Appendix 8: Soils Report

Prepared for
Arrow Energy Pty Ltd
ABN: 73078521936

Wells and Gathering Construction

Phase 1 Desktop Soil Assessment

07-Sep-2021

Commercial-in-Confidence

Wells and Gathering Construction

Phase 1 Desktop Soil Assessment

Client: Arrow Energy Pty Ltd

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1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was appointed by Arrow Energy Pty Ltd (Arrow) to undertake a desktop soil assessment for the proposed development of new wells and gathering (herein referred to as the 'Project'), to support Arrow's Regional Interests Development Approval (RIDA) application under the Regional Planning *Interests Act 2014* (RPI Act).

The proposed Project is located approximately 15 km south-west of Dalby along the Moonie Highway, shown in **Figure 1**.

1.1 Site Description

The impacted land parcels and approximate disturbance areas are summarised in **Table 1**:

Table 1 Project disturbance area

Petroleum Tenure (PL)	Land parcel	Parcel size (Ha)	Disturbance area (Ha)
PL 252/ PL 260	Lot 57 of SP193329	294.9	11.3
	Lot 36 of DY45	89.0	0.51
PL 260	Lot 1 of RL2451	12.6	0.12
	Lot 1 of DY931	241	11.78
	Lot 70 of DY138	254.9	4.8
	Lot 1 of RP154777	245.7	8.65
	Lot 1 of DY787	266.4	6.2
	Lot 60 of DY802	129.2	2.8
	Lot 2 of RP106958	127.8	1.1
Total		**1661.5**	**47.26**

1.2 Proposed Disturbance

The two main components of the Project are construction of well pads and associated gathering pipeline and other infrastructure. A generalised disturbance overview of these components is given below.

1.2.1 Well Pads

In general, the sizes of the well pads can be managed so that the maximum level of overall disturbance is consistent with the existing EA intensity of impact (1 ha per well for a single well pad to 0.3 ha per well for up to eight well pad).

The size of well pads is determined by several factors, including

- the number of wells,
- the type of wells,
- the type and manoeuvrability of drill rigs,
- the terrain which determines whether cut and fill earthworks are required,
- whether the area is cleared or supports vegetation,
- the existing land use,
- the equipment stored temporarily on the pad,
- the area required for offices, light vehicle parking, equipment and supplies deliveries and

- the required separation distance between wells and the area required to complete drilling operations safely.

In some cases, additional area is required for areas with higher slope, heavy vegetation and/or to provide sufficient room for cut and fill earthworks batters, diversion drainage and additional erosion and sediment controls. As such, including the additional area (if needed), the total disturbance area varies between 1 ha for single well pads, 1.15 ha (2-well pad), 1.3 ha (3-well pad and 1.45 ha for 4-well multi-well pad.

Well locations will be determined following consultation with the landholder to manange impacts to their operations and lifestyle. . As such, well sites are located in areas that reduce impact on farming where possible, such as:

- on the fringes of Intensively Farmed Land (IFL)
- in corners of paddocks
- or areas of land unsuitable for farming
- on or near access tracks, easements and road reserves
- Right of ways

The key steps in the well pad construction are given below:

- Clearing of the area (if not already cleared by agricultural activities), including stripping and stockpiling of topsoil. For minimal disturbance well pads the topsoil will be left in place.
- Laying and levelling the well pad foundations to provide a stable platform for the drilling rig.
- Carrying out site preparation works using earthmoving equipment such as graders, excavators and bulldozers. Where the subgrade material is deemed to be inadequate and unsuitable for heavy vehicle access or where all weather access is required, consideration shall be given to:
  - Amendment of soil (using additives and / or dynamic compaction); or
  - Use of technologies (rig mats, tracked vehicles, roll-out sheets, etc.); or
  - Clear, grub and remove unsuitable material and replace with more suitable material such as gravel.

For this Project, a total of five well pads are being proposed including one minimal disturbance well pad.

1.2.2 Gathering and Pipelines

The main disturbance area will be a common easement, containing water/gas pipelines and fibre optic/power cables within an approximately 30 m wide right of way (ROW) for gathering on these properties. (**Plate 1**).

Conventional trenching for pipeline installation involves an open trench between 1-2 m wide and approximately 2.0 m deep to install, inspect or maintain piping, conduits or cables. After installation, the trench is backfilled with the original material and the surface is restored.

Where the pipelines are required to be installed below existing roads or infrastructure, other trenchless technologies such as thrustbore may be used.

The key steps in the pipeline construction are given below:

- Detailed survey of the ROW and construction areas.
- Establishing temporary access tracks if necessary.
- Installing temporary gates and fences as required.
- Clearing vegetation, where required, and grading the ROW to prepare a safe construction working area (on average the ROW will be 30 m in width).
- Separating and stockpiling topsoil and subsoil to protect and preserve topsoil.

- Crossing watercourses, roads and existing buried pipelines by open cut, boring or alternate trenchless technology (e.g. Horizontal Directional Drilling [HDD] methods) depending upon the type and nature of the crossing.
- Delivering pipe sections along the ROW.
- Welding the low-pressure high-density polyethylene (HDPE) pipe sections together to form 'a string'.
- Creating a trench in which to lay the pipeline. The trench is excavated by a trenching machine and may include the use of rock saws, excavators, rock hammers or blasting in hard rock terrain.
- Lowering the pipeline strings into the trench and placing padding (e.g. screened trench subsoil) around the pipe to protect the pipe from external damage.
- Returning the subsoil and topsoil to their original horizons.
- Testing the integrity of the pipeline by pneumatic testing or filling it with water and pressurising it to above the maximum allowable operating pressure (i.e. hydrostatic pressure testing).
- Cleaning up, restoring and progressively rehabilitating the construction ROW and all temporary and permanent tracks, gates and fences.

Installation of multiple pipelines in a single ROW is sequential. The first pipeline is installed, and the trench backfilled before the next pipeline installation commences.

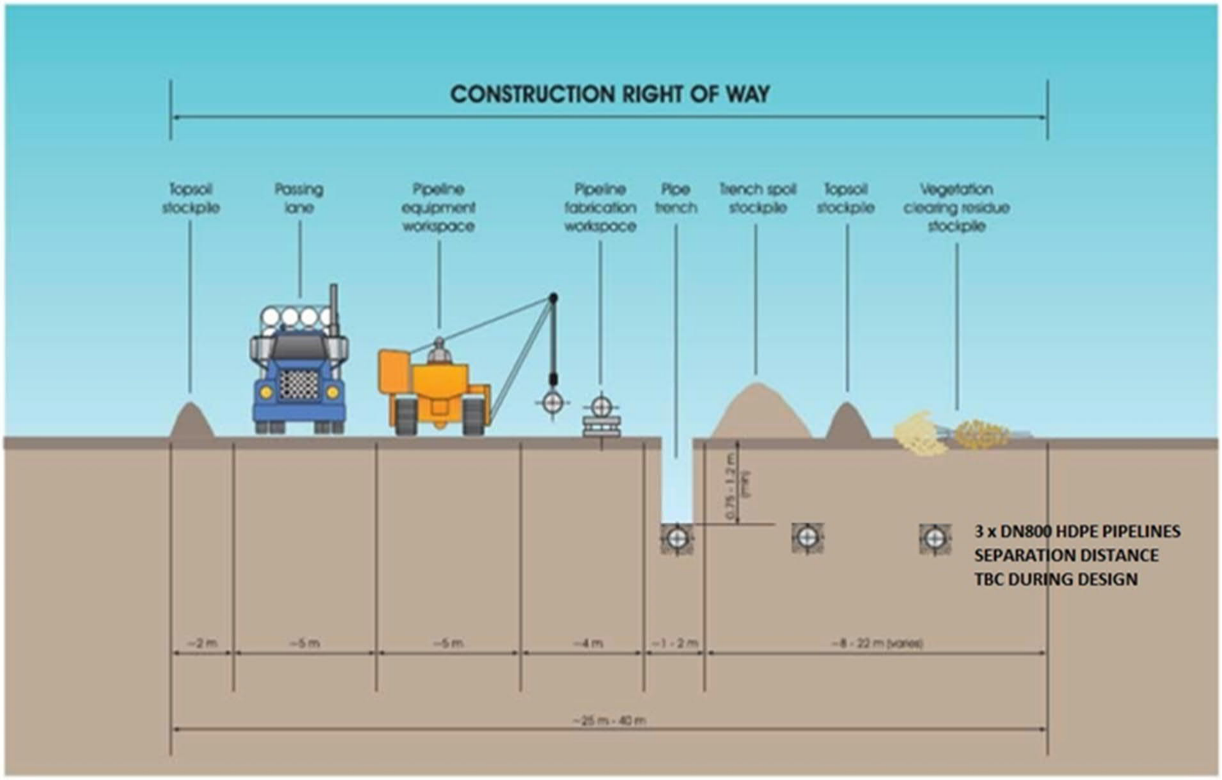
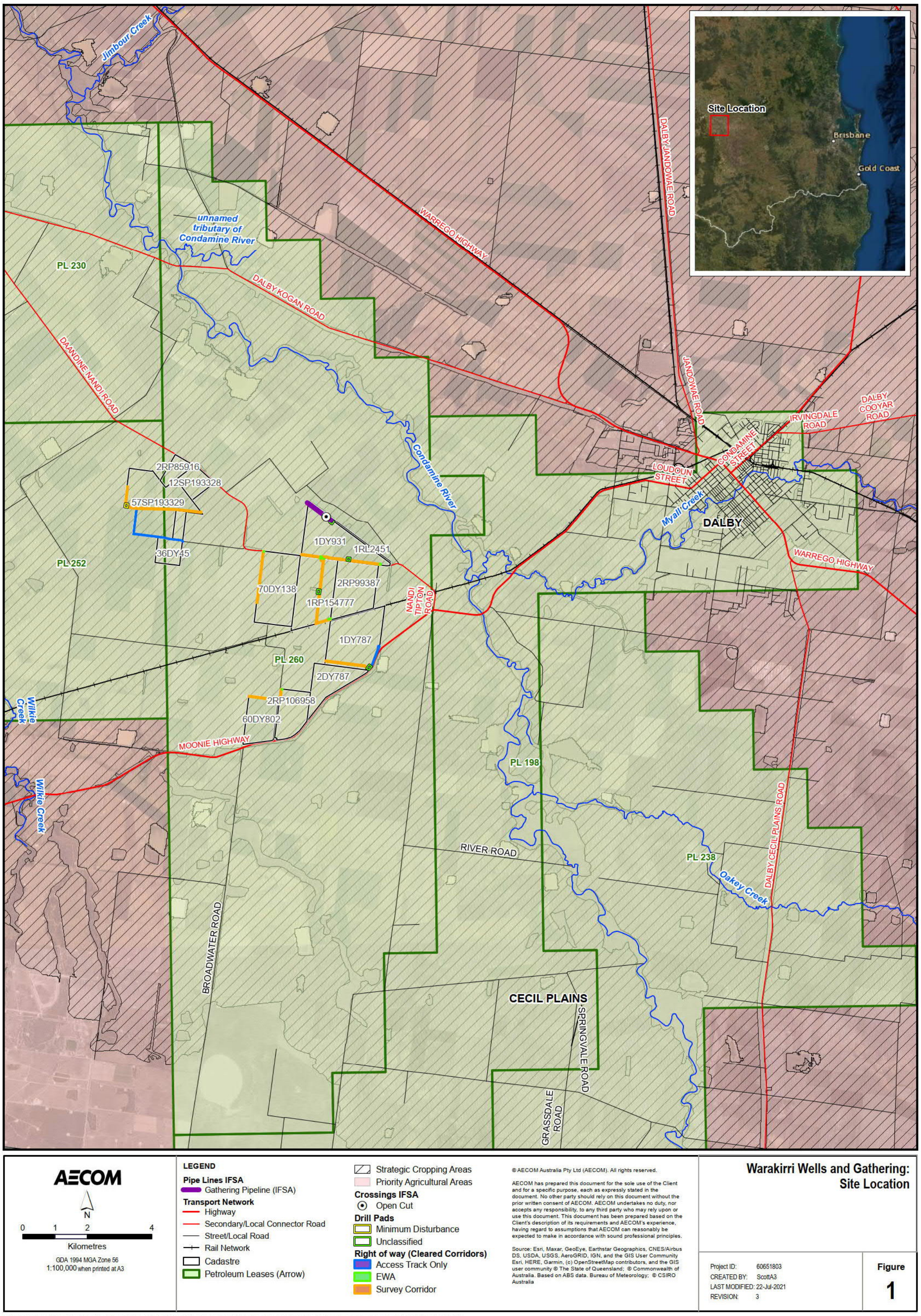


Plate 1 Typical Pipeline ROW Layout

Figure 1 Project Site Location



2.0 Objective

The key objectives of the desktop soil assessment for the Project were to:

- Assess various soil types within the Project.
- Assess key issues including soil degradation, loss of productivity and subsidence related to the identified soil types.
- Provide strategies to manage these identified soil issues during construction.

3.0 Scope of Works

The scope of works for undertaking the desktop soil assessment includes:

- Desktop review encompassing:
  - Review of available mapping and publications sourced from the Queensland Government Open Data Portal and Queensland Spatial Catalogue.
  - Review of available data provided by Arrow relevant to the Project.
- Preparation of this desktop soil assessment report, including recommendations for each soil type including soil stripping, stockpile storage, returning topsoil and subsoil to trench, addition of ameliorants and/or fertilizers (if needed), compaction strategies, erosion controls, post-construction inspection and maintenance regimes.

4.0 Methodology

The methodology for the desktop soil assessment is summarised below:

4.1 Relevant legislation and guidelines

The key legislation applicable to the works undertaken as part of this desktop soil assessment is the RPI Act, administered by the Department of Infrastructure, Local Government and Planning (DILGP). The Act restricts the carrying out of resource of regulated activities where the activity is not exempt from the provisions of the RPI Act, or a RIDA has not been granted.

The Act identifies four Areas of Regional Interest (ARIs), including: a priority agricultural area (PAA); a priority living area (PLA); the strategic cropping area (SCA); and a strategic environmental area (SEA). The alignment (the resource activity) intersects PPA and SCA.

- PAA: an area which includes one or more areas used for a priority agricultural land uses (PALU), identified in the relevant regional plan. PALUs may include certain types of agriculture, plantations, and/or intensive horticulture. In the case of the alignment, the PALUs are identified in the Darling Downs Regional Plan.
- SCA: defined as an area mapped as potential Strategic Cropping Land (SCL) on the Department of Natural Resources, Mines and Energy (DNRME) trigger map. The SCL is likely to be highly suitable for cropping due to a combination of the soil, climate, and landscape features.

This desktop soil assessment has been prepared in accordance with Australian legislations, Standards and Guidelines and Arrow's Standard Operating Procedures (SOP) for Surat Basin including:

- *RPI Act, Statutory Guideline 02/14, Carrying out resource activities in a Priority Agricultural Area,* State of Queensland, Department of State Development, Manufacturing, Infrastructure and Planning, August 2019
- *RPI Act, Statutory Guideline 03/14 Carrying out resource activities in a Strategic Cropping Area,* State of Queensland, Department of State Development, Manufacturing, Infrastructure and Planning, August 2019
- *Environmental Authority EA0002659 Non-Scheduled Petroleum Activity Petroleum Pipeline Licence -PPL2052,* dated 5 February 2021

- *Environmental Authority EPPG00972513,* dated 14 January 2021
- *Guidelines for Soil Survey along Linear Features,* Soil Science Australia, 2015
- *Arrow Land Disturbance Procedures* (ORG-ARW-HSM-PRO-00146)

4.2 Desktop review

The purpose of the desktop review was to obtain background information within the Project on potential soil types and landscapes, information on the underlying geology and topography and understand potential PAA and SCA limitations.

The Project area presented in the desktop mapping and interpretations is represented by a 1 km buffer applied to the proposed drill pads and gathering network (ROW, crossing and pipeline).

4.2.1 Publicly available data

The desktop review involved a search of publicly available soil data, sourced from the Queensland Government Open Data Portal and Queensland Spatial Catalogue, including:

- Priority Agricultural Area mapping (Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP), 2013).
- Strategic Cropping Land trigger map (Department of Natural Resources and Mines (DNRME), 2020).
- Central Darling Downs Land Management Manual (Harris *et al.*, 1999).
- Australian Soil Resource Information System (ASRIS) Atlas of Australian Soils (Northcote *et al.*, 1960-1968).

This information was used to develop a map of soils and physical limitations for the Project.

4.2.2 Arrow provided data

Arrow provided the following data to assist in validating the potential soil types and landscapes likely to occur within the Project area, including:

- Disturbance areas of the drill pads, ROW, pipeline and crossing.
- Standard pipeline construction, rehabilitation requirements and procedures.
- Relevant Environmental Authorities (EA).

4.3 Suitably Qualified Person

AECOM confirms that the desktop review and interpretation of available data, has been undertaken directly or under the supervision of a suitably qualified person (SQP). Copies of curriculum vitae have been provided in **Appendix A**.

5.0 Desktop Review

5.1 Topography and geomorphology

5.1.1 Regional physiography

The Project area is located wholly within the Condamine Central Lowlands physiographic region (**Figure 2**). The region is described as a low-lying area of undulating siltstone hills with alluvial sediments on the floodplains of the Condamine River and highly weather bedrock on the slopes (CSIRO, 2011).

5.1.2 Topography

Regionally, there is a north-south topographic high of the Taroom Hills and an east-west topographic high of the Great Dividing Range. Two major drainage systems separate these topographic highs: the Condamine River and Wilkie Creek, both draining towards the north-west (**Figure 1**).

The surface elevation across the Project area is relatively flat at 330 m Australian Height Datum (mAHD), which is consistent with the area being located on the Condamine Lowlands and floodplains of the Condamine River (**Figure 2**) (State of Queensland, 2021).

The digital elevation model (DEM) for the Project area is presented in **Figure 3**[1], and was used to calculate the slope of the surrounding landscape. Based on the calculations, the slope within majority of the Project area range from near level (<1%) to 3%,.

5.2 Surface geology

Based on the Queensland detailed surface geology (presented in **Figure 4**) the Project area is a part of the extensive Surat and Clarence Moreton Basins, including a sequency of sedimentary rocks (Kumbarilla Beds [JKk] and Springbok Sandstone [Jis]) overlain by surficial Cenozoic sediments (undifferentiated alluvium and the Condamine Alluvium) (DNRME, 2018). These alluvium units are described as unconsolidated [Qs], poorly consolidated [TQ] and semi-consolidated [Qa] sediments typically comprised of sand, silt and clay (DNRME, 2019).

Shallow soils likely to be disturbed in the Project area are expected to be dominated by the Condamine Alluvium, which is an extensive accumulation of Tertiary to Quaternary age alluvial sediments, forming a broad (greater than 20 km wide) alluvial plain, extending from Millmerran to Chinchilla. The thickness ranges from less than 10 m to more than 120 m in the floodplain near Dalby (DNRME, 2019). The sediments are dominated by coarse grained gravels and sands, interbedded with clays. The coarse-grained alluvium is associated with higher transmissibility and are the primary source of groundwater.

[1] The DEM for the Project area was sourced from the 1 second Shuttle Radar Topographic Mission (SRTM) DEM-S (smoothed) v1.0 (Geoscience Australia, 2021).

Figure 2 Regional Physiography- Central Lowlands Province

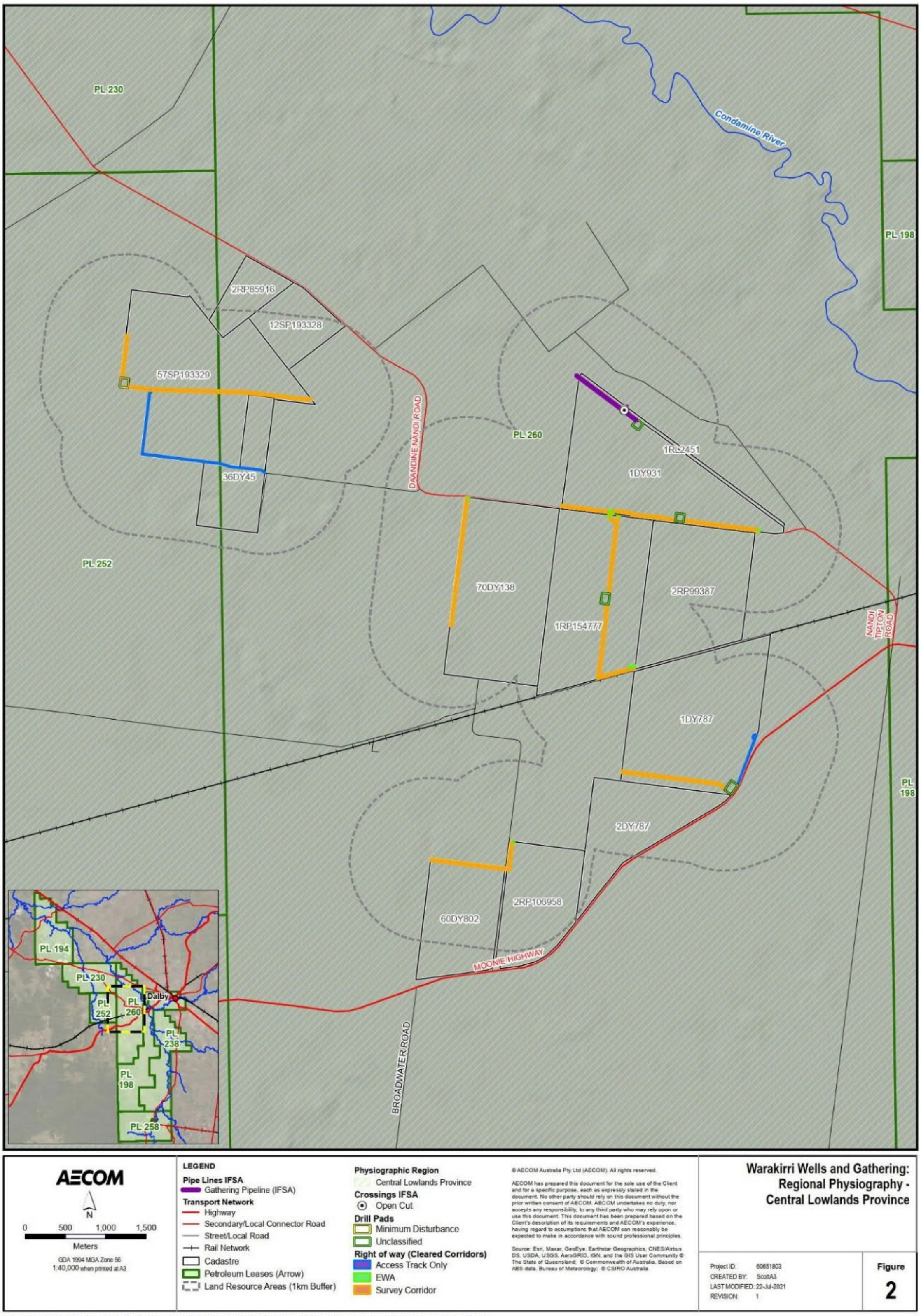


Figure 3 Slope Class and Slope Range (%)

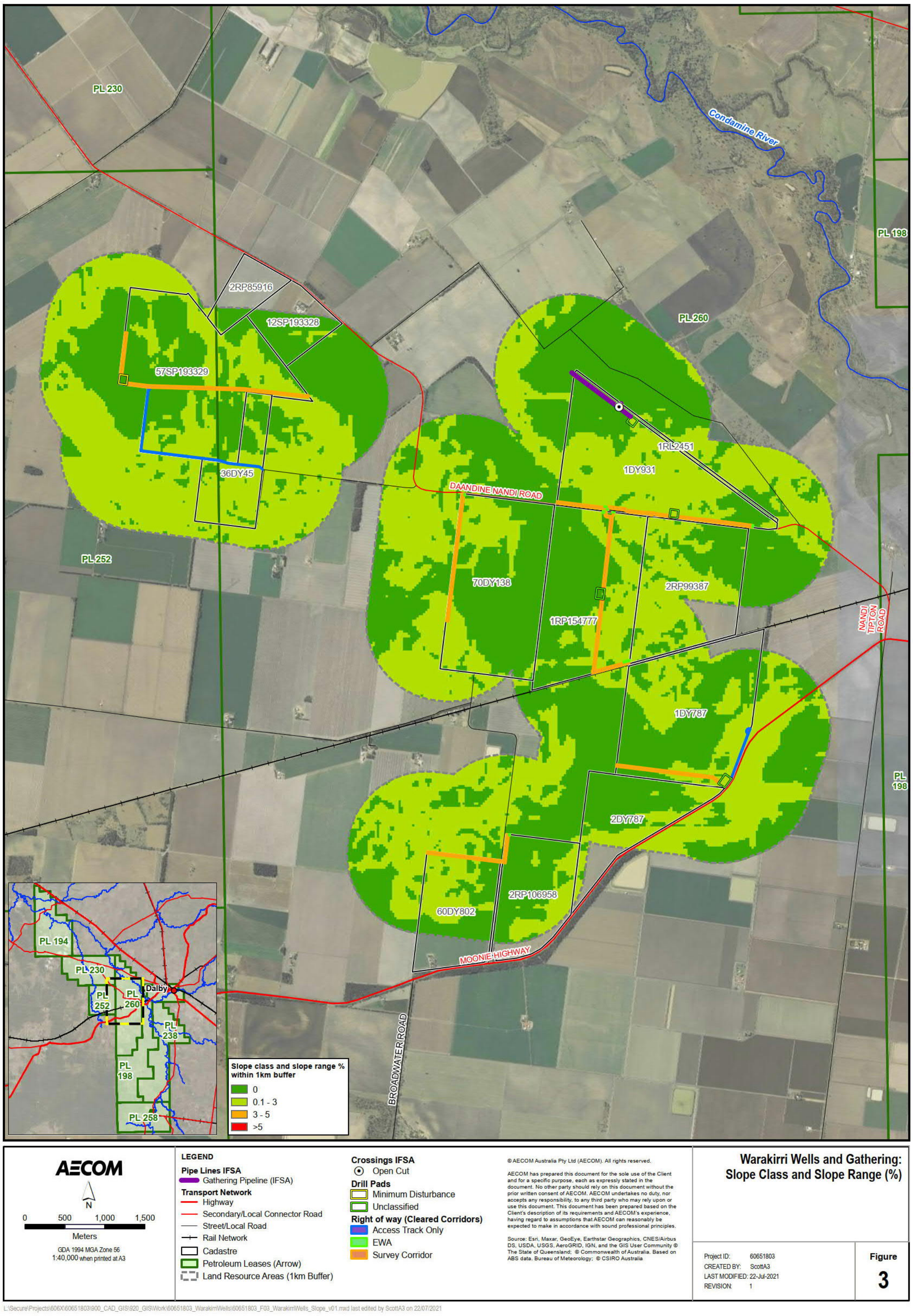
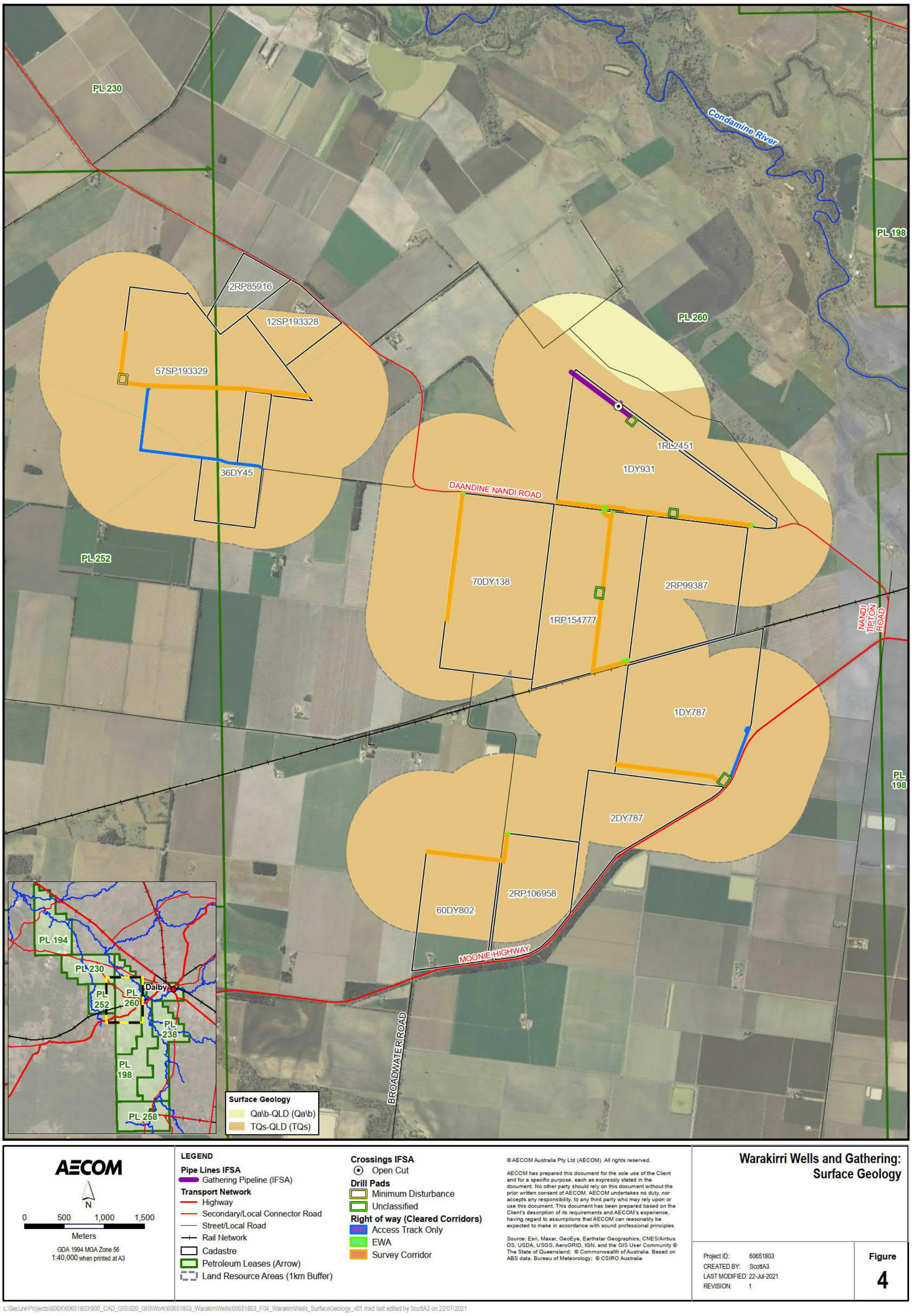


Figure 4 Surface Geology



5.3 Atlas Soil Landscape Units

The relevant soil landscape units have been sourced from the ASRIS Atlas of Australia Soil (Northcote *et al.*, 1960-1968) (herein referred to as 'the Atlas'), which was compiled by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to provide a nationally consistent description of Australian soils. Mapped units are published at a scale of 1:2,000,000, but the original 10 map compilation were at scales from 1:250,000 to 1:500,000. This scale mapping is commonly used for desktop studies.

The soil landscape units identified in the Atlas provide a description of the physical environmental, displaying the occurrence and distribution of geological regimes, landscape units and associated soil types. Soil landscape units are reoccurring soil mapping units with shared geology, landform, soil and vegetation associations. More than one soil type can occur within a landscape unit, represented with a dominate and several subdominant types.

The Atlas indicates two soil landscape units within 1 km of the proposed drill pads and gathering network, which are summarised in **Table 2**, and presented graphically in **Figure 5**.

The dominant soil type of each landscape unit is presented alongside the corresponding Australian Soil Classicisation (ASC) soil order and Principle Profile Form (PPF), to aid in the interpretation of soil types encountered along the alignment and is based on Ashton & Mackenzie (2001).

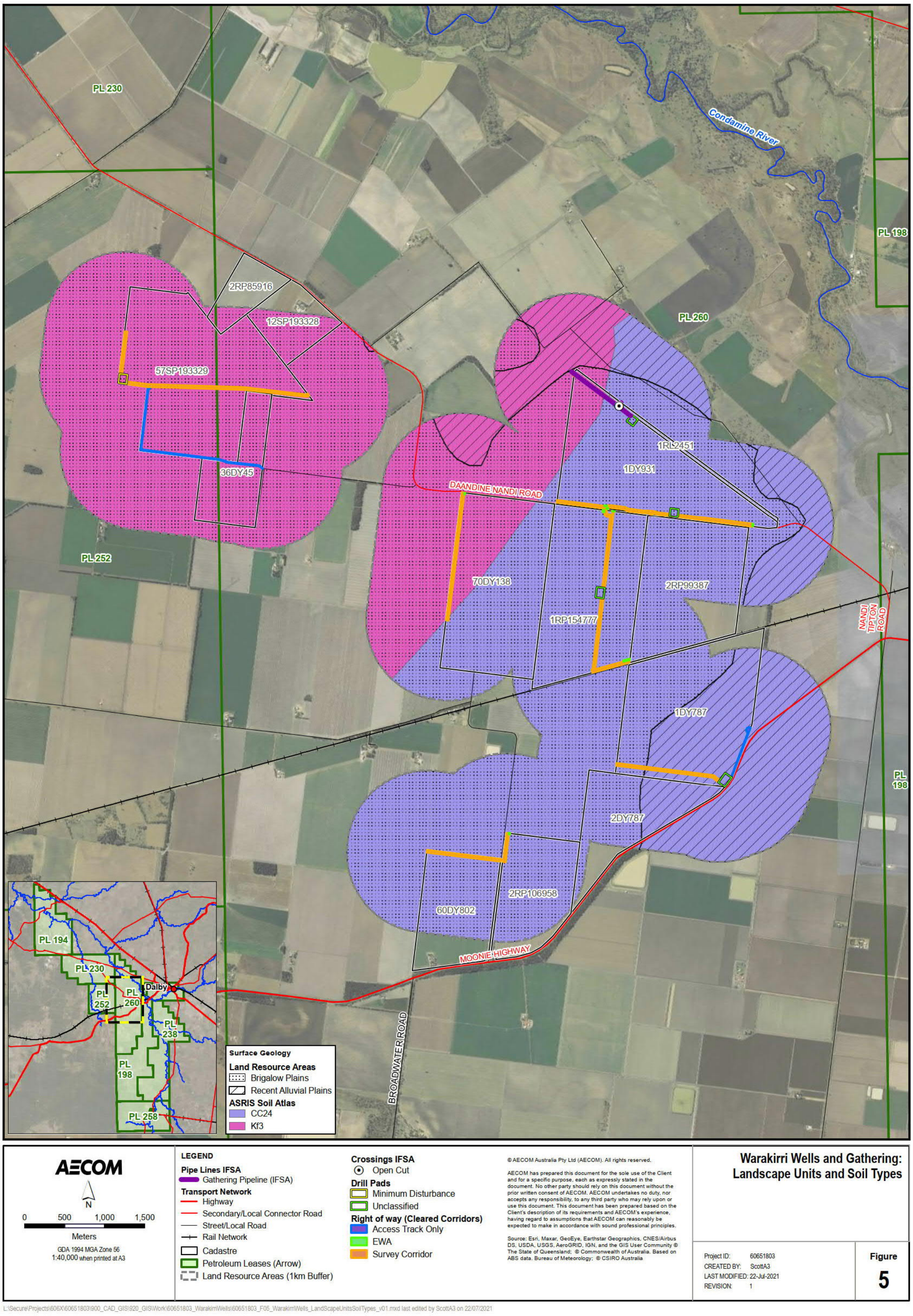
Table 2 Soil landscapes which intersect the Project

Soil landscape units	Landform description	Dominant soil type[1]	Dominant PPF[2]	Dominant ASC Group[3]
CC24	Plain	Dominant soils are grey cracking clays with some dark cracking clays	Ug5.24, Ug5.28, Ug5.16	Vertosol
Kf3	Plain with very low sandy rises and banks separated by flats and depressions	Dominant soils are dark cracking clays	Ug5.16	Vertosol

Notes:

1. ASRIS Atlas of Australian Soils (Northcote *et al*., 1960-1968)
2. Principal Profile Form (Northcote, 1974)
3. Dominant Australian Soil Classification (Isbell, 2002)

Figure 5 Soil Landscape Units



5.4 Land Resource Area: Central Darling Downs

Due to the broad scale of the Atlas (1:2,000,000), a review of the Land Resource Areas (LRA) mapping was used to further assess the soil types within the Project. LRA identified to intersect the Project are presented in **Table 3.**

LRAs have been determined from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), and are based on the combination of geology, landscape features (slope/relief), vegetation and groups of soils. LRA maps are not designed to strictly identify soils in a particular map unit but predict their probable occurrence.

Land suitability indicates the identified LRAs have agricultural potential as cropping land (broadacre and horticulture) and pasture (sown and native pastures).

Typical soil characteristics show a good correlation with the soil landscape units mapped in the Atlas (Northcote *et al.*, 1960-1968), with the Project likely to mainly encounter cracking clay soils.

The typical soil types likely to be encountered in each LRA, along with generic soil properties, are detailed in the following subsections.

5.4.1 Recent alluvial plains (1a)

Common soils within this LRA are deep to very deep (0.8 to 1.8 m) coarse, self-mulching cracking clays on recent alluvial plains on mixed basalt/sandstone alluvium. Soil are distributed along the active floodplain of the Condamine River and tributaries, including river terraces, streambanks, old river channels and plains.

Generic soil features include a medium to heavy clay, self-mulching surface soils, which are moderate to coarse and granular. The surface soil is often non-sodic and can sometimes be lightly crusted. The subsoil is commonly sodic to strongly sodic with medium to very high salinity. The profiles have an alkaline trend, consistent with depth.

The land is suitable for dryland/irrigated cropping and grazing of native pastures, depending on the risk presented by inundation and erosion.

Native vegetation has mostly been cleared but contains fringing woodland to open forests of river gum, Queensland blue gum and some acacia species.

5.4.2 Brigalow plains (5a/5b)

Typical soils associated with this LRA are deep to very deep (1.0-1.6 m), self-mulching grey cracking clays with shallow gilgai on the brigalow claysheet. Soils are located on flat to very gently sloping undulating brigalow clay plains north of Warra and around Kupunn, west of Dalby.

Generic soil features include an angular blocky surface structure, which is strongly alkaline. The subsoil is often a structured clay, with mild alkalinity in the upper subsoils, tending to strongly acidic deeper in the profile. The subsoil is both strongly sodic and saline.

The land is suitable for continual grain and cotton cropping, only limited by strongly sodic and saline subsoils. The soils are susceptible to erosive flooding.

Native vegetation has mostly been cleared but contains brigalow, belah, wilgas scrub and black tea tree in low lying areas.

Table 3 Identified LRAs in the Central Darling Downs (Harris *et al.*, 1999)

LRA	Landform description	Major soils	Estimated ASC	Agricultural land classification	Typical vegetation	Generic physical and chemical soil properties				
						Soil (m)	pH	Dispersion[1]	Sodicity[2]	Salinity[3]
Recent alluvial plains (1a): Condamine	Board level plains of mixed basaltic and sandstone alluvium	Black and grey cracking clays with bleached sands or loams over brown or black clays	Vertosol	A1 – crop land: broadacre and horticulture	Poplar box or Queensland blue gum open woodlands, or grasslands	Surface soil: 0-0.15	8.7	Low	Non-sodic	Very low
						Upper subsoil: 0.15-0.6	9.1	Medium	Sodic	Medium
						Lower subsoil: 0.6-1.4	8.1	Medium	Strongly sodic	High to Very high
Brigalow plains (5a/5b): Kupunn	Flat plains, with gently undulating clays plains with shallow to deep gilgai	Grey self-mulching cracking clays	Vertosol	A1 – crop land: broadacre and horticulture	Brigalow, belah forest with wilga with some black tea tree	Surface soil: 0-0.05	8.5	Low	Non-sodic	Low
						Upper subsoil: 0.05-1.2	9.0	Low to medium	Sodic	Low
						Lower subsoil: 1.2-1.5	4.3	High	Strongly sodic	High

Notes:

1. Clay dispersion is measured as a dispersion ratio (Baker and Eldershaw, 1993)
2. Sodicity calculated as the percentage of exchangeable sodium (ESP) (Baker and Eldershaw, 1993)
3. Salinity estimated from the measurement of the electrical conductivity in a 1:5 suspension of soil to water (Shaw, 1988)

5.4.3 Summary

Based on available chemical and physical data from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999) (**Table 3**), soils within the Project are expected to have an alkaline upper subsoil (pH 8.0 to 9.0). The soils are also expected to be sodic or strongly sodic and have medium to very high levels of salinity in the subsoil. Levels of sodicity and salinity are generally expected to be lower in surface soils, increasing with depths in the soil profile.

A summary of identified LRA within the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), cross-referenced with the Atlas soil landscape units and associated ASC soil classification is presented in **Table 4**.

Based on the available Atlas and LRA mapping, the soils within the Project are expected to be is dominated by self-mulching cracking clays, such as Vertosols.

Table 4 Summary of the Project soil units and LRA

LRA	Soil landscape units (ASRIS)	Dominant ASC	Land parcels	Approximate disturbance area (ha)	% of total Project area
Recent alluvial plains (1a)	CC24	Vertosol	Lot 1 of DY787	4.1	8.7%
	Kf3	Vertosol	-	0	0%
Brigalow plains (5a/5b)	CC24	Vertosol	Lot 1 of DY787 Lot 1 of RL2451 Lot 1 of DY931 Lot 1 of RP154777 Lot 2 of RP106958 Lot 60 of DY802 Lot 70 of DY138	25.4	37.5%
	Kf3	Vertosol	Lot 57 of SP193329 Lot 36 of DY45 Lot 1 of DY931	17.7	53.8%

6.0 Disturbance Management

The major limiting factors for the soils encountered within the Project area are soil structure and texture, along with subsoil salinity and sodicity issues. The proposed management options for these issues are presented in the following subsections.

6.1 Topsoil suitability and management

The generic soil properties in the Central Darling Downs Land Management Manual (Harris *et al.*,1999), were reviewed against the criteria set out in the *Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley* (Elliott and Veness, 1981) to determine the suitability of available soil material for reuse as topsoil, as detailed in **Table 5**. The depth of primary growth media was estimated using the reported plant available water capacity. These estimates should be reviewed following a detailed pre-characterisation assessment of soils within the Project area to assist in identifying rooting depth and nutrient deficiencies.

Table 5 Guide to estimated stripping depths

LRA	Estimated primary growth media (m)	Limiting factors
Recent Alluvial Plains (1a)	0.15-0.2	Soils have a narrow moisture range for effective workability, which can be improved by adding a sandier textured material.
Brigalow Plains (5a/5b)	0.2-0.25	Gypsum can be incorporated into the subsoil material to limit dispersion and erosion.

6.2 Soil stripping and stockpiling/storage

The Project area largely crosses existing agricultural land, with some isolated clusters of timbered areas along the lot/plan boundaries. Where clearing is required, timber should be cleared and retained for chipping or habitat recreation. Chipping can provide a useful soil amendment and limit weed growth.

Suitable topsoil should be stripped for the width of the pipeline trench and access track plus (nominally) 1 m each side of the trench. The estimated primary growth media depths provided in **Table 5** can be used as a guide.

Topsoil and subsoil (which may have dispersive or sodic subsoil horizons) should be stockpiled separately to avoid mixing. Topsoil management should be undertaken in line with the requirements listed in Arrow's *Land Disturbance Procedure* (ORG-ARW-HSM-PRO-000146).

Stockpiles are not recommended to exceed 3 m in height, to manage degradation through physical, biological and chemical processes. Based on the typical ROW construction, stockpiling is expected to be undertaken in section along the length of the trench to maintain access/egress. The stockpile should not be compacted to reduce surface runoff and facilitate infiltration.

Stockpiles should be in place for the minimum duration practicable to safely install the infrastructure, which is understood to be typically less than three months. Where practicable work should be staged to not extend over a wet season. In situations where this is unavoidable, quick vegetation such as pasture species and mulches can be used to reduce surface erosion.

Consideration should be made for drainage flow direction and diversions in place to prevent stockpile erosion. Appropriate erosion and sediment control measures should be documented prior to works commencing.

6.3 Returning topsoil/spoil to the trench

Excavated soils should be returned to the trench in the pre-disturbance soil profile. Topsoil that has been stripped can be re-spread as part of stabilisation and rehabilitation activities.

Sodic soils are expected to be encountered along the alignment and should be blended with appropriate soil ameliorants (gypsum and organic matter) during the rehabilitation process to reduce the potential for soil dispersion. Sampling and analysis of soil prior to reuse is recommended to assist in identifying nutrient deficiencies and ameliorant requirements. The use of such ameliorants should also be discussed with landholders prior to application.

The disturbance area should be re-shaped into a stable landform with consideration for surface drainage lines.

6.3.1 Compaction Strategies

The backfilling and compaction of the trench is also dependant on the use of appropriate equipment suited for compacting soil in trenches, ensuring the soil is moisture conditioned (i.e. if the soil is too wet or dry to compact) adding moisture based on the inherent moisture content.

The soils are generally placed in thin layers (typically 300 to 400 mm), adding moisture conditioning, if needed, followed by thorough tampering with the bucket (or a roller attachment for the excavator). The site-specific compaction strategies should be informed by the geotechnical assessment and construction design for various components including well pads, gathering, pipeline, access tracks etc.

Compaction of surface layers within the ROW disturbance areas should be undertaken in a way to improve the water infiltration capacity and aeration along the contour, prior to the re-shaping and re-spreading of topsoil and revegetation.

6.4 Reinstatement and erosion controls

The different soil types traversed by the alignment have variable erodibility characteristics, determined primarily by soil structure, texture and sodicity. An overview of the erodibility ratings associated with each soil type is provided in **Table 6**, based on typical Queensland soils described in the Department of Transport and Main Roads (DTMR) Road Drainage Manual (DTMR, 2019).

An estimate of the long-term soil loss from both sheet and rill erosion can be calculated using the Revised Universal Soil Loss Equation (RUSLE) (IECA, 2008). This issue is less of a concern in the Project area due to the flat terrain, including many laser levelled paddocks.

Erosion and sediment controls should be identified, documented and implemented as part of soil preparation works. These documents should remain in place until stabilisation of the disturbance area is achieved.

Table 6 Typical Erodibility Ratings

Soil type and ASC	Description of erodibility characteristics	Erodibility rating
Uniform non-cracking clays - *Dermosols*	Light to heavy clays with strong structure: • fine aggregates • coarse aggregates	Very Low (1) Low (2) to Moderate (3)
Uniform cracking clays – *Vertosols*	Light medium to heavy clays that shrink and crack open when dry and swell when wet, gilgai micro relief common.	Low (2) to moderate (3)

6.5 Construction inspection and maintenance regimes

The disturbance area should continue to be visually monitored until such time that the site is considered effectively stabilised or rehabilitated, in line with Arrow's rehabilitation criteria. To help in adequate rehabilitation, the quantity of ameliorants needed (if any) for topsoil and subsoil based on pre-construction land use are generally calculated based on site specific laboratory analysis.

After completion of pipeline installation, cropped areas should be stabilised to combat erodible / dispersive surface soils (below topsoil) and then topped with a topsoil dressing to match the thickness and quality of the surrounding topsoils of undisturbed areas, as a minimum.

Ideally, topsoils stripped during pipeline installation would have been stockpiled and reused in the same location and to the same thicknesses to match the original soil profile as closely as was practical. Inspection and maintenance should include assessment of surface stabilisation (e.g. lack of erosion of the topsoil / crop-supporting layer and the health of surface vegetation) in accordance with Arrow's rehabilitation criteria.

Waterway crossings (if any) might require specific inspection and maintenance regimes, which should be considered at the time of conceptualising and designing each crossing.

7.0 Conclusions

The proposed Project area intersects two ARIs, PAA (PALU) and SCA, and as such requires a RIDA application to be submitted under the RPI Act.

Based on the desktop review of the geology, landscape features, vegetation and groups of soils, two landscape units (CC24 and KF3) and two land resource areas (Recent alluvial plains and Brigalow plains) were identified within 1 km of the proposed drill pads and gathering network.

The Project is located between the Condamine River and Wilkie Creek, described as the Condamine Lowlands. The area contains low-lying siltstone hills with alluvial sediments on the floodplains of the Condamine River and highly weather bedrocks on the slopes. The low-lying area has an elevation of 330 mAHD and slope ranges from near level <1% to 3%.

The surface geology is a part of the Surat and Clarence Moreton Basins, dominated by alluvial sediments overlying sedimentary rocks. The Condamine Alluvial sediments are extensive and can range in thickness from 10 m to more than 120 m in the floodplain near Dalby.

Based on the existing mapping (a scale of 1:2,000,000), the soils within the study area were dominated by self-mulching cracking clays (i.e Vertosol). The available mapping reviewed as part of the desktop review are not designed to strictly identify soils in a particular map unit but predict their probable occurrence.

Based on available chemical and physical data from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), most soils along the alignment are expected to have an alkaline upper subsoil (pH 8.0 to 9.0). The soils are also expected to be sodic or strongly sodic and have medium to very high levels of salinity in the subsoil. Levels of sodicity and salinity are generally expected to be lower in surface soils, increasing with depths in the soil profile.

The major limiting factors for the soils encountered within the Project area are soil structure and texture, along with subsoil salinity and sodicity issues. Most issues are likely able to be controlled by suitable soil handling, construction management practices and application of appropriate spoil ameliorants (gypsum and organic matter).

8.0 Recommendations

It is recommended that a detailed soil investigation be undertaken to refine the assessment of soils identified within the Project area, with the objective to facilitate the creation of suitable control measures which are reflective of site-specific soil conditions.

Further soil investigations are recommended to be generally completed prior to any earth works commencing within the ROW.

9.0 References

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10.0 Limitations

AECOM Australia Pty Ltd (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Arrow Energy Pty Ltd (Arrow) and only those third parties who have been authorised in writing by AECOM to rely on this soil assessment (report).

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the professional services agreement (10315CNT) and Call-off-Order (COO) dated 25 November 2020.

Where this Report indicates that information has been provided to AECOM by third parties, AECOM has made no independent verification of this information except as expressly stated in the report. AECOM assumes no liability for any inaccuracies in or omissions to that information.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

Appendix A

Curriculum Vitae

Simon Muniandy
ANZ Upstream Oil and Gas Market Sector Lead

Qualifications
Bachelor of Science (Hons, Geology)

Career History

Areas of Experience

- Conventional and Unconventional Oil and Gas
- Programme and Project Management
- Contamination Assessment and Remediation
- Geology, hydrogeology, & geochemistry
- Operations Management

Career Summary
Simon is the ANZ Upstream Oil and Gas Market Sector Lead and Technical Director with more than 20 years' experience in the geoscience/environmental industry, with projects across Australia, Pacific Islands, Papua New Guinea and S.E. Asia. Simon has a leading role the Oil and Gas market sector responsible for the delivery of AECOM projects to the onshore upstream oil and gas industry across ANZ.

Simon has extensive experience in the oil and gas and mining industry specifically in the risk management of environmental liabilities related to the acquisition, operation, decommissioning and demolition of facilities associated with all aspects of these industries.

Simon has managed the design, implementation and execution of a range of environmental projects including decommissioning and remediation of fuel terminals, marine, aviation and retail facilities. Simon also has extensive experience in upstream unconventional oil and gas, including development approvals and associated environmental assessments, baseline monitoring, water/brine management related to treatment and storage infrastructure, surface water discharge and aquifer storage. Simon has also been responsible for the design, management and execution of a $20M (Office of Groundwater Impact Assessment) groundwater monitoring bore program for Santos.

Due to his achievements associated with the OGIA drilling project, Simon was awarded the URS Pyramid Award for project management in 2014.

Simon has been able to apply his oil and gas industry experience to work collaboratively to achieve his Client's objectives and develop business for AECOM across technical disciplines and geographies.

Detailed Experience

ANZ Upstream Oil and Gas Market Sector Lead
Queensland Office, AECOM Australia Pty Ltd
Simon is responsible for the delivery of upstream oil and gas projects across ANZ. His responsibilities include; health and safety, cost control, contract management, scheduling and resourcing to enable the flawless execution of AECOM projects for our oil and gas clients. Whilst Simon's remit is across all AECOM technical services, he reports to Asia Pacfic Environment Managing Director

Work Group Manager Geoscience and Remediation Services, Queensland
Queensland Office, AECOM Australia Pty Ltd
As Work Group Manager, Simon is responsible for the leadership and management of the Geoscience and Remediation Services group consisting of approximately 30 staff. Simon is accountable for the group's financial performance, technical direction, business development and the technical delivery of a wide range services including:

- Contaminated land assessments and remediation
- Hydrogeological assessments and modelling
- Geochemistry
- Soil Science
- Geophysics
- Geology

Client Management
Santos & Caltex - National Client Account Manager, AECOM Australia Pty Ltd
Simon was AECOM's national client account manager for Santos & Caltex, responsible for the successful delivery of all AECOM projects nationally and throughout the Pacific. Simon provides Santos & Caltex with a single point of contact for contract or issues critical to project delivery. Simon also is Principal in Charge for a range of Coal Seam Gas (Coal Bed Methane) groundwater and environmental projects including; the management of associated water, infrastructure decommissioning, remediation and environmental assessments. His responsibilities as the National Client Account Manager include:

- Contracts negotiation and reporting;
- Financial management;
- Project support and technical review;
- Stakeholder management;
- Strategy Planning, Budgeting and Forecasting;
- Health and Safety Management and Leadership.

Project Management
Project Manager, ExxonMobil Environmental Services - Major Projects, Mobil Oil Australia, Australia, PNG, Indonesia
Simon was the Project Manager responsible for the management of ExxonMobil's environmental liabilities associated with the operation and/or decommissioning of major facilities in Australia. Critical to the successful execution of projects was the ability to evaluate risk and prioritise a large number of sites across the portfolio, then effectively manage the environmental risk and commercial objectives for each site.

Simon has successfully completed multi-million dollar site assessment and remediation projects across Australia with a number of projects receiving recognition for flawless execution across health and safety (zero recordable incidents), on schedule and under budget. Simon was responsible for the following portfolios:

- Non-Operating Distribution Terminals and Pipelines (National);
- Aviation Terminals (National);
- Marine Fuel Terminals (Queensland);
- PNG LNG Office and Housing;
- Oil Field Divestment – Aceh, Indonesia

His responsibilities as a project manager with ExxonMobil Environmental Services included:

Duties:

- Management of environmental risks and liabilities;
- Management of consultants and contractors on major projects (>$15M AUD).
- Technical review and stewardship of environmental assessment and remediation.

Skills:

- Contractor Management;
- Cost and budget controls;
- Health and safety stewardship;
- Technical expertise including soil and groundwater remediation, and risk assessment;
- Risk management;

- Communication of project risks and analysis to stakeholders including senior management.

Oil and Gas

Project Director, Shallow Groundwater Assessment, QGC
Design and construction of 44 groundwater monitoring bores in the Surat Basin Aquifers targeted: Springbok Sandstone and Walloon Coal Measures. The groundwater monitoring program to assess CGS impacts on groundwater and potential groundwater dependant ecosystems. A small mobile drill rig to install shallow groundwater well, compliant with the Code of Practice and API specifications. The project received an QGC Wells team award for excellence.

Project Manager, Spring Gully and Taloona Evaporation Pond Assessment and Remediation
Assessment of an 83ha and 10ha brine storage and evaporation ponds, and development and design of a remedial strategy to protect nearby sensitive receptors. The multidisciplinary delivery team has produced the first remediation and approvals plan of this type in the CGS industry in QLD.

Principal in Charge, Water Facilities Upgrade Project Scotia – Design Phase, Brisbane Team, Queensland
In 2012 URS designed and subcontracted the construction and supervised the filed assembly and oversaw commissioning of a managed aquifer recharge (MAR) water injection system. URS was commissioned to design and oversee construction of the injection equipment and manage the design of the reverse osmosis plant. URS had previously successfully installed the injection bore and had performed hydrogeological testing to ensure that the aquifer had the capacity to accept the required injection volume and rate.

Principal in Charge, Deep Monitoring Program, Queensland
URS engaged a combination of large oil and gas service providers (Halliburton, Weatherford, GE Oil & Gas) and smaller scale drilling and services companies to design a turnkey approach for developing, managing and executing large scale groundwater drilling projects for Coal Seam Gas (CSG) operators.

The 16-well campaign based in Roma, targeted zones of the Springbok and Hutton sandstones to depths of up to 1,150 mBGL. In order to manage potential influxes from gas bearing units (Walloon Coal Measures), a full BOP stack (annular, double rams) was been employed, and all auxiliary gear on site (mud systems, generators, pumps) were intrinsic safety rated.

URS was responsible for the planning, procurement, management and delivery of a groundwater well installation campaign targeting aquifers in close proximity to, and underlying economics CSG reserves. Our technical team, comprising experienced project managers, field hydrogeologists, site supervisors, drilling and completions engineers enable the delivery of reliable groundwater monitoring infrastructure which is designed, drilled and completed to CSG standards.

Principal in Charge, Old Bogandilla, Emu Park Wells, Queensland
URS was commissioned to design, procure and manage the installation of a 1500m deep monitoring well at Old Bogandilla site and a 1600m deep brine injection monitoring well at Emu Park site, located near Roma QLD. The project was completed on budget without any recordable health and safety incidents.

Principal in Charge, Roma MAR Pumping Tests, Queensland
During the construction phase of the Roma Managed Aquifer Recharge Project (MAR), URS was commissioned to perform pumping tests on the Roma MAR injection bores. The objective to gain a better understanding of the hydraulic parameters of target aquifers and to determine the bore efficiency of each injection bore.

Principal in Charge, MAR Numerical Model, Queensland
The project included, update of the numerical model for injection which URS had previously designed, review baseline assessments of all private bores within the Roma MAR injection impact zone, provide recommendations on remedial actions which may be required due to injection.

Principal in Charge, Regional Bore Inventory- Data Review, Queensland
In order to comply with the Queensland Department of Environment Resource Management, Baseline Assessment Guidelines for Roma Regional Bore Inventory, the Client required data collected by their field staff to be reviewed by a third party. URS attended 10% of the baseline assessments being conducted by the Client RBI team and reviewed all information presented in the baseline assessment reports completed by the Client RBI team, enabling sign off by the regulator.

Principal in Charge, Landholder Bore Investigations, Queensland
The Client was required to conduct down-hole surveys of landholder bores in the Fairview field. The surveys will be used to establish which formation the well is screened in, review the construction of the bore and the integrity of the casing, and to determine their suitability for use as ongoing groundwater monitoring points. URS was commissioned to manage the down-hole survey of the bores and perform the data analysis of the survey data. Use of existing bores for monitoring purposes gave a large cost saving to the client.

Project Manager, Regional Bore Inventory - Roma Fairview Arcadia Valley, Queensland
The aim of the project was to collect accurate, verifiable and representative information on the private bores within and surrounding the clients' petroleum leases or Authorities to Prospect (ATPs). The baseline assessments were required to assist with any potential make good agreements with landholders and the assessment was a requirement of the Queensland Water Act 2000. The baseline assessment included all water bores within and potentially surrounding coal seam gas tenures, including water bores not formally registered or notified to the Department of Environment and Resource Management.

Project Manager, Narrabri Surface Water Monitoring, New South Wales
Development and completion of a baseline surface water monitoring program for the Clients Narrabri operations. Scope of work incudes; site familiarisation and orientation, desktop analysis and site selection, map preparation, detailed catchment characterisation, monthly field visits, sampling, preparation of post monitoring memorandums, tracking and review of laboratory data, reporting and data analysis.

Project Manager, Narrabri Environmental Monitoring, New South Wales
Field groundwater and environmental monitoring for the Narrabri operations team including, collection of 22 groundwater samples, collection of 16 raw CSG groundwater samples and collection of 5 surface water samples, and tracking and review of lab data.

Project Manager, Screening Study – Hydraulic Connectivity Studies
Assessment of telemetry bores for suitability of aquifer hydraulic assessment. There were 70 private bores that have been equipped with telemetry to monitor groundwater levels within the bores. During the regular operation of these bores by the landholder, water level data is collected on the drawdown and recovery within the wells. This information alongside flow rates and information available through various sources can be used to determine localised aquifer hydraulics. The desktop assessment through interrogation of all available information was to identify which of the approximate 70 bores have the suitability for further analysis for hydraulic assessment, based on; Groundwater level pumping and recovery data, pumping rate is constant, and availability of well flow rate or volume of water extracted.

Project Manager, Scotia MAR – Injection Equipment Modification and Implementation, Queensland
URS was commissioned to investigate the modification of existing Managed Aquifer Recharge equipment used for permanent use in a separate scheme. The study lead to a full redesign of the existing system and project management of the design of a separate reverse osmosis plant.

Environmental Studies

Principal in Charge GE Project Eldridge - Due Diligence Assessment
URS was commissioned by GE to perform Due Diligence assessment for the sale of 5 chemical sites across eastern Australia. The project required that URS complete the entire project; desk top, intrusive assessment and reporting) within two weeks. GE were able to successfully complete the transaction based on the timeliness and quality of the URS reports.

Principal in Charge – Santos Moonie to Brisbane Pipeline Assessment and Decommissioning Plans
URS were appointed as the environmental consultants to assess and manage the environmental impacts and decommission planning for the entire 300km Moonie Brisbane crude oil pipeline. Through an extensive review of operational records, URS were able to rank each section of the pipeline for the risk of impacts and tailored an assessment process for each risk level (high, medium low,). On the basis of the assessment URS identified a limited number of impacted site requiring remediation or further risk assessment, ensuring management of Santos risk into the future.

In preparation for the potential decommissioning of the pipeline URS prepared an abandonment plan recommending the most cost effective and safest options for decommissioning the pipeline along its entire length including; agricultural regions, urban residential regions, road and rail crossings, and creek crossings. On the basis of the plan Santos were able to select the best decommission techniques for all section of the pipeline.

Team Leader/Principal in Charge, Various environmental projects, Mobil/Shell/Caltex/BP, Australia, Pacific Islands, S.E. Asia
Simon has successfully filled a number of key roles (project manager, technical reviewer, Principal in Charge) on contaminated site assessment and remediation projects for the oil majors. Simon has acted as a team leader for URS contaminated site projects in Victoria, Northern Territory and Queensland where his tasks included the management and technical review of multiple projects to ensure the technical delivery of project for our Clients.

Project Manager, Department of Planning and Infrastructure, Northern Territory
Simon was the project manager for the remediation and ongoing assessment of the Darwin Waterfront Redevelopment. The project management included the development and completion of remedial work plans for each of the construction areas, independent environmental consultant supervision of construction and remedial works, ongoing groundwater monitoring of the site, assessment of former navy fuel storage tanks,

bio-remediation of hydrocarbon contaminated soil, groundwater modelling of the site, trial installation of groundwater interception drains and assessment of 800,000m^3 of imported fill.

Project Manager, Soil and groundwater contamination assessment Leederville Pty Ltd, Cranbourne South, Victoria
Soil and groundwater contamination assessment of former pastoral grazing land rezoned for residential development. Simon had involvement in the planning and conduct of the field component, project management, reporting and also remediation and validation of impacted areas. Following the final assessment report the auditor was able to provide the client with a Certificate of Statutory Environmental Audit for the site.

Project Manager, Confidential Client, Ansett Facilities, Tullamarine, Victoria
A potential purchaser of the Ansett maintenance facilities at Tullamarine required a due diligence environmental site assessment performed prior to purchase. Involvement included managing field activities on two sites simultaneously, three drill rigs and three field staff. Installation of eight groundwater wells to depths of up to 50 m and approximately 60 soil boreholes. Simon was also involved in the groundwater modelling and production of detailed lithological cross-sections and reporting.

Project Manager, Groundwater Assessment, Orica Engineering Pty Ltd, Yarraville, Victoria
A large chemical plant adjacent to the Yarra River required a detailed groundwater assessment prior to the divestment of part of the site. Simon's involvement included installing aquifer specific wells across the three significant aquifers at the site, utilising sophisticated drilling and well installation techniques. Simon also project managed the groundwater monitoring component, involving analysis of non-standard, organic, analytes.

Project Manager, Mirvac Victoria Pty Ltd, The Heath, Heatherton, Victoria
The project involved a groundwater nitrate investigation, assessment of extent and rate of migration of groundwater nitrate plume extending beneath former market garden area. This included the review of possible remediation technologies for groundwater nitrate.

Project Manager, Auspine Pty Ltd, Kalangadoo, Tarpeena, SA and Scotsdale, Tasmania
Simon was the project manager for timber processing and treatment plants, requiring on-going monitoring of groundwater to assess for potential site use impacts on groundwater. Involvement also included groundwater sampling, reporting and peer review.

Project Manager, Australand Apartments Pty Ltd, Abbotsford, Victoria
Australand were developing a former textile mill on the banks of the Yarra River in Abbotsford, Melbourne. The site requires a statement or certificate of environmental audit prior to the completion of the residential development. Involvement included project management of field staff for the installation of 11 groundwater bores, groundwater flow modelling, conceptual geological and groundwater modelling and reporting. Issues in completing to fieldwork included, drilling on an asbestos contaminated site, liaison with CFMEU representatives, OH&S consultants, local council and residents.

Project Manager, Beverford Pty Ltd, Sheep Dip Assessment, Swan Hill, New South Wales
Two former sheep dips are located in a proposed residential subdivision area. Simon's involvement included project management, initial site inspections, sampling and cement stabilisation trials for remediation and disposal of arsenic contaminated soil.

Geotechnical Investigations
Project Manager, Henty Goldmine West Coast, Tasmania
Henty was developing a major extension to the underground workings involving a long drive requiring two vent shaft for ventilation and emergency exists. Involvement included geotechnical logging the pilot hole for Vent Shaft 2, consisting of over 600 m of diamond core. Simons' involvement also extended to point load testing of core samples, organising mine geologists and field staff.

Project Manager, Temco Pty Ltd, Bell Bay, Tasmania
An additional wastewater storage dam was required by a major industry. Simon's involvement included geotechnical investigations of soil and installations of groundwater wells providing information for the dam design.

Project Manager, Comalco Pty Ltd, Bell Bay, Tasmania
A major erosion gully had developed below a historical landfill on the Tamar River causing and increase risk of a landslip occurring. Simon's involvement included soil and groundwater sampling, groundwater and landfill leachate modelling, land slip modelling using SLIP software, reporting, risk assessment and further investigation recommendations.

Project Manager, Leightons Pty Ltd, Melbourne, Victoria
A major petroleum company proposed to develop a large tank farm adjacent to West Swanson Dock. The initial assessment involved geotechnical and environmental components. Simon's involvement included geotechnical logging of 30 - 40 m deep, cored boreholes.

Project Manager, Hydro Tasmania Pty Ltd, Meander Dam, Meander, Tasmania
Soil mapping and sampling to locate sufficient quality and quantity of clay to construct an earth dam wall. Issues included working in remote areas and logistics.

Project Manager, Eastern Treatment Plant, Tertiary Treatment Plant Investigation, Melbourne, Victoria
Excavation of approximately 20 testpits and the construction of three groundwater piezometers to provided geotechnical information for the design of the tertiary treatment plant. Testpits were excavated to a depth of 4 m and bag and bulk samples were collected, in-situ consistency was measured and lithologies logged. Bulk samples were used for standard compaction tests and bag samples were used for particle size analysis and Atterburg limits. Three deeper boreholes were advanced with SPTs performed and U63 collected during drilling. Piezometers were then installed to investigate groundwater levels in the area. Simon's involvement included the reporting of this project which establishing background geology and hydrogeology, summarising field results, laboratory results and allowable soil bearing pressures.

Project Manager, John Mullen Partners, Aldi Food Stores, Melbourne, Victoria
The project involved a joint geotechnical and environmental investigation of numerous proposed Aldi Food stores in Melbourne. Simon's involvement in these projects ranged from fieldwork to project management. The geotechnical component consisted of a limited number of testpits, usually one at each corner of the proposed building and one or two in the vicinity of the proposed car park and CBR testing and limited reporting on allowable bearing pressures for footings and reporting CBR results for pavement design.

Project Manager, Melbourne Water, Mains Water Supply Pipeline, Melton, Victoria
The project involved the geotechnical investigation of a small section of a proposed mains water supply pipeline, where the proposed route went beneath a railway. Simon's involvement included drilling two auger and cored bores on either side of the railway, the installation of piezometers in each bore and surveying the borehole levels. The core was logged, specifically weathering, fracture density and hardness. This information was reported and supplied to the contractor for excavation design.

Project Manager, Melbourne Water, Bridge Investigation, Koo wee rup, Victoria
A geotechnical investigation of a small bridge crossing was required for this project. Simon's involvement included drilling two boreholes, conducting SPTs and collection U63 tubes during drilling and the installation of piezometers. Reporting consisted of regional and local geological and hydrogeological conditions, field and laboratory results and discussion of soil bearing capacities.

Project Manager, Nillumbik City Council, Bridge Investigation, Diamond Creek, Melbourne, Victoria
The project involved a geotechnical investigation of a small foot bridge. Simon's involvement included drilling two boreholes, conducting SPTs and collection U63 tubes during drilling, the installation of piezometers and performing DCPs. Reporting consisted of regional and local geological and hydrogeological conditions, field and laboratory results and discussion of soil bearing capacities. In addition, the project involved liaison with anthropologists and representatives of the local aboriginal tribe.

Project Manager, Radfords Abattoir Pty Ltd, Effluent Lagoon Liner Investigation, Warragul
As a part of a wastewater irrigation project a geotechnical investigation of a proposed effluent storage lagoon site was performed. Simon's involvement ranged from project management to fieldwork. A number of testpits were excavated and bulk samples collected for compaction and tri-axial permeability testing at a range of compaction and moisture conditions. Based on the results of the fieldwork and laboratory results, recommendations were made as to the suitability of the material for uses as a lagoon liner and the required compaction and moisture conditions for the construction of the liner.

Mining
Exploration Geologist Duketon, Western Australia
Exploration geology experience involved a broad range of field, office and managerial tasks. Simon was involved in fieldwork including design and implementation soil sampling program, regional and local scale geological mapping, regolith mapping and geomorphology mapping, groundwater level mapping and supervision of test bore installation for dewatering, supervision and logging of RC, RAB, and diamond core drilling. Office work consisted of database management, GIS management including plan and section production, ore body modelling and wire-framing and geological interpretation and drilling program design. Managerial work consisted of logistical organisation, coordinating drill-rigs and other associated heavy machinery, field technicians, and surveyors.

Wastewater Projects
Exploration Geologist Kraft Foods Ltd, Mil Lel, Mt Gambier, South Australia
The project involved wastewater irrigation assessment and monitoring. High strength, industrial wastewater has been irrigated onto pasture for a number of years. Environmental Protection Act (EPA) required as a part of the licence agreement, the annual monitoring of soils

and biennial monitoring of groundwater, to be reported annually. Simon's involvement included project management, fieldwork and reporting. The report summarises the data, interpolates trends and makes recommendations for reducing adverse environmental impacts. The report is reviewed by an independent reviewer for South Australian EPA.

Exploration Geologist, Starwood Pty Ltd, Bell Bay, Tasmania
Wastewater irrigation assessment for a wood processing plant proposing to reuse the wastewater generated from the plant. The Department of Primary Industries, Water and Environment (DPIWE) required a detailed assessment of the soil and groundwater characteristics of the proposed irrigation site before irrigation could commence. The assessment included soil mapping and sampling, groundwater well installation and sampling, infiltration, permeability and water holding capacity testing. Simon was involved in project manager, fieldwork and reporting.

Exploration Geologist, North West Rendering Pty Ltd, Devonport, Tasmania
Wastewater irrigation and effluent lagoon assessment for a proposed rendering plant site in northern Tasmania. The assessment consisted of soil mapping, soil sampling, infiltration and permeability testing and a lagoon condition assessment. Simon had involvement in project management, soil sampling, permeability and infiltration tests, and reporting.

Exploration Geologist, Sandhurst Development Joint Venture Pty Ltd, Carrum Downs, Victoria
A large residential and golf-course development is utilising treated effluent from the Eastern Treatment Plant for irrigation purposes. Prior to irrigating the effluent EPA require baseline groundwater quality data. The project consisted of the installation and sampling of groundwater monitoring wells and the decommissioning of old irrigation wells. Simon was involved in project management and reporting.

Exploration Geologist, Melbourne Water, Werribee Golf Course and Equestrian Centre, Werribee, Victoria
Western Treatment Plant is providing the Werribee golf course and equestrian centre with treated effluent for irrigation. Prior to irrigating the effluent *EPA* require baseline groundwater quality data. The project consisted of the installation and sampling of groundwater monitoring wells. Simon was involved in project management and reporting.

Exploration Geologist, Coliban Water, Envirosafe 2001, Victoria
Conducting site selection and site assessment for wastewater treatment projects in seven regional Victorian towns, involving GIS assessment, detailed soil and groundwater assessments, permeability testing, salinity susceptibility and agronomic recommendations. The work was performed in conjunction with geotechnical and anthropological assessments.

Exploration Geologist, Wagga Wagga City Council, Wagga Wagga, Victoria
A new industrial area located to the north of Wagga Wagga required a new large effluent treatment system. Simon's involvement included geophysical interpretation and field soil mapping to determine the suitability of proposed effluent irrigation sites.

Exploration Geologist, Oztek Rendering Plant Wadonga, Victoria
As a part of a works approval application for the rendering plant, Oztek required the installation of a groundwater monitoring network surrounding the effluent treatment lagoons and irrigation area. Simon's involvement included, project management and data interpretation and reporting of results to EPA for the works approval.

Exploration Geologist, Epsom Racecourse Redevelopment, Cheltenham, Victoria
The project required the redevelopment of the Epsom racecourse required the relocation of a significant remnant wetland, requiring a detailed soil and groundwater assessment of the existing wetland and the proposed relocation position. This included analysis of bulk density, permeability and major chemical constituents of the soil.

Training
Santos Eastern Queensland, NSW and Cooper Basin Level 1 & 2 inductions

URS Project Manager Certification - 2012

First Aid International Training - 2012

ExxonMobil Stakeholder Engagement Training - 2011

ExxonMobil LPS Training 2007 (annually updated through 2012)

40hr URS Health and Safety Training - 2004

URS Project Management Training (2 days) - 2004

ExxonMobil Incident Investigation Training - 2005

Fundamentals of Groundwater Science, Technology and Management - 2002

Defensive driving and FWD course - 1999

Mining and Resource Contractors Safety and Training Association (MARCSTA) - 3 day training course - 1999

Remote Area Survival Course - 1999

Professional History

2012 - Present
AECOM Services Pty Ltd (formerly URS Australia Pty

Ltd), Brisbane
Principal Geologist

2008 - 2011
Mobil Oil Australia
Contractor

2004 - 2008
URS Australia Pty Ltd, Melbourne
Associate Environmental Scientist

2003 - 2004
Coffey Geosciences Pty Ltd, Victoria
Victorian Environmental Manager

2001 - 2003
Coffey Geosciences Pty Ltd
Environmental Scientist

2000
Van de Graaff and Associates Pty Ltd
Soil Scientist

1999
Johnson's Well Mining
Exploration Geologist

Navjot Kaur
Technical Lead - Acid Sulfate Soils, Principal Soil Scientist

Qualifications
Certified Professional Soil Scientist (CPSS) 2016 to present
MSc (Hons) Agronomy, Punjab Agriculture University, Punjab, India
BSc (Hons) Agriculture Science, Punjab Agriculture University, Punjab, India

Affiliations
Member of Australian Society of Soil Science
Member of Australian Land and Groundwater Association

Awards
URS International Pyramid Award of Excellence - Health and Safety 2011

URS International Pyramid Award of Excellence - Health and Safety 2009

URS 4sight Health and Safety Excellence Award - 2008

University Merit scholarship and awarded merit certificate in Both BSc and MSc

Career History
Navjot Kaur is an Environmental professional with technical background and competent knowledge of soil science and more than 17 years' experience in working with natural resource sector with respect to environmental management. At AECOM she is placed as Principal Soil Scientist with the Geoscience and Remediation Services team.

Her project experience includes environmental impact statement (EIS) assessments from soils perspective including land and soil classification as per Australian Soil Classification (ASC) system; Land Suitability, Land Use, Good Quality Agriculture Land (GQAL) and Strategic Cropping Land (SCL) assessment; Identification and management of acid sulfate soils (ASS); Land Rehabilitation including assessment of potential impacts of problem soils and mitigation measures, erosion and sediment control, topsoil reuse and management

She was also involved in various contaminated site assessments involving Phase I and Phase II site investigations including soil and groundwater sampling, Quantitative and Qualitative Risk Assessment for human health and environmental receptors and Remediation works including development of sampling and analysis plans (SAP), remedial action plans (RAP) and site management plans (SMP).

Her project management experience includes scope development, cost estimation, project administration, budget management, cost control, project completion sub-contractor administration, bid/tender evaluation, procurement and invoicing. She was also involved in supervision of junior staff and sub-contractors

She also has extensive experience with various data management software (gINT, ESDAT, EQUIS) and MS office for graphs, logs, presentations, statistics and report preparation.

Detailed Experience

Navjot's range of experience includes conducting environmental management works on oil & gas, mining, commercial and industrial sites undertaking the following:

- Environmental Impact Assessment
  - Soil and Land Classification based on Australian Soil Classification System
  - Land Suitability, Strategic Cropping Land (SCL) and Topsoil assessment
  - Identification and management of Acid Sulfate Soils (ASS)
  - Site reinstatement and rehabilitation
- Environmental Sites Assessment and Remediation:
  - Environment and Human health risk assessment and mitigation
  - Soil, soil gas, surface water and groundwater investigations
  - Remediation of hydrocarbon, metals, salts and solvent impacted sites
- Environmental Compliance:
  - Environmental Management Plans (EMP) development and implementation
  - Environmental audits (internal and 3rd party) and approvals/ license documents
  - Incident response, monitoring, sampling, mitigation, and reporting
- Water Management:
  - Dewatering programs and groundwater treatment systems
  - Bore drilling and well installation; compliance monitoring and sampling
- Waste Management:
  - Contaminated/ hazardous and non-hazardous waste management and transport
  - Drilling waste management including drilling muds disposal
- Health, Safety & Environment:
  - Development and implementation of project specific health and safety plans
  - Conduct inductions, risk assessments, incident investigation, auditing
- Data management, Interpretation and Report Writing
  - Data management software (gINT, ESDAT, EQUIS) and MS office for graphs, logs, statistics and report preparation
- Project Management:
  - scope development, cost estimation, project administration, budget management, cost control and project completion
  - Contractor administration, bid/tender evaluation, procurement and invoicing
  - Supervision of junior staff and contractors

Key Projects at AECOM:

- Acid Sulfate Soils intrusive investigation and development of ASSMP for Cross River Rail – Rail Integration System (RIS) – Lead Acid Sulfate Soils Specialist - Co-ordination of fieldwork, data analysis, interpretation and Reporting
- Frac Ponds Decommissioning and Rehabilitation, QGC, Technical Lead and Project Manager. Co-ordination of fieldwork, data analysis, interpretation and Reporting
- Acid Sulfate Soil assessment for road upgrade works at Walkerston Bypass, Mackay, Project – Desktop assessment, data analysis and reporting as per Qld Guidelines
- Contaminated land and Acid Sulfate Soil assessment for underground rail tunnel in Brisbane – Desktop assessment
- Acid Sulfate Soil assessment for road upgrade works at Port Alma Road, Bajool, Project – Desktop assessment, data analysis and reporting as per Qld Guidelines
- Stage 1 and Stage 2 Contamination Investigation across the whole RAAF Base Amberley – Desktop, fieldwork, data analysis and reporting
- Stage 1 and Stage 2 Contamination Investigation across the whole Gallipoli Barracks Enoggera – Desktop, fieldwork, data analysis and reporting
- Stage 2 Contamination Investigation across the whole Jennings Defence Base – Desktop, fieldwork, data analysis and reporting
- Soil Assessment for PFAS and other Contaminants for Growler Project, RAAF

Amberley - Desktop assessment, data analysis and reporting

- Coastal Acid Sulfate Soil assessment (CASS) for North East Link (NELA) Project – Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Land Capability Assessment for onsite Effluent Disposal at a site in Melbourne. It included assessment of topsoil and subsoil and water balance calculations.
- Coastal Acid Sulfate Soil assessment (CASS) for Melbourne Metro Project – Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Stage C Groundwater Assessment – AACO Base, Oakey – Reporting
- Groundwater Radioactive Assessment - Defence Science and Technology Group, Fishermans' bend – Fieldwork and reporting
- Exxon Mobil Altona Refinery Sediment Assessment - project management and reporting
- Coastal Acid Sulfate Soil assessment (CASS) for Edithvale and Bonbeach Level Crossing Removal (LXRA) Projects - Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Project manager, Soil sampling at Oakey Base for PFC assessment in Soils for disposal
- Project manager, Soil sampling at Oakey Civil Terminal for PFC assessment in Soils for disposal
- Santos Remediation Project at Roma – Project team, fieldwork and reporting
- Oakey Groundwater Investigation, AACO base Oakey – Project team, fieldwork and reporting
- Growler Project, RAAF Base Amberley Additional Soil Characterization including assessing soils for PFC contamination
- C-17 Project RAAF Base Amberley Additional Soil Characterization including assessing soils for PFC contamination
- Contamination Investigation for Acid storage dam, Incitec Pivot, Phosphate Hill
- Origin Energy, Deep Drilling for groundwater monitoring wells at Ironbark.
- LendLease – RNA Showgrounds Development Project – Contaminated land and ASS investigation and management – Team member
- Part of the Team for Origin Energy CSG Dams Remediation Project SELECT Phase
- Defence – RAAF Base Amberley, Phase 1 and site contamination Investigation, C17, Growler, Battlefield airlifter etc. – fieldwork and reporting
- Caltex Gold Coast Airport, JUHI and PRA Remediation including ASS management
- UPSS Inspections at various sites for Goodman Pty Ltd – Project Team, fieldwork and reporting
- Deputy Project manager (DPM) for BP contaminated land investigation at Charters Towers.
- Caltex Sites Groundwater Investigation at North Queensland - DPM
- Origin Energy former gasworks sites Bundaberg, QLD Project Team, fieldwork and reporting.
- Origin Energy former gasworks sites, Maryborough, QLD Project Team, fieldwork and reporting.
- Remediation Plans for Origin Energy former gasworks sites at Warwick and Bundaberg, QLD Team lead.
- Part of the Team for Origin Energy CSG Dams Remediation Project Phase 2.
- Origin Energy Asbestos Investigation Project – Project Team, fieldwork and reporting.
- Caltex UPSS 2014, reporting for select sites.
- Phase I Environmental Investigation at different sites for Goodyear Pty Ltd – Project Team, fieldwork and reporting
- Soils and topography as part of the EIS for a major underground combined Bus and Train (BAT) tunnel project in Brisbane – Team lead.

Historical Projects:

- Groundwater monitoring sampling and report writing for key Shell retail and distribution sites in and across Brisbane – Project team
- Groundwater investigation including halogenated compounds for an Industrial site

(BOC), fieldwork and report preparation – Project team

- Environmental Site assessment (Phase I and Phase II) – Project Manager/Site Supervisor.
- Posted on secondment for an year with a major CSG project (Santos), Data manager for Quality control and assurance of environmental data
- CSG Pipeline Construction (Origin Energy via East Coast Pipeline) – Project Manager, SCL and Topsoil Assessment.
- Disposal Options for Drilling Muds for CSG industry (Origin energy) – Project Team, Desktop review, field trials.
- CSG Gas fields EIS – Project Team, Soil survey and land assessment.
- Major underground tunnel project – Team lead, ASS investigation and management.
- Site closure for Box cut mine – Team Lead, Dewatering, Soil treatment and re-interment.
- Soils and groundwater remediation including ASS soils management at a major fuel distribution centre (ExxonMobil) – Project Team
- ASS soils investigation for various projects at Brisbane Airport including fieldwork – Project team
- Marine sediment sampling program associated with the proposed LNG (Liquefied Natural Gas) plant in the Port of Gladstone (Santos)
- Marine Sediment analysis involving a proposed dredge area for the removal of the subsea section of a decommissioned pipeline bundle (Caltex Refineries Pty Ltd)

Conferences
Soil Science Conference, Canberra, 2018

Mine Closure, Brisbane 2012

Training
- AECOM Certified Project Manager
- Acid Sulfate Soils; Identification, Assessment and Management, Three day short Course
- Nature and Distribution of Queensland Soils as per Australian System of Classification, Two Day Training
- Software Training gINT, Three day training
- Software Training ESDAT, one day training
- How to Write Effective Reports, one day training at Australian Institute of Management (AIM)
- 40 Hour Health and Safety Training (HAZWOPER)
- 30215 QLD Construction Industry Safety Induction (Blue Card)
- PMASUP236A Operate Vehicle in the Field 4WD,
- Santos Environment Health and Safety Induction Rev 7.3 including gas Certificate
- Senior First Aid and CPR training
- Australian Institute of Petroleum Permit System
- MOBIL Loss Prevention System Training
- Shell Coles Express Online Induction A and B
- Shell Approved Retail and Distribution Permit Holder Training
- Working in Electrified Territory (WET), Safely Accessing the Rail Corridor (SARC), Fatigue Management, Category 3 Medical
- Rail Industry Worker (RIW) card

Other Languages
Punjabi, Hindi

Professional History

2020 - Present
AECOM
Principal Soil Scientist – Technical Lead Acid Sulfate Soils

2016 - 2020
AECOM
Senior Soil Scientist - RCE

2014 - 2016
AECOM
Professional Environmental Scientist - RCE

2008 - 2013
URS Australia Pvt Ltd
Soil Scientist

2005 - 2008
Simmonds and Bristow Pvt Ltd
Scientist

2003 - 2004
Sydney Environmental & Soil Laboratory Pvt Ltd
Analyst

Appendix 9: Summary of Progress of Consultation (Confidential – Not for Public Release)

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Appendix 10: Arrow CSG Water Management Plan

Plan

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Appendix 10 - CSG Water Management Plan

Surat Gas Project

CSG Water Management Plan

Contents

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Tables

Figures

1. Introduction

1.1 Location and Project Description

This Coal Seam Gas Water Management Plan (CWMP) is for Arrow Energy Pty Ltd.'s (Arrow) Surat Gas Project (SGP). The project development area is located approximately 160 km west of Brisbane in Queensland's Surat Basin and extends from the township of Wandoan in the north towards Millmerran in the south, in an arc through Dalby (Figure 1-1). The towns of Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, and Miles are located in or adjacent to the project development area.

The SGP will be a phased development over the approximate 40 year life of the project. Within the Surat Basin Arrow operates existing domestic gas facilities referred to as the Dalby Expansion Project (DXP). The SGP will utilise existing DXP water assets (e.g. dams and water treatment plants), and will also provide water to existing QGC operated assets. Over the life of the project, new assets will be developed by drilling wells and constructing associated infrastructure to transport both gas and water.

The project development area comprises Petroleum leases (PLs) 194, 198, 230, 238, 252, 258, 260, 185, 253, 304, 305, 491, 492, 493, 494, 1039, 1040, 1041, 1042, 1043, 1044 and ATP 676.

1.2 Purpose

The purpose of this CWMP is to:

- Address the requirements of section 126 of the EP Act as required for a site specific EA application (in this instance a site specific amendment application) ;[1]
- Address Arrow's commitment under the Surat Gas Project Environmental Impact Statement (EIS) to produce a CWMP; and
- Describe how SGP's CSG water will be managed in a way that protects and maintains environmental values whilst balancing social and economic considerations.

This CWMP has been prepared in accordance with the following Queensland Government regulatory guidance documents:

- The *Environmental Protection Act 1994* (Qld) (EP Act) – specifically Section 126 (1) and 126 (2); and
- The Department of Environment and Heritage Protection *Coal Seam Gas Water Management Policy*[2] – specifically its prioritisation hierarchy for managing and using CSG water and for managing saline waste.

Figure 1-1 Surat Gas Project Development Area

[1] Section 126 requirements for each project EA are provided as part of each site specific EA application.

[2] Queensland Department of Environment and Heritage Protection (2012*), Coal Seam Gas Water Management Policy*.

Plan

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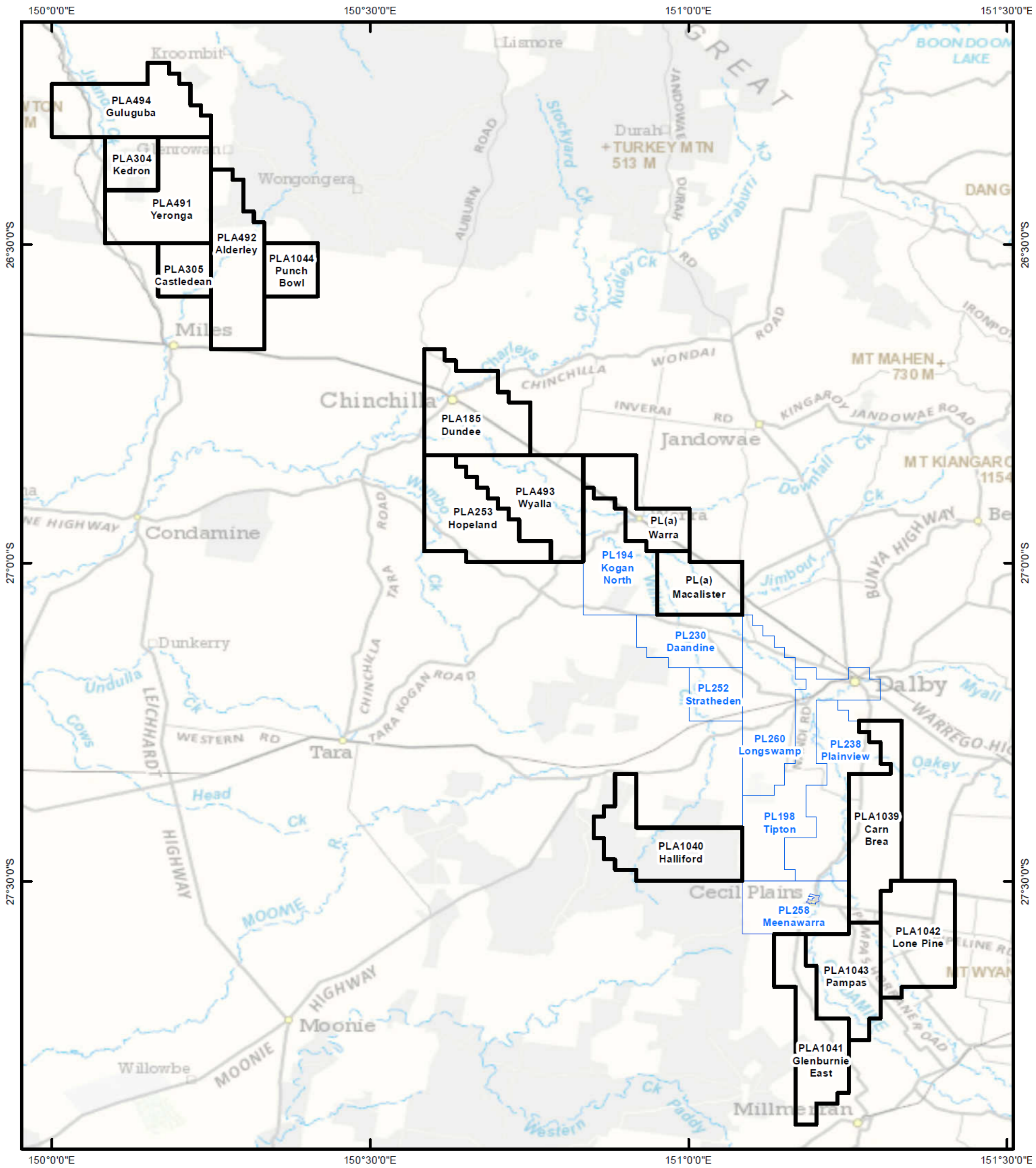


PL Granted (Arrow)

PL Application

Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management). In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws

 The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

Issued To: J Carew
Author: tstringer

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it.

Note: The information shown on this map is a copyright of Arrow Energy Limited and, where applicable, its affiliates and co-venturers.

Source:
Arrow Energy Limited, Geosciences Australia
Dept. Envir. and Resource Mgmt.

N

Coordinate System: GCS GDA 1994

0 5 10 20
km

Surat Gas Project Tenures

go further

Date: 9/04/2018

go further

1.3 Scope

The scope of this CWMP includes:

- Characterisation of CSG water and the existing environment;
- Description of current and proposed CSG water management including the use, treatment, storage and beneficial use of water; and
- Description of procedures, controls and monitoring programs that minimise risk of CSG water management causing environmental harm.

The strategies for managing CSG water described in this CWMP align with Arrow Energy's broader vision for CSG water management in the Surat basin, as outlined in its Surat Gas Project CSG Water Management Strategy[3].

1.4 Conformance Table

Table 1-1 lists specific CWMP regulatory requirements specified under Section 126 of the EP Act, and identifies the relevant sections of the CWMP which address each specific requirement.

Table 1-1 EP Act Conformance Table

Requirement Under Section 126 of the EP Act	Relevant Section of CWMP
The quantity of CSG water the applicant reasonably expects will be generated in connection with carrying out each relevant activity.	Section 3.1
The flow rate at which the applicant reasonable expects CSG water will be generated.	Section 3.1
The quality of the water, including changes in the water quality that the applicant reasonably expects will happen while each relevant activity is carried out.	Section 3.2
The proposed management of CSG water including use, treatment, storage or disposal.	Section 4 and 5
The measurable criteria (the management criteria) against which the applicant will monitor and assess the effectiveness of water management including: • The quantity and quality of the water used, treated, stored or disposed of; • Protection of environmental values affected by each relevant activity; and the disposal of waste, including, for example, salt.	Section 6
The action proposed to be taken if any of the management criteria are not complied with, to ensure the criteria will be able to be satisfied in the future.	Section 6

[3] Arrow Energy (2017), *Surat Gas Project CSG Water Management Strategy*, Rev: 0, Doc No: ORG-ARW-ENV-STR-00001.

1.5 Project Approvals

Table 1-2 lists the status of Arrow Energy's CSG water management approvals applicable to the scope of this CWMP.

Table 1-2 Arrow Energy's CSG Water Management Approvals in the Surat Basin

Responsible Department	Area of Regulation	Requirement of Regulation	Status
Department of Environment and Science	CSG activities including CSG water management	Environmental Authorities (EAs)	Approved - Dalby Expansion Project EA (EPPG00972513) for PLs194, 198, 230, 238, 252, 258 and 260.
			Approved - EA North for PLs 304, 305, 491, 492, 494, and 1044.
			Approved - EA South PLs 185, 253, 493, 1039, 1040, 1041, 1042, and 1043.
			Approved - EA Kogan – for PLs 1052 and 1053
			Approved - EA Hopeland for PL 253.
			Approved – EA Kenya Pipelines and Brine Dams PPL 2034
		CWMP	Finalised May 2018 to support EA applications and updated June 2020 to support the Hopeland EA amendment application

1.6 DES CSG Water Management Policy

The *CSG Water Management Policy* (DEHP, 2012) outlines the Queensland Government's position on the management of CSG water and guides CSG operators to consider the feasibility of using such water to meet the obligations of the EP Act as part of developing their CSG water management strategies and plans.

The policy aims to encourage the beneficial use of CSG water in a way that protects the environment and that maximises its productive use as a valuable resource. To achieve this, the policy outlines prioritisation hierarchies for managing and using CSG water, and for managing saline waste.

The policy focuses on the management and use of CSG water under the EP Act, and does not change obligations the *Water Act 2000* (Water Act), including 'making good' any relevant impacts that may result from a CSG operation on water bores. Such measures executed under the Water Act may require the provision of water to mitigate impacts.

Arrow has adopted the DES prioritisation hierarchy as its starting point for determining the options for management of CSG water and brine. DES's prioritisation hierarchies for

CSG water and brine are presented in Figure 1-2. In accordance with the Policy, Arrow evaluates potential management options for water and brine against the prioritisation hierarchy, and implements Priority 1 options wherever feasible. Where Priority 1 options are not feasible, Priority 2 options are implemented. In determining the feasibility of options, factors that may be considered include technical and economic aspects in assessing identified options.

	CSG Water	Brine
PRIORITY 1	CSG water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries	Brine or salt residues are treated to create usable products wherever feasible
PRIORITY 2	After feasible beneficial use options have been considered, treating and disposing CSG water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values	After assessing the feasibility of treating the brine or solid salt residues to create usable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment

Figure 1-2 DES Prioritisation Hierarchies for CSG Water and Brine Management

2. Existing Environment

2.1 Climate

The Darling Downs has a warm climate typical of subtropical regions with mean temperatures in the project development area ranging from a mean monthly minimum of 3.6 in winter months (June to August) to a mean monthly maximum of 35°C in summer months (December to February).

The majority of rain falls between November and February. The average annual rainfall varies across the region and ranges from an average of 20 to 40 mm a month in winter, to 70 to 100 mm a month in summer. Around 20 thunderstorm days per year occur in the region, often involving strong winds, heavy rainfall and flooding.

2.2 Surface Water

The regional surface water environment is represented by four drainage basins, all of which intersect the SGP development area: Condamine-Culgoa Basin (Condamine River and Balonne River), Fitzroy Basin (Dawson River), Border Rivers Basin (Weir and Macintyre rivers and Macintyre Brook), and Moonie Basin (Moonie River). The Condamine-Culgoa, Border Rivers, and Moonie basins form part of the Murray-Darling drainage division, while the Fitzroy Basin is part of the North-East Coast drainage division.

Basins can be divided into sub-basins, with six sub-basins in the project development area: Balonne River, Condamine River, Macintyre Brook, Macintyre and Weir rivers, Moonie River and Dawson River. The Condamine is the predominant sub-basin within the project development area, accounting for over 50% of the total area.

The location or origin of each drainage basin is as follows:

- The Condamine-Culgoa Basin forms the northern headwaters of the Murray-Darling river system;
- The Border Rivers Basin, comprising the Weir and Macintyre rivers, lies mostly within Queensland. Macintyre Brook is a major tributary of the Macintyre River, which eventually joins the Weir River near Talwood, Queensland;
- The Moonie Basin contains the Moonie River, a tributary of the Barwon River forming part of the Murray-Darling Basin; and
- The Fitzroy Basin is located in central eastern Queensland and contains the Dawson River sub-basin. The Fitzroy River is formed by the confluence of the Dawson and MacKenzie rivers and then flows into the Coral Sea north of Rockhampton.

The project area is characterised by an extensive network of watercourses that are largely ephemeral, with varying geomorphic stream types that provide geomorphic diversity and contribute to habitat diversity. Rivers and creeks are generally intermittent, with surface waters in many streams receding to disconnected pools and dry beds during the dry season.

Potential water uses within catchments that include the SGP are:

- Agricultural (crop production and stock watering)
- Pastoral;
- Urban;
- Power generation;
- Mining; and
- Recreation.

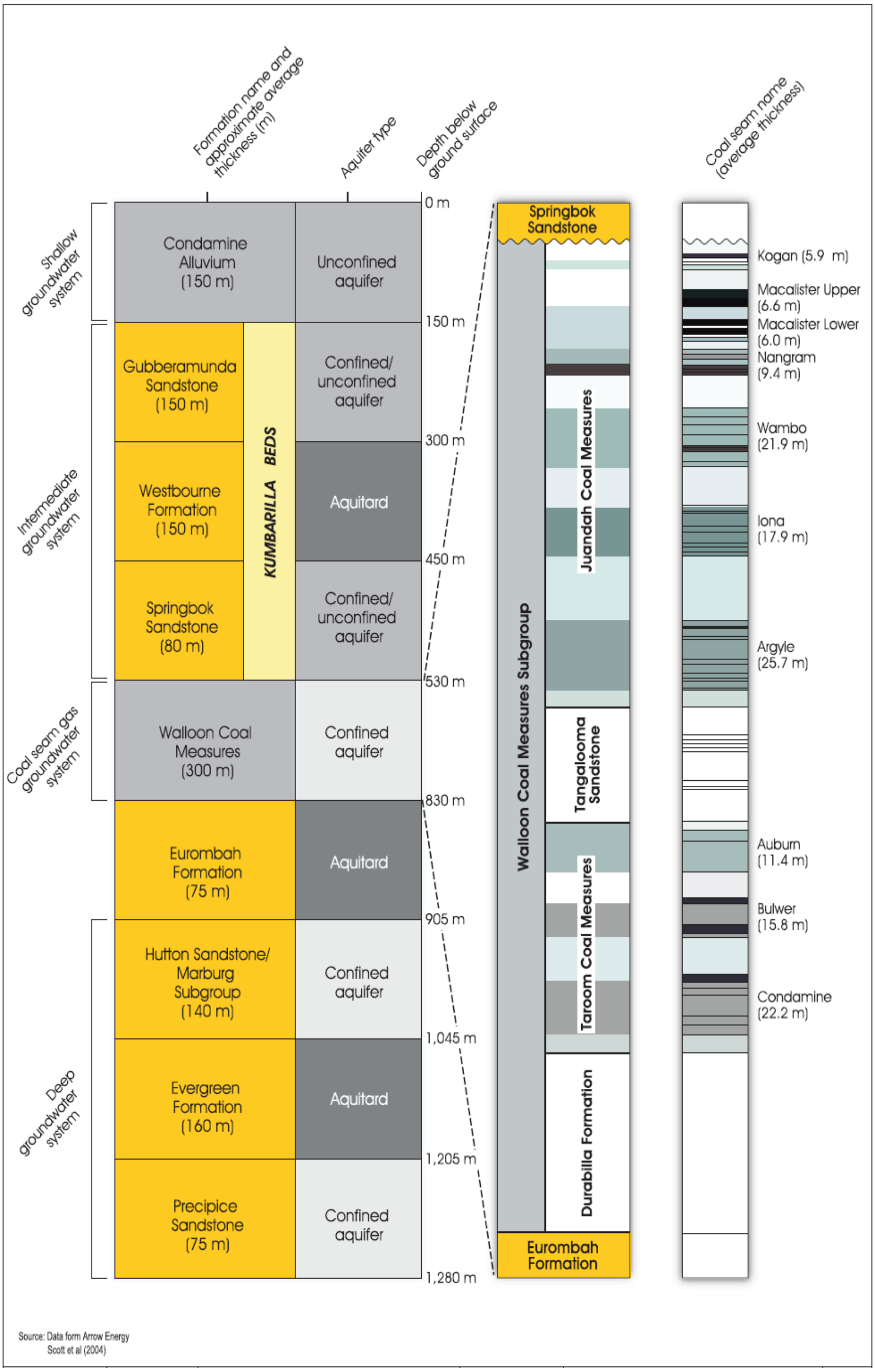
2.3 Groundwater

The geology of the Surat Basin is presented in Figure 2-1, and reflects approximately 200 million years of sedimentation producing a sedimentary sequence with up to a 2,500 m maximum depth. Geology underlying the project area consists of a sequence of interbedded aquifers and aquitards and is situated on the eastern section of the Great Artesian Basin (GAB) and the western margin of the Clarence-Moreton Basin.

The following groundwater systems have been identified in the vicinity of the project area (listed in order of increasing depth):

- Shallow groundwater system – Condamine Alluvium;
- Intermediate groundwater system – Gubberamunda Sandstone, Westbourne Formation and Springbok Sandstone;
- Coal seam gas groundwater system – Walloon Coal Measures; and
- Deep groundwater system – Hutton Sandstone, Evergreen Formation and Precipice Sandstone.

Figure 2-1 SGP Groundwater Geology



2.4 Terrain, Geology and Soils

2.4.1 Terrain

Topography of the SGP area is characterised by gently undulating land formed by fluvial deposition and erosion processes. Rock outcrops are present where resistance to erosion and channel scour has occurred. The underlying geology and geomorphic conditions have influenced the landscape and the area is characterised by the Great Dividing Range highlands, the Kumbarilla Ridge uplands and four drainage basins, the Condamine-Culgoa, Fitzroy, Border Rivers and Moonie.

2.4.2 Geology

Gas reserves within the SGP project area are primarily contained within the Walloon Coal Measures. The Walloon Coal Measures were formed during the Middle Jurassic period and are characterised by carbonaceous mudstone, siltstone, minor sandstone and coal. The geology of the Walloon Coal Measures is presented above in Figure 2-1 and comprises the following formations:

- Juandah Formation;
- Tangalooma Sandstone;
- Taroom Coal Measures; and
- Euromah Formation.

Only the Juandah Formation and Taroom Coal Measures are targeted for CSG production for the SGP.

2.4.3 Soils

Soil types across the SGP area have been classified under the Australian Soil Classification System and divided into seven broad types:

- Gilgai Clays - Occurring on flat to gently undulating terrain.
- Cracking Clays - Widespread across the Project area.
- Uniform Non-cracking Clays - Occurring on gently undulating plains and rises, and upper slopes of hills.
- Texture Contrast Soils - Sharp textural contrast between surface and subsoil horizons of low agricultural value.
- Uniform Loams and Clays - Loams found along upper slopes whereas clay occur on lower slopes.
- Sands and Sandy Loams - Consists of alluvial and residual sands found on plains.
- Skeletal, Rocky or Gravelly Soils - Occur adjacent to rocky outcrops.

2.4.4 Land Use

The SGP is located within the Darling Downs, which is an important agricultural area. The land use in the area is strongly related to the different soil types and topography. Soils within the project development area are dominated by heavy clays, which form rich agricultural soil around the Condamine River. These soils are characterised by self-mulching, cracking clays with a deep profile. At higher elevations, shallow, gravelly soils are present.

Soil erosion is evident in areas where brigalow woodland has been extensively cleared. Agricultural land use within the project development area ranges from concentrated agriculture on the Condamine River floodplain, where many paddocks have been laser-levelled to achieve effective flood irrigation, through to cattle grazing in more marginal areas located to the north and west. Limited agricultural activity exists in areas of higher elevation and within state forests.

Current agricultural activities in the greater Darling Downs region include:

- Dryland broadacre farming;
- Irrigated broadacre farming;
- Horticulture;
- Fruit;
- Vineyards;
- Livestock industries; and
- Timber production.

3. CSG Water Characteristics

This section presents forecast CSG water production data and expected water quality.

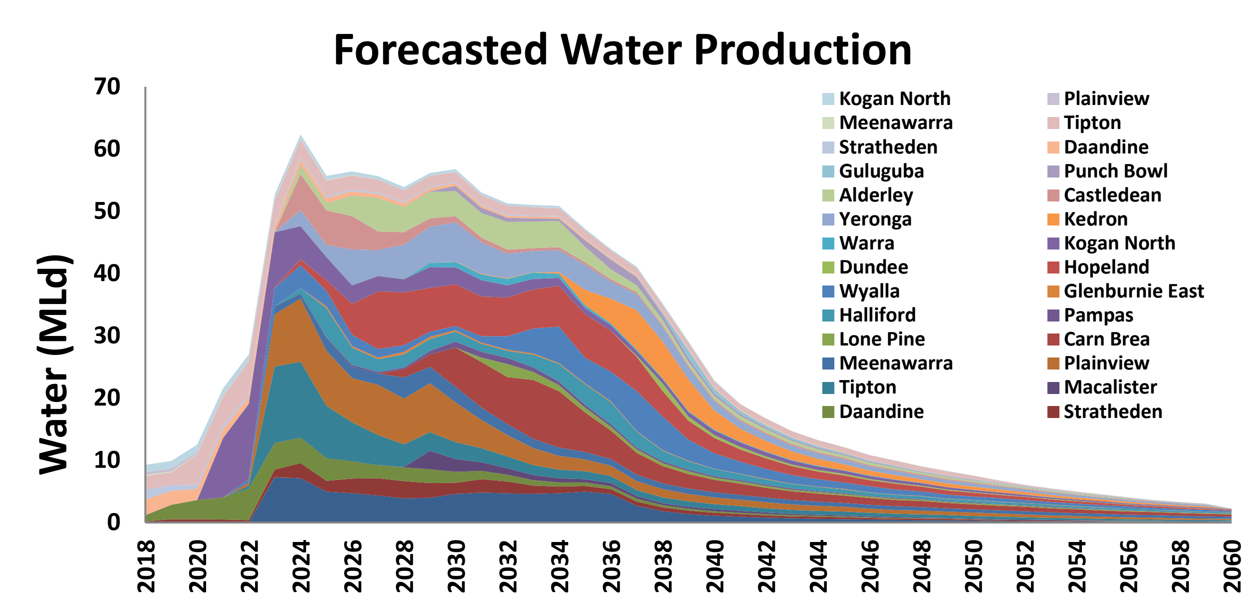
3.1 CSG Water Quantity

CSG is the name given to naturally occurring gas trapped in underground coal seams by water and ground pressure. The gas lines the open fractures between the coal (called cleats) and the inside of the pores within the coal (the matrix). Coal seams store both gas and water. When the water pressure is reduced, the gas is released. In the production process, the water pressure is reduced when a well is drilled into a coal seam and the water is gradually pumped out of the seam. This allows the gas to flow to the surface via the well. CSG water production volumes and qualities vary considerably with location, well-spacing and coal seam depth. Water production forecasts fluctuate over time as a product of progressively commissioning and decommissioning wells to meet Gas Sale Agreements. For these reasons, forecasts for the timing, volumes and quality of CSG water production are updated on a monthly basis. Production forecasting involves the following steps:

1. Developing key assumptions such as expansion areas, gas sales targets and gas usage for production activities;
2. Simulating the required production rates using a reservoir engineering model;
3. Developing and maintaining well program based on forecast timing; and
4. Reviewing model performance against actual production data and history matching.

Figure 3-1 presents the CSG water production forecast for the SGP. The forecast indicates that approximately 400 GL of water will be produced over the life of the project. Water production starting in 2018 was the continuation of production in the existing DXP EA development areas, with production from new areas commencing in 2021. Water production peaks at a flow rate of approximately 62 ML/day achieved in 2024. Water production will diminish from the peak until project completion in approximately 2060.

Figure 3-1 SGP Forecasted Water Production



3.2 CSG Water Quality Characteristics

3.2.1 CSG Water at the Well

The SGP targets the Walloon Coal Measures. CSG water quality in these formations varies from slightly brackish to brackish. The water typically has the following characteristics:

- pH of approximately 8 to 9;
- Salinity in the range of 5,000 to 13,000 µS/cm (i.e. brackish);
- Suspended solids that will usually settle out over time;
- Trace metals and low levels of nutrients.

Table 3-1 presents a summary of expected water quality for wells across the SGP development area.

Table 3-1 SGP Expected Water Quality[4]

Parameter	LOR	Units	10%	Median	90%
Alkalinity					
Bicarbonate Alkalinity as CaCO3	1	mg/L	389.8	815.5	1387.0
Carbonate Alkalinity as CaCO3	1	mg/L	< 1	27.5	119.7
Hydroxide Alkalinity as CaCO3	1	mg/L	< 1	< 1	< 1
Total Alkalinity as CaCO3	1	mg/L	392.6	872	1440.0
Major Anions					
Bromide	0.02	mg/L	3.6	4.99	10.6
Chloride	1	mg/L	1040.0	1705	4231.0
Fluoride	0.1	mg/L	1.0	1.8	2.6
Silicon	0.05	mg/L	7.5	8.2	9.5
Sulfate as SO4 2-	1	mg/L	< 1	< 1	2.0
Sulfide as S2-	0.1	mg/L	< 0.1	< 0.1	< 0.1
Major Cations					
Calcium	1	mg/L	4.0	9	39.7
Magnesium	1	mg/L	2.0	3	13.0
Potassium	1	mg/L	5.0	7	13.0
Sodium	1	mg/L	1233.0	1630	2720.0
Major Ions					
Ionic Balance	0.01	meq/L	21.5	106.72	191.9
Total Anions	0.01	meq/L	85.9	171.1	256.3
Total Cations	0.01	meq/L	86.2	171.4	256.6
Metals (Dissolved)					
Aluminium	5	µg/L	< 5	< 5	12.8
Arsenic	0.2	µg/L	< 0.2	< 0.2	0.6
Barium	0.5	µg/L	603.4	1100	4212.0
Beryllium	0.1	µg/L	< 0.1	< 0.1	< 0.1
Boron	5	µg/L	235.6	340	590.0
Cadmium	0.05	µg/L	< 0.05	< 0.05	0.1
Chromium	0.2	µg/L	< 0.2	< 0.2	2.4
Cobalt	0.1	µg/L	< 0.1	< 0.1	< 0.1
Copper	0.5	µg/L	< 0.5	< 0.5	2.0
Ferric Iron	0.05	mg/L	< 0.05	< 0.05	0.2
Ferrous Iron	0.05	mg/L	< 0.05	< 0.05	0.5
Hexavalent Chromium	0.01	mg/L	< 0.01	< 0.01	< 0.01
Lead	0.1	µg/L	< 0.1	< 0.1	< 0.1
Manganese	0.5	µg/L	2.0	9	45.0
Mercury	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Molybdenum	0.1	µg/L	< 0.1	< 0.1	2.0

[4]The information presented in this table is aggregated data from production sampling at Arrow's Dalby Expansion Project and exploration sampling across ATP tenures proposed for conversion to PLs as part of the SGP. A < value indicates observations below the limit of reporting.

Nickel	0.5	µg/L	< 0.5	< 0.5	1.0
Selenium	0.2	µg/L	< 0.2	< 0.2	0.2
Strontium	1	µg/L	1036.0	1920	9234.0
Trivalent Chromium	0.01	mg/L	< 0.01	< 0.01	< 0.01
Vanadium	0.2	µg/L	< 0.2	< 0.2	10.0
Zinc	1	µg/L	< 1	< 1	16.0
Metals (Total)					
Aluminium	5	µg/L	20.0	640	4244.0
Arsenic	0.2	µg/L	< 0.2	< 0.2	2.0
Barium	0.5	µg/L	717.2	1250	4510.0
Beryllium	0.1	µg/L	< 0.1	< 0.1	< 0.1
Boron	5	µg/L	250.0	360	580.0
Cadmium	0.05	µg/L	< 0.05	< 0.05	0.2
Chromium	0.2	µg/L	< 0.2	2	9.4
Cobalt	0.1	µg/L	< 0.1	< 0.1	3.0
Copper	0.5	µg/L	0.5	3	18.0
Lead	0.1	µg/L	< 0.1	1.4	8.0
Manganese	0.5	µg/L	8.0	31	118.4
Mercury	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Molybdenum	0.1	µg/L	< 0.1	< 0.1	0.4
Nickel	0.5	µg/L	< 0.5	1	6.0
Selenium	0.2	µg/L	< 0.2	< 0.2	0.2
Strontium	1	µg/L	1136.0	2110	9496.0
Vanadium	0.2	µg/L	< 0.2	< 0.2	1.4
Zinc	1	µg/L	< 1	13	65.4
Nutrients					
Ammonia as N	0.01	mg/L	0.8	1.13	1.7
Nitrate as N	0.01	mg/L	< 0.01	0.01	0.1
Nitrite + Nitrate as N	0.01	mg/L	< 0.01	0.01	0.1
Nitrite as N	0.01	mg/L	< 0.01	< 0.01	< 0.01
Reactive Phosphorus as P	0.01	mg/L	< 0.01	0.01	0.0
Total Kjeldahl Nitrogen as N	0.1	mg/L	0.9	1.3	1.8
Total Nitrogen as N	0.1	mg/L	0.9	1.3	1.8
Total Phosphorus as P	0.01	mg/L	0.0	0.06	0.2
Organic Carbon					
Dissolved Organic Carbon	1	mg/L	< 1	6	14.1
Total Organic Carbon	1	mg/L	< 1	13	35.1
Physico-Chemical					
Electrical Conductivity @ 25°C	1	µS/cm	5640.0	7070	13060.0
pH Value	0.01	pH Unit	8.1	8.385	8.6
Suspended Solids (SS)	5	mg/L	11.9	100.5	520.5
Total Dissolved Solids @180°C	5	mg/L	3190.0	4215	7546.0
Turbidity	0.1	NTU	6.1	50	401.8
Silica					

Reactive Silica	0.1	mg/L	14.1	15.9	19.2
Silica	0.1	mg/L	15.7	17.4	20.4

3.3 Arrow Energy CSG Water and Salt Management Strategy

Arrow is committed to managing CSG water in a way that maximises beneficial use and that minimises environmental impact. To demonstrate this, Arrow has developed a Surat Gas Project Water Management Strategy[5] to ensure that the SGP manages water and salt consistently and within the Queensland Government regulatory framework. The strategy is supported by a series of plans and procedural documents to ensure that the following objectives are achieved:

- Communicate corporate policy and principles for the management of CSG water and salt;
- Align with the regulatory framework that applies to the:
  - Gathering, treatment, storage, distribution, beneficial use and disposal of CSG water and salt;
  - Monitoring and management of groundwater and predicted impacts to groundwater level changes in quality;
- Facilitate management of CSG water and salt in a way that maximises beneficial use and minimises the potential for environmental impacts; and
- Establish a framework for development of aquifer, surface water and infrastructure groundwater monitoring programs.

3.3.1 Water and Salt Management Options

Arrow CSG Water and Salt Management Strategy aligns with the DES CSG Water Management Policy as defined in Section 1.6.

To ensure that the most sustainable CSG water management portfolio is implemented, Arrow evaluates all strategy management options using a systematic and transparent multi-criteria assessment (MCA) process (refer Figure 3-2). The performance of each identified option is assessed against a set of weighted criteria and options selected as either “preferred”, “reserved” or “not preferred” based on the weighted score derived from the MCA[6].

Preferred options are prioritised for investment whilst reserved options continue to be evaluated through targeted feasibility studies. Non-preferred options are put on hold. To ensure that Arrow’s approach to CSG water utilisation remains reflective of the latest information, MCAs may be updated on a periodic basis.

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[5] Arrow Energy (2017), *Surat Gas Project CSG Water Management Strategy*, Rev: 0, Doc No: ORG-ARW-ENV-STR-00001.

[6] Safety is a core value of Arrow Energy and all activities and processes require safety to be at the forefront of assessment. Therefore, safety is not incorporated into the MCA.

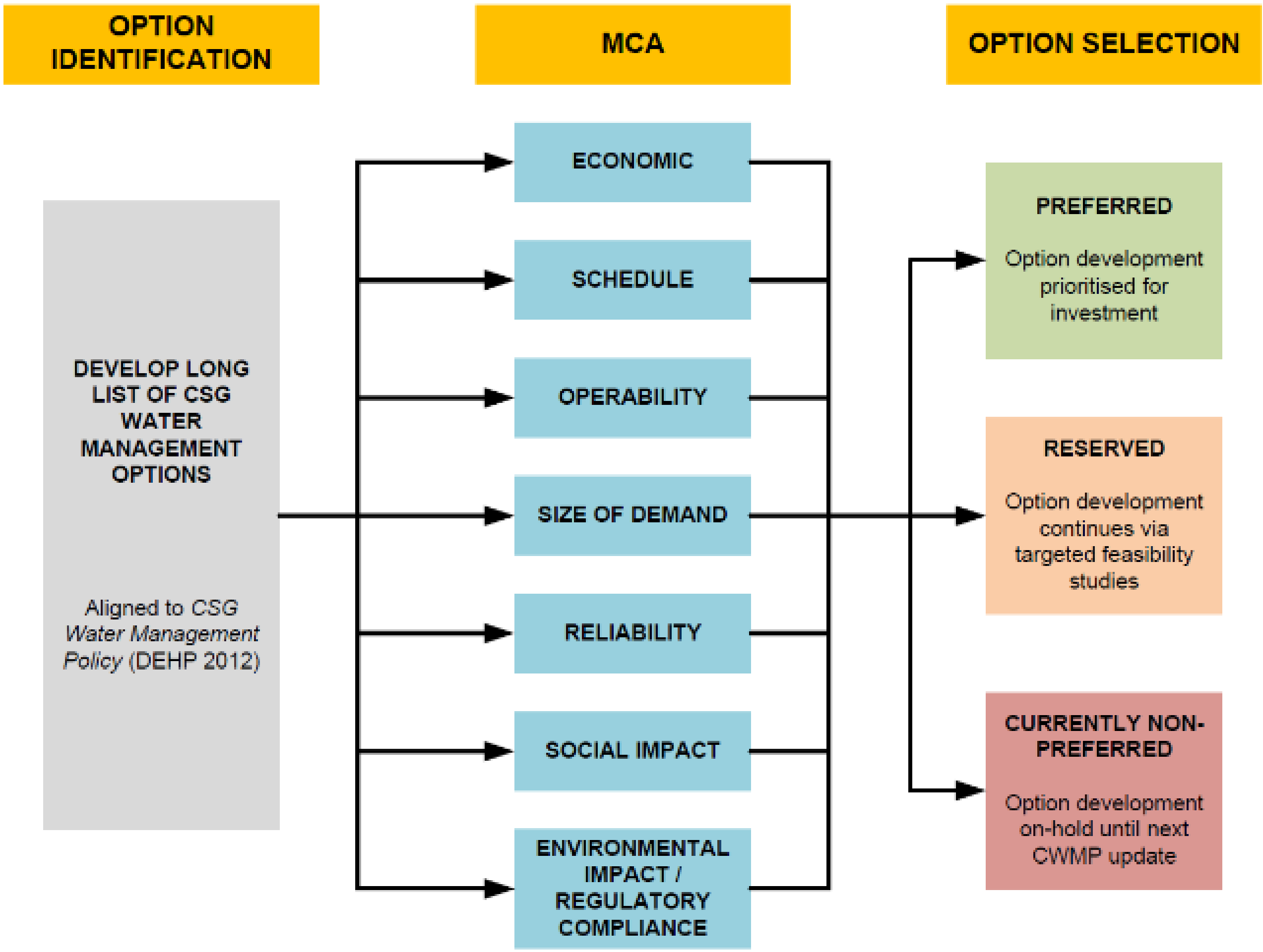

Figure 3-2 Option Selection and MCA Framework

3.4 Water management options

This section presents the water management options considered for the SGP. Saline waste management is discussed in Section 3.5.

Implementation of the preferred CSG water management options will result in the distribution of CSG water to a range of beneficial uses. Currently identified options are described below.

3.4.1 Agricultural uses

Irrigation is the predominant water use within the SGP development area. Options exist to provide water to existing irrigators, to replace other water sources used for irrigation (including through substitution of their existing groundwater allocations), or to supply water to new irrigation projects.

Key considerations for providing CSG water to end users for irrigation include:

- The ability of end users to take large volumes of water regularly and reliably;
- The location of end users in relation to the water treatment facility (due to the cost of transporting water over large distances);
- The approvals framework;

- The extent to which the user is going to become reliant on water supplied by Arrow; and
- The appropriateness of the supply given the short term nature of CSG water availability.

The water and implications of its use will be the responsibility of the end users. Arrow retains no control over how the water is used beyond the transfer point.

Where practical, Arrow's preferred management option for CSG water is beneficial use through substitution of existing groundwater allocations in the operating area. Substitution of allocations has the advantage that it constitutes both a beneficial means of managing produced CSG water, and a means of offsetting the potential impacts of Arrow's CSG production to bore owners with groundwater allocations.

Currently, there is no regulatory basis to facilitate substitution. Therefore, Arrow would develop a commercial scheme to support the supply of treated CSG water to groundwater users who hold allocations. Under this scheme end users would receive and utilise water supplied by Arrow in lieu of their groundwater allocations.

Arrow has committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown, as a result of CSG water extraction from the Walloon Coal Measures. This can be achieved through a beneficial use network that will distribute water to groundwater users within specified areas of the Condamine Alluvium to mitigate the modelled likely flux impact by substitution of their allocations. These users, or other existing users, could be offered excess water in addition to the substitution requirements to manage peaks in the water production profile.

3.4.2 Other agricultural uses

Other potential agricultural beneficial uses include provision of water for livestock watering purposes (including feedlots) or for aquaculture.

3.4.3 Discharge

Discharge of treated CSG water to watercourses is a reserved option in the event that other beneficial uses of CSG water are temporarily unavailable.

3.4.4 Urban uses

Urban supply remains a potential CSG water end use, but is subject to further negotiation and a suitable supply arrangement that economically satisfies regulatory requirements.

3.4.5 New uses

Over the course of the SGP, water demands across areas in which Arrow operates will vary and it is anticipated that new opportunities for use of treated and untreated water may emerge.

Whilst Arrow may choose to evaluate any such opportunities in accordance with the adopted selection methodology (refer Section 3.3.1), supply to new users is not a preferred water management option. This is because the CSG water supply will only be available for a reasonably short period of time, and the development of new water reliant uses may result in potential legacy issues when CSG water is no longer available.

3.4.6 Aquifer injection

Aquifer injection, either for re-pressurisation or as a means for CSG water management, is not currently proposed for the SGP due to the potential risks and the lack of an appropriate regulatory system.

3.4.7 Ocean outfall

Disposal of CSG water to the sea via an ocean outfall pipeline is recognised as a technically feasible option, but currently non-preferred due to environmental and community concerns, and potential schedule impact.

3.4.8 Alignment of Arrow and DES priorities

A summary of the CSG water management options is presented in Table 3-2 which aligns Arrows preferred and non-preferred options with the DES prioritisation hierarchy.

Table 3-2 CSG water management – alignment of Arrow and DES priorities

Arrow priority	Option	Comments	DES Priority
Preferred	Arrow operational supply	Dust suppression, construction, potable, etc.	Priority 1
	Substitution of allocations	Beneficial use to existing abstractors (virtual injection)	Priority 1
	Industrial supply to existing users	Non-Arrow use, where established	Priority 1
Reserved	Discharge to watercourse	Subject to Environmental Authority conditions	Priority 2
	Urban water supply	Subject to negotiation and approvals	Priority 1
Non-preferred	MAR	Managed aquifer recharge	Priority 1
	Industrial supply to new users	Non-Arrow use, where established	Priority 1
	Ocean outfall	Non-preferred due to environmental and community concerns, and potential schedule impact	Priority 2
	Deep aquifer injection	Currently no identified target aquifer	Priority 2

3.5 Brine and salt management options

Water treatment processes that include desalination, such as reverse osmosis, produce a brine stream by-product.

Assuming an average salt concentration of 4,500 mg/L for CSG water in the Surat Basin, treatment of CSG water via reverse osmosis (to ~500 mg/L TDS) will generate in the order of 4 tonnes of salt per megalitre of treated water. Raw water feed concentrations vary across tenements and may also change over time within a given CSG field. Brine stream concentrations will therefore change accordingly.

Specific measures are required to manage the storage and use (or disposal) of brine. A range of brine management options are identified, and described in the following sections.

3.5.1 Salt recovery

The concentrated brine by-product of desalinated water from the Surat Basin coal measures is comprised primarily of sodium chloride, sodium carbonate and sodium bicarbonate salts. A range of options for salt recovery are under consideration for the SGP.

i. Non-selective salt recovery and landfill

Non-selective recovery can be undertaken in purpose designed, lined solar evaporation ponds, through other thermal processes, or using mechanical crystallisers. The mixed salt product recovered has little or no commercial value, therefore landfill of the solid product is required, either in third-party landfills, or through encapsulation of the solid salts in purpose designed cells.

ii. Selective salt recovery

SSR requires the selective crystallisation of salts from RO brine to provide separate end product streams – typically sodium chloride, sodium carbonate and sodium bicarbonate, enabling commercial opportunity for sale of the product. A waste salt by-product is also produced that is dependent on the chemical characteristics of the brine processed at the salt recovery facility.

SSR is currently a reserved option because work to date has demonstrated that the recovered salt product has only modest value and the market is fully supplied by existing low cost producers. Furthermore, the process is energy intensive and substantial transport distances to market would present issues of safety and cost. The combined energy and transport requirements would also result in high emissions intensity for the final product.

3.5.2 Brine injection

Brine injection requires identification of a target formation with permeability and parameters sufficient to enable injection and storage, and where the water quality is such that injection of the brine will not impact the environmental values of the groundwater system.

To date, suitable aquifers have not been identified within Arrow's Surat tenements, and brine injection is a non-preferred management option.

3.5.3 Ocean outfall

As for water, disposal of brine to the sea via an ocean outfall pipeline is recognised as a technically feasible option, but is currently non-preferred.

3.5.4 Alignment of Arrow and DES Priorities

A summary of the brine and salt management options is presented in Table 3-3 which aligns Arrows preferred and non-preferred options with the DES prioritisation hierarchy.

Table 3-3 Saline waste management – alignment of Arrow and DES priorities

Arrow priority	Option	Comments	DEHP Priority
Preferred	Non-selective salt recovery and landfill encapsulation	Solid product landfill in purpose designed regulated waste facilities	Priority 2
Reserved	Selective salt recovery	Currently uneconomic, unable to demonstrate a commercial market, has high emissions intensity and greater safety risk.	Priority 1
Non-preferred	Brine injection	Currently no identified target aquifer	Priority 2
	Ocean outfall	Non-preferred due to community concerns, and potential schedule impact	Priority 2

4. SGP Coal Seam Water Management Network

4.1 SGP Water Management

As stated in Section 1, the SGP will utilise existing DXP gas and water assets (e.g. water treatment plants), but will also provide both gas and water to existing QGC assets. SGP water management will comprise six main process components:

1. CSG production wells and associated water gathering system;
2. Water transfer pipeline(s);
3. Aggregation dam(s);
4. Water Treatment Plants (WTP);
5. Treated water dam(s) and associated beneficial use offtakes; and
6. Brine dam(s).

Figure 4-1 provides a conceptual diagram of this process. Figure 4-2 provides an overview of the proposed SGP water management network.

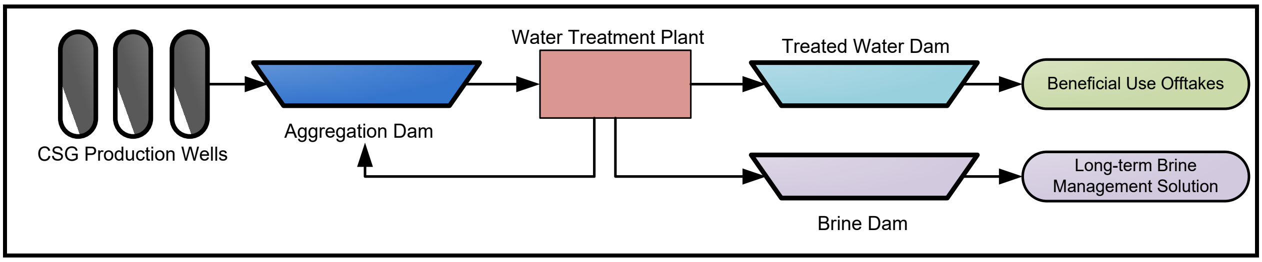

Figure 4-1 Conceptual Diagram of CSG Water Management

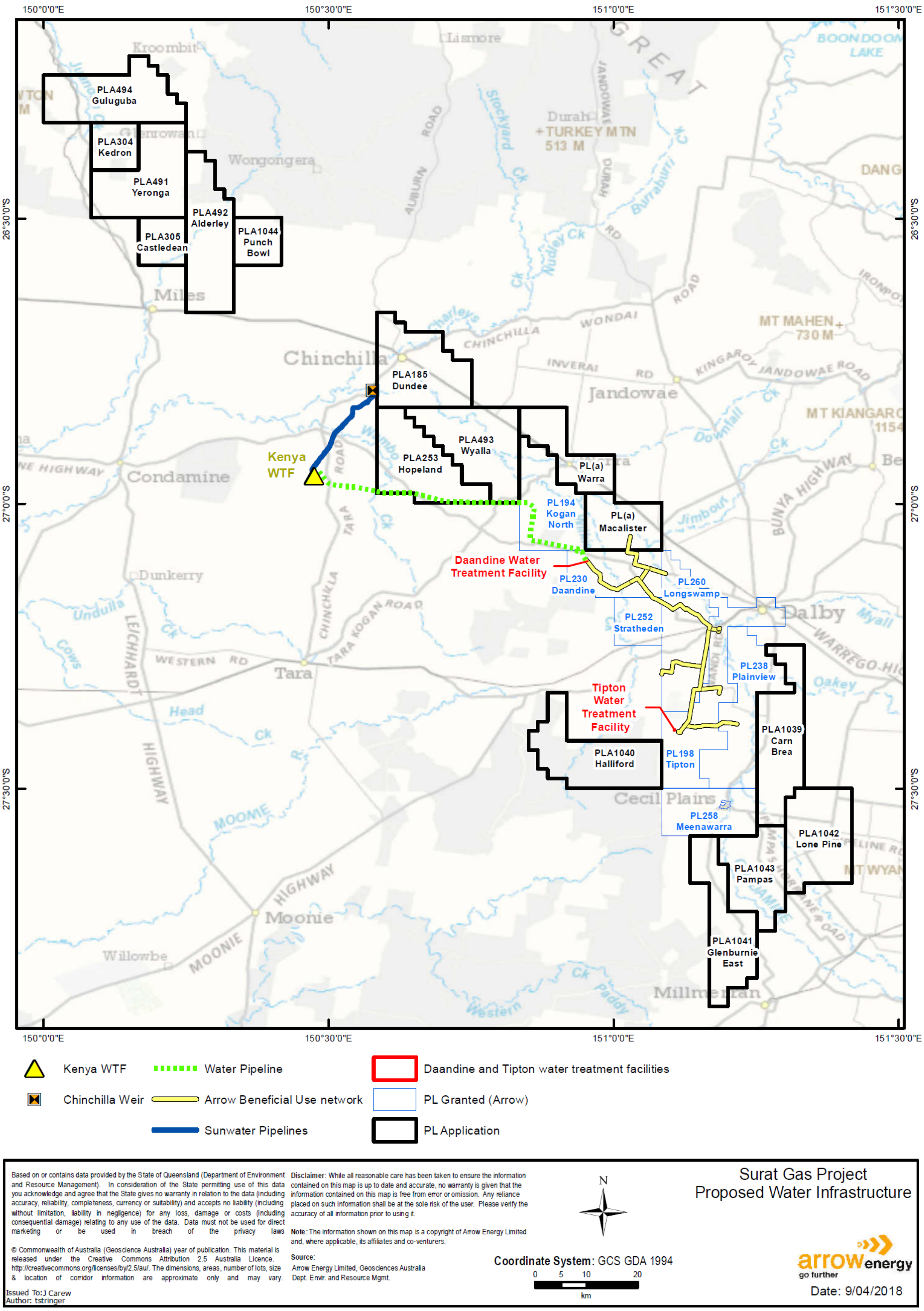

Figure 4-2 Proposed SGP CSG Water Management Network

4.1.1 Gathering System and Storage

CSG water is gathered via a network of buried HDPE low pressure pipes to a series of aggregation dams. Arrow Energy defines its dams as follows:

- **Aggregation Dams** – contain CSG water from gathering network. Aggregation dams provide a buffer to address variations in CSG water production and water treatment capacity.
- **Treated Water Dams** – contain treated CSG water. Treated water dams provide a buffer between treatment plant output and beneficial use demand.
- **Central Gas Processing Facility (CGPF) and WTP Utility Dams** – contain waste lubricants and chemicals used in treatment and compression systems.
- **Brine Dams** – contain brine produced from the reverse osmosis water treatment process.

DES requires that consequence categories of dams are assessed. The DEHP 2013 *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*[7] provides guidance on the assessment process. Arrow has implemented the assessment procedure outlined in the manual.

4.1.2 CSG Water Treatment

Arrow Energy currently treats CSG water through a process of MF and RO. QGC uses similar technologies at its Kenya water treatment facility. MF is a microporous membrane separation process with selectivity on the basis of the size of the particle. Most MF membranes are screen filters with the feed inlet pressure serving as the driving force for filtration. The membranes allow the removal of turbidity, bacteria, cysts and particulates from the water to sizes of 0.1 to 3 μm. Following MF, water is treated using RO to remove dissolved salts. RO is significantly more complex than MF and involves the separation of salts from solution through a semi–permeable, microporous membrane under elevated hydrostatic pressure creating a permeate stream of treated CSG water and a brine waste stream containing concentrated salts.

4.1.3 Brine Management

Water treatment processes that include desalination, such as reverse osmosis, produce a brine stream by-product. The resulting brine will be stored in purpose built brine storage dams until such time as Arrow selects a brine management solution. A range of brine management options have been identified and are described above in Section 3.4.

Both Arrow and QGC WTPs include (or have planned) technologies to minimise the brine stream and thereby reduce the number of required brine storage dams. The Kenya facility already has thermal brine concentrators to produce a highly concentrated brine stream whilst the Arrow facilities plan to utilise membrane concentration technology to further concentrate the brine stream.

[7] Queensland Department of Environment and Heritage Protection, *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures,* DEHP, Queensland, Australia (ESR/2016/1934).

4.1.4 Beneficial Use

As detailed above in section 3.4, the preferred DES CSG water management strategy is beneficial use. Across the SGP, the most substantial beneficial use option is irrigation. Other major beneficial use options include supply to industrial users (power stations or coal mines) and intensive livestock (feedlots, piggeries). Selection of beneficial use options requires careful consideration of the predicted water volumes, stakeholder requirements and Arrow's approval obligations.

Arrow's preferred management option for CSG water is beneficial use through substitution of existing Condamine Alluvium groundwater allocations. Under this scheme end users would receive and utilise water supplied by Arrow in lieu of their groundwater allocations. Arrow has committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown as a result of CSG water extraction from the Walloon Coal Measures and is conditioned to do so under its Federal environmental approval.

A beneficial use network (BUN) will be constructed to distribute treated water to groundwater users within specified areas of the Condamine Alluvium. Users connected to the network will receive water from the Tipton and Daandine facilities as well as a proportion of Arrow's water treated at the QGC Kenya facility. Water from the Kenya facility will be provided back to the Arrow BUN via pipeline. The proposed BUN and associated water pipelines are presented above in Figure 4-2. Any remaining treated water from Kenya will be supplied to the existing SunWater beneficial use scheme which connects Kenya to the Chinchilla weir.

It is expected that treated water distributed by Arrow will be supplied under conditions in the relevant EA or by using the relevant End of Waste Code. Treated water specifications from all of the water treatment facilities will meet the requirements of these approvals.

A small portion of produced water may selectively be used by Arrow for construction purposes or dust suppression, or may be supplied for industrial uses (e.g. coal mines or power stations) or stock watering.

4.2 Arrow Daandine Water Management Network

As discussed in section 4.1, the SGP will integrate with Arrow's existing facilities at both Daandine and Tipton. The Daandine water management network connects Daandine, Kogan North and Stratheden fields to a WTP at Daandine. Figure 4-3 schematically illustrates Daandine water management network infrastructure.

4.2.1 Dams

The Daandine water management network includes six (6) dams. Five dams are located within the Daandine field, and a sixth dam is located at Kogan North. The Kogan North dam enables aggregation and transfer of CSG water to the Daandine WTP for treatment. Table 4-1 lists dam storage characteristics.

Table 4-1 Daandine Water Management Network Storages

Dam Description	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)	Volume at Design Storage Allowance (ML)
Daandine Aggregation Dam	1,239	1,458	1,166
Daandine Feed Water	418	458	392
Daandine Treated Water	208	238	199
Daandine Brine	1,096	1,184	1,045
Daandine Utility	31	48	26
Kogan North	299	427	261

Note: DSA and MRL volumes have been updated to reflect the 2017 Annual Dam Inspections (AECOM, 2017).

4.2.2 Water Treatment Plant

In December 2009, Arrow Energy constructed and commissioned a 12 ML/d water treatment plant (WTP) at Daandine, to facilitate beneficial use and align Arrow's operation with the *CSG Water Management Policy* (DEHP, 2012).

For a description of the water treatment process refer to section 4.1.2. For characterisation of treated CSG water quality refer to section 3.

4.2.3 Beneficial Use

A number of beneficial use offtakes have been developed as part of the Daandine water management network. Table 4-2 identifies currently operating offtakes and peak daily usage. Additional offtakes will be added when the SGP enters the development phase. These offtakes will form part of the proposed Arrow BUN.

Table 4-2 Current Daandine Third Party Water Off-takes

Beneficial Use Offtake	Peak daily usage (ML/day)	DEHP Hierarchy Priority
Irrigation	8*	Priority 1
Power Station	1.5	Priority 1
Power Station	1	Priority 1
Arrow Projects (construction and operational uses)	1	Priority 1
Feedlot	1	Priority 1

Note: Irrigation offtake rate has no minimum or maximum under the existing agreement. Supply rates are limited to pumping and pipeline infrastructure at 8ML/day.

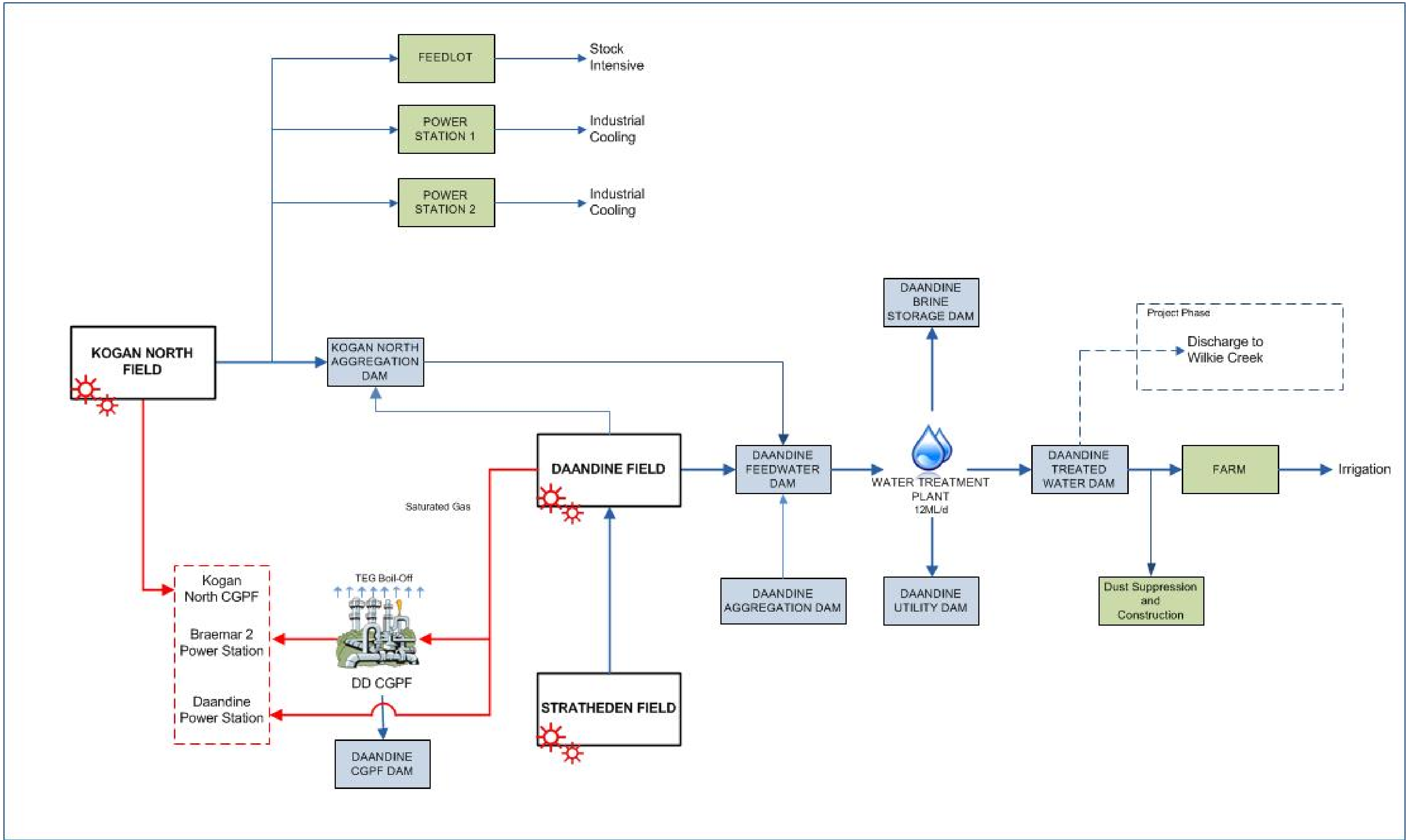

Figure 4-3 **Schematic diagram of the Daandine Water Management Network**

4.2.4 Brine Management

Brine at Daandine is currently stored in a dam compliant with the DEHP 2013 *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*[8] and the DXP EA conditions. Arrow is currently pursuing brine management options in line with its Surat CSG Water and Salt Management Strategy (refer Section 3.5). A long term brine management solution has not been selected at this stage.

4.2.5 Contingency Discharge

Arrow is currently licensed under the DXP EA to release treated CSG water to Wilkie Creek. Arrow is committed to maximising beneficial use of its CSG water prior to disposal methods and thus discharge to Wilkie Creek is held as a contingency measure to adapt to seasonal fluctuation in irrigation demand or to preserve dam integrity during excessive rainfall. The infrastructure required to facilitate discharge to Wilkie Creek has not yet been constructed.

4.3 Arrow Tipton Water Management Network

Figure 4-4 illustrates the existing Tipton water management network.

4.3.1 Dams

Refer to Section 4.1.1 for a description of the gathering network and conditions pertaining to dams. Arrow operates six (6) dams at Tipton. Table 4-3 provides dam storage characteristics for Tipton.

Table 4-3 Tipton Storage Characteristics

Dam Description	Volume at Spillway (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Design Storage Allowance (ML)
Tipton Aggregation Dam 1	1,443	1,240	1,096
Tipton Aggregation Dam 2	2,046	1,728	1,781
Feedwater Dam	422	388	357
Treated Water Dam	422	404	367
Brine Dam	1,141	989	879
Utility Dam	61	57	41

Note: DSA and MRL volumes have been updated to reflect the 2017 Annual Dam Inspections (AECOM, 2017).

4.3.2 Water Treatment Plant

In April 2013, Arrow Energy commissioned a 12 ML/d WTP at Tipton to facilitate beneficial use and align Arrow's operations with the updated CSG water management policy (DEHP, 2012). For a description of the water treatment process refer to Section 4.1.2. For characterisation of treated CSG water quality refer to Section 4.2.

[8] Queensland Department of Environment and Heritage Protection, *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures,* DEHP, Queensland, Australia (ESR/2016/1933).

4.3.3 Beneficial Use

Table 4-4 outlines the beneficial use offtakes from Tipton. The only current offtake is supply to a feedlot. Additional offtakes will be added when the SGP enters the development phase. These offtakes will form part of the proposed Arrow BUN.

Table 4-4 Tipton Third Party Water Offtakes

Beneficial Use Offtake	Maximum Possible Volume (ML/day)	DEHP Hierarchy Priority
Feedlot	Min = 1.75, Max = 4	Priority 1

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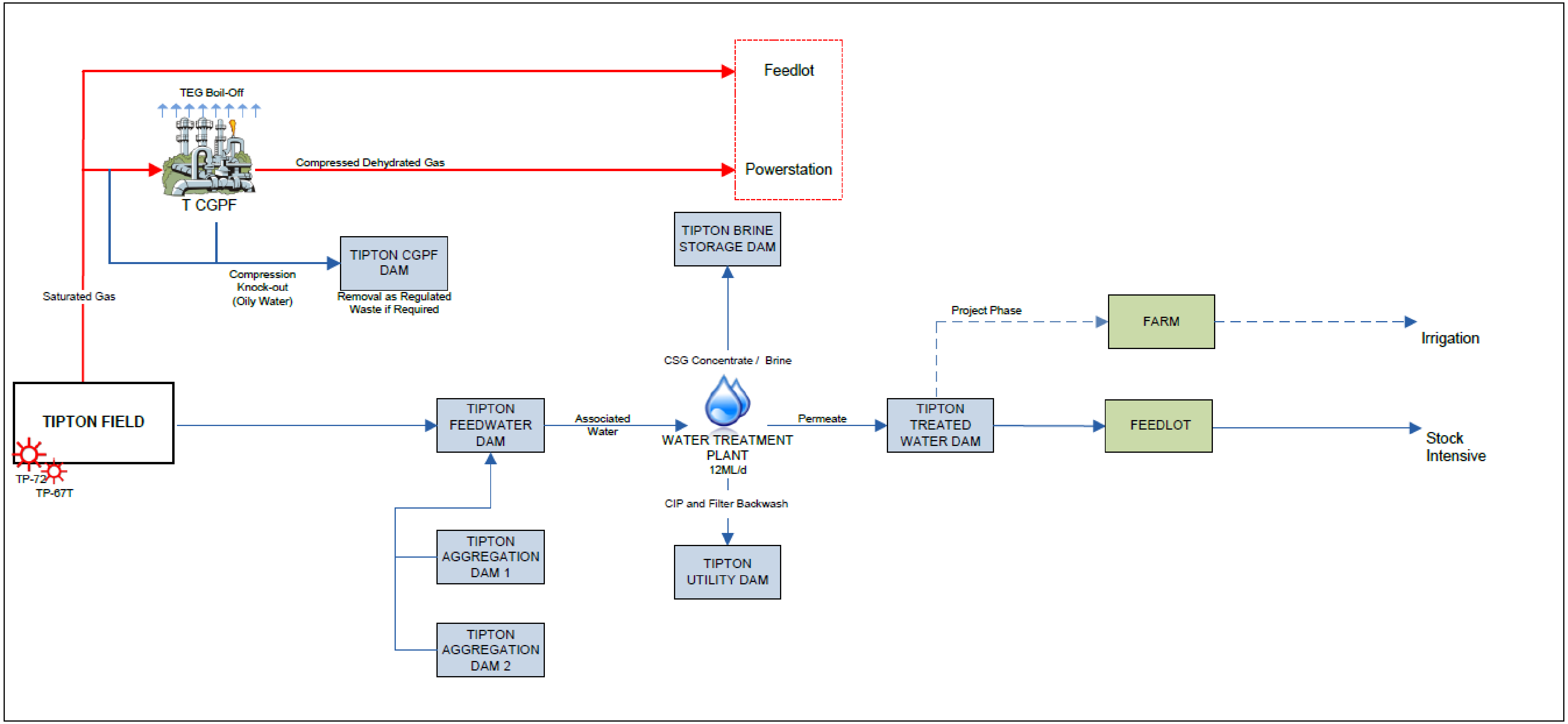

Figure 4-4 **Schematic diagram of the Tipton Water Management Network**

4.3.4 Brine Management

Brine at Tipton is currently stored in a dam compliant with the DEHP 2013 Manual for Assessing Consequence Categories and Hydraulic Performance of Structures and the DXP EA conditions. Arrow is currently pursuing brine management options in line with its Surat CSG Water and Salt Management Strategy (refer Section 3.5). A long term brine management solution has not been selected at this stage.

5. RISK MANAGEMENT

Arrow implements a standardised approach to risk management enabling risks to be ranked and prioritised across all operations. Arrow's approach to risk management seeks to:

- Identify and understand risks inherent to the business; and
- Apply adequate risk response by:
  - Decreasing the likelihood and consequence of adverse effects;
  - Increasing the likelihood and impact of positive effects;
  - Implementing effective controls;
  - Setting boundaries for risk acceptance;
  - Focusing assurance activities towards the highest areas of risk.

5.1 SGP Risk Assessment

An assessment of the risks related to CSG water management for the SGP was completed in March 2018. The risk assessment used the Arrow Energy framework[9]. Table 5-1 summarises the most pertinent CSG water management risks for the DXP, alongside mitigation measures that will control all risks to acceptable levels.

The risk assessment shows that:

- Most risks are ranked as Low considering existing management controls;
- Risks related to the failure of the WTP to achieve desired design water quality, the failure to secure off-take agreements and the failure to deliver a long term brine management solution ranked as Medium;
- For risks which ranked as Medium, the residual risk ranking is Low after consideration of risk response measures.

[9] Arrow Energy, 2018 *Arrow Energy Risk Management Procedure, Appendix 1 - Risk Assessment Matrix*, Version 5.0, Doc No: ORG-ARW-RMT-PRO-00001.

Table 5-1 Summary of Risk Assessment

Hazard / Threat	Consequences	Existing Controls	Current Risk Ranking	Risk Response	Residual Risk Ranking
Dam Break – collapse of the structure due to any possible cause	Dam break has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and non-compliance with EA conditions.	Dams are designed and operated in accordance with Queensland regulation. Monitoring and maintenance is undertaken in accordance with Dam Operating Plans. Annual dam inspections conducted. Weekly operator inspections of dam levels.	LOW *Aggregation Dam* LOW *Treated Water Dam* LOW *Brine Dam*	Implementation of emergency procedures as defined in the Dam Operating Plans.	LOW *Aggregation Dam* LOW *Treated Water Dam* LOW *Brine Dam*
Failure to contain – seepage - significant changes to Groundwater from seepage	Seepage has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and non-compliance with EA conditions.	Dams are designed and operated in accordance with Queensland regulation. Regular monitoring of groundwater quality in the immediate vicinity of regulated dams as per the Groundwater Monitoring Program. Seepage controls such as HDPE liners and collection systems are in place where required by Queensland regulation. Brine management dams include capability to capture any seepage that may pass through HDPE lining. Monitoring and maintenance undertaken in accordance with Dam Operating Plans.	LOW *Aggregation Dam* LOW *Treated Water Dam* LOW *Brine Dam*	Implementation of emergency procedures as defined in the Dam Operating Plans.	LOW *Aggregation Dam* LOW *Treated Water Dam* LOW *Brine Dam*
Failure to Contain – overtopping – releases due to overtopping of the structure	Overtopping has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and	Dams are designed and operated in accordance with Queensland regulation. Operation of storages in accordance with dam operating plans and EA conditions. Adherence to DSA and MRL operating rules.	LOW	Construct contingency release infrastructure. Implementation of emergency procedures (including emergency discharge strategy) as defined in the Dam Operating Plans.	LOW

Hazard / Threat	Consequences	Existing Controls	Current Risk Ranking	Risk Response	Residual Risk Ranking
	non-compliance with EA conditions.	Water production forecasting and water balance modelling. Emergency spillways on dams.			
Failure of water treatment plant to achieve required water quality	Plant failure has the potential to cause: an inability to use treated CSG water for intended beneficial use options; and non-compliance with EA conditions.	Upstream buffer storage to allow for temporary system shut down to resolve potential issues. Automated monitoring within the WTP system to allow for early detection and mitigation of issues. Automated water quality sampling in permeate dam prior to beneficial use. Ability to retreat water from permeate dam if there are significant exceedances.	LOW	Further in-field blending to address potential exceedances. Water treatment plant upgrades (including pre and post treatment systems) or replacements to achieve water quality objectives. Option to turn down / shut in wells if upstream storage becomes limiting.	LOW
Failure to secure water off-takes	Insufficient off-takes have the potential to require disposal of CSG water instead of beneficial use.	CSG water utilisation portfolio to be maintained with sufficient capacity (above upper bound water production curves) to address this risk. Market analysis and identification of off-take opportunities.	LOW	Ability to provide excess capacity into existing SunWater beneficial use pipeline to Chinchilla weir.	LOW
Failure to deliver long-term brine management solution.	No long-term brine management solution has the potential to: require additional brine storage construction when existing capacity is exhausted; and increase operational footprint and create additional impact on environmental receptors.	Brine feasibility studies to identify a long term brine management solution (refer Section 3.5). Construction of additional brine storage dams.	MODERATE[10]	Full evaluation of multiple options in order to ensure long term management approach will be in place.	LOW

[10] Risk ranks as moderate due to costs associated with disposal at a third-party waste facility.

6. MANAGEMENT CRITERIA

6.1 Measurable Criteria

Arrow Energy has defined Measurable Criteria for the SGP in accordance with Section 126 (1) of the *EP Act 1994*. To ensure criteria are targeted towards those CSG water management activities and elements that require greatest control, they have been developed from the outcomes of the risk assessment described in Section 5. The Measurable Criteria will be used to monitor and assess the effectiveness of CSG water management across a range of indicators and will be reported in the annual return.

Table 6-1 presents the measurable criteria required to satisfy the requirements of the EP Act. The criteria will be re-evaluated if required as a result of changes in the way which Arrow manages CSG water.

Table 6-1 Measurable Criteria

Management Component	Objectives	Environmental Value Protected	Controls	Measurable Criteria
Transmission of CSG water via pipelines	Effective containment of water throughout transmission activities from well to beneficial use / disposal.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Regular monitoring and maintenance in accordance with asset integrity and maintenance plan. Process safety in design and controls.	No reportable unplanned releases of CSG water.
Storage of CSG water in regulated dams	Effective containment of CSG water in dams. Regulated dams operated and maintained in accordance with approvals.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Annual dam integrity inspections. Groundwater monitoring program. Scheduled maintenance of infrastructure and facilities. Dam operating plans. Water balance modelling to develop operating philosophy and strategy.	Water level below DSA at Nov-1.[11] No breaches of MRL. Annual inspections completed. No unplanned releases.
Beneficial Use	Maximise beneficial use of CSG water. Ensure that supplied beneficial use water is in accordance with approvals.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Regular monitoring of the qualities and quantities of water suppled for beneficial use. Scheduled maintenance of infrastructure and facilities. CSG Water and Salt Management Strategy.	Water supply agreements in place. Water quality for beneficial use meets approval conditions.
Management of salt and brine	Management of salt in accordance with the regulatory framework.	Land use capability, having regard to economic considerations. Surface and ground water quality. Soil quality (including structural and chemical properties).	Continual assessment of feasible options for beneficial use and/or disposal of salt in accordance with the CSG Water Management Policy 2012. Containment of salt and brine in fit for purpose storage infrastructure operated and maintained in accordance with approvals.	Water level below DSA at Nov 1. No breaches of MRL. Annual inspections completed. No reportable unplanned releases.

[11] If the dam is a regulated structure as per the failure to contain overtopping scenario in the *Queensland Department of Environment and Heritage Protection, Manual for Assessing Consequence Categories and Hydraulic Performance of Structures,* DEHP, Queensland, Australia (ESR/2016/1933).

6.2 Response Procedures

Should any of the Measurable Criteria in Table 6-1 not be met, the following response procedure will be implemented:

- Where relevant, reporting of incident in line with DES requirements;
- Evaluation (including root cause analysis) of the underlying cause of the criteria not being met;
- Review of relevant procedures, protocols and management plans and make changes where required;
- Implementation of corrective actions to address underlying cause. This, for example, could include:
  - Engineering solutions;
  - Amendments to operating procedures; and/or
  - Change to management process.

6.3 Arrow Operating Procedures

Arrow Energy commits its staff to the adoption of a series of procedures that control important elements of CSG water management. These procedures include:

- 99-H-PR-0010 (5) Incident Reporting Recording and Investigation Procedure;
- ORG-ARW-HSM-PRO-00016 (8) Chemical Management Procedure;
- ORG-ARW-HSM-PRO-00066 (4) Waste Management Procedure; and
- ORG-ARW-HSM-PRO-00073 (7) Land Rehabilitation Procedure.

Each of Arrow Energy's procedures is reviewed regularly in order to ensure that all operating factors are considered, and that procedures continue to reflect latest understanding.

7. MONITORING

7.1 Environmental Monitoring

7.1.1 Surface Water

Contingency discharge of treated CSG water to watercourses is a potential option in the event that other beneficial uses of CSG water are temporarily unavailable. Prior to the release of treated CSG water to a watercourse, Arrow will develop a Receiving Environment Monitoring Plan (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, water quality, and flows due to authorised releases. The REMP will be developed in accordance with granted EA conditions. Arrow does not currently have any installed watercourse release infrastructure.

7.1.2 Groundwater

The Groundwater Monitoring Program will provide for the early detection of significant risks and changes in groundwater quality and levels as a result of activities authorised under the SGP EAs.

The Groundwater Monitoring Program will be based on the current program at Arrow's DXP and may include:

- regular monitoring of groundwater quality in the immediate vicinity of regulated dams;
- monitoring of background sites;
- monitoring of dam water quality;
- establishment of site-specific environmental values for the shallow groundwater system;
- development of site-specific trigger values;
- ongoing monitoring of groundwater to identify environmental impacts; and
- implementation of management actions in the event of environmental impact.

Monitoring groundwater quality at dam sites requires installation of monitoring bores in close proximity to dams. The exact location of these bores is guided by geotechnical investigations to identify the direction in which in groundwater impact is likely to travel. Background sites are also installed at distances of 500m to 1,500m (where access allows) both up and down gradient of the dams.

Site-specific trigger levels are developed by considering the background groundwater quality, established trigger levels (such as ANZECC water quality criteria), and the potential impacts of seepage from regulated dams. Ongoing monitoring is then used to identify whether, and to what extent, environmental impacts, with reference to the aforementioned criteria, are occurring. Where unacceptable impacts have occurred, management actions are initiated to remedy these.

7.2 Monitoring of CSG Water Management Dams

In accordance with dam operating plans, Arrow Energy will conduct the following monitoring:

- Weekly monitoring:
  - Dam water levels monitored against MRL and DSA;
  - Visual inspections to consider integrity issues; and
  - Visual inspections for algae, surface slicks or fauna interaction.
- Monthly Monitoring:
  - Visual structural inspection for early identification of integrity issues; and
  - Identification of any changes to the dam service/contents.
- Biannual monitoring:
  - Groundwater impact monitoring for physico-chemical parameters.
- Annual monitoring:
  - Each regulated dam will be inspected by a suitably qualified and experienced person with an Annual Inspection Report prepared and certified; and
  - An assessment of the DSA will be undertaken on or before 1 November each year.

8. REPORTING

8.1 Annual Return

In accordance with the requirements of the SGP EAs, Arrow Energy will complete and submit an Annual Return which will include an evaluation of the effectiveness of the management of CSG water under the criteria described in Section 126(1)(e) of the EP Act.

8.2 Annual Inspection Report

Arrow Energy will provide to DES upon request a copy of the Annual Inspection Report for each of its regulated structures. This will be certified by a suitably qualified and experienced person and will include any recommended actions to ensure the integrity of inspected dam.

8.3 Annual Monitoring Report

An Annual Monitoring Report summarising monitoring results over the previous 12 month period will be prepared and made available to DES upon request. All monitoring results will be retained for no less than five years.

8.4 Incident Reporting

If any contaminant levels are identified as having caused, or have the potential to cause environmental harm, this will be reported to DES in accordance with EP Act and EA requirements.

9. REFERENCES

ANZECC & ARMCANZ 2000, Australian and New Zealand guidelines for fresh and marine water quality, ANZECC & AMCANZ, Australia.

Arrow Energy, 2018 *Arrow Energy Risk Management Procedure, Appendix 1 - Risk Assessment Matrix*, Version 5.0, Doc No: ORG-ARW-RMT-PRO-00001.

Arrow Energy, 2013 Coal Seam Gas Water Management Plan – Surat Basin, Rev: 0, Doc No: ENV11-133.

Arrow Energy 2017, *Surat Gas Project CSG Water Management Strategy*, Rev: 0, Doc No: ORG-ARW-ENV-STR-00001.

Arrow Energy, 2017 Dalby Expansion Project (DXP) – Dam Operating Plan, Rev: 2, Doc No: 19-W-PL-0001.

Arrow Energy, 2013 Daandine Expansion – Field Development Plan, Rev: 3, Doc No: 05-PE-PL-0002 (3).

Arrow Energy, 2017 Daandine and Kogan North Water Management Review, Rev: 0, Doc No: 05-W-REP-0012.

Arrow Energy, 2017 Monthly Daandine Water Operations Report, Rev: 0, Doc No: 05-W-REP-0015.

Arrow Energy, 2017 Monthly Tipton Water Operations Report, Rev: 0, Doc No: 00-W-REP-0008.

Arrow Energy, 2017 Tipton West Management Review, Rev: 0, Doc No: 00-W-REP-0007, Arrow Energy, Australia.

Department of Environment and Heritage Protection, 2017 Environmental Authority: Arrow Energy Dalby Expansion Project, Permit No: EPPG00972513, effective 21 September, Queensland, Australia.

Department of Environment and Heritage Protection, 2013 *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*, Queensland, Australia (ESR/2016/1934).

Department of Environment and Heritage Protection, 2012 Coal Seam Gas Water Management Policy, Queensland, Australia.

Sinclair Knight Merz, 2012 Daandine Gas Project Environmental Assessment of Wilkie Creek, SKM, Australia.

Appendix 11: Example Baseline Report

Report

Safe Work. Strong Business.

target zero

Baseline Report

Surface Elevation Data – 1DY931 & 1RL2451

Version	1
Released	20/07/2021

Once printed, this is an uncontrolled document unless issued and stamped Controlled Copy.

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Contents

List of Figures

1. Purpose

This Report provides the following surface elevation datasets overlaid for lots on plans, 1DY931 & 1RL2451 :

- 2012 Digitial Elevation Model (DEM) (Figure 1),
- 2014 DEM (Figure 2),
- 2020 DEM (Figure 3),
- Slope analysis (at 10 m by 10 m squares) of 2012 DEM (Figure 4),
- Slope analysis (at 10 m by 10 m squares) of 2014 DEM (Figure 5), and
- Slope analysis (at 10 m by 10 m squares) of 2020 DEM (Figure 6).

Electronic copies of the above datasets can be made available upon request.

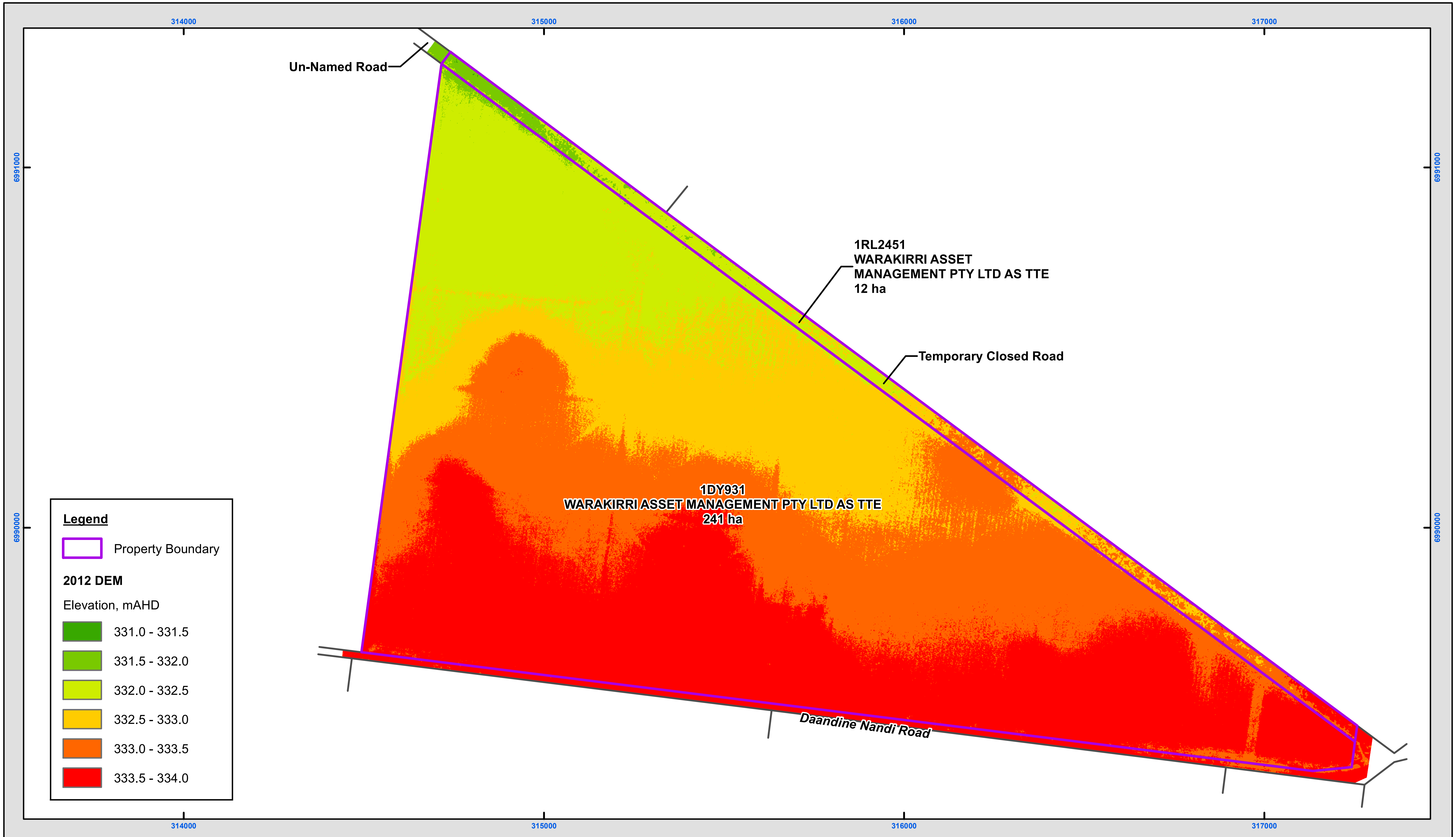

Figure 1 : 2012 DEM : Lots on Plans 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25 Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION

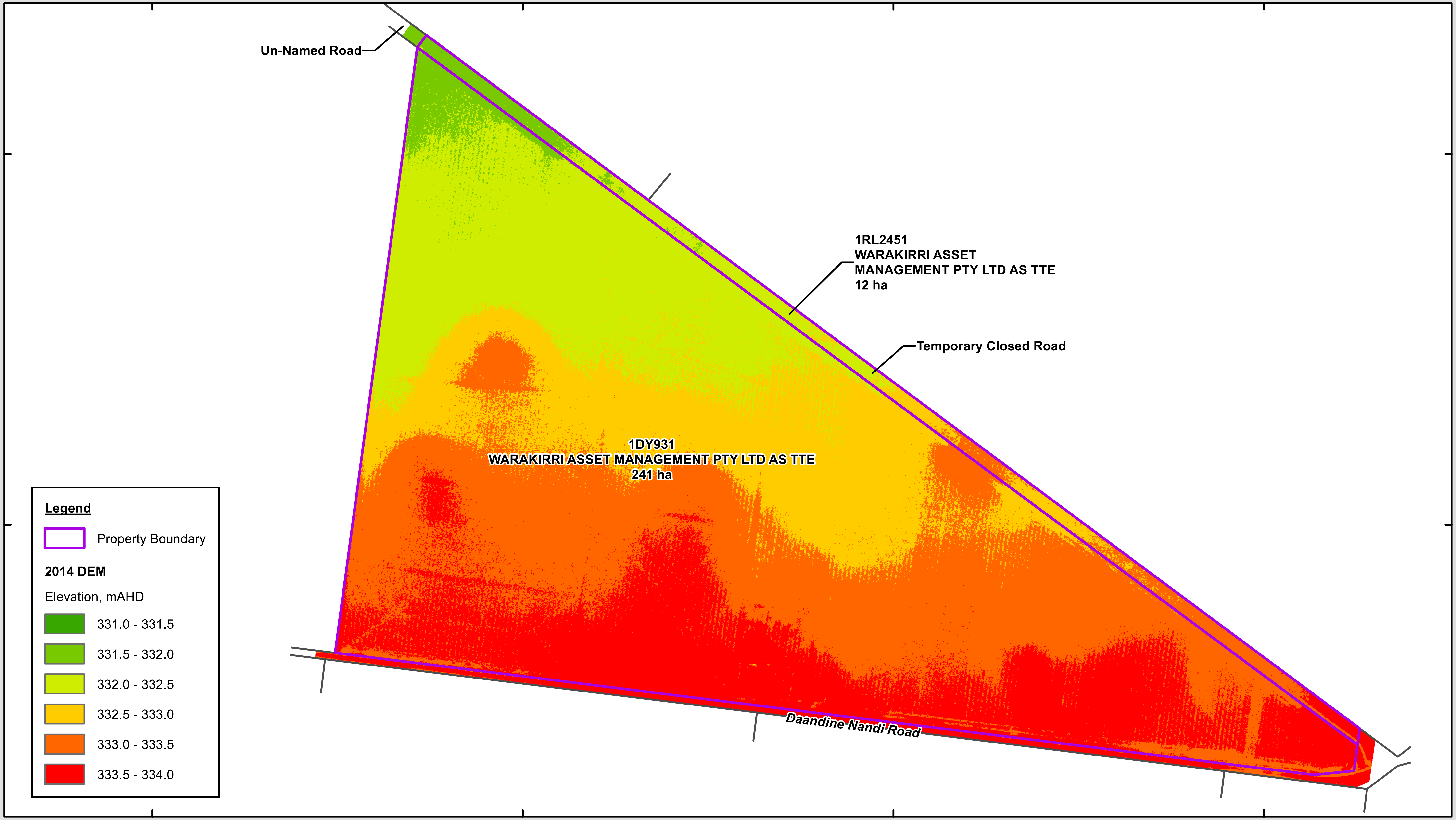

Figure 2 : 2014 DEM : Lot on Plan 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25 Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

GDA

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The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION

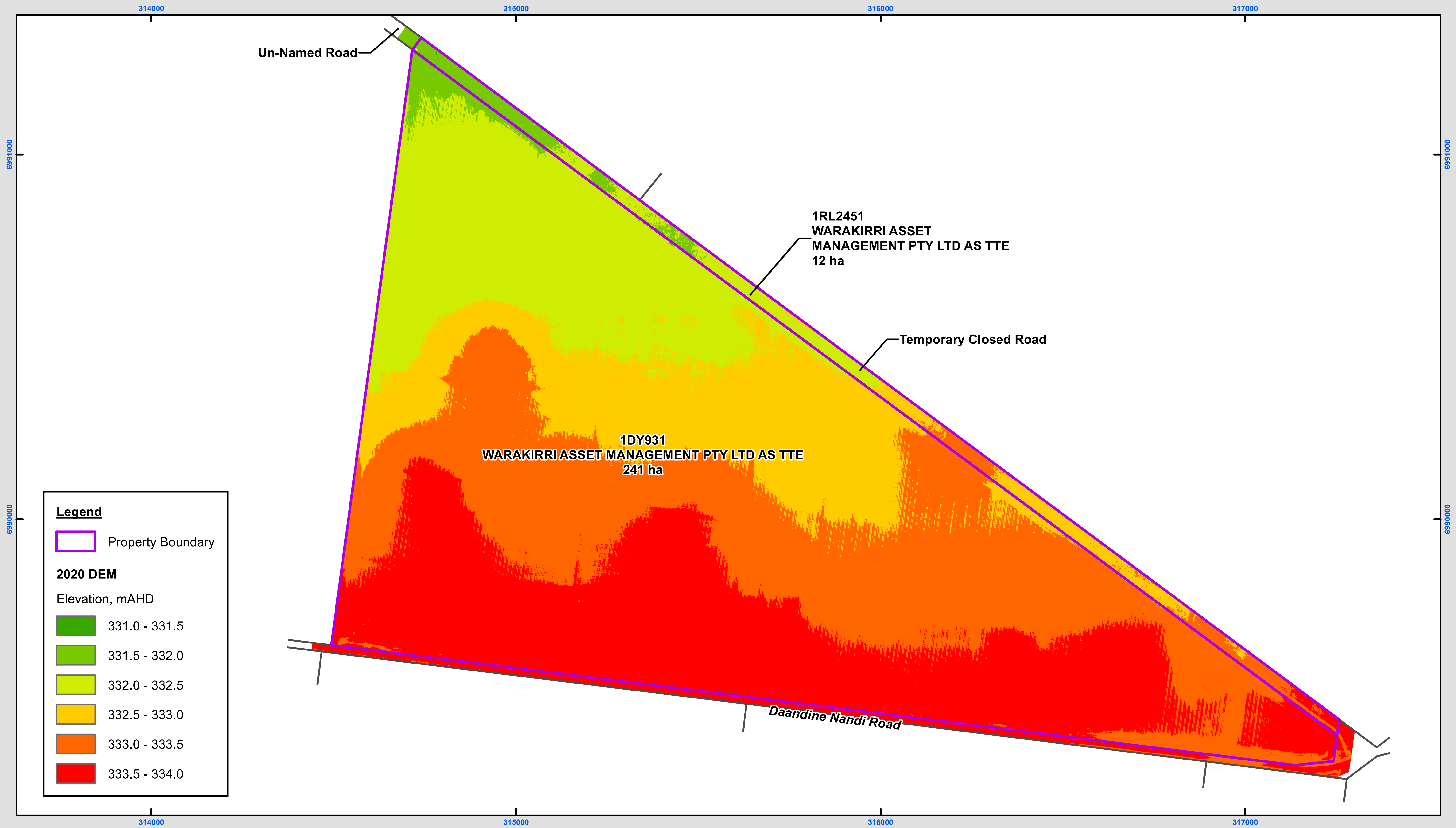

Figure 3 : 2020 DEM : Lot on Plan 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25 Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA2020 MGA Zone 56

The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION

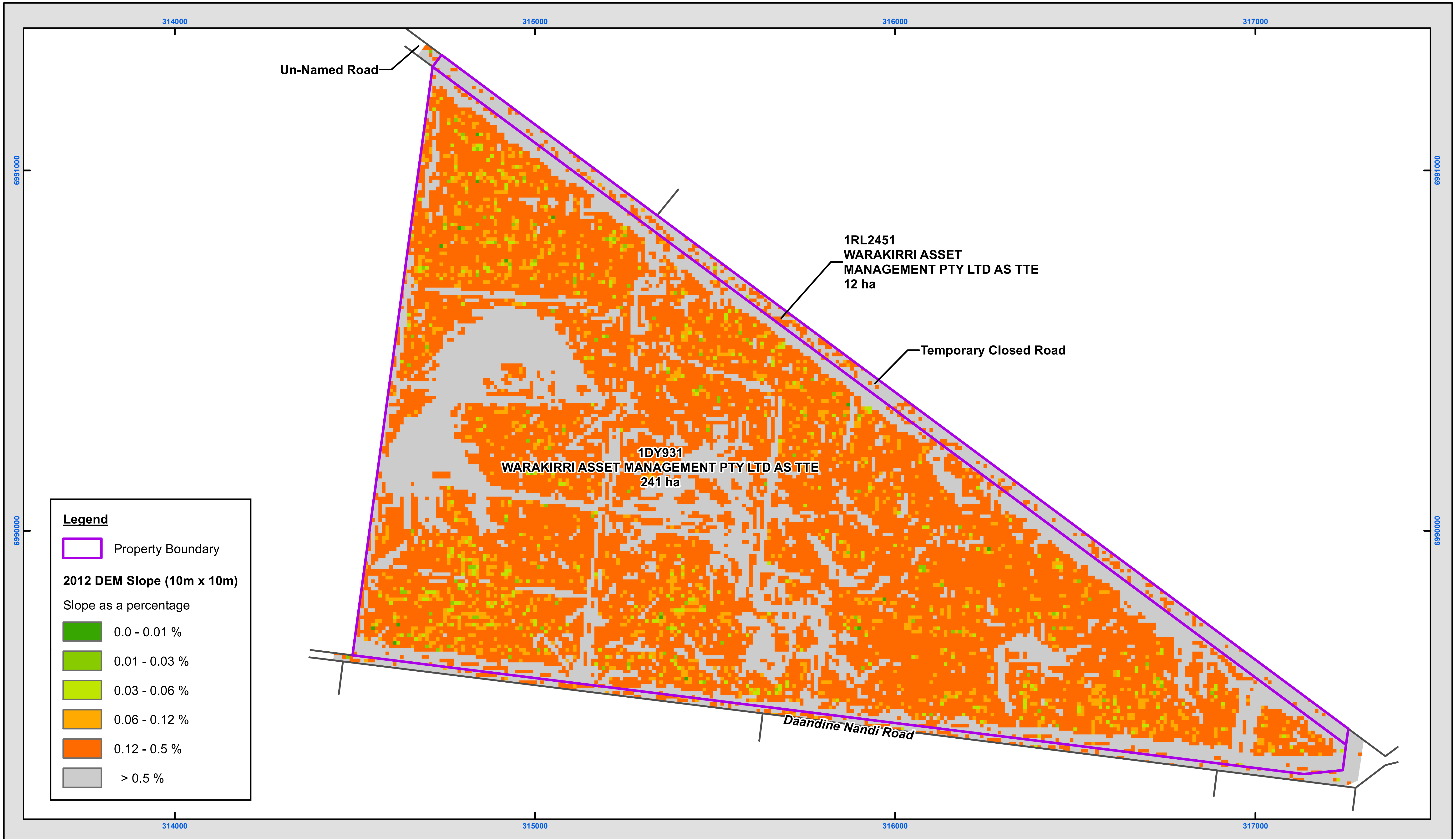

Figure 4 : Slope Analysis (10m x 10m squares) of 2012 DEM : Lot on Plan 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25 Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

GDA

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The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION

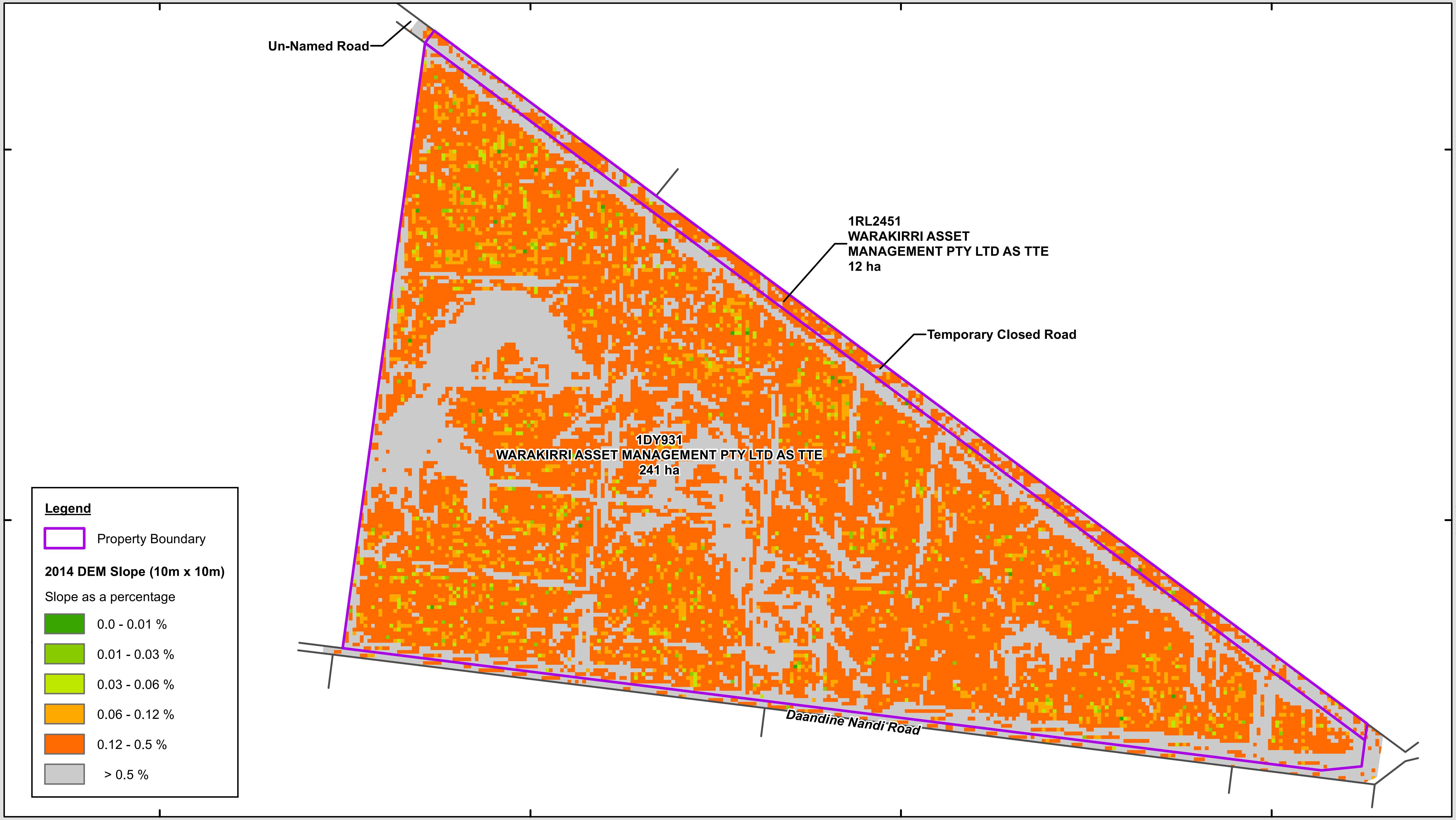

Figure 5 : Slope Analysis (10m x 10m squares) of 2014 DEM : Lot on Plan 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25 Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION

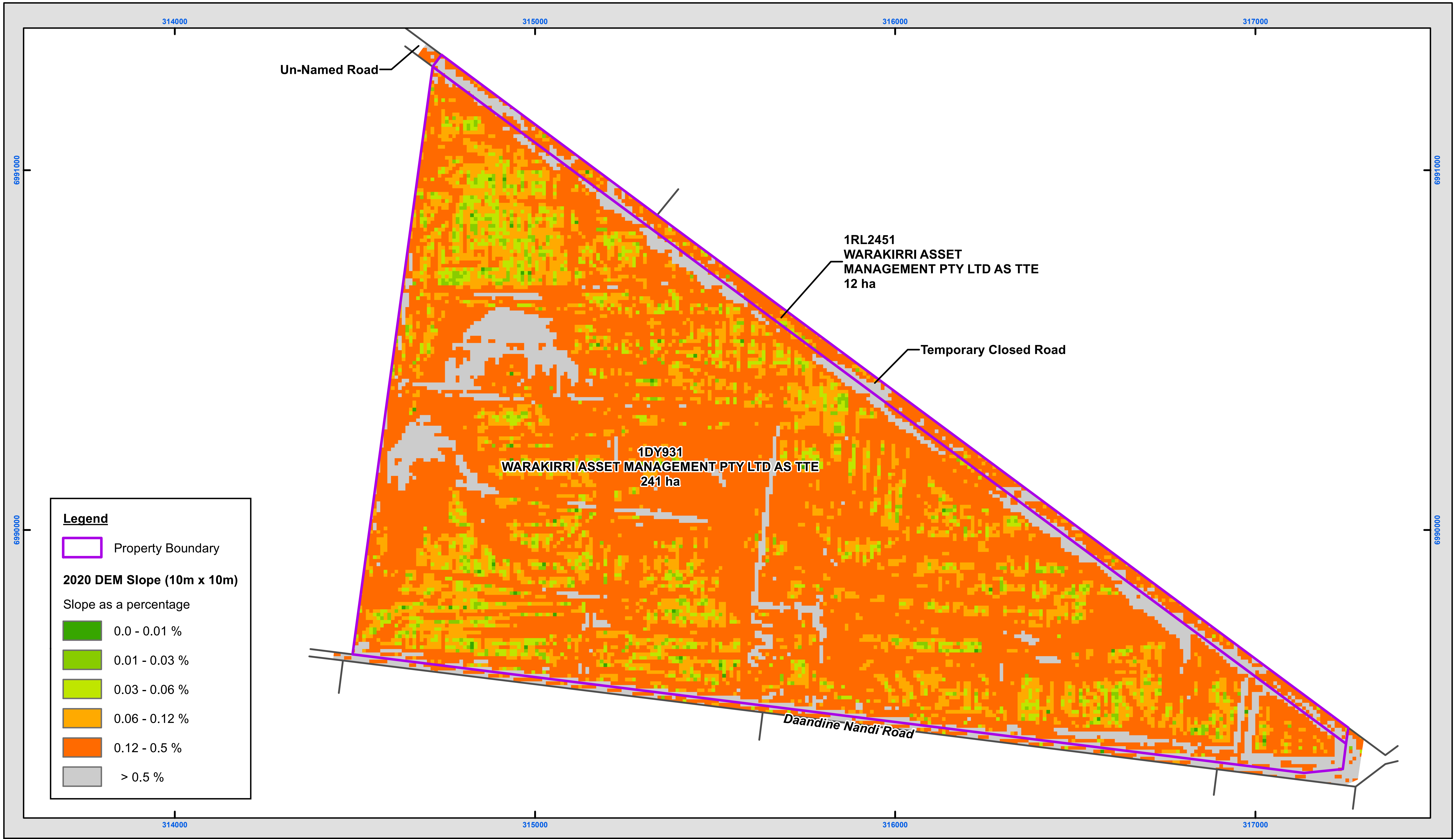

Figure 6 : Slope Analysis (10m x 10m squares) of 2020 DEM : Lot on Plan 1DY931 & 1RL2451

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Natural Resources and Mines

Date: 21/07/2021

Author: Arrow Energy

0.25 0.125 0 0.25
Kilometres

Scale: 1:10,000 @ A3

Coordinate System: GDA2020 MGA Zone 56

The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

NOT FOR CONSTRUCTION