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6. GEOLOGY AND SOILS

This section addresses Section 3.2.3 of the ToR. The geology and soils of the area have been documented in a number of previous reports. As a result this study has been carried out as a desktop appreciation of the available data to form a knowledge base for the assessment of potential impacts of the Project on the geological and soils environment. Brief field verification of existing geological and soil mapping was undertaken.

6.1. Description of environmental values

6.1.1. Regulatory framework

Construction of the dam and pipeline covers land under coal exploration permits and mineral development licences and therefore captures requirements under the *Minerals Resources Act 1989* and *Petroleum Act 1923*. Section 403 of the *Mineral Resources Act 1989* requires the consent of the owner and holder of the mining claim or lease before the property can be entered. Sections 807 and 808 of the *Petroleum and Gas Act 2004* require consent from the pipeline licence holders before works can be undertaken. SunWater has been liaising with the relevant parties regarding access.

Under the *Sustainable Planning Act 2009* (SP Act) a series of State Planning Policies (SPPs) are in place to safeguard various aspects of the State's natural assets. SPP 2/07 refers to conservation of Key Resource Areas (KRAs) to protect significant extractive industry resources. There are no identified KRAs affected by the Project.

SPP1/92 refers to the conservation of Good Quality Agricultural Land (GQAL) and is addressed in Section 6.1.4.2 and Section 6.1.5.2. Complementing the SP Act at the time of preparing this EIS was the is the *Strategic Cropping Land Policy Framework (SCLPF)* which was being developed to protect the best cropping land resources in Queensland so that they are able to be used for cropping and support a robust agricultural sector into the future. The SCLPF was released in August 2010 and included reference to new legislation introduced in 2012. *The Strategic Cropping Land Act 2011, Strategic Cropping Land Regulation 2011 and State Planning Policy 1/12: Protection of Queensland's strategic cropping land* commenced on 30 January 2012 and will be assessed prior to approval of the Project.

Utilising draft Strategic Cropping Land maps it was identified that much of the Project is located within Strategic Cropping Land.

The outcomes sought by the State, regional and local planning frameworks would be affected by the loss of GQAL and SCL, due to inundation of land within the water storage and disruption due to surface infrastructure along the pipeline route. This is discussed further in this Chapter.

6.1.2. Methodology

Geology and soils are described for the Project area including:

- catchment of the proposed Nathan Dam;
- Nathan Dam site, storage area and surrounds;
- the pipeline corridor; and
- major road upgrade or construction sites.

Descriptions are based on geological and soils mapping, interpretation of aerial photography, review of published information, and field observation. Baseline field observations were undertaken by MWH in 2008. Field observations to allocate soils to mapping units were made at 50 sites and profiles were described in detail according to McDonald *et al*. (1990) at five sites and sampled for analysis at three sites (Appendix A). Soils have been classified according to Isbell (1996).

The Banana Shire Council (BSC) and the Western Downs Regional Council (WDRC) have policies for the protection of Good Quality Agricultural Land (GQAL) as set out in *State Planning Policy 1/92: Development and the Conservation of Agricultural Land* in their Planning Schemes. The Planning Schemes of the former Taroom, Murilla, Chinchilla and Wambo Shires and Dalby City Council still apply in the Project area. These have been used in the assessment of impacts on GQAL.

Potential impacts have been assessed from likely levels of disturbance to natural features that will result from the Project and, where appropriate, mitigation strategies have been developed based on the levels of disturbance and recognised rehabilitation techniques.

6.1.3. Nathan Dam catchment

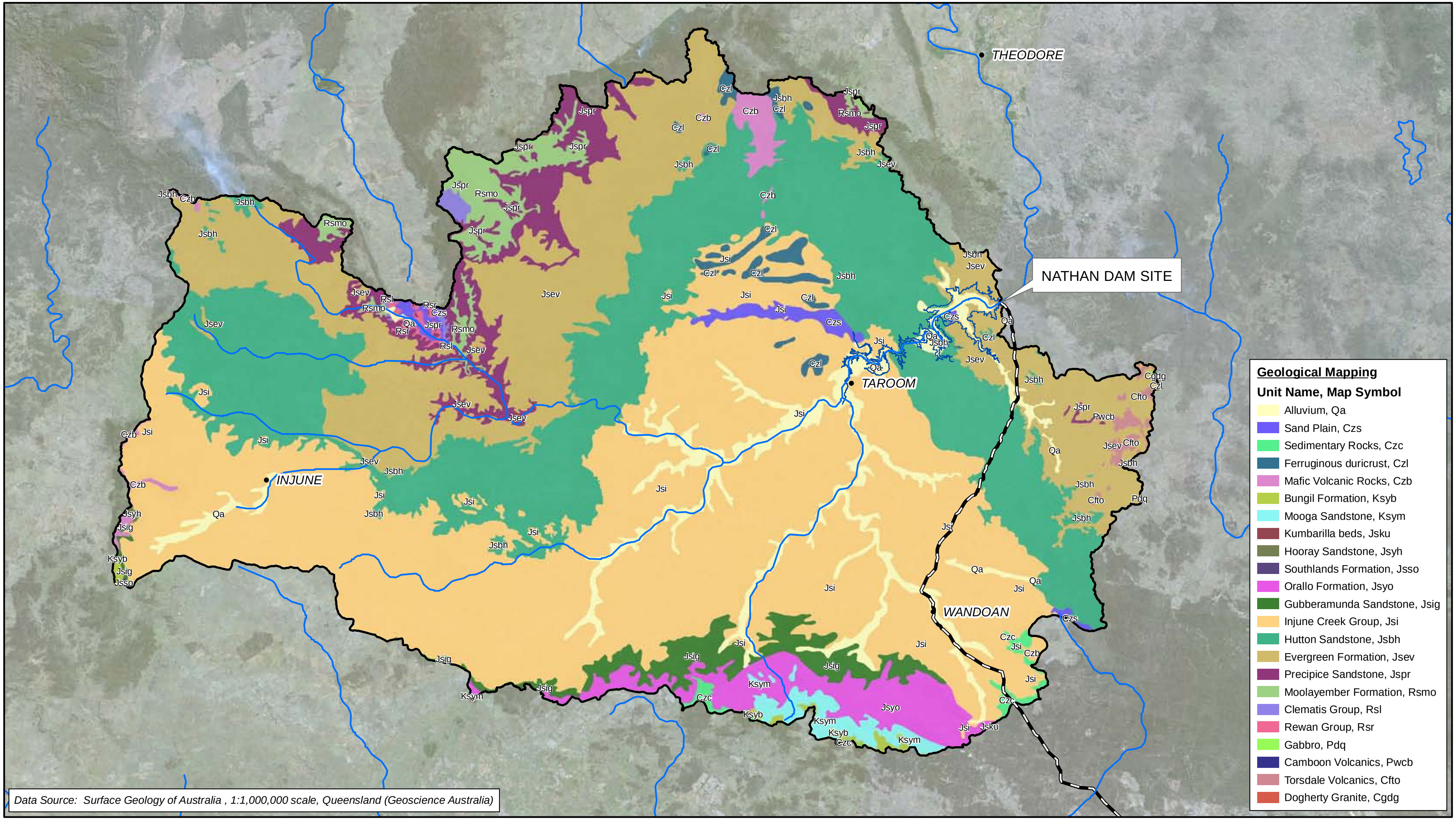
6.1.3.1. Geology

The Nathan Dam catchment represents the southern part of the Fitzroy Basin. The major structural and depositional units of the Fitzroy Basin (Malone, 1966) are:

- the Great Artesian Basin (GAB), including the Surat Basin in the south;
- the Bowen Basin in the centre;
- a group of Pre-Permian units, principally metamorphic rocks and granite, in the north-west; and
- a complex of units, principally granite and volcanic rocks, related to the Connors Arch, the Yarrol Basin and the Auburn Arch in the east.

The surface geology of the Nathan Dam catchment area is dominated by Jurassic sediments of the Surat Basin (DNRMW, 2006a and b; Forbes, 1968; Whitaker et al., 1980; Geoscience Australia, 2007) (Figure 6-1, Table 6-1). The Surat Basin rocks are generally underlain by older, Permian to Middle Triassic sediments of the Bowen Basin (Geoscience Australia, 2008b and c). The Bowen Basin is one of the structural elements of the Tasman Geosynclinal Zone and has been subjected to substantial folding and faulting, probably through the Middle to Upper Triassic, with intrusive activity as well (Wright, 1967a). The nearest outcrops of Bowen Basin sediments to the Nathan Dam area lie to the north, towards the lower end of Nathan Gorge where the Late Permian sedimentary rocks of the Blackwater Group occur.

The Surat Basin is an extensive unit within the Great Artesian Basin. It is a large, intracratonic, Early Jurassic to Early Cretaceous basin where deposition commenced during a period of passive thermal subsidence of much of eastern Australia. Depositional environments within the basin include fluvial, lacustrine, paludal, and marine. Sediments are largely flat and relatively uniform.



LEGEND

- Towns
- Proposed Pipeline
- Major Watercourse
- Nathan Catchment
- Full Supply Level (183.5m AHD)

Projection: GDA94

Figure 6-1

0 10 20 40
Kilometres

N

Scale 1:1,200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Geology of the Nathan Dam Catchment

Table 6-1 Geological units occurring in the Nathan Dam Catchment

Unit code	Unit name or description	Lithology	Age[1]
Qa	Quaternary alluvium	Channel and flood plain alluvium; gravel, sand, silt, clay	Quaternary
Czs	Sand plain	Sand plain, may include some residual alluvium; sand dominant, gravel, clay	Cainozoic
Czc	Sedimentary rocks	Undifferentiated consolidated Cainozoic sedimentary rocks; sandstone, limestone, conglomerate, siltstone; commonly ferruginised, silicified or poorly consolidated	Cainozoic
Czl	Ferruginous duricrust	Ferruginous duricrust, laterite; may include massive to pisolitic ferruginous subsoil, mottled clays	Cainozoic
Czb	Mafic volcanic rocks	Volcanic rocks, predominantly mafic; basalt, trachyte, trachybasalt, trachyandesite, leucitite, basanite, nephelinite, limburgite, rhyolite, tuff and high level intrusives; rare volcaniclastic sediments	Cainozoic
Ksyb	Bungil Formation	Glauconitic, labile to quartzose, siltstone, mudstone	Lower Cretaceous
Ksym	Mooga Sandstone	Sandstone, siltstone, mudstone	Lower Cretaceous
Jsku	Kumbarilla Beds	Sandstone, siltstone, mudstone, conglomerate	Jurassic to Lower Cretaceous
Jsyh	Hooray Sandstone	Sandstone, siltstone, mudstone, conglomerate	Jurassic to Lower Cretaceous
Jsso	Southlands Formation	Quartzose to lithic sandstone, siltstone, mudstone	Jurassic to Lower Cretaceous
Jsyo	Orallo Formation	Sandstone, siltstone, mudstone, conglomerate, coal	Upper Jurassic
Jsig	Gubberamunda Sandstone	Sandstone, minor conglomerate, siltstone	Upper Jurassic
Jsi	Injune Creek Group	Calcareous lithic sandstone, siltstone, mudstone, coal, conglomerate	Middle to Upper Jurassic
Jsbh	Hutton Sandstone	Poorly sorted, coarse to medium-grained, feldspathic sublabile sandstone (at base) and fine-grained, well-sorted quartzose sandstone (at top); minor carbonaceous siltstone, mudstone, coal and rare pebble conglomerate	Middle to Upper Jurassic
Jsev	Evergreen Formation	Labile and sublabile sandstone, carbonaceous mudstone, siltstone and minor coal; local oolitic ironstone	Lower Jurasic
Jspr	Precipice Sandstone	Thick-bedded, cross-bedded, pebbly quartzose sandstone, minor lithic sublabile sandstone, siltstone, mudstone	Lower Jurassic
-Rsmo	Moolayember Formation	Micaceous lithic sandstone, micaceous siltstone	Late Triassic to Middle Triassic
-Rsl	Clematis Group	Medium to coarse-grained quartzose to sublabile, micaceous sandstone, siltstone, mudstone and granule to pebble conglomerate	Middle Triassic to Early Triassic
-Rsr	Rewan Group	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)	Triassic
Pdq	Gabbro	Gabbro, diorite	Early Triassic to Late Permian
Pwcb	Camboon Volcanics	Basaltic to andesitic lava and equivalent volcaniclastic rocks; subordinate felsic	Early Permian

Unit code	Unit name or description	Lithology	Age[1]
		ignimbrite, other felsic volcaniclastic rocks and minor lava; commonly deformed	
Cfto	Torsdale Volcanics	Grey, brown or purple, crystal-poor to crystal-rich, dacitic to rhyolitic ignimbrite and other volcaniclastic rocks; minor porphyritic rhyodacitic to rhyolitic lava; rare andesitic rocks; minor volcanilithic conglomerate and sandstone	Late Carboniferous
Cgdg	Dogherty Granite	Pink, coarse-grained biotite leucogranite, commonly fractured, commonly weathered	Late Carboniferous

Source: Surface Geology of Australia, 1:1,000,000 scale, Queensland (*Geoscience Australia)*
Note 1. Descending in table order implies age relationships, youngest to oldest though this may not apply to units assigned the same age that are widely separated geographically.

The Dawson River catchment above Nathan Dam is dominated by the following Jurassic geological units of the Surat Basin:

- Injune Creek Group (sandstone);
- Hutton Sandstone (feldspathic at base, quartzose at top); and
- Evergreen Formation (a number of constituents including mudstones and sandstones).

Appreciable areas of Precipice Sandstone (quartzose sandstone), which is part of the Surat Basin Jurassic sedimentary sequence (and frequently underlies the Evergreen Formation) occur as well. The Hutton and Precipice Sandstones form important Great Artesian Basin aquifers in the area while extensive areas where sediments of the Evergreen Formation and the Injune Creek are exposed support the major agricultural areas of the catchment.

Minor areas of older Bowen Basin sediments occur around the north-western margin of the catchment and there are minor areas of igneous rocks in the north-east. There are substantial areas of Quaternary alluvium along major streams and some older Cainozoic sediments.

6.1.3.2. Soils

The Land Systems mapping and associated soils mapping of Speck *et al*. (1968) show that the dominant soils in the Nathan Dam catchment are Dermosols and Vertosols. These are most common in the central, southern and eastern parts of the catchment and are often associated with areas of Injune Creek Group sandstone. Other important soil groups are the texture contrast Sodosols and Chromosols. These are most common in western and northern parts of the catchment and are frequently associated with Hutton Sandstone and Evergreen Formation sandstone. Shallow Rudosols, Tenosols and Chromosols are usually associated with the Precipice Sandstone.

6.1.4. Dam site and surrounds

6.1.4.1. Geology

A number of geological units from the Early Jurassic to Early Cretaceous Surat Basin occur in and around the proposed Nathan Dam (Figure 6-2). Sediments of the Surat Basin overlay sediments of the Early Permian to Middle Triassic Bowen Basin in the Nathan Dam area (Geoscience Australia, 2008a and b). The Bowen Basin sediments overly older

Permian and Carboniferous age rocks of the Connors – Auburn Province of the Tasman Orogenic Zone. The older Permian and Carboniferous rocks are of largely volcanic origin and outcrop to the east and north-east of the Bowen Basin.

Fresh surface rock outcrops in the vicinity of the Nathan Dam site are Precipice Sandstone but most of the immediate surface material is unconsolidated. The unconsolidated surface materials are underlain by sandstone, generally shallower than 5 m but at up to approximately 13 m in the Dawson River bed. There are some shale and mudstone beds in the sandstone. The surface geology surrounding the Dawson River bed for approximately 13 km downstream of the Nathan Dam site is dominated by the Jurassic Precipice Sandstone (Figure 6-2). The river bed at the dam site and downstream of the dam is dominated by clayey alluvium.

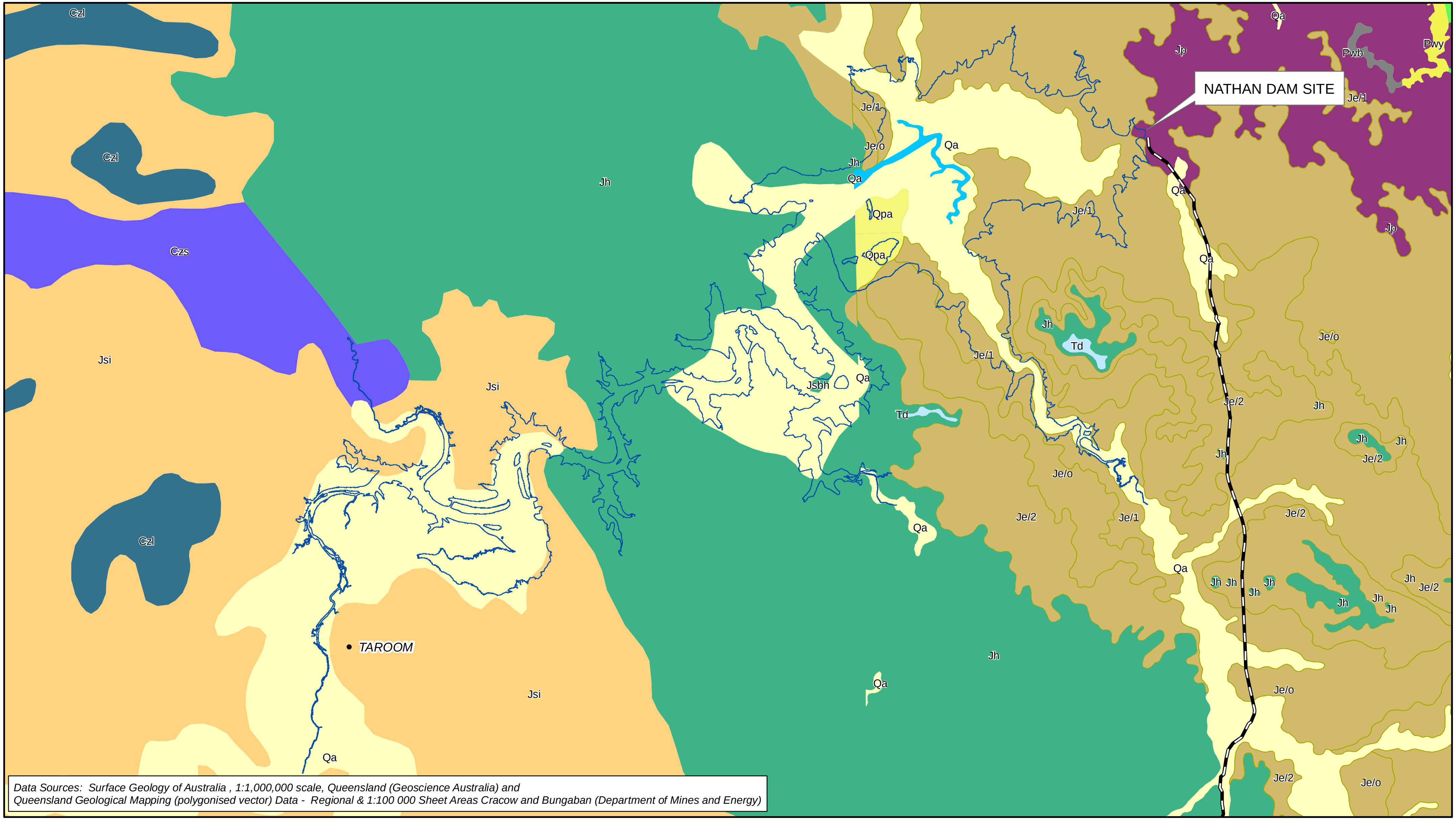
Based on records obtained from the Geoscience Australia Earthquake Database (Geoscience Australia, 2008), areas in the vicinity of the Nathan Dam have experienced some very minor earthquakes in recent years. Historically, there have been no earthquakes of appreciable magnitude recorded in the area. The largest recorded earthquake was a Magnitude 4.7 earthquake in November 1910, approximately 75 km to the east-south-east of the dam site. An earthquake of this scale would have been felt by many people (e.g. rattling windows, disturbing dishes and rocking standing cars), but is unlikely to have caused significant damage.

The closest recorded earthquake to the dam site was recorded in 1994 with a Magnitude of 2.5, approximately 22 km to the north-east. There are a number of recorded earthquakes in the Geoscience Australia Earthquake Database within 1 degree of latitude and longitude rectangle centred on the dam site. Earthquakes recorded within 1.5 degrees latitude and longitude of Nathan Dam are shown in Figure 6-3.

The dam site lies within an intermediate hazard zone with a 10% chance of an acceleration coefficient of 0.06 – 0.08 being exceeded in 50 years. Earthquake hazard is generally greater in areas of unconsolidated sediments because of the risk that vibration will cause the sediments to take on some of the characteristics of fluids, particularly if the sediments are wet (a process known as liquefaction). The dam site is underlain by sandstone at shallow depth so that hazard is less than would be the case if it were underlain by deep, unconsolidated materials.

Broad scale geological mapping does not reveal any structural features in the immediate vicinity of Nathan Dam. The structural features shown nearest to the Nathan Dam are:

- the Mimosa Syncline striking north-north-west to south-south-east approximately 45 km west of the site and approximately 15 km west of Taroom;
- a fault striking north-west to south-east approximately 30 km south-west of the site, just east of Palm Tree Creek;
- two faults striking south-west to north-east approximately 21 km east-north-east of the site, approximately 12 km south of Cracow;
- a fault striking north-north-east to south-south-east approximately 35 km north-east of the site, approximately 8 km north-east of Cracow;
- a fault striking south-south-west to north-north-east approximately 28 km north-north-east of the site, approximately 12 km north-west of Cracow; and;
- a monocline striking north to south approximately 30 km south-south east of the site.



Data Sources: Surface Geology of Australia , 1:1,000,000 scale, Queensland (Geoscience Australia) and Queensland Geological Mapping (polygonised vector) Data - Regional & 1:100 000 Sheet Areas Cracow and Bungaban (Department of Mines and Energy)

LEGEND

- Towns
- Proposed Pipeline
- Cadastre
- Full Supply Level (183.5m AHD)

Surface Geology

- Alluvium - Qa
- Alluvium - Qpa
- Sand Plain - Czs
- Ferruginous Duricrust - Czl
- Td-QLD - Td
- Injune Creek Group - Jsi
- Hutton Sandstone - Jh
- Evergreen Formation - Je/0, Je/2, Je/1
- Precipice Sandstone - Jp
- Rewan Group - Rr
- Water body

Projection: GDA94 Zone 56

Figure 6-2

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater
Making Water Work

NATHAN DAM AND PIPELINES EIS

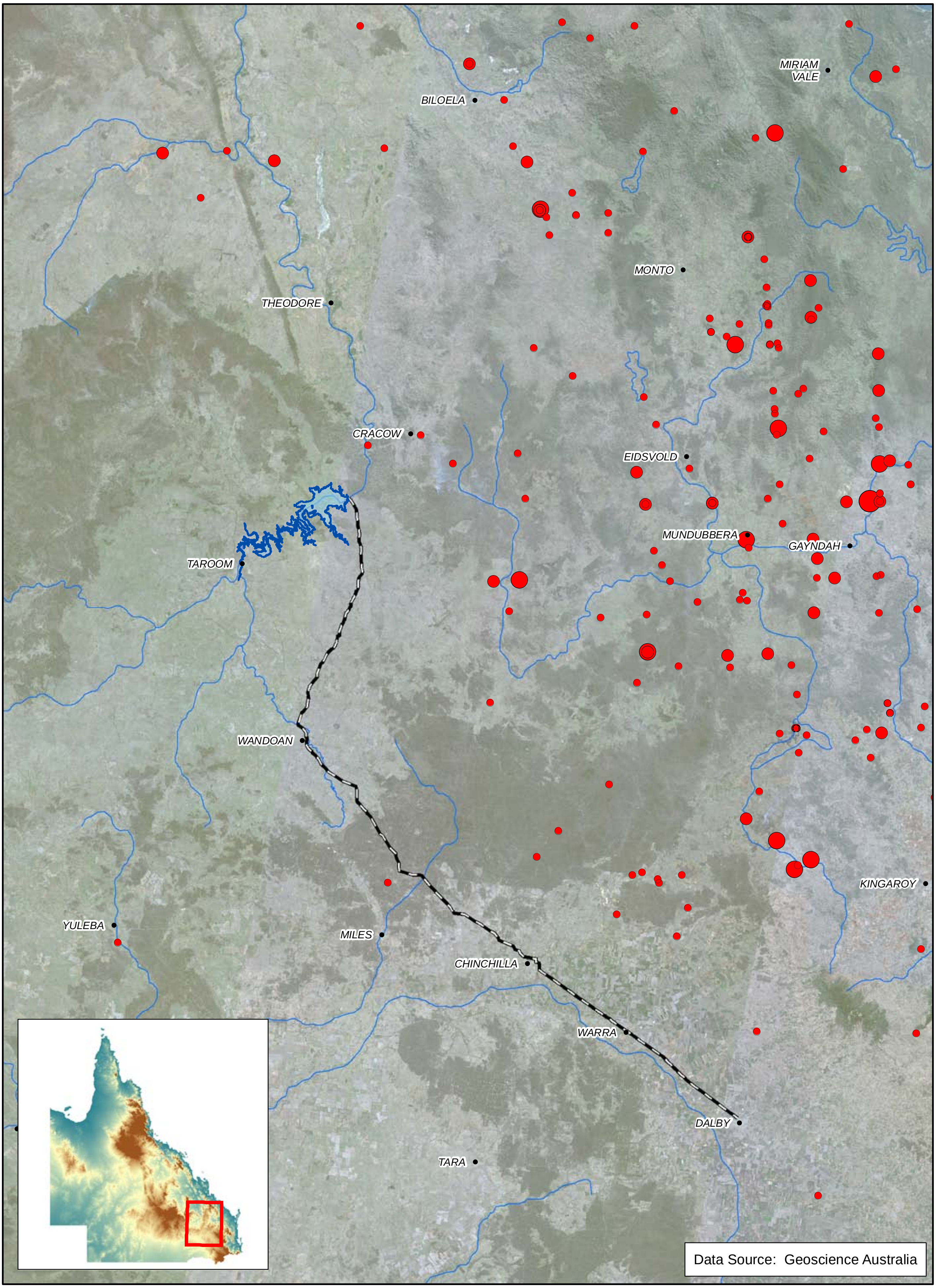
Geology of the proposed dam and surrounds

Table 6-2 Geological units occurring in the vicinity of Nathan Dam

Unit	Lithology	Age[1]	Occurrence
Qa	Clay, mud, silt, sand, gravel; mainly stream-channel and floodplain deposits	Quaternary	Alluvium associated with the Dawson River and Cockatoo, Boggomoss, Binghi, Bentley, Palm Tree, Juandah, and Kungaymungay Creeks in the Nathan Dam reservoir area and Price Creek just downstream of the dam wall
Qpa	Sand, mud and gravel; alluvium on higher terraces, commonly with 'melon holes' (gilgai country)	Quaternary	Higher-lying alluvium on Lot 15 CP FT2 in the vicinity of Glebe Weir
Cz	Soil, sand	Cainozoic	Relict floodplains along Palm Tree Creek and adjacent areas
Td	Indurated and ferruginised top of deep weathering profiles, locally including ferricrete	Tertiary	Plateaus on hills east of Dawson River at approximately 342.5 km AMTD (Glebe Mountain) and on hills north-east of Cockatoo Creek at approximately 12 km AMTD
Ji (Injune Creek Group)	Sandstone, siltstone, mudstone, coal, conglomerate	Middle Jurassic to Late Jurassic	Hills and rises adjacent to Dawson River or its alluvium upstream of 361 km
Jh (Hutton Sandstone)	Pale brown to white, or pale grey, poorly sorted, medium-grained, feldspathic sublabile sandstone (at base) and fine-grained, well sorted, quartzose sandstone (at top); commonly friable; minor dark grey carbonaceous siltstone, mudstone, rare pebble conglomerate	Middle Jurassic	Hills and rises adjacent to the Dawson River or its alluvium from approximately 332 km AMTD to approximately 361 km AMTD), upper slopes of hills north-east of Cockatoo Creek at approximately 12 km AMTD
Je_2 (Part of Evergreen Formation)	Mudstone, siltstone and fine-grained labile to sublabile sandstone	Early Jurassic	Mid-slopes of rises north-east of the Dawson River in the vicinity of 338 km to 342 km AMTD, mid-slopes of hills and rises north-east of Cockatoo Creek upstream of 10 km AMTD
Je_0 (Part of Evergreen Formation)	Yellowish brown to brown, oolitic or pelletal ironstone, sublabile sandstone, siltstone, mudstone	Early Jurassic	Narrow occurrence on undulating rises and hills north-west of approximately 329.5 km AMTD to 330.1 km AMTD on the Dawson River with other occurrences on both sides of Cockatoo Creek
Je_1 (Part of Evergreen Formation	Pale grey to greenish grey, flaggy, fine to medium-grained, micaceous, labile to sub-labile sandstone; pale green or khaki mudstone; minor white siltstone, shale, coal	Early Jurassic	Adjacent to Dawson River or its alluvium from just upstream of Nathan Dam to upstream of Spring and Cockatoo Creeks and adjacent to the alluvium of these creeks.
Jp (Precipice Sandstone)	White, buff or brown poorly sorted fine to very coarse-grained quartzose sandstone; minor white to yellowish brown, laminated siltstone (in upper part), carbonaceous shale, lithic sublabile sandstone, granule conglomerate	Early Jurassic	Adjacent to the Dawson River from just upstream of the dam site and extending approximately 13 km downstream.

Unit	Lithology	Age[1]	Occurrence
Rr (Rewan Group	Lithic sandstonene, pebbly lithic sandstonene, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)	Early Triassic	Footslopes adjacent to the Dawson River downstream of approximately 13 km downstream of the dam site

Source: DNRMW, 2006a; DNRMW, 2006b; Forbes, 1968; Whitaker *et al.*, 1980
Note 1. Descending in table order implies age relationships, youngest to oldest



LEGEND

- Towns
- Proposed Pipeline
- Major Watercourses
- Full Supply Level (183.5m AHD)

Recorded Earthquakes (Magnitude)

- 0.1 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5.5

Projection: GDA94 Zone 56

Figure 6-3

0 10 20 40 Kilometres

N

Scale 1:1,500,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Recorded earthquakes in the vicinity of the proposed dam and the pipeline (Geoscience Australia, 2008)

The surface outcrop of the Precipice Sandstone, the oldest of the Surat Basin sediments, in the vicinity of the dam site at higher levels than adjacent younger Surat Basin sediments suggests that faulting and uplift may have occurred. Nevertheless, there is no obvious surface evidence of faulting.

The major geological structure of the Taroom 1:250,000 map sheet area is the south-plunging Mimosa Syncline (Forbes, 1968). This is a major regional fold which impacts on both the Surat Basin rocks and the underlying Bowen Basin rocks. It formed during the Permian and Triassic so has affected the Bowen Basin rocks more than the Surat Basin sediments (DNR, 1996). The Nathan Dam site lies on the eastern flank of this structure and the major sedimentary units in the area dip very gently to the south-east towards the core of the syncline. There is also a gentle monoclinal fold in the Jurassic age sequence trending along Cockatoo Creek towards Boggomoss Creek and there may be faulting and fracturing associated with this monocline.

There is a sub-surface graben (a downthrown block fault) in the Bowen Basin sequence to the west of the dam site and this structure trends north-west (Paton, 2008). The dominant joint set at the dam site has a north-westerly trend, sub parallel to the graben and Cockatoo Creek monocline and this may reflect re-activation of the earlier structures during post Jurassic deformation. It is likely that Nathan Gorge itself is fault or fracture controlled (DNR, 1996).

All geological units in the vicinity of the dam and the construction area are sedimentary and of Jurassic age or younger, so there is a potential for fossils to be present. Detailed unit descriptions for the Surat Basin sediments occurring in the area generally mention spore and pollen fossils and a number mention plant fragments including fossil wood. Plant fossils are particularly likely to occur in or in association with coal seams but there are no known surface or near-surface coal deposits in the vicinity of the dam site.

Geological mapping does not identify any known fossil localities at or near the dam site. In-filled lithified faunal channels, apparently worm or insect burrows, have been observed in sandstone blocks at the site. These blocks probably come from the Precipice Sandstone and other fossils may occur though none have been observed.

It is possible that fossils of recently-extinct species occur in the Quaternary alluvium in the Dawson River streambed at the dam site. However, this is unlikely because the confined nature of the broad streambed at the site will make the residence time of streambed sediments short in terms of the geological time scale.

Properties of the rocks present at the dam site relevant to the Project and which need to be considered as part of the dam design include:

- rock type – sandstones, siltstones, shales and mudstones are common (Table 6-2);
- degree of weathering – this ranges from extremely weathered to fresh rock; and
- jointing and other weaknesses – vertical and horizontal jointing is present in the rocks at the site (SunWater, unpublished data).

6.1.4.2. Soils

Soils at the Nathan Dam site and in and around the reservoir area have been described and mapped as part of a land systems study (Speck *et al*., 1968) and as part of an agricultural land evaluation study (Forster, 1985). More details of the distribution of soils considered in the Land System study are available in a description of land units in the region

(Gunn and Nix, 1977). Soils in the vicinity of Nathan Dam were described and mapped as part of the Dawson Dam Impact Assessment Study and their suitability for a range of agricultural uses was assessed (Shields, 1997). Observations and additional interpretation of aerial photography as part of this study have resulted in adjustments to the boundaries in the mapping of Shields (1997), extension of the area covered to include riparian areas downstream, and minor additions and adjustments to soil description (Table 6-3, Table 6-4).

Descriptions and analytical data for soils of significance to the Project are given in Appendix 6A. Soil properties of particular relevance to Project works include:

- sodicity and resultant dispersibility of soil materials –a potential problem in some Sodosols, Kurosols and Vertosols;
- shrink-swell potential – a potential problem in Vertosols and some Sodosols;
- salinity – a potential problem in Sodosols and some Vertosols; and
- acidity – a potential problem in the deep subsoils of some Vertosols, in Kurosols, and in some deep sandy soils.

Soil distribution within the vicinity of the dam site may be summarised as:

- broad stream bed adjacent to incised low flow channel – sandy clay loam to light medium clay Rudosols with some Dermosols and Vertosols (layering is usually evident in the lower profiles);
- footslopes and steep slopes on left bank – sandy Rudosols with >50% surface rock, boulder, and stone;
- upper slope and ridge crest on left bank – sandy-surfaced Brown Sodosols and Chromosols and sandy Tenosols with zero to 30% surface coarse gravel and cobble;
- footslopes and lower slopes on right bank – sandy Rudosols and Tenosols with zero to 25% surface rock and boulder; and
- upper slopes and ridge crest on right bank – sandy Tenosols and sandy-surfaced Yellow and Grey Sodosols frequently with up to 20% surface boulder and stone.

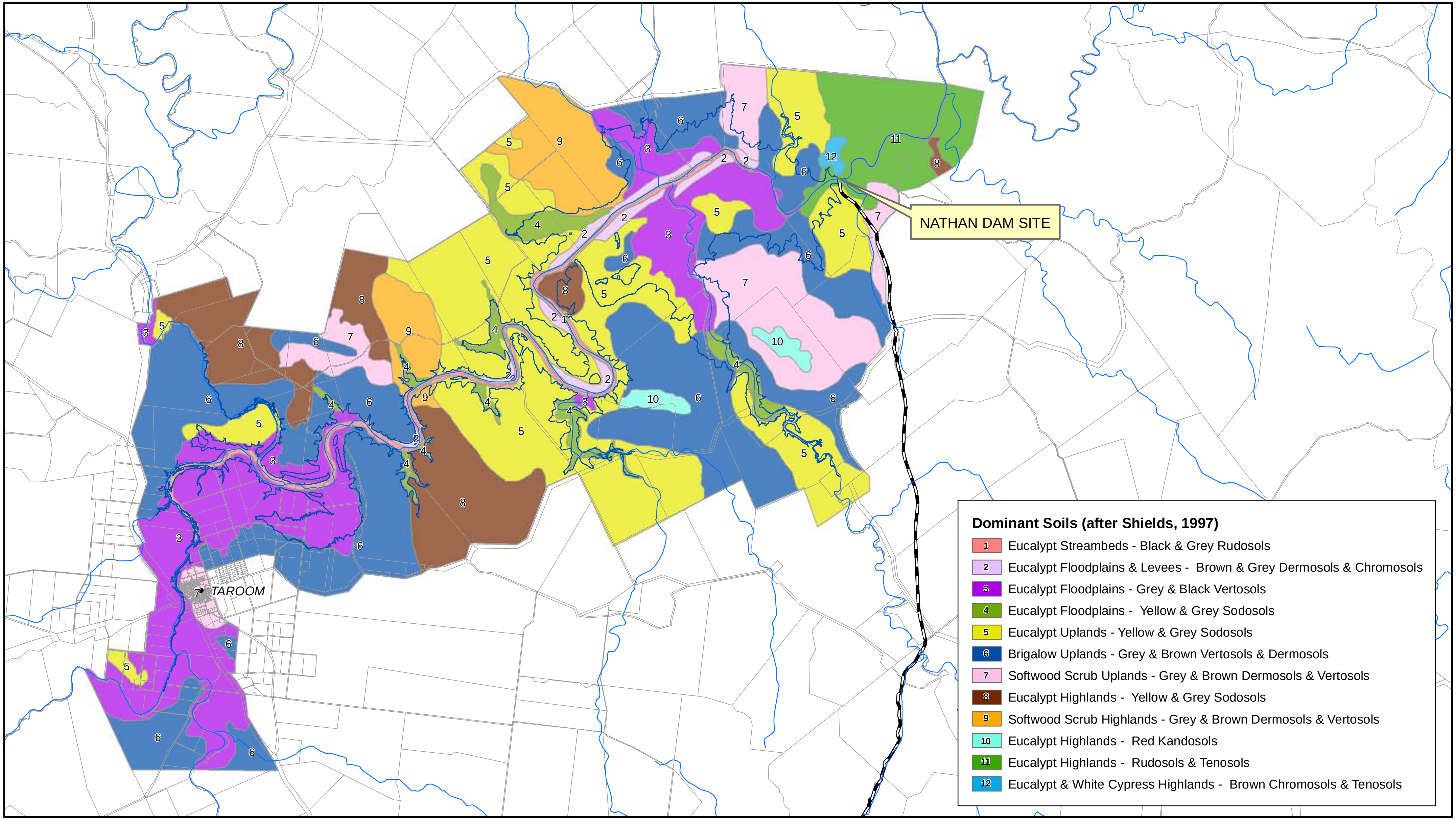
Soil distribution in the streambed and adjacent slopes is similar downstream of the dam site except that, downstream of Price Creek and into Nathan Gorge, the right bank soil landscape is replaced by that on the left bank. Inundation of the river bed by the tailwaters of Gyranda Weir increases with distance downstream from the dam.

Table 6-3 Soil mapping units of the Nathan Dam area (after Shields, 1997)

Soil mapping unit	Dominant soils	Associated soils
Eucalypt Streambeds — Black and Grey Rudosols (layered clay loams and clays)	Soil texture at the surface varies from sandy clay loam to light medium clay. Soil development is usually restricted to weak or occasionally moderate structure in the surface horizon with layering usually evident below approximately 0.3 m	Dark and Grey Dermosols and Vertosols

Soil mapping unit	Dominant soils	Associated soils
Eucalypt Floodplains and Levees — Brown and Grey Dermosols and Chromosols	Soil texture at the surface varies from sandy loam to clay loam to light medium clay, gradually increasing with depth to sandy clay loam in the lighter soils and medium clay in the heavier soils. Soil structure is related to texture with the surface horizon being massive (no natural soil aggregates) in the lighter soils and the heavier soils having moderate structure (at least one-third of the soil mass composed of natural aggregates). All soils are moderately to strongly structured in the subsoil. Soils are moderately well drained and overlie buried alluvial layers below 1 m. Water storage is moderate and fertility is quite high in the virgin state.	Brown, Yellow and Grey Chromosols — These soils have a clear or abrupt boundary between coarser textured surface horizons and finer textured subsoils which are not high in exchangeable sodium and are not strongly acid
Eucalypt Floodplains — Grey and Black Vertosols	These are heavy clay soils that shrink and swell with changing soil water status, developing vertical cracks at the soil surface when dry. They are strongly structured but the size of the aggregates at the surface varies from fine to coarse (self-mulching). The soils are only slowly permeable but have high water storage capacity and high natural fertility.	Yellow and Grey Sodosols
Eucalypt Floodplains — Yellow and Grey Sodosols	Soil texture at the surface varies from sandy loam to sandy clay loam with an abrupt boundary to a yellow or grey medium to heavy clay subsoil. A pale or white band may occur between the surface layer and the clay subsoil. The clay subsoil is coarsely structured (large soil aggregates) with few pores and voids for water and roots to penetrate. As well as being relatively impermeable, the clay subsoil has a high exchangeable sodium percentage making it dispersible and highly erodible if exposed to running water. Water storage capacity is quite low but fertility is moderate where they occur on eucalypt floodplains.	Grey and Black Vertosols
Eucalypt Uplands — Yellow and Grey Sodosols	As for Eucalypt Floodplains — Yellow and Grey Sodosols	Grey and Brown Vertosols, Brown and Yellow Chromosols, occasional Rudosols and Tenosols — these soils have limited soil development and can occur where profile depth is very shallow (less than approximately 0.2 m)
Brigalow Uplands — Grey and Brown Vertosols and Dermosols	Vertosols — Very similar to Grey and Black Vertosols on Eucalypt Floodplains though brown colours are more common. Total soil depth is often shallower (<1.5 m) where soils overlie sedimentary rocks. They are only slowly permeable but have a high water storage capacity and high fertility in the virgin state (most common). Dermosols — Soil texture at the surface varies from clay loam to light clay and gradually increases to medium-heavy clay at depth. Soil structure is moderate to strong throughout the profile with fine to medium aggregate sizes. Total profile depth can be <1 m where the soils overlie sedimentary rocks. The soils have moderate permeability and water storage capacity varies from moderate in very shallow profiles to high in deeper soils. Natural fertility is high	Yellow and Grey Sodosols, occasional Rudosols and Tenosols
Softwood Scrub Uplands — Grey and Brown Dermosols and Vertosols	Dermosols — As for Dermosols in Brigalow Uplands unit (most common) Vertosols — As for Vertosols in Brigalow uplands unit	Occasional Rudosols and Tenosols

Soil mapping unit	Dominant soils	Associated soils
Eucalypt Highlands — Yellow and Grey Sodosols	As for Eucalypt Floodplains — Yellow and Grey Sodosols	Grey and Brown Vertosols, occasional Rudosols and Tenosols
Softwood Scrub Highlands — Grey and Brown Dermosols and Vertosols	Dermosols — As for Dermosols in Brigalow Uplands unit (most common) Vertosols — As for Vertosols in Brigalow uplands unit	Occasional Rudosols and Tenosols
Eucalypt Highlands — Red Kandosols	Soil texture at the surface is sandy loam to sandy clay loam and this gradually increases to light clay in the subsoil. The soils are massive with few, if any, natural soil aggregates and have a typical 'earthy' appearance. Total profile depth is generally greater than 2 m. The soils have high permeability, low water storage capacity and very low natural fertility	Occasional Rudosols and Tenosols
Eucalypt Highlands — Rudosols and Tenosols	These soils have limited soil development and can occur where profile depth is very shallow (less than approximately 0.2 m)	Brown Chromosols
Eucalypt and White Cypress Highlands — Brown Chromosols and Tenosols	These soils have a clear or abrupt boundary between coarser textured surface horizons and finer textured subsoils which are not high in exchangeable sodium and are not strongly acid	Tenosols and Rudosols



LEGEND

- Towns
- Proposed Pipeline
- Watercourses
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 6-4

0 2 4 8
Kilometres

N

Scale 1:250,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Dominant soils in the vicinity of the water storage

The *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI, 1993) classify land into the following four classes:

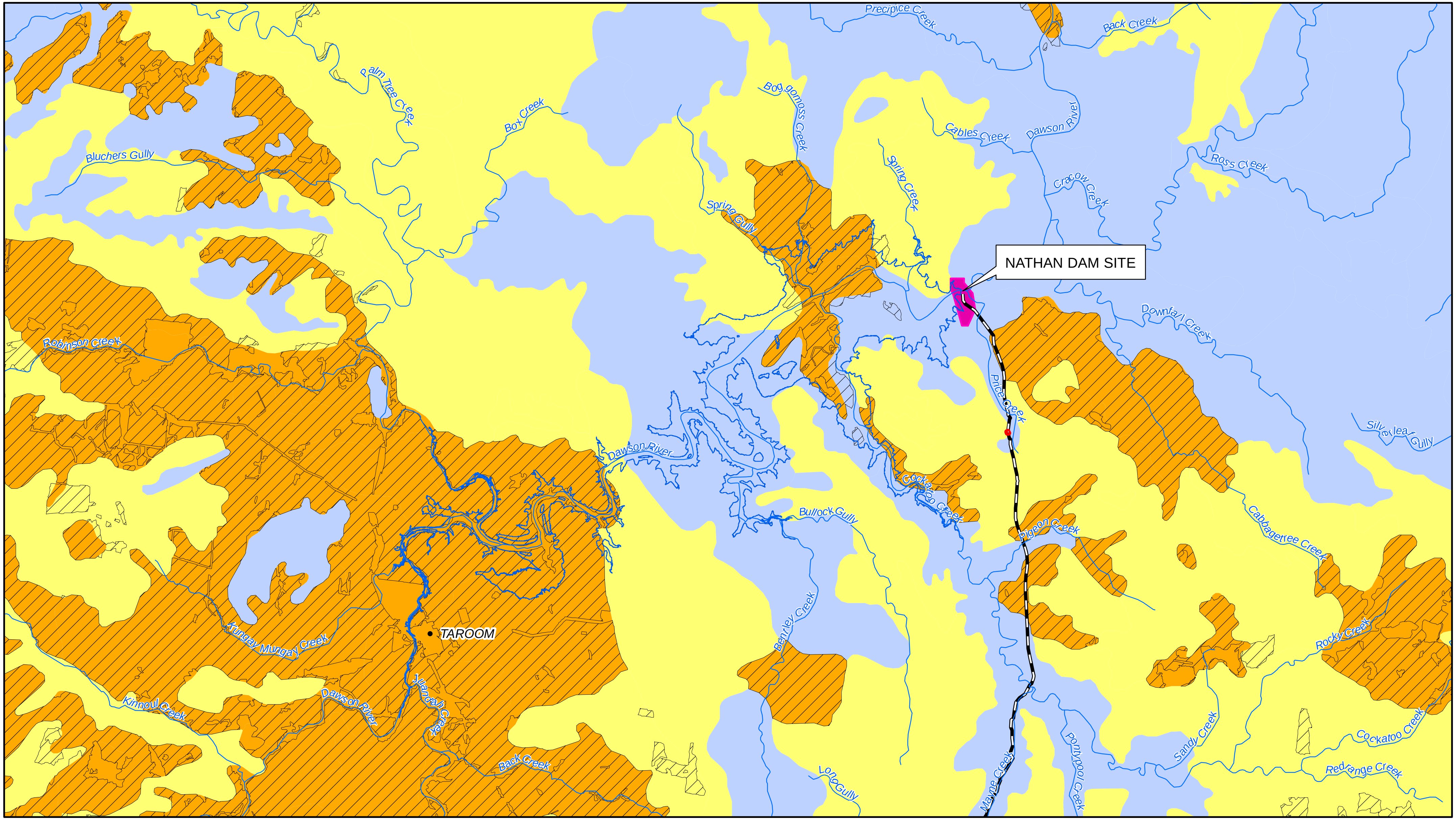
- **Class A – Crop Land** – Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels;
- **Class B – Limited Crop Land** – Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping;
- **Class C – Pasture Land** – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas many tolerate a short period of ground disturbance for pasture establishment; and
- **Class D – Non-agricultural Land** – Land that is not suitable for agricultural uses, including undisturbed land with significant habitat or areas with severe limitations precluding agricultural production.

Class A land is always considered as GQAL. Class D is never considered as GQAL. Local planning schemes identify whether Class B or C are considered as GQAL within the local government area. Classes A, B and C are mapped as GQAL within the Taroom Planning Scheme.

Figure 6-5 illustrates the areas classified as GQAL within the water storage area. Including islands, there is approximately 5,981 ha of Class A, 1,589 ha of Class B and 6,254 ha of Class C land.

Figure 6-5 also presents the trigger layer for Strategic Cropping Land Areas. Approximately 33% of the water storage is classed as Strategic Cropping Land, encompassing most of the Class A and some of the Class B land.

The dam construction footprint (excluding the water storage) includes approximately 4 ha of Class B and 210 ha of Class C land. No Class A or Strategic Cropping Land is located within the dam construction footprint.



LEGEND

- • Towns
- Proposed Pipeline
- Watercourses
- Full Supply Level (183.5m AHD)
- Strategic Cropping Land (Trigger Layer)
- Dam Construction Footprint
- Balancing Storages

Agricultural Land Class

- Class A
- Class B
- Class C

Projection: GDA94 Zone 56

Figure 6-5

0 2.5 5 10
Kilometres
N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

GQAL in the inundation and buffer

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\060_Geology_Soils\Figure_6-5_GQAL_Inundation_and_Buffer.mxd Produced: 9/6/2011

6.1.5. Pipeline

6.1.5.1. Geology

The most common geological units along the pipeline are (**Figure 6-6**):

- Quaternary alluvium – this is most commonly clay, particularly in the portions of the route east of Miles;
- Chinchilla Sand – this unit is predominantly sand grading into granule conglomerate and sandy clay and it occurs south-east of Chinchilla;
- Kumbarilla Beds – this unit is predominantly sandstone, siltstone and mudstone and the main occurrences are between the Great Dividing Range and Chinchilla;
- Injune Creek Group – this unit is predominantly comprised of calcareous lithic sandstone, siltstone and mudstone and occurs from approximately 38 km north-north-east of Wandoan almost to the Great Dividing Range, interrupted by minor areas of Quaternary alluvium;
- Hutton Sandstone – this unit is predominantly coarse-grained and occurs from Cockatoo Creek south to approximately 38 km north-north-east of Wandoan; and
- Evergreen Formation – this unit is predominantly comprised of labile and sublabile sandstone, carbonaceous mudstone, and siltstone and occurs from north of Cockatoo Creek almost to the dam site.

More detail of the geological units along the pipeline between Nathan Dam and the Great Dividing Range (Nathan Dam catchment) are given in **Table 6-1** while details of units occurring in the vicinity of the pipeline but outside the Nathan Dam catchment shown in **Figure 6-6** are given in **Table 6-4**.

Table 6-4 Geological units along the Nathan Dam to Dalby pipeline that only occur outside the Nathan Dam catchment

Unit code	Unit name or description	Lithology	Age[1]
Czcch	Chinchilla Sand	Fluviatile labile sand grading into granule conglomerate and sandy clay, some pebbles	Pliocene
Pok	Blackwater Group	Sandstone, siltstone, shale, mudstone, coal, tuff conglomerate	Late Permian

Based on records obtained from the Geoscience Australia Earthquake Database (Geoscience Australia, 2008), areas in the vicinity of the pipeline have experienced very minor earthquakes in recent years but historically there have been no earthquakes of appreciable magnitude.

The closest earthquakes to the pipeline were a Magnitude 2.5 event, approximately 22 km north-east of the northern end of the pipeline and a Magnitude 2.2 event approximately 18 km north of Miles (**Figure 6-3**).

The pipeline lies within an intermediate hazard zone with a 10% chance of an acceleration coefficient of 0.06 - 0.08 being exceeded in 50 years. Earthquake hazard is greater in areas that are built on unconsolidated sediments so that, in general, hazard is more significant in areas south of the Great Dividing Range where such sediments are common along the route.

The only faults or similar structures identified in broad scale geological mapping along the pipeline are in the vicinity of the Great Dividing Range (Exon *et al*., 1971). Four faults cross the route as it follows the Leichhardt Highway and there are other faults adjacent in this area. Two of the faults that cross the route run north-east to south-west while two run north-west to south-east. There is no evidence of recent activity along these faults.

All geological units along the pipeline are sedimentary and of Jurassic age or younger so that there is a potential for fossils to be present. Detailed unit descriptions for the Surat Basin sediments occurring along the route generally mention spore and pollen fossils and a number mention plant fragments. Plant fossils are particularly likely to occur in or in association with coal seams but there are no known surface or near-surface coal deposits likely to be disturbed by pipeline construction. The fossil dinosaur *Rhoetosaurus brownei* was discovered in Surat Basin sediments, probably of the Injune Creek Group, approximately 90 km west of Wandoan and the pipeline crosses this geological unit for some distance north and south of Wandoan so that there is a small probability that Jurassic fossils occur along the route.

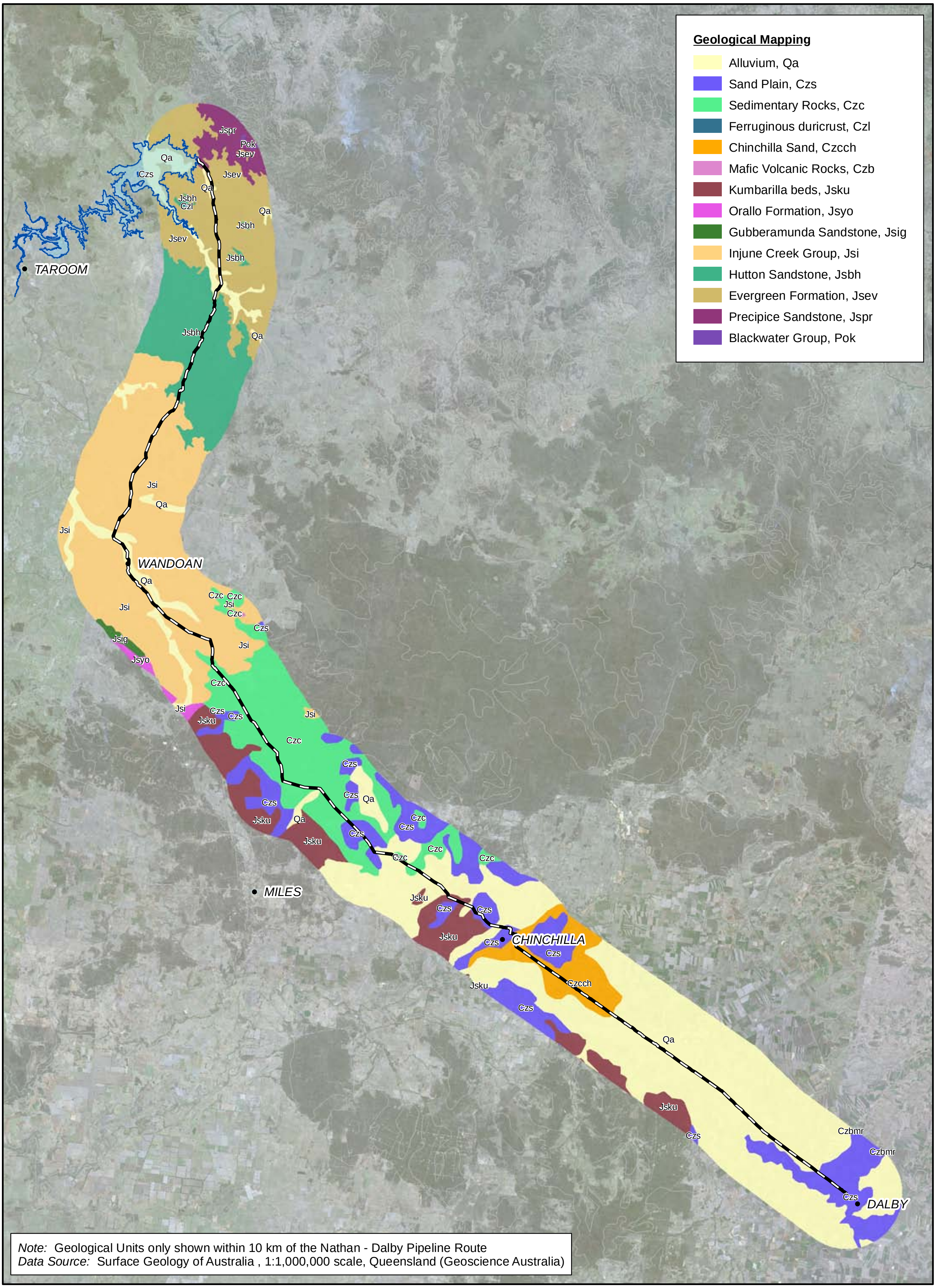
Geological mapping (Whitaker *et al*., 1980; Exon *et al.*, 1971) identifies three fossil localities within along the pipeline as follows:

- a macrofossil locality is shown in the Jlo component of the Evergreen Formation just south of Pigeon Creek;
- a plant fossil locality just north of the Great Dividing Range in the Jlo (Orallo Formation) unit; and
- three vertebrate fossil localities in the vicinity of the Condamine River between 1 km and 2 km south of the route in the Czcch (Chinchilla Sand) unit.

The pipeline passes within 600 m of the boundary to the Chinchilla Sands Local Fossil Fauna Site (Figure 6-7) which is listed in the Australian Heritage Database (DEWHA, 2009). This Local Fossil Site includes one of the localities in the Chinchilla Sand geological unit mentioned above and is located to the south of the Warrego Highway on the eastern outskirts of Chinchilla. The site, as listed, is a wedge-shaped block running from the blade of the wedge on the highway to the Condamine River approximately 2.5 km to the south. It provides a relatively complete Pliocene faunal assemblage including molluscs, frogs, bony fishes, reptiles, birds, and mammals. It is considered a highly significant Australian fossil site.

Geological mapping identifies fossil sites in the vicinity of the river but none adjacent to the highway and the Australian Heritage Database notes that the fossil beds of the site lie towards the Condamine River.

In addition to the above, plant fossils were observed in sandstone of the Hutton Sandstone unit along the pipeline on Nathan Road in the vicinity of the Maidens Road intersection (approximately 56J 208810E 7143810N).



LEGEND

- Towns
- Proposed Pipeline
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 6-6

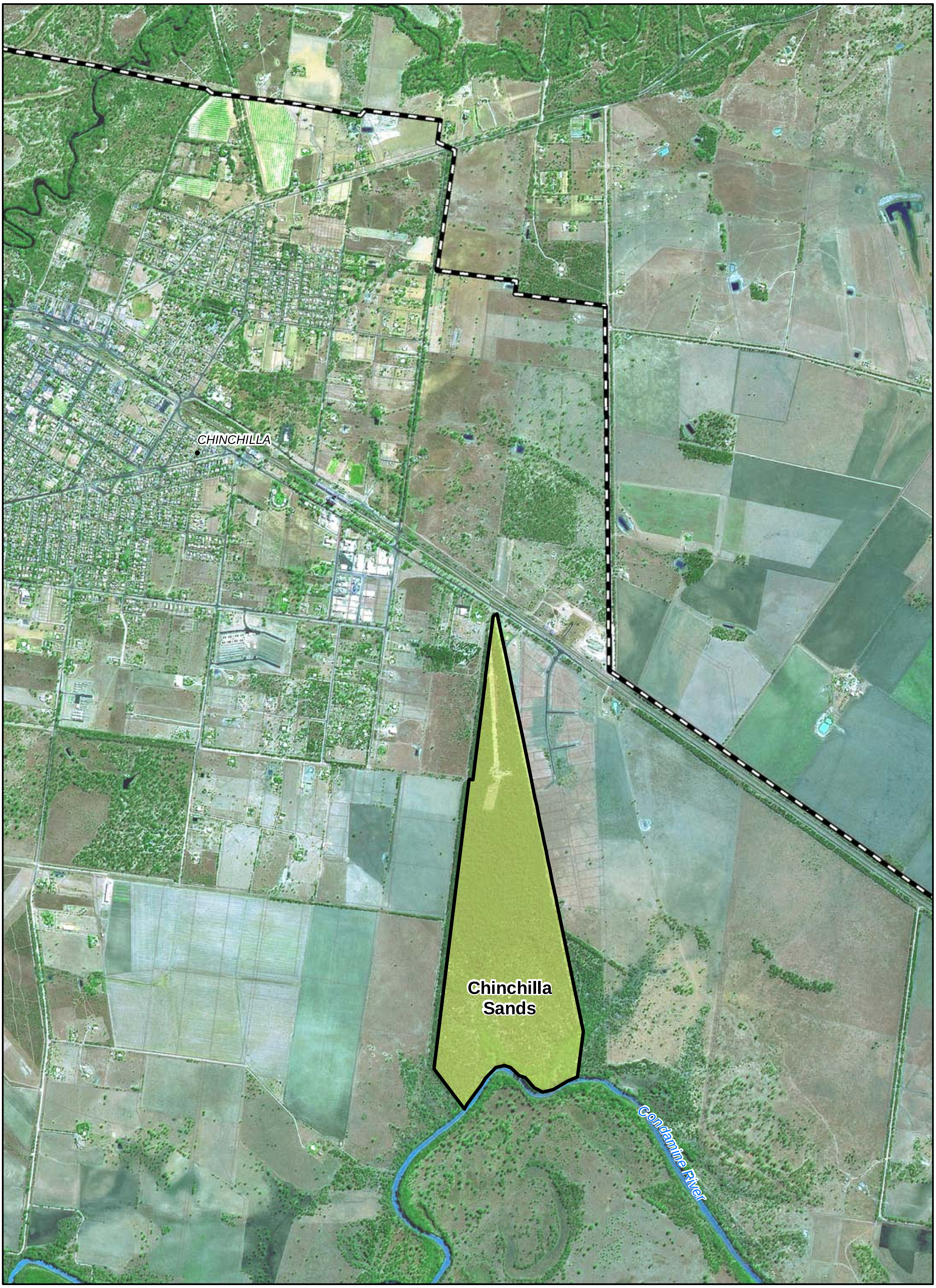
0 5 10 20
Kilometres
N

Scale 1:900,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Geology along the pipeline from Nathan Dam to Dalby



LEGEND

- Towns
- Proposed Pipeline
- Watercourse
- Chinchilla Sands
- Cadastre

Projection: GDA94 Zone 56

Figure 6-7

0 250 500 1,000
Metres
N

Scale 1:30,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Location of Chinchilla Sand Local Fossil Fauna Site in relation to pipeline

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\060_Geology_Soils\Figure_6-7_ChinchillaSand_Local_Fossil_FaunaSite_Pipeline.mxd Produced: 9/06/2011

6.1.5.2. Soils

Soils along the pipeline from Nathan Dam to Dalby have been described and mapped on the basis of Land Resource Areas (LRAs) (Table 6-5, Table 6-6, Table 6-7, Figure 6-8 and Figure 6-9). More detail on the soils is given in Appendix 6A.

As discussed in Section 6.1.4.2, the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI, 1993) classify land into the following four classes based on their suitability for agricultural production. Class A land is always considered as GQAL while Class D land is never considered as GQAL. Local planning schemes identify whether Class B or C are considered as GQAL within the local government area. The pipeline corridor traverses areas covered by five Planning Schemes still in force from the previous Local Government Areas of Taroom, Chinchilla, Murilla, Wambo and Dalby Town. Further information on these Planning Schemes can be found in Chapter 7. Classes A, B and C are mapped as GQAL within the Taroom Planning Scheme. Classes A and B are mapped within the Chinchilla, Murilla and Wambo Planning Schemes. Only Class A land is mapped as GQAL within the Dalby Planning Scheme.

Along its length, the pipeline traverses GQAL as follows:

- 347 ha is situated on areas mapped as Class A GQAL;
- 175 ha is situated on areas mapped as Class B GQAL; and
- 91 ha is situated on areas mapped as Class C GQAL.

The remainder of the pipeline corridor is located on land not mapped as GQAL within local planning schemes.

Approximately 46% of the pipeline corridor is classed as Strategic Cropping Land, encompassing most of the Class A and some of the Class B land. Figure 6-11 to Figure 6-13 illustrate the areas classified as GQAL and SCL within the pipeline corridor.

The balancing storages are located on land that includes approximately 5.9 ha Class A, 1.2 ha Class B and 24.2 ha Class C land but no SCL.

Table 6-5 Land Resource Areas occurring in the vicinity of the pipeline from Nathan Dam to the Great Dividing Range (after Forster, 1985)

Land resource area	Dominant soils	Associated soils
1 — Coolabah	Predominantly Black and Grey Vertosols, moderate to high surface fertility, moderate to high soil water storage, some saline and sodic deeper subsoils	Brown Vertosols and Sodosols
3 — Juandah	Predominantly deep Sodosols, low surface fertility, moderate water storage and saline subsoils,	Grey and Brown Vertosols
5 — Montana	Moderately deep Sodosols and Grey Vertosols, low surface fertility, moderate soil water storage, saline and sodic subsoils	Shallow Sodosols and Tenosols on sandstone on rises
7 — Tara	Predominantly deep Grey Dermosols and Grey Vertosols, moderate to high surface fertility, moderate to high soil water storage, sodic subsoils	Brown Vertosols and Sodosols
8 — Wandoan	Moderately deep Grey , Brown and Black Vertosols,	Shallower soils on crests and steep

Land resource area	Dominant soils	Associated soils
8 — Wandoan	Moderately deep Grey , Brown and Black Vertosols, moderate to high fertility, high soil water storage for deeper profiles and some saline and sodic subsoils	Shallower soils on crests and steep upper slopes, sometimes with rock and stone
10 — Hawkswood	Moderately deep Red Kandosols and shallow gravelly Yellow Kandosols, low surface fertility, low to moderate soil water storage	Kurosols and Sodosols
11 — Duaringa	Shallow Tenosols, Kandosols and Rudosols, low fertility and soil water storage	Sodosols and stony Brown Vertosols
13 — Mundell	Shallow Grey, Brown and Black Vertosols and Dermosols, moderate to high fertility and moderate soil water storage	Similar to dominant soils but with stone
14 — Narran[2]	Shallow Sodosols and Rudosols on quartzose sandstone, low surface fertility, low soil water storage	Rudosols and shallow, stony Grey and Brown Vertosols
15 — Glenhaughton	Shallow Sodosols and Kurosols, low surface fertility, low soil water storage	Rudosols and Tenosols
16 — Nathan	Shallow Rudosols and Tenosols, low surface fertility, low soil water storage	Sodosols and Kurosols

Table 6-6 Land resource areas occurring in the vicinity of the pipeline from the Great Dividing Range to just west of Warra (after Maher, 1995; Maher, 1996)

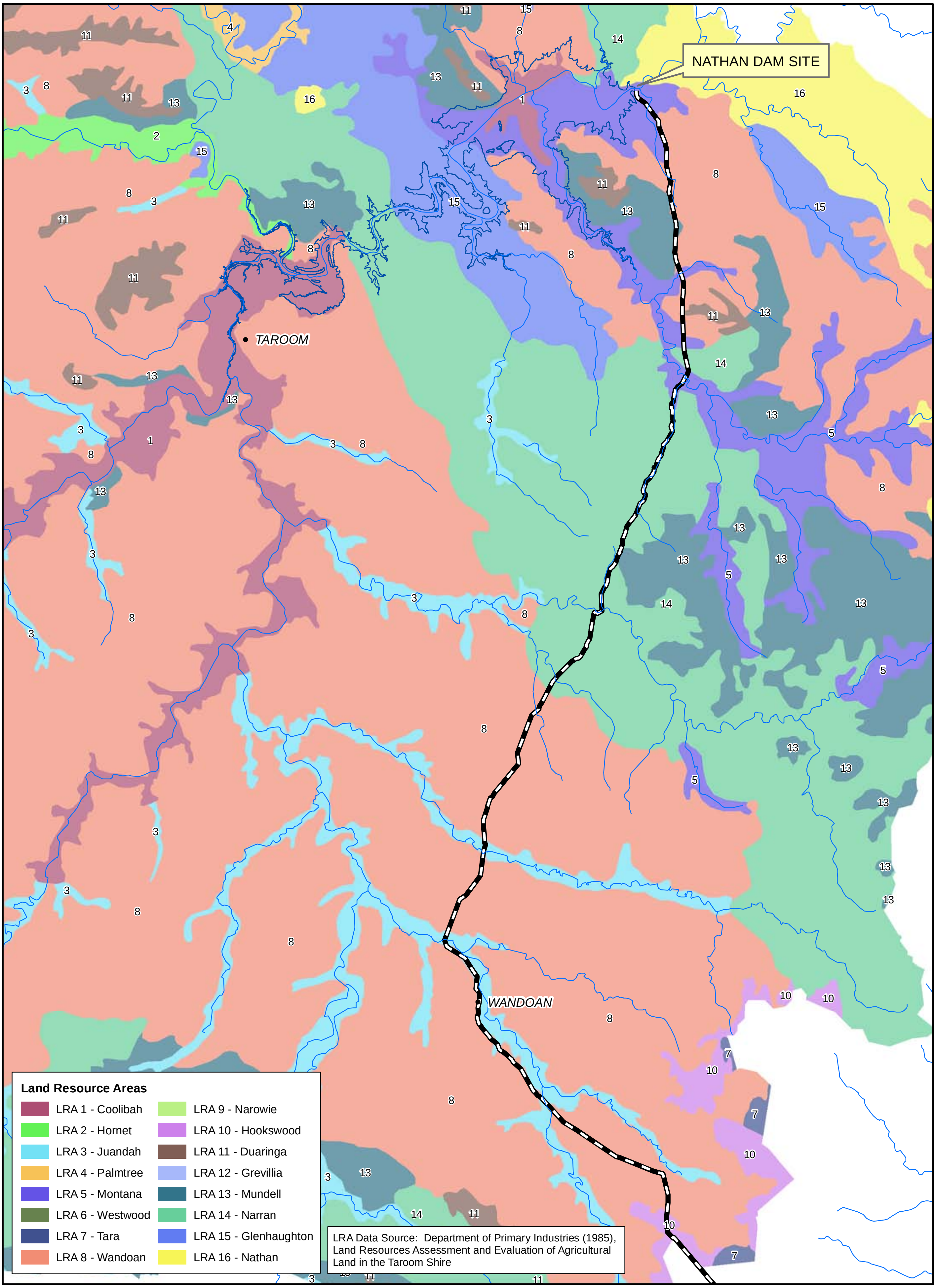
Land resource area	Dominant soils	Associated soils
Clay alluvial plains		
1a	Predominantly deep Dark or Grey Vertosols with self-mulching or sealing surfaces, moderate to high surface fertility, low to moderate soil water storage, sodic subsoils	Shallow and deep-surfaced Brown, Dark or Yellow Chromosols and Sodosols and deep Red or Brown Tenosols
1b	Predominantly deep Dark or Grey Vertosols with self-mulching or sealing surfaces, moderate to high surface fertility, low to moderate soil water storage, sodic subsoils	Shallow-surfaced Brown, Dark or Grey Sodosols and deep Red Tenosols
1c	Predominantly Grey or Dark Vertosols with sealing surfaces, low to moderate surface fertility, low to moderate soil water storage, sodic subsoils	Shallow-surfaced Dark or Grey Sodosols
Poplar box alluvial plains		
2b	Moderately deep-surfaced and shallow-surfaced mottled Brown Kurosols and Sodosols, low surface fertility, low soil water storage, saline and sodic subsoils	Deep-surfaced mottled Grey, Brown and Yellow Kurosols, Chromosols and Sodosols and deep Brown and Red Tenosols
Cypress pine sands		
3a	Deep Red and Brown Tenosols and deep-surfaced Brown Chromosols, low to moderate surface fertility, low to moderate soil water storage	Thin-surfaced Brown, Dark or grey Sodosols
Brigalow plains		
4a	Gilgaied Grey or Black Vertosols, low to moderate surface fertility, low to moderate soil water storage, saline and sodic subsoils	Deeply gilgaied Grey Vertosols and thin-surfaced Brown, Grey or Dark Sodosols
4b	Deeply gilgaied Grey Vertosols, moderate surface fertility, moderate soil water storage, saline and sodic subsoil	Gilgaied Grey or Dark Vertosols and thin-surfaced Dark or Grey Sodosols

Land resource area	Dominant soils	Associated soils
Ironbark / bull oak forests		
7a	Moderately deep-surfaced and shallow-surfaced mottled Brown Kurosols and Sodosols, low surface fertility, low soil water storage, saline and sodic subsoils	Thin-surfaced Grey and Brown Sodosols, thin-surfaced yellow and Brown Kurosols and Brown Tenosols
Poplar box rises		
8a	Thin-surfaced Brown, Black and Grey Sodosols, low surface fertility, low soil water storage, saline and sodic subsoils, very saline deep subsoils	Moderately deep-surfaced Yellow and Brown Kurosols and Red Chromosols
Light forests		
9a	Shallow Red Rudosols and Tenosols, low surface fertility, very low soil water storage	Thin-surfaced Brown Kurosols
9b	Shallow Red Rudosols and Tenosols, low surface fertility, very low soil water storage	Shallow Kurosols

Table 6-7 Land resource areas occurring in the vicinity of the pipeline from just west of Warra to Dalby (after Harris *et al*.,1999; Maher 1998)

Land resource area	Dominant soils	Associated soils
Recent alluvial plains		
1A	Predominantly deep Dark or Grey Vertosols with self-mulching or coarse-structured surfaces, moderate to high surface fertility, low to moderate soil water storage, sodic subsoils	Shallow-surfaced Dark Sodosols
1B	Predominantly deep Dark or Grey Vertosols with self-mulching or sealing surfaces, moderate to high surface fertility, low to moderate soil water storage, sodic subsoils	Shallow-surfaced Dark Sodosols
Older alluvial plains		
2A	Predominantly Dark Vertosols with fine self-mulching surfaces, moderate surface fertility, high soil water storage, deep subsoil may be saline and sodic	Deep Dark or Grey Vertosols with self-mulching or coarse-structured surfaces
2B	Predominantly Grey or Black Vertosols with sealing surfaces, low to moderate surface fertility, low to moderate soil water storage, sodic subsoils	Dark or Grey Vertosols with self-mulching surfaces and shallow-surfaced Sodosols
Loamy Sodosols		
3A	Thin-surfaced Brown, Dark and Grey Sodosols, moderate surface fertility, low to moderate soil water storage	Moderately deep-surfaced Yellow and Brown Kurosols and Red Chromosols
Alluvial plains – sandy Sodosols		
4A	Shallow-surfaced Dark, Yellow or Brown Sodosols, moderate surface fertility, low soil water storage, saline subsoils	Hard setting Grey Vertosols and Red Tenosols
Brigalow plains		
5A	Gilgaied Grey or Dark Vertosols, low to moderate surface fertility, low to moderate soil water storage, saline and sodic subsoils	Deeply gilgaied Grey Vertosols and thin-surfaced Brown, Grey or Dark Sodosols

Land resource area	Dominant soils	Associated soils
Brigalow uplands		
6A	Shallow gilgaied, self-mulching Grey-Brown Vertosols, low to moderate surface fertility, low to moderate soil water storage, saline and sodic subsoils	Red and Brown Dermosols, shallow surfaced Brown Chromosols and Brown Tenosols
6D	Moderately deeply gilgaied, self-mulching Dark, Brown or Grey Vertosols and shallow-surfaced Brown Sodosols, low to moderate surface fertility, moderate soil water storage, saline and sodic subsoils	Red-Brown Vertosols
Basaltic uplands		
7A	Self-mulching Brown to Dark Vertosols, moderate surface fertility, high soil water storage	Shallow and very shallow Brown and Dark Vertosols
Poplar box Sodosols		
9A	Shallow-surfaced Black, Yellow or Brown Sodosols, moderate surface fertility, low soil water storage, saline subsoils	Thin-surfaced Dark or Brown Sodosols
Ironbark / bull oak Sodosols		
10A	Thin-surfaced, mottled, Yellow and Grey Sodosols, low surface fertility, low soil water storage, saline deep subsoils	Thin-surfaced Brown Chromosols and Kurosols



LEGEND

- Towns
- Proposed Pipeline
- Watercourse
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 6-8

0 2.5 5 10
Kilometres

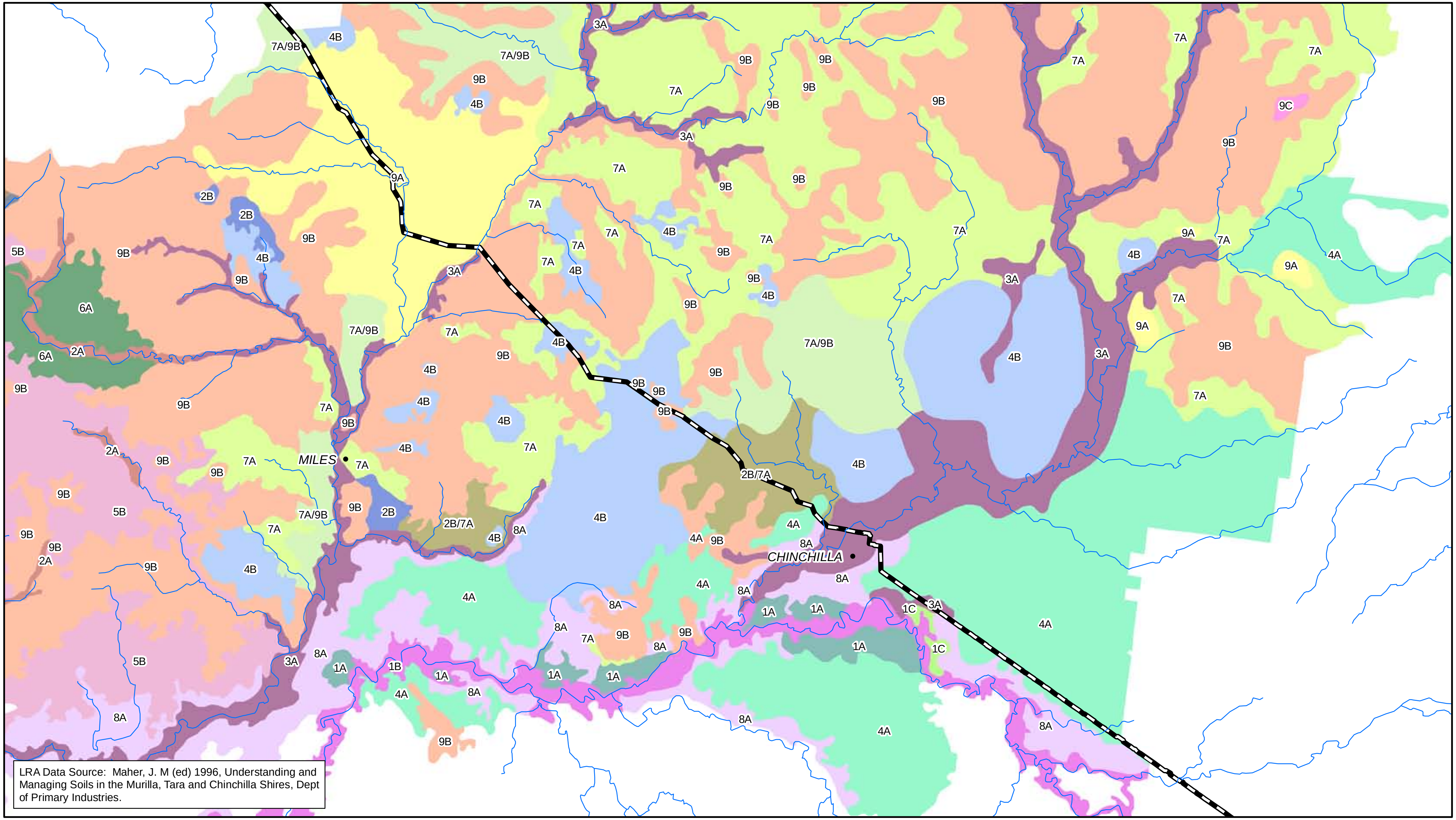
N

Scale 1:400,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Land resource areas in the vicinity of the pipeline from Nathan Dam to the Great Dividing Range (after Forster, 1985)



LEGEND

- • Towns
- Proposed Pipeline
- Watercourse

Land Resource Areas

1A	2B	4B	7A	9A
1B	2B/7A	5B	7A/9B	9B
1C	3A	6A	7B	9C
2A	4A	6A/7B	8A	

Projection: GDA94 Zone 56

Figure 6-9

0 2 4 8
Kilometres

N

Scale 1:450,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Land resource areas in the vicinity of the pipeline from the Great Dividing Range to Warra (after Maher, 1998)

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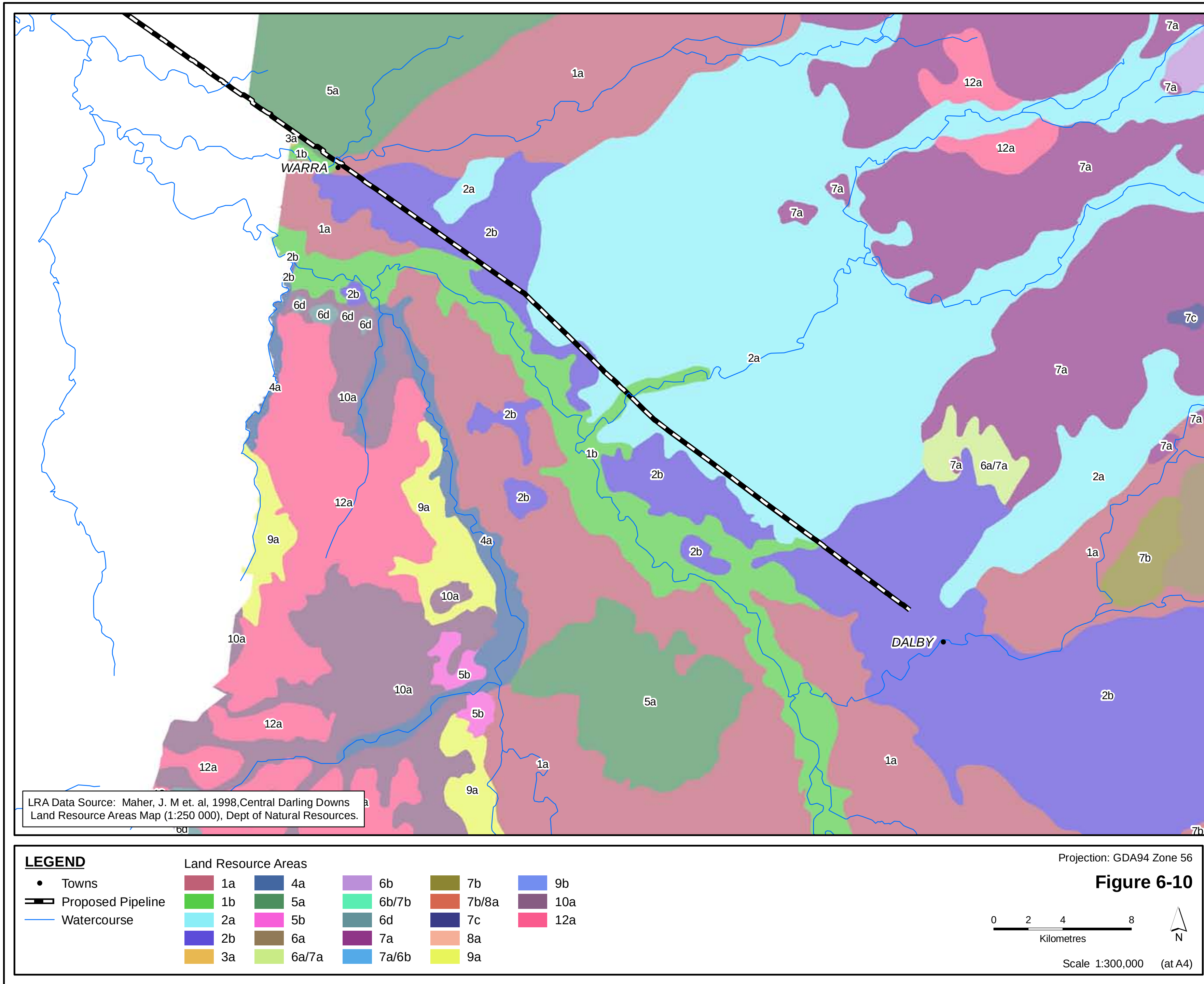

Figure 6-10

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Land resource areas in the vicinity of the pipeline from Warra to Dalby (from Maher, 1998)

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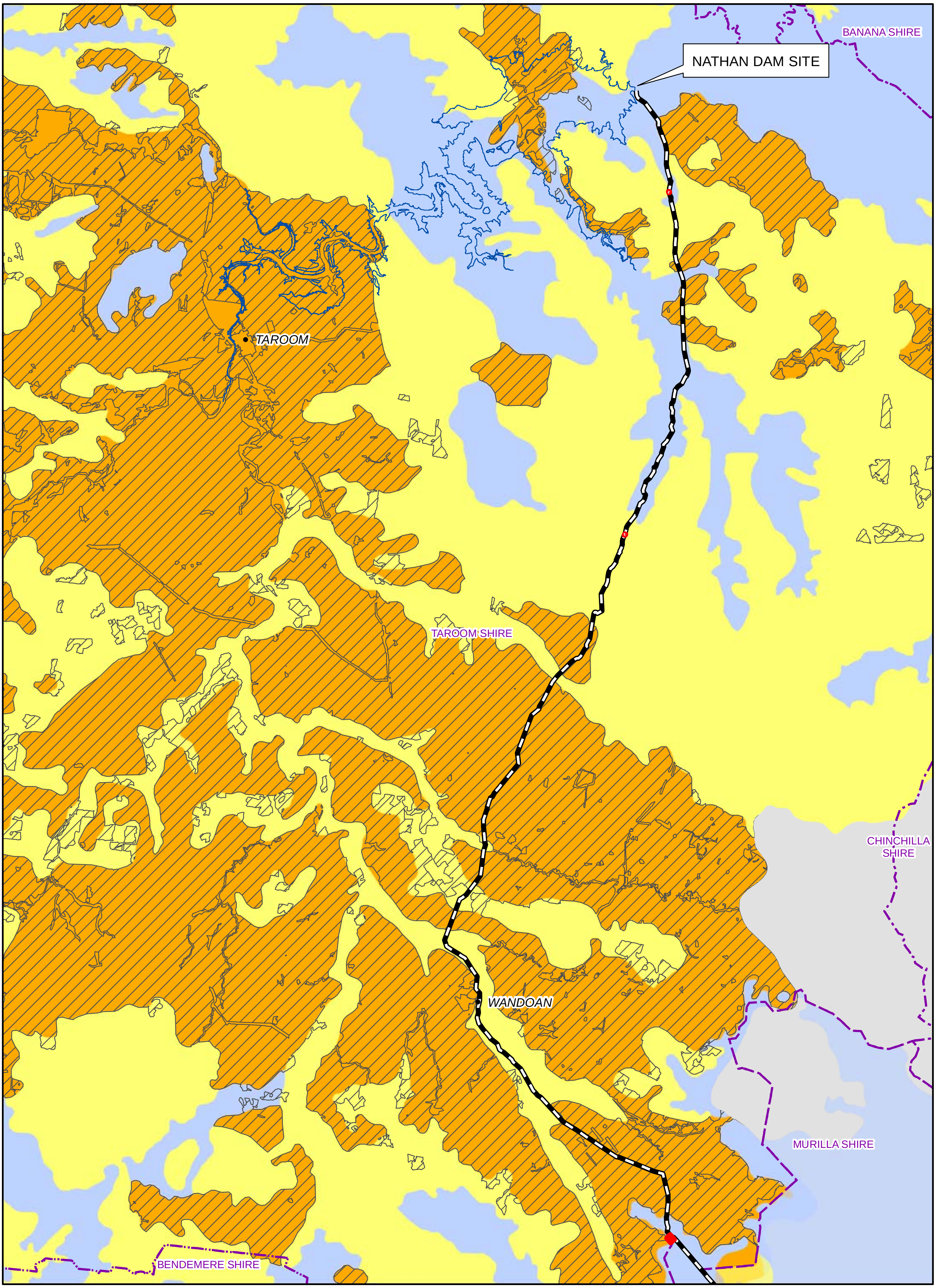


LEGEND

- Towns
- Proposed Pipeline
- Full Supply Level (183.5m AHD)
- Previous LGA Boundaries
- Strategic Cropping Land (Trigger Layer)
- Balancing Storages

Agricultural Land Class

- Class A
- Class B
- Class C
- Class D
- No Data

Projection: GDA94 Zone 56

Figure 6-11

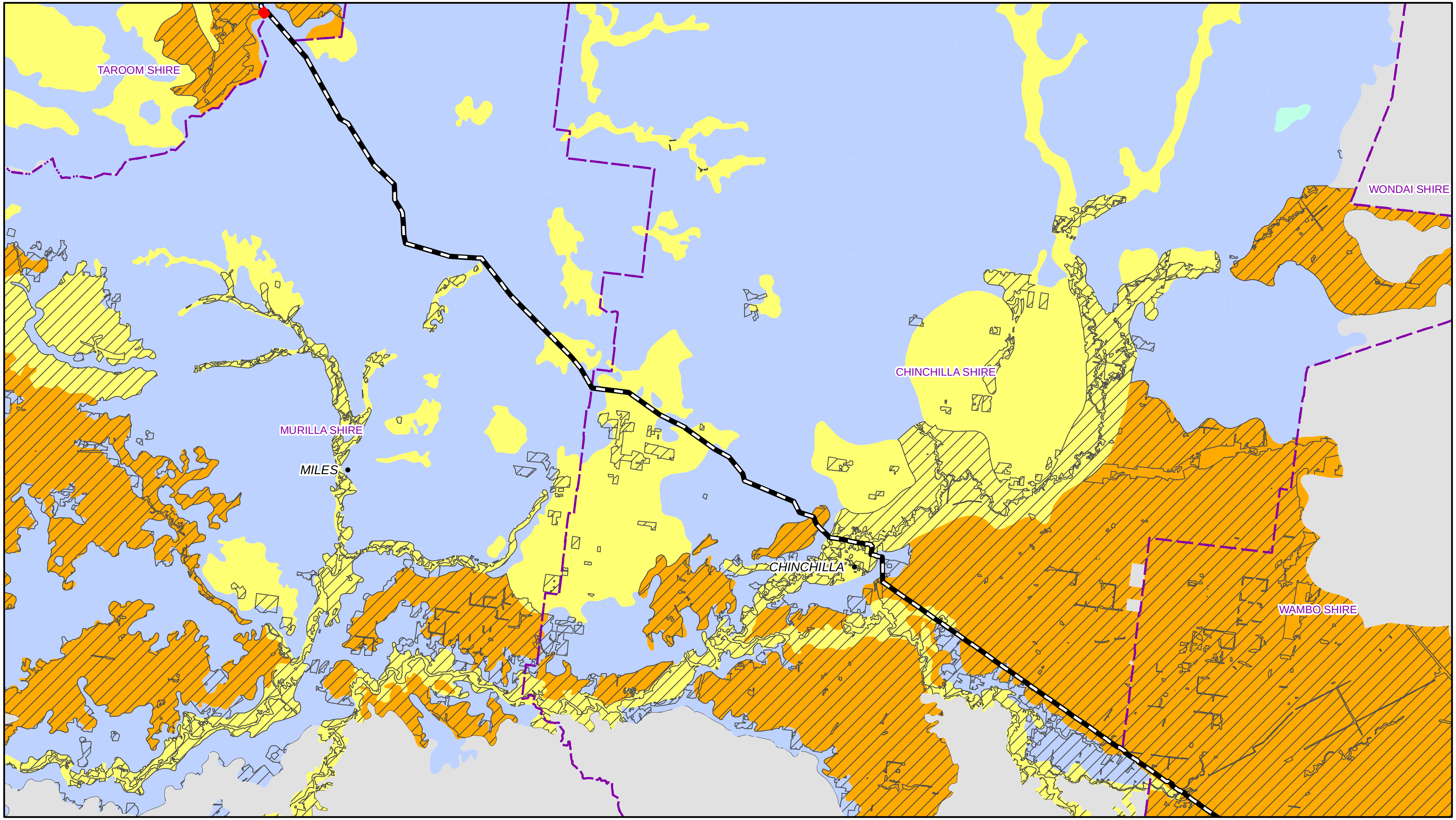
0 2.5 5 10
Kilometres
N

Scale 1:400,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

GQAL in the vicinity of the pipeline from Nathan Dam to the Great Dividing Range



LEGEND

- Towns
- Proposed Pipeline
- Previous LGA Boundaries
- Strategic Cropping Land (Trigger Layer)
- Balancing Storages

Agricultural Land Classes

- Class A
- Class B
- Class C
- Class D
- No Data

Projection: GDA94 Zone 56

Figure 6-12

0 2 4 8
Kilometres

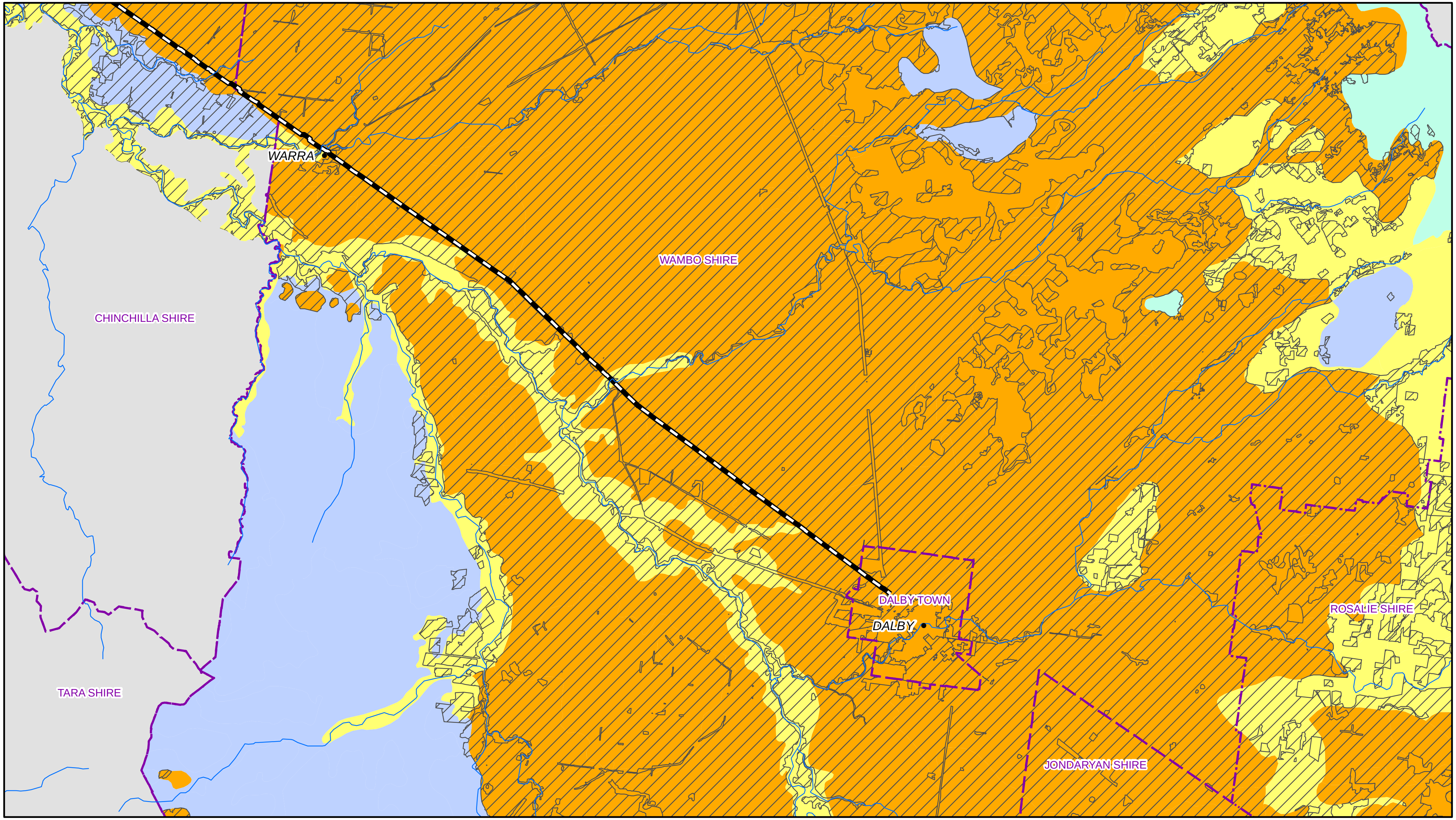
N

Scale 1:450,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

GQAL in the vicinity of the pipeline from the Great Dividing Range to Warra



LEGEND

- Towns
- Proposed Pipeline
- Previous LGA Boundaries
- Strategic Cropping Land (Trigger Layer)

Agricultural Land Class

- Class A
- Class B
- Class C
- Class D
- No Data

Projection: GDA94 Zone 56

Figure 6-13

0 2 4 8
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

GQAL in the vicinity of the pipeline from Warra to Dalby

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6.1.6. Associated infrastructure

6.1.6.1. Geology

Nine potential clay burrow areas are located within close proximity of the dam site (Figure 2-8) and within the water storage. The local roads identified in Section 2.2.3.1, excluding Spring Creek Road extension are also located within the water storage. The dam site and water storage area are underlain by Jurassic sandstone formations though these contain shale, siltstone, mudstone and pebble conglomerate beds. Almost all of the rock is weathered near the surface and covered by a thin veneer of soil or a thicker veneer of Quaternary alluvium. There are appreciable rock exposures at the dam site for approximately 0.3 km upstream on the left bank and on steeper areas on or adjacent to both banks of the Dawson River between approximately 334 km AMTD and approximately 366 km AMTD.

Geology along most of the route of the proposed Spring Creek Road extension to the dam site is sub-unit one (Je_1) of the Evergreen Formation. This unit is mostly comprised of sandstone and mudstone. Depending on the exact location of the route, there may be narrow, shallow alluvial deposits along the unnamed gully and along Spring Creek. As the route approaches the dam site, it enters an area mapped as Precipice Sandstone (Jp). This unit is dominated by sandstone but it does contain granule conglomerate. There are rounded surface and near-surface coarse gravel and cobble along parts of the route in the Precipice Sandstone unit and these materials are probably a lag deposit from weathering and erosion of a conglomerate.

6.1.6.2. Soils

Soils have been described and mapped on the basis of Land Resource Areas (Table 6-3, Table 6-4, and Figure 6-4). Section 6.1.4.2 and Section 6.1.5.2 provide further information on soil types. The road upgrade areas are located on land that includes approximately 21 ha of Strategic Cropping Land.

6.2. Potential impacts and mitigation measures

This section discusses potential impacts and mitigation measure associated with the construction and operation phases of the Project, further details are provided in respect to topography and geomorphology (Chapter 4) and fluvial geomorphology (Chapter 14) .

6.2.1. Dam site and storage area

6.2.1.1. Geology

Construction works, rock handling at the dam site, water storage and release/extraction should have no adverse consequences for the geological environment provided that:

- work areas and temporary stockpiles that include highly weathered sandstones or mudstones, shales and siltstones are surrounded by sediment barriers that direct runoff into sedimentation ponds;
- any areas of highly weathered sandstones or mudstones, shales and siltstones exposed at the completion of construction are given long-term surface protection; and
- downstream protection works during the construction and operational phases are adequate.

Unweathered sandstones from the dam site should be suitable for use as surface protection in rehabilitation programs in situations where its performance can be monitored and maintenance carried out as necessary such as:

- constructed rock walls for terraces; and
- rock armouring on surfaces exposed to rainfall runoff.

The sandstone is unlikely to be suitable for rip rap or other stabilisation works on the dam wall or downstream of the dam where it would be exposed to long-term wave action or flows over the spillway. Any shales or mudstones encountered would not be suitable for use in rehabilitation programs as these may weather rapidly to release dispersive clays.

The sedimentary rocks from the dam site and around the new road construction sites are of compositions such that they should not affect the quality of wastewater leaving the site except through suspended sediments washed from any exposed siltstones, mudstones or shales. Also, some beds in the Precipice Sandstone may yield small amounts of suspended sediment that initially increase runoff turbidity when left exposed.

Waste rock from the dam site in excess of that required for landscaping and stabilisation works can be disposed of in the following ways:

- filing excavated areas such as borrow pits which will then be inundated;
- strategically placing small heaps of unweathered sandstone at a variety of depths in the storage area to provide aquatic habitats and to attenuate wave action at a range of storage levels;
- strategically placing small heaps of unweathered sandstone above FSL to provide terrestrial fauna habitat and/or aesthetic features; and
- mounding above FSL with slopes similar to the surrounding landscape, covering with subsoil and topsoil, providing stable surface drainage and revegetating.

It is possible that the additional loading and lubrication resulting from water in the storage will trigger small, near-surface, earth movements. This is not considered significant as dam design and construction methods will take full account of earthquake hazards and geologic hazard.

Whilst no designated surveys are proposed, fossils may be encountered during rock excavations for dam construction but the probability of significant finds is low. If interesting specimens such as plant buds, seeds or insects are encountered, these will be sent to the Queensland Museum Geoscience unit for identification. If more unusual and potentially significant fossils such as bones of vertebrate fauna are encountered, work in the immediate area will cease and the Queensland Museum Geoscience unit will be notified.

Adverse environmental consequences are most likely if high rainfall events and/or high river flows occur when the dam foundation areas are exposed and when the main spillway is being constructed to fixed crest level (Chapter 2). Strategies to minimise impacts of rainfall and/or flooding will include:

- hydrologic assessment of construction risk based on the likelihood of different events as a function of the time of the year (e.g. timing these works so they are undertaken through the drier March to October (inclusive) period (Chapter 14); and
- ensuring that adequate erosion and sediment control measures are in place for all phases of construction (Chapter 14).

6.2.1.2. *Soils*

The effects of the Project on erosion and sedimentation can be considered in terms of the area surrounding the water storage, the water storage area, downstream areas and the dam wall and works area. The soil stability and suitability has been assessed as part of the design process and is considered appropriate for construction of the dam.

The landscape around the water storage area is generally stable except for the two situations which extend above and below FSL detailed subsequently. The buffer nominated by SunWater (to be based around the 1:100 AEP flood level (Chapter 2) as the area to be acquired outside the water storage area will provide a convenient area to manage and protect the water storage. This area will be managed to maintain high levels of grass, tree and shrub cover to protect the area from erosion and to trap sediment and associated nutrients from upslope. Nevertheless, the area will require periodic grazing or burning to reduce bushfire hazard.

Areas of appreciable active erosion in and around the water storage area are restricted to sheet and gully erosion on the slope on the outside of the bend at approximately 335 km AMTD and gully erosion in some areas of Sodosols associated with eucalypt uplands and highlands between approximately 334 km AMTD and approximately 366 km AMTD.

Because of the extent of the instability on the bend at approximately 335 km AMTD, it is considered that efforts to reshape the area and spread topsoil over the exposed clays and clay-rich sedimentary rock would cause so much disturbance that the situation would be aggravated. The exposed materials are highly dispersible and large-scale disturbance will result in further instability. In addition to the strategies of providing rock protection in selected areas below FSL, minimising run-off from upslope, revegetating remaining patches of soil and hydromulching with grasses, the area above FSL would benefit from application of mulch from vegetation cleared from the storage area to bare areas after steps have been taken to minimise run-on from up slope – coarse mesh sediment barriers may be required to ensure mulch does not wash into the water storage during extreme rainfall events.

When treating the actively eroding gullies, care will be required to ensure that none of the sodic, dispersible subsoil material is left exposed at the surface. A relatively thin (for example 40 to 50 mm) cover of mulch and minimal additions of nitrogen and phosphorus fertiliser will aid grass establishment and persistence after gully rehabilitation.

Clearing and removal of existing vegetation in the water storage area, at the dam wall and in the works area will create an erosion risk. Strategies to minimise this include, noting that most are already included in the Project Description:

- minimising the area to be cleared overall;
- staged clearing;
- felling vegetation using chainsaws wherever practical rather than bulldozing it out;
- burning vegetation (which cannot be salvaged for other uses) as close as possible to where it is felled to minimise disturbance associated with moving it, if it is to be burnt on-site; and
- restricting grazing prior to clearing to ensure good grass cover (fire risks will need to be managed if vegetation is burnt on-site).

Wave action has the potential to cause erosion at FSL and at lower levels if the water level is stationary for a prolonged period. Also, there is a risk of land slip in steeper areas around water level. FSL is the only level where there is an appreciable probability that the water level will be stationary, as inflows equal or exceed total demand and environmental releases, for prolonged periods. Wave action will have most impact downstream of approximately 336 km AMTD because the surface extent of the water storage here provides opportunity for wind fetch of up to approximately 15 km. Wind roses for Taroom (all observations) show a tendency for marginally more wind from the north (Chapter 3) suggesting that greatest impacts of wave action will be on the southern side of the open part of the storage. Sands mobilised by wave action will form small beach deposits while non-dispersive silts and clays will form miniature mud flats at and just below water level. It is considered unlikely that wave action will be sufficient to expose highly dispersible subsoils that would result in appreciable increases in the levels of suspended sediments in the storage provided that some measures to minimise wave impacts at FSL are put in place. Strategies to minimise the impacts of wave action in higher risk areas include:

- planting species tolerant of wet conditions such as rushes, forest red gum, river oak and tea tree at and just upslope of FSL to provide vegetative protection;
- placing part-buried piles of large woody debris or rock protruding above FSL to attenuate waves; and
- allowing natural regeneration of grass and shrub vegetation in occasionally exposed areas below FSL provided that the colonising species are not weeds.

Stream banks in the current Glebe Weir storage area show no evidence of slumping as a result of rapidly falling water levels during downstream releases. There will also be no vegetation clearance within 1.5 m vertical of FSL. Though volumetric rates of extraction from the dam will be greater than those from Glebe Weir, the rate water level falls will be much slower because of the large surface area where water is stored outside stream channels. Thus, bank slumping along existing stream channels should not be a problem.

Environmental consequences of inundation of soils within the storage area will include:

- loss of nitrogen as oxides of nitrogen are converted to nitrogen gas through denitrification;
- release of phosphorus within the soils as a result of the reducing environment – transfer of this phosphorus to the water column will be very slow because it will depend on diffusion rates; and
- destruction of seed reserves in the soil – as water levels recede, plant establishment will be dependent on plant propagules that float to the receding shorelines, are blown onto the exposed area, or are carried onto the exposed area by fauna.

The lack of competition and reliance on seed transport onto exposed areas will give ‘weedy’ plants a competitive advantage in exposed areas below FSL so that monitoring and control of declared species will be necessary.

Observations of the bed of the Dawson River upstream of the Glebe Weir wall in 2006 indicate that a veneer of fine sediment accumulated over the 35 years since the weir was completed, at least in deeper parts of the storage. Accumulations of suspended sediment in Glebe Weir probably represent a small proportion of that entering the storage because of the relatively short residence time of water in the storage. Observation during times of relatively low inflow showed the apparent turbidity of inflows, water in storage, and outflows was similar, suggesting that most suspended sediment entering the storage was being carried through.

The dam will trap a much larger proportion of the suspended sediment entering the storage than Glebe Weir because the longer residence time of water in the storage will result in settling of a larger proportion of suspended sediment.

The streambed long sections of the Dawson River and its tributaries will change little through the storage area because of the small volumes of bedload sediment entering. Deposition of fine sediments will increase with increasing water depth towards the dam wall but this increase will not have a significant effect on stream gradient (Chapter 14).

Less sediment will move past the dam wall and the ebbing flows of floods that appear to be important in depositing fine material in the broad stream channel will be carrying less sediment and will deposit less. This will result in gradual scouring of the low flow channel and the low floodplain immediately downstream though this effect will be minimised at the tailwaters of Gyranda Weir where there will tend to be marginally increased sediment deposition. The long-term result may be a minor flattening of the stream long section gradient between the foot of the dam wall and Gyranda Weir wall though this is likely to be masked by channel rejuvenation during large flood flows (Chapter 14).

Scouring of the downstream low flow channel and low floodplain will be minimised by maintaining vegetative cover, protecting and rehabilitating disturbed areas, and designing the spillway outfall so that flood flow patterns are disrupted for the minimum possible distance downstream. These potential impacts and mitigation measures are discussed further in Chapter 14.

The following general guidelines can be given for managing soils disturbed by dam construction works:

- topsoil of soils formed on alluvium including Eucalypt Streambed, Eucalypt Floodplain and Levee, and Eucalypt Floodplain soils (Table 6-3) should be reasonably fertile and not require fertiliser applications to aid re-establishment of vegetation after disturbance provided the soil is not stockpiled in a compacted condition for long periods;
- topsoil of other Dermosols and Vertosols should be reasonably fertile and not require fertiliser applications to aid vegetation re-establishment;
- topsoil of Sodosols will generally be less fertile and may require fertiliser applications;
- topsoil should only be stripped and stockpiled for subsequent rehabilitation works down to the top of any clay subsoil or to an appreciable colour change including any bleached layer (pale grey or white when dry) – lower layers are generally infertile and may be sodic and/or saline;
- topsoil should be stockpiled for the minimum practical time before it is used for rehabilitation to minimise loss of biota – where topsoil has been stockpiled for more than eight weeks, a layer of material from a more recent stockpile about 0.05 m thick should be used at the immediate surface if available;
- topsoil should be returned to the area from which it was stripped (if above FSL) when used for rehabilitation wherever practicable to maximise return of plant propagules to their area of origin;
- progressive stripping of topsoil, removal of underlying material and rehabilitation should be undertaken in borrow areas and other situations where it is possible to minimise exposure of unprotected subsurface materials and stockpiling of topsoil;
- works requiring high levels of soil disturbance and high traffic on surface soils should be timed for the dry season to minimise compaction of wet soils and erosion risk;
- rehabilitation works involving revegetation should have plantings in place, with adequate temporary erosion protection, by the end of September so that spring and summer rainfall will aid establishment; and

- rehabilitation works involving revegetation should have plantings in place, with adequate temporary erosion protection, by the end of September so that spring and summer rainfall will aid establishment; and
- clay subsoil materials should not be left exposed because most are sodic (Table 6-3) and likely to disperse under rainfall – where stockpiles or excavated surfaces must be left exposed, temporary erosion protection, sediment traps and sedimentation ponds should be in place.

More specific recommendations for works at the dam site include:

- design of the work area to include adequate provision for temporary erosion control measures, runoff capture and sediment removal before discharge of water;
- rock armouring or rock-faced terracing to provide long-term erosion protection on steeper areas adjacent to the broad low floodplain of the Dawson River; and
- topsoil that contains appreciable stone or cobble should be sieved before placement or stone picked after placement in areas where slashing will be used to manage grass cover to avoid machinery damage and to maintain safety on site.

During operations, the water storage area and immediate surrounds, the dam site, and downstream areas will be monitored to detect any instances of erosion, salinity, or other landscape instability so that any necessary remedial work can be arranged.

Areas of GQAL impacted by the dam construction footprint and/or water storage are discussed in Section 6.1.4.2. These areas will no longer be available for agricultural uses. As per SPP 1/92, development on good quality agricultural land may only be supported where there is an overriding need for the development in terms of public benefit and no other site is suitable for the particular purpose.

In accordance with the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI, 1993), overriding need for the proposed development can be demonstrated through one or more of the following:

- there are significant direct and indirect employment benefits (i.e. on-site and flow-on benefits);
- there are significant local or regional economic benefits in terms of growing a State industry;
- there are significant economic benefits to the State as a whole in terms of growing a State industry; and
- major infrastructure with specific siting / location requirements.

Chapter 25 of the EIS includes an assessment of the impacts of the Project on the local economy and confirms there are a number of economic and industry benefits associated with the Project, which addresses the above criteria. The Project will provide a positive economic impact by way of providing additional water security primarily to support the development of the coal mining industry and to ensure water supplies for regional urban development.

As discussed in Chapter 1, Nathan Dam has been identified as the preferred solution for the short to medium term water demands from urban, industrial and irrigation sectors in the Dawson-Callide and Upper Dawson sub-regions. The Project has specific siting/location requirements in order to service these sub-regions and no other sites were determined to be suitable based on engineering, social and ecological considerations. The potential efficiency gains associated with alternatives for meeting supply demand in the region have also been assessed as being insufficient to cater for future growth of water requirements.

The declaration of the Project as a “significant Project for which an EIS is required” by the Coordinator-General pursuant to section 26(1)(a) of the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act) confirms the strategically important nature of the Project.

An overriding need for the Project has been identified based on the public benefits outlined. As no other suitable location exists for the provision of similar infrastructure in the region, the loss of GQAL (Section 6.1.4.2) as a result of the Project is justified in terms of the SPP 1/92.

6.2.2. Pipeline

6.2.2.1. Geology

Most of the route traverses landscapes where the trench will only encounter soils formed from weathered rock, underlying weathered rock or soil formed on more recent alluvial deposits. Jointing and hardness of all rock likely to be encountered is such that all materials, including some indurated, ferruginised sandstone beds up to 0.3 m thick, should be rippable with heavy machinery to allow trench excavation. Blasting is not likely to be required.

Rock and soil materials along the route are generally coherent so that the trench is unlikely to require shoring for pipe placement unless this is required to meet workplace health and safety requirements where people are required to enter the trench or work close to the edge. Conditions requiring shoring for pipe placement may occur in sandy creek beds, on some sandy creek levees, in some areas of sand plain (Czs in Figure 6-6) and in some areas of Chinchilla Sand (Czcch in Figure 6-6).

Little-weathered sandstones from along the pipeline should be suitable to provide surface protection in rehabilitation programs in situations such as steep creek banks and creek beds where rock armouring is required. Any shales, siltstones or mudstones encountered would not be suitable for this use as these rock types may weather rapidly to release dispersive clays.

The sedimentary rocks along the pipeline are of a composition such that they should not affect the quality of wastewater leaving the site except through suspended clay sediments washed from any exposed shales, siltstones or mudstones.

The diameter of the pipe, the amount of bedding material that will surround it and the difficulty of compacting replaced materials to their undisturbed bulk density will result in considerable volumes of rock and soil spoil all along the route. Disposal options have been considered in Chapter 4.

The pipeline crosses one known fault line in the vicinity of the Great Dividing Range and another west of Guluguba. There are other faults in this area as well (Figure 6-6). The pipeline, pumping stations and balancing storages will be designed to take account of earthquake hazard with automated systems including those for pump shutdown that will prevent, as far as is possible, large water discharges in the event of failure.

Fossils may be encountered during rock excavations for pipeline construction but the probability of significant finds appears low except in the Chinchilla Sand geological unit and particular care will be taken to ensure any fossils encountered in this unit are recognised. If interesting specimens such as plant buds, seeds or insects are encountered during construction, these will be sent to the Queensland Museum Geoscience unit for identification. If more unusual and potentially significant fossils such as bones of vertebrate fauna are encountered, work in the immediate area will cease and the Queensland Museum Geoscience unit will be notified.

6.2.2.2. Soils

The soil stability and suitability for pipeline construction has been assessed and incorporated into the pipeline design and is considered appropriate for pipeline construction. This assessment was completed in June 2010 and consisted of a review of the available topographic, geotechnical and regional geological data, to enable preliminary design of the pipeline and the identification of areas that require further site specific field investigation. The selected locations will be investigated by intrusive field methods to confirm and/or review the predicted subsurface conditions. The investigation also identified potential geotechnical constraints that mainly impact the constructability and construction costs. As a result the various measures have been developed to deal with the varying soil conditions these are described in Chapter 2 and below.

Soils along the pipeline will be disturbed during the construction period but provided reinstatement is carried out correctly there should be little long-term impact on soils and land suitability. Nevertheless, there will be some long-term impacts associated with:

- flow control structures and air valves;
- balancing storages and associated pumping stations;
- the Nathan Dam pumping station;
- any access tracks that may required; and
- disposal of excess excavated material.

Pumping station and pipeline construction will involve excavation and trenching with access track and maintenance easement track construction in some areas, possibly between Nathan Dam and the intersection of Nathan Road and the Taroom — Cracow Road and probably in the vicinity of Miles where the line crosses private property. Pipeline construction will affect a wide range of soils, many of which have sodic, dispersible subsoils. Some of the soils along the pipeline have saline subsoils as well.

All disturbed areas including pumping stations and pipeline excavation areas and access tracks will require temporary erosion protection if they are in a disturbed state for more than approximately one week, or if rain is forecast or likely for the period when it is anticipated they will be open. As open trenches have the potential to intercept flows and act as drains and as they will often be excavated into sodic, dispersible material, open lengths should be short and temporary stops may be needed if rain is imminent. However, if the time from route clearing to final reshaping and rehabilitation is kept to a few days, temporary erosion control works can be kept to a minimum when fine weather is forecast. Erosion control strategies will be developed and implemented to ensure there is limited risk of erosion during the construction period such as those set out for dam construction (Section 6.2.1.2). Pipeline specific erosion protection measures could include:

- ensuring that temporary stream crossings needed do not restrict natural flows and have downstream erosion protection where required;
- diverting overland or channel flow away from disturbed areas and ensuring that the pipeline trench does not capture runoff and discharge it as concentrated flow down slope;
- installing flow and sediment control structures on and down slope of disturbed areas;

- constructing any stockpiles so that the surface is reasonably level, but with sufficient roughness to trap water and aid infiltration as opposed to large conical or elongate crested stockpiles.

Long-term erosion protection for disturbed areas will include strategies such as:

- avoiding flow concentration within the area, particularly any flow concentration that may run down slope over the pipeline;
- shaping landforms to provide slopes similar to or lower than those of the surrounding landscape and establishing vegetative cover with species that will provide ground cover rapidly;
- placing anchored, biodegradable, erosion protection or, in some cases, rock mattresses or rip rap in stream channels and on banks while establishing trees, shrubs or ground cover species similar to those that now occur in similar situations (note that trees and shrubs will not be planted within the pipeline maintenance easement); and
- re-creating the natural soil profile as far as is practicable by placing a layer with appreciable water holding capacity, such as a non-sodic clay or clay loam, and covering this with the original topsoil from the site.
- planning drainage from sites subject to prolonged disturbance, such as pumping stations and balancing storages, and installing sediment barriers and sedimentation ponds where required;
- minimising exposure of dispersible, sodic subsoil materials;
- placing clay barriers in the bedding sand surrounding the pipe to ensure the sand does not provide a subsurface conduit for downslope water movement;
- planting quick-growing plant species that are naturalised or native to the area to provide ground cover as soon as work is completed;
- ensuring that any drainage required for access tracks discharges where flows will spread naturally;
- ensuring that access tracks do not disrupt flows in natural drainage lines; and
- monitoring rehabilitation work and taking corrective actions immediately after any problems occur – material over the pipeline is likely to settle over time so that mounding and / or topping up may be required to maintain the required surface level.

Natural fertility and other properties of the soils likely to be disturbed by pipeline construction are variable but the general soil management recommendations for dam construction also apply to pipeline construction (Section 6.2.1.2). Pipeline specific soil management recommendations include:

- application of gypsum at rates equivalent to two to five tonnes per hectare should be considered on disturbed areas where the topsoil is clay because it will improve soil structure and water infiltration;
- deep subsoil (below approximately 0.8 m) from some Vertosols and Dermosols under brigalow may be acid and, if encountered, should be limed if it is to be placed less than 0.8 m below the surface of any reconstructed soil profile;
- areas where grass is to be established will benefit from minimal addition of phosphorus, nitrogen and potassium fertiliser; and
- works that will result in high levels of soil disturbance or high traffic and work in drainage lines should be timed for the dry season when rainfall is lowest to minimise erosion and soil compaction risk.

No outbreaks of salinity or non-saline seepage have been observed along the pipeline. Salinity is not expected to occur as a result of pipeline construction or operation and non-saline seepages should not occur provided that precautions such as placing a compacted clay layer above the pipe and bedding material to prevent down-slope movement of water in the bedding material with subsequent discharge in footslope areas. The extent of any clearing that may be required for the pipeline is extremely unlikely to be sufficient to cause salinity outbreaks.

The pipeline alignment runs through areas that are classed as GQAL. A breakdown into GQAL classes along the route is provided in Section 6.1.5.2. In accordance with SPP1/92, non-agricultural development needs to demonstrate an overriding need in terms of public benefit to justify the loss of GQAL.The pipeline will primarily be buried after construction therefore the Project will only result in temporary disturbance to GQAL. Any agricultural land disturbed due to the laying of the pipeline will be restored to its previous condition where possible, and it is anticipated that the previous cropping and pastoral activities can resume subject to the terms of any easement arrangements. Cropping areas that are laser levelled will require very careful reinstatement. Only minimal areas of GQAL associated with access tracks, above-ground infrastructure such as flow control valves and balancing storages and above ground sections of the pipeline will be alienated from agricultural uses.

The pipeline alignment has been chosen to maximise co-location opportunities with other linear infrastructure. This will minimise impacts on landholders and alienation of GQAL from agricultural uses. In addition, carefully managed works associated with the Project including rehabilitation of the pipeline corridor may result in the enhancement of GQAL through the stabilisation of soils that were otherwise at risk of erosion.

An overriding need for the Project has been identified based on the public benefits generated by the Project. No other suitable location exists for the Project in the region consequently the loss of GQAL (Section 6.1.4.2) as a result of the Project is justified in terms of the SPP 1/92.

6.2.3. Associated infrastructure

6.2.3.1. Geology

The sedimentary rocks are weathered in the zones likely to be disturbed by road construction so are unlikely to require blasting or result in adverse impacts from road construction.

Any fossils encountered will be dealt with in a similar manner to fossils at the dam site.

6.2.3.2. Soils

The general guidelines for managing soils disturbed by dam construction works (Section 6.2.1.2) should be applied to the soils that will be disturbed by construction of associated infrastructure (i.e. roads, recreation areas, clay borrow areas). Banana Shire and Main Roads guidelines will also be applied.

There is gully erosion in the vicinity of some of the existing roads that will require upgrading or other modifications, and remedial action may be required to accommodate the upgraded roads or as part of the general duty of care of the dam constructor. The recommendations given for treating actively eroding gullies set out in Chapter 4 and Section 6.2.1.2 should be applied.

No salinity was observed in the vicinity of areas where road construction will take place and none is expected to occur as a result of the works proposed.

The road upgrades will alienate approximately 22 ha of Strategic Cropping Land.

As discussed in Sections 6.2.1.2 and 6.2.2.2, the Project demonstrates an overriding need in community terms of public benefit and therefore satisfies the requirements of SPP1/92.

6.2.4. Impact assessment and residual risks

The methodology used for risk assessment is discussed in Section 1.8.

This section assesses risks to the Project that may be caused by the geology, soils or geological processes. Mitigation measures, if necessary to minimise those risks, are summarised. It is not anticipated that any significant risks relevant to geology, soils or geological processes will remain after mitigation.

Unmitigated and mitigated consequence and likelihood ratings for the identified hazards are shown with explanatory notes in Table 6-8. The risk assessment is of the Project as described in Chapter 2, in which SunWater has already incorporated a range of risk reduction and mitigation measures.

Based on this risk assessment, the following conclusions can be made:

- risk of tectonic activity in the form of an earthquake or fault movement that might cause structural damage to the dam or the pipeline facilities is low. Appropriate design factors will be included for dam and pipeline construction;
- the possibility of significant erosion being induced by the Project is real, but provided the numerous well tested mitigation measures outlined herein are implemented appropriately, this risk can be averted entirely;
- risk of land degradation occurring due to the Project causing salinity increases in soils is minimal based on the very low natural salt content and regular flushing by floods in the catchment area;
- no risk to loss of knowledge exists through inundation of fossil sites in the storage area because there are good representative collections of the fossils of the area in permanent government collections; and
- GQAL lost through inundation of the inundation and buffer is unavoidable and compensation for agricultural productivity is mitigated by economic impacts of improved water supply security.

Table 6-8 Risk assessment results

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current risk			C	L	Mitigated risk
Earthquake	The dam lies in an area with a 10% chance of an acceleration coefficient of 0.06 to 0.08 being exceeded once in 50 years and earthquakes have occurred in the area though most have been centred well to the east. It is possible that the additional loading and lubrication resulting from water in the storage will trigger small, near-surface, earth movements.	Potential structural damage to the dam and/or pipeline	Appropriate design factors for dam and pipeline construction. These are standard methods	Major	Rare	Medium			Major	Rare	Medium
Fault movement	The pipeline crosses one known fault line in the vicinity of the Great Dividing Range and another west of Guluguba. There are other faults in this area as well.	Potential structural damage to the dam and/or pipeline. These are standard methods	Appropriate design factors for dam and pipeline construction	Moderate	Rare	Medium			Moderate	Rare	Medium

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current risk			C	L	Mitigated risk
Erosion	Erosion is a risk wherever excavation and soil disturbance take place. However, given high rainfall of the catchment and regular floods down the Dawson River and watercourses crossed by the pipeline any erosion effects caused by Project construction are likely to be minimal compared to that by the natural events.		Refer EMP section 29.9.4. Minimum disturbance of soils. Stockpiles to be protected from dispersal by runoff. Rehabilitation of sites as soon as practicable on completion of construction (to include revegetation where possible). Erosion and Sediment Control Subplans to be developed and implemented for all construction sites. Pipeline crossings of watercourses to be well protected against erosion.	Minor	Unlikely	Low			Minor	Unlikely	Low
Increased salt levels in area or downstream	Salt levels in soils and waters of Dawson River catchment generally low.	Deterioration and land and/or water quality		Minor	Unlikely	Low			Minor	Unlikely	Low

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current risk			C	L	Mitigated risk
Adverse effect on fossil sites	Fossils may be encountered during rock excavations for dam and pipeline construction but the probability of significant finds appears low except in the Chinchilla Sand geological unit.	Fossil sites inundated are not unique, species are well known from elsewhere and specimens are held in government collections.	If interesting specimens such as plant buds, seeds or insects are encountered, these will be sent to the Queensland Museum Geoscience unit for identification. If more unusual and potentially significant fossils such as bones of vertebrate fauna are encountered, work in the immediate area will cease and the Queensland Museum Geoscience unit will be notified.	Minor	Possible	Medium	Personnel working in the Chinchilla Sand Geological Unit to receive training in the identification of fossil material.		Minor	Unlikely	Low
Loss of good quality agricultural land (GQAL) farmland.	Loss of GQAL is unavoidable. In terms of GQAL, approximately 5,981 ha of Class A, 1,589 ha of Class B and 6,254 ha of Class C will be inundated.	Long term impacts within the water storages and associated with above ground infrastructure.	The pipeline alignment has been chosen to maximise where possible co-location opportunities with other linear infrastructure to minimise impacts on landholders and alienation of GQAL from agricultural uses.	Minor	Absolute	Medium			Minor	Absolute	Medium

6.3. Summary

Dam design and construction methods will take full account of earthquake and geologic hazards. The potential for soil erosion impacts resulting from construction and operation is considered to be minor. However, mitigation measures will be employed around all construction activities to minimise erosion and sediment transport. Pipeline construction will be completed by restoring the land surface to pre-disturbance condition as far as practicable and as soon as possible after completion of construction.