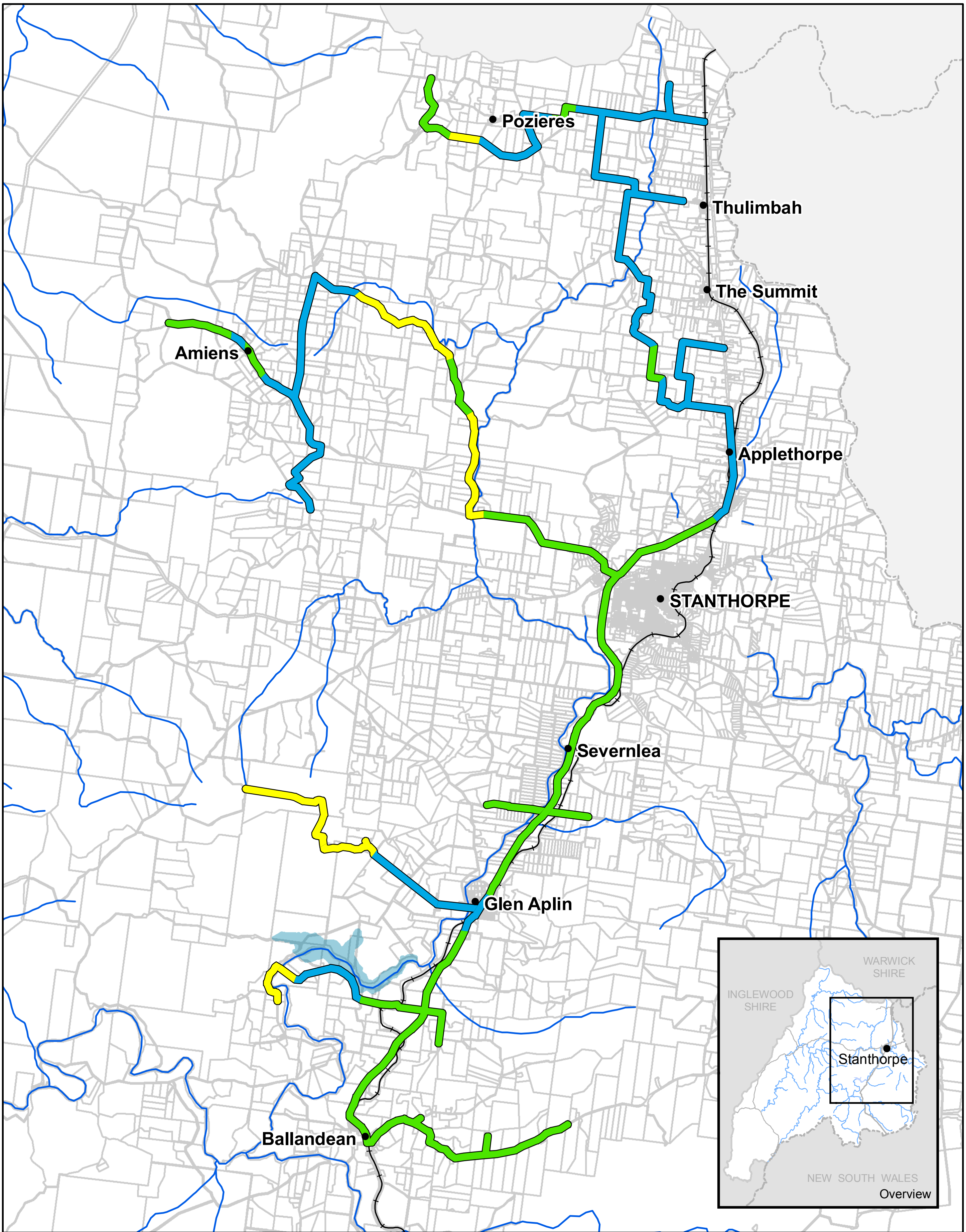
Map unit	Soil Description and Distinguishing Land Features
B	▪ Soil profiles are uniform dark grey to brown, gritty siliceous sand over hardpans, bedrock or mottled subsoils. ▪ Gently undulating plains and rises with colluvial lower hillslopes. ▪ May have stony surface and areas of rock outcrop. ▪ New England Blackbutt tall open forest. ▪ Average slopes 2 -5 %.
C	▪ Deep soil with gritty dark grey sandy surface to 30-45cm over coarse sands or mottled, brown to grey acid clay subsoils. Often becoming more gritty with depth. ▪ Flat and gently undulating plains with occasional rock outcrops. ▪ Average slopes <2%.
D	▪ Dark grey to brown, gritty coarse sands to duplex soils often very shallow with acidic reaction trend and often underlain by bleached subsoils with hardpans. ▪ Soil depth varies between nil and 120cm+.Low granite hills with areas of tors and rock outcrops common. ▪ Blue gum, stringybark grassy woodlands. ▪ Also includes alluvial channels.

There was no analysis during the soil samples along the pipeline route. Analytical results of Powell (1977) representative of the soil types along the pipeline route are presented in the Supporting Technical Document - *Emu Swamp Dam Soil and Land Suitability* (GT Environmental Services 2007). The results are summarised below.

For soil map unit B, the laboratory analysis at Spring Creek Road (Powell 1977) suggest low fertility with very low nitrogen, phosphorous, and copper, moderate potassium and high zinc, and an acid reaction trend. Plant available water storage potential is quite low. The soil is non-sodic or saline, and excessive drainage may cause waterlogging.

For soil map unit C, plant available water storage potential is quite low and has an acidic reaction trend. The laboratory analysis at Church Road, Summit (Powell 1977) suggests reasonable (but not high) fertility. Nitrogen remains low, but phosphorous, potassium, copper and zinc are better than soil map unit B. The subsoil is strongly sodic and may be saline (below 60 cm). Excessive drainage may cause waterlogging.

For soil map unit D, plant available water storage potential is very low. The laboratory analysis (Powell 1977) suggests nitrogen, phosphorous, copper are also very low. Levels of potassium and zinc are moderate. Soils are non-sodic or saline and have an acidic reaction trend. Excessive drainage may cause waterlogging.



SHIRE OF STANTHORPE

Soil Unit

- Shallow to Mid Depth Sands
- Shallow to Mid Depth Sands sometimes with Duplex soils
- Deep Soil with Sandy Surface

N W E S

0 0.5 1 2 3 4 5
Kilometres
Scale - 1:150,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Project Area

Figure 4-7
Soils Along Pipeline Routes

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4.3.2 Potential Impacts

4.3.2.1 Inundation area

This survey evaluated topsoil and subsoil with regard to potential for downstream environmental impact from erosion, dispersion, salinity and potential structural issues should they be exposed to the weather. **Table 4-5** provides a summary of the topsoil usability, main environmental risks and management measures. Further detail on erosion and soil management is provided in **Section 4.3.3**.

Table 4-5 Topsoil Management Measures

Soil Type	Stripping	Major environmental risk	Management of Topsoil
All	The entire soil profile to hard rock, hardpan or yellow/red mottled material may be stripped for construction or rehabilitation activities.	Most soils are non sodic or saline however minor occurrences of sodic clay subsoil were found in the inundation area. The soils have a neutral to slightly acidic reaction and do not pose any downstream risk from acidity. The major downstream risk is sedimentation from erosion.	Preferably reuse topsoil as soon as possible to avoid time of exposure and erosion risk. If stockpiling is required then these coarse sandy soils may be stored indefinitely without significant deterioration. The major issue is the control of erosion. Long term stockpiles should be constructed with a height <3 m such that a plant cover can be quickly developed sustained. Any stockpiles should be located outside local drainage catchments or pathways as far as is possible. A replacement depth of at least 25 cm is recommended if the material is used for regeneration of disturbed areas.

Wills (1980) in his survey of erosion in the Granite Belt region, concluded that sandy granitic soils which dominate the inundation area and pipeline routes are considered to have a low erosion potential. The soils surveys undertaken as part of this EIS support this view and indicate that the potential environmental risks to downstream areas from soil erosion is low. **Table 4-6** provides a summary of the erosion potential identified for major soil types within the Inundation area.

Table 4-6 Erosion Potential for Major Soil Types identified within the Inundation area

Soil Map Unit	Erosion Potential
A	In steeper creek embankments the silty loamy sand surface has high potential for erosion if adequate surface cover is not maintained
B	Due to higher slope gradients and areas of concentrated water runoff due to rocky outcropping, erosion risk may be significant is sufficient surface cover is not maintained. While infiltration rates are high and the soils are non-dispersive, losses
C	No dispersive soils indicated but sediment wash a risk. Graded rows should be constructed across contours when cultivation done on slopes >2%.

The major soil types identified within the inundation area are uniform coarse sands overlying bedrock or gritty gravels. These soils are non dispersive.

Major ground disturbance works will be required in this area during the construction of the dam, quarry areas, access roads and haul roads and will include the removal of vegetation as well as the stripping, transport and stockpiling of topsoil within the construction area. The area will consequently be exposed and vulnerable to erosive processes during construction and prior to stabilisation.

Environmental risks from the effects of construction activities on soils within the Inundation area include:

- All soils have moderate risk of sediment being removed (siltation) downstream from exposed surfaces or topsoil stockpiles which increases with slope gradient and proximity of disturbed areas to natural water flow paths.
- A low risk of soil dispersion or salinity exists on the uniform sands and sandy A horizons of texture contrast soils which may be encountered.

The main consequences of erosion are loss of topsoil/subsoil and degraded water quality in downstream areas. Loss of topsoil and subsoil will reduce the ability to reinstate disturbed areas following completion of construction, thus exacerbating erosion impacts in the longer term. Water quality issues are discussed further in **Section 7** of the EIS. Erosion may also cause visual impacts, particularly where revegetation cannot be achieved because of loss of topsoil.

In order to manage these risks during construction a range of management measures would be adopted, including those outlined in **Section 4.3.3**. A detailed erosion and sediment control plan will be included in the Construction Environmental Management Plan and will be implemented throughout the works. Control measures should initially verify the soil type which occur in work locations and outline work methods which include progressive rehabilitation.

The higher risk texture contrast soil can be identified by the red and yellow mottling of the hard clayey subsoil.

4.3.2.2 Pipeline

As outlined above, the major soil types within the proposed Pipeline routes are uniform coarse sands referred to as soil types B and C. Areas of hilly and shallow soil type D also occur in some areas. The environmental risks associated with these soil types include:

- A moderate environmental risk is noted from the existence of texture contrast soil variant which may occur in soil type B. It is only after excavation that the clayey subsoil becomes evident. Construction activity should therefore expect such soil variation. These soils have clayey subsoils below 50 cm depth which may be approaching levels described by Baker and Eldershaw (1993) as dispersive and saline. Excavated or exposed subsoils which are clayey have increased risk of saline or sodium affected sediment in runoff to local streams.
- All soils have moderate risk of sediment being removed downstream from exposed surfaces or topsoil stockpiles which increases with slope gradient and proximity of disturbed areas to natural water flow paths.
- A low risk of soil dispersion or salinity exists on the uniform sands and sandy A horizons of texture contrast soils.

The main consequences of erosion discussed above for the Inundation area also relate to works within the Pipeline routes. **Section 4.3.3** provides a summary of management strategies and mitigation measures which would be included as part of the construction environmental management plans for the works.

4.3.3 Mitigation Measures

The principles of soil erosion and sediment control applicable to construction within the inundation area and along the pipeline routes are similar. **Table 4-7** provides a summary of recommended controls for a number of construction aspects within the Project area.

Table 4-7 Summary of Soil Erosion and Sediment control measures during Construction

Aspect	Risk	Controls
General Works	Soil erosion and sedimentation	▪ Before commencing earthworks on any part of the Project, sufficient materials to protect against erosion will be available on Site ▪ Work will be scheduled to ensure that temporary erosion control works are in place by the end of work each day, especially before weekends, if rain is imminent or when permanent erosion control works are not in place. ▪ Construction activity will be scheduled so that work in sensitive areas can be completed and rehabilitated as quickly as feasible. ▪ Sedimentation traps and detention basins will be designed for a 24 hour storm event of a return period of 10 years and cleaned out regularly and managed to ensure the required retention capacity is maintained. ▪ If detention basins are incapable of removing suspended matter effectively and standards for suspended solids contents are being exceeded in the river, environmentally benign chemicals will be added to aid settling subject to approval from the Environmental Protection Agency (EPA) ▪ Exposed areas shall be protected as soon as possible after finishing by hydroseeding or other appropriate processes to provide a protective cover
Clearing of vegetation	Soil erosion risk increases as surface laid bare.	▪ Consider options to maximise vegetation preservation. ▪ Develop a clearing plan which clearly designates areas to be disturbed and removal of such vegetation. ▪ Requirements for environmental controls to be included in all works procedures involving disturbance of land. ▪ Responsible persons to be nominated to ensure that environmental controls are maintained.
Construction of Access Roads	Soil erosion risk increases as surface laid bare and subsoils potentially exposed.	▪ Construction of site access roads for heavy vehicles will need to be suitably scour protected and drained. ▪ Care should be taken to minimise exposure of subsoils particularly where contaminated runoff may exit the area. ▪ Measures outlined below for Soil dispersion and salinity to be followed ▪ Wherever practicable, the order of construction of surface protection works including grassing shall be such that they provide erosion and sediment control to the parts of the works that they are designed to protect as those parts of the works are constructed.
Soil erosion	A moderate to high risk of sediment removal exists from exposed surfaces and topsoil stockpiles (see below). This risk increases with slope gradient and proximity of disturbed areas to natural water flow paths. Possible saline/sodic effected runoff.	▪ Prior to commencement of clearing, topsoil removal and other construction activity, an operational plan be developed which seeks to stage operations to reduce environmental risk as far as possible. ▪ This may involve prior construction of temporary waterways, containment basins, contour diversion banks, reduction of overland flow velocity (hay bales, hession weirs etc), delaying vegetation removal along key natural waterways and considered locations of stockpiles. Specific controls to be implemented will vary with tasks to be performed. ▪ Monitoring of major downstream waterways during flow events should verify that impacts from sedimentation, salinity and pH are not occurring.
Topsoil stockpiles	Instigation of excessive erosion. Possible saline/sodic effected runoff. Loss of valuable resource.	▪ Operations should seek to minimise the time of exposure of temporary and long term topsoil stockpiles as far as is possible. ▪ All stockpiles should not exceed 3 m in height and not located near major drainage pathways. ▪ Longer term stockpiles should be shaped and fertilised and seeded immediately to pastures and annual cover crop. ▪ Most soil in the dam inundation area should be uniform

Aspect	Risk	Controls
		sand to bedrock but persons involved in land disturbance works should be made aware of the need for extra care and controls as slope increases and if clayey subsoils are encountered. Such soils are common along pipeline routes and are highly erodible and may be saline. (see following points)
Soil dispersion and salinity	Inundation Area All soils observed in this survey are considered a low risk of soil dispersion and all samples tested in the laboratory were non-sodic. A similarly low risk of saline discharge is apparent. All tests conducted for soils showed very low salinity..	▪ No additional controls required other than that above
	Pipeline Routes In addition to the risks from the uniform sandy soils (as above), the route will include soils with mottled clayey subsoil below about 50 cm. This sub-soil material may be saline and sodic which significantly increases risks of erosion and saline runoff	▪ All operational personnel should be made aware of the possible existence of these soils. ▪ Care should be taken to minimise exposure of subsoils particularly where contaminated runoff may exit the area. ▪ Should clayey subsoil be exposed then the following additional requirements are needed; ▪ This material should not be stockpiled for reuse in revegetation, ▪ Minimise exposure time, ▪ Extra care in excluding surface wash where this material is exposed, ▪ Replace this material back into excavation holes first with the sandy material above it.
Wind erosion and dust nuisance	As coarse sand particle size fractions dominate these soils, wind erosion risk may be considered low in the undisturbed state but increases to moderate depending on the type of disturbance and prevailing climatic conditions. For example, in windy dry conditions, topsoil removal using scrapers may initiate excessive wind erosion and nuisance.	▪ Operational procedures should include provision for visual monitoring of conditions to ensure required controls are implemented in a timely manner. Such controls may include watering for dust suppression and operations generally.

4.4 Geomorphology

4.4.1 Existing Environment

SSRIT (1996) noted that local streams and rivers were inherently stable and suffered little erosion because of the regional granite and traprock geologies. The geomorphology of the upper catchment was primarily granite bedrock and sand.

With the predominantly granular soils in the Severn River catchment sediment transport and deposition is to be expected.

The sedimentation at Storm King Dam appears to have been quite limited. Tree stumps from the agricultural clearing more than 50 years ago have been exposed by the falling water level demonstrating that deposition has been generally limited to the stream channel.

The small weirs downstream of the Emu Swamp Dam site have trapped sediments. Evidence of sedimentation at the Weir near Bents Road can be seen in **Figure 4-8**. Some of these weirs have been "de-silted" in the past.

- **Figure 4-8 Sedimentation at Weir near Bents Road**

4.4.2 Potential Impacts

The geomorphic impacts resulting from the construction of the Emu Swamp Dam are expected to be:

- erosion of the Severn River would not be significantly affected because the operation of the Emu Swamp Dam will not significantly alter the flooding frequency or duration; and
- deposition of alluvial material is likely to decrease downstream of the dam because less material will be carried over the dam.

Sedimentation in Emu Swamp Dam is to be expected but the volumes are not expected to be large. While sedimentation is not expected to be a problem for the dam, the availability of an alternate town supply (Storm King Dam) provides the flexibility to de-silt the dam if it is ever required in the future.