5. PROJECT DESCRIPTION

The Surat Basin hosts a number of gas fields with significant coal seam gas resources. Arrow proposes to develop these resources for both domestic and international markets through exploration, field development, gas production, gas transport, gas distribution and export as depicted in Figure 5.1.

As outlined in Section 1.2.1, the Surat Gas Project is located approximately 160 km west of Brisbane in Queensland's Surat Basin. Figure 1.1 shows the project development area, which comprises the area containing all of Arrow's proposed development under the Surat Gas Project. The project development area covers an area of approximately 8,600 km^2 and extends from the township of Wandoan in the north towards Goondiwindi in the south, in an arc through Dalby. The figure also shows the petroleum leases, petroleum lease applications, authorities to prospect, and authority to prospect applications that are contained in the project development area.

Within the project development area will be five development regions: Wandoan, Chinchilla, Dalby, Millmerran/Kogan and Goondiwindi (see Figure 1.2). Each development region will contain a number of gas fields (approximately three or four each) and all of the proposed wells and facilities located in those fields. The project will primarily be managed at a development region level. Division of the project development area into development regions allows the project to be phased, or staged, across the regions to optimise production over the life of the project, as discussed further in Section 5.3, Development Sequence.

Project infrastructure, such as production wells and production facilities, will not be located in the towns that are in or adjacent to the project development area. However, supporting facilities, such as depots, stores and offices, may be located in or adjacent to those towns.

This section describes the coal seam gas resources; the activities and major infrastructure required to develop these resources; the processes for the sequencing, planning, construction, operation and decommissioning of the major infrastructure components within the project development area; and the strategy for management of coal seam gas water and brine. It concludes with a discussion of technical alternatives for power distribution.

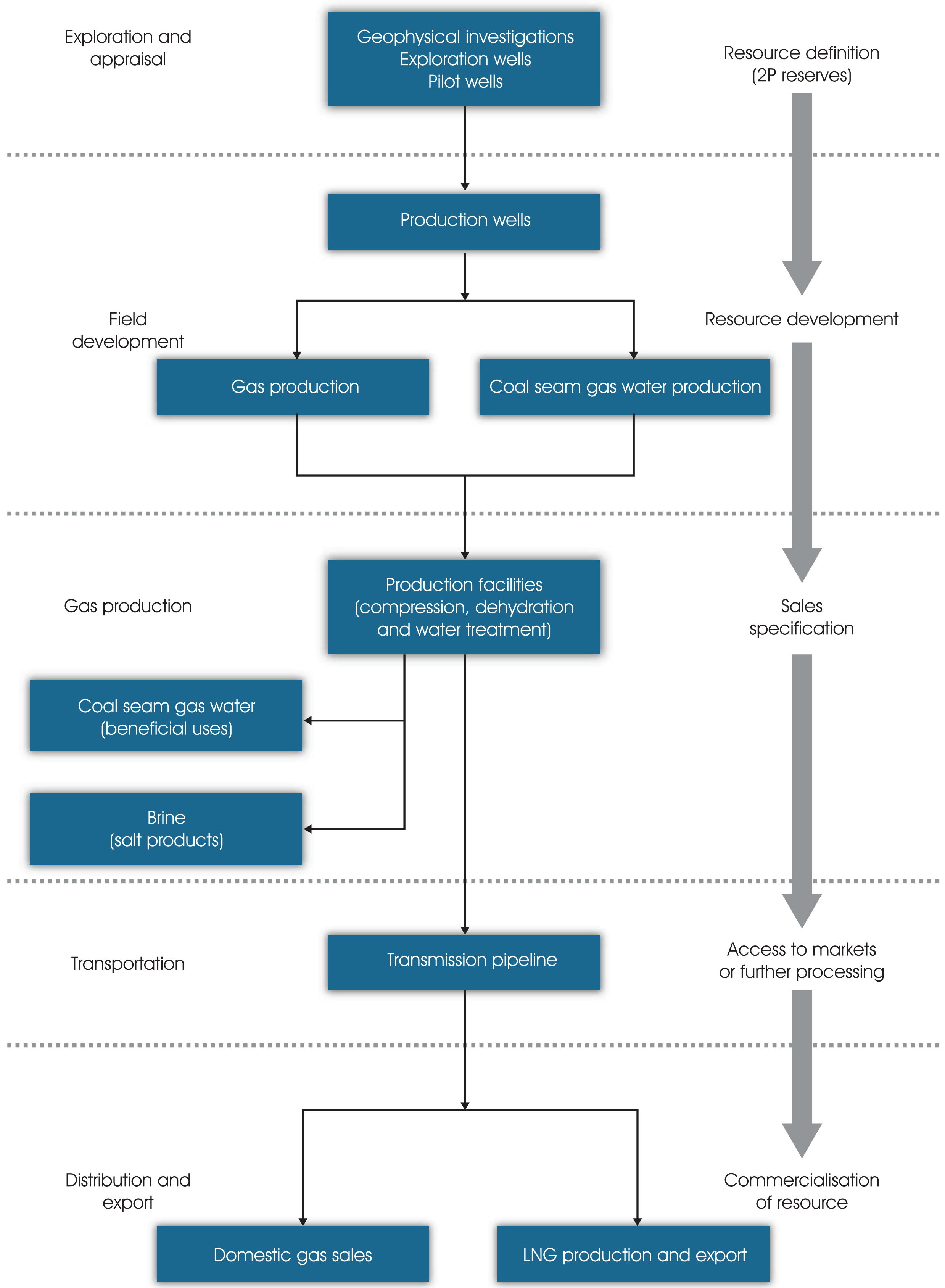
5.1 Description of the Gas Resource

The resources for the Surat Gas Project lie within the coal seams of the Walloon Coal Measures of the Surat Basin. The Surat Basin accounts for 61% of Australia's current 1P (proven) and 2P (proven and probable) coal seam gas reserves (GA & ABARES, 2010). Arrow's gross 1P, 2P and 3P (proven plus probable plus possible) reserves in the Surat Basin are 472 PJ, 3,789 PJ and 4,587 PJ, respectively (NSAI, 2009).

The following sections provide an overview of coal seam gas and describe the regional geology and stratigraphy of the Surat Basin coal seam gas resources that will supply the project. The final section describes the coal seam gas composition.

5.1.1 Coal Seam Gas

Coal seam gas refers to the methane gas lining the open fractures between the coal (called the cleats) and the inside of pores within the coal (called the matrix).



coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Surat Gas Project development activities	Figure No: 5.1
	File Name: 7040_04_F05.01_GL	Surat Gas Project			

Coal seams store both gas and water. The water, which is under pressure from the weight of overlying rock material, holds the gas in place. 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 in the well.

Once a well has been drilled, it becomes the only method for gas and water to reach the surface. The two products are separated below ground, with water being transferred to centralised collection and treatment points and the gas being piped to production facilities where it is dried, compressed and piped to market.

5.1.2 Regional Overview

The project development area covers the eastern margin of the Surat Basin and the westernmost part of the Clarence-Moreton Basin, as shown on Figure 5.2. The geological formations of these basins are relatively continuous at their adjoining margins; however, given that the majority of Arrow’s tenements and project development area are located within the Surat Basin, the project is referred to as the ‘Surat Gas Project’. For simplicity, geological descriptions in this section apply to both basins, but are referred to as only the Surat Basin.

The Surat Basin comprises thick sedimentary sequences, which in the westernmost portion of the project development area have formed above the older sedimentary sequences of the Bowen Basin. The formation of coal seam gas in the Surat Basin began during the Early Jurassic Period, some 200 million years ago. During this time, dead plant matter that accumulated in swamps was eventually buried under sediment. Over time, these deposits became compressed organic layers that transformed into coal. Arrow's coal seam gas exploration and production is focused on the Walloon Coal Measures, which formed during the Middle Jurassic Period.

5.1.3 Stratigraphy

The Walloon Coal Measures lie beneath the Kumbarilla Beds and above the Eurombah Formation sandstone (Figure 5.3). The Walloon Coal Measures are complex; are characterised by carbonaceous mudstone, siltstone, minor sandstone and coal; and contain the following formations:

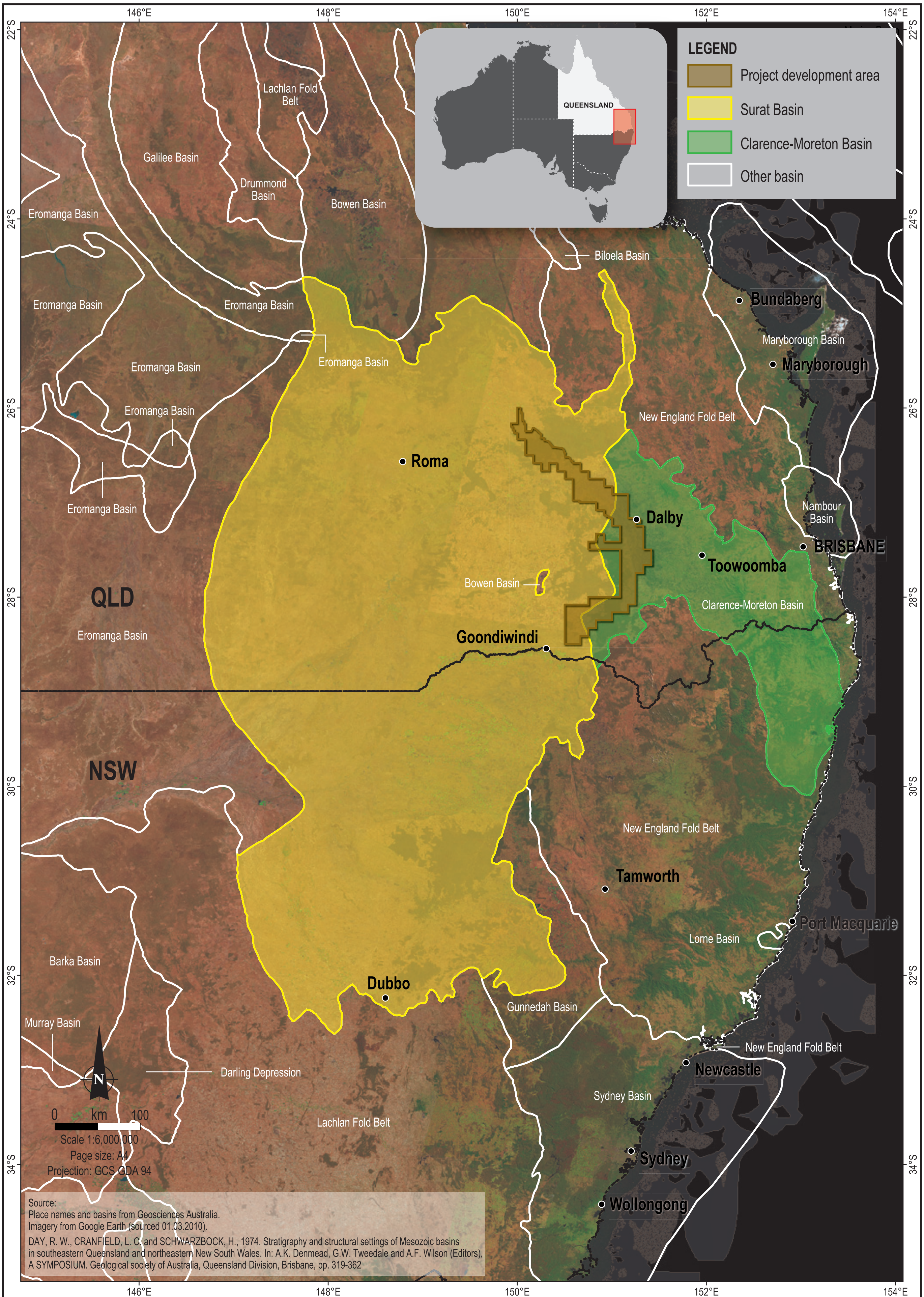
- Juandah Coal Measures.
- Tangalooma Sandstone.
- Taroom Coal Measures.
- Durabilla Formation.

Of these four formations, the Juandah and the Taroom coal measures, which generally range in depth from 150 to 750 m below ground surface across the project development area, are targeted for exploration and production.

Properties of the Walloon Coal Measures that influence the production of coal seams include:

- Geological factors, including structure, depth, faulting and cleating.
- Coal seam and confining strata porosity and permeability.
- Gas content, gas sorption capacity and pressure.

Further details of Surat Basin geology is provided in Chapter 12, Geology, Landform and Soils.



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Surat Gas Project

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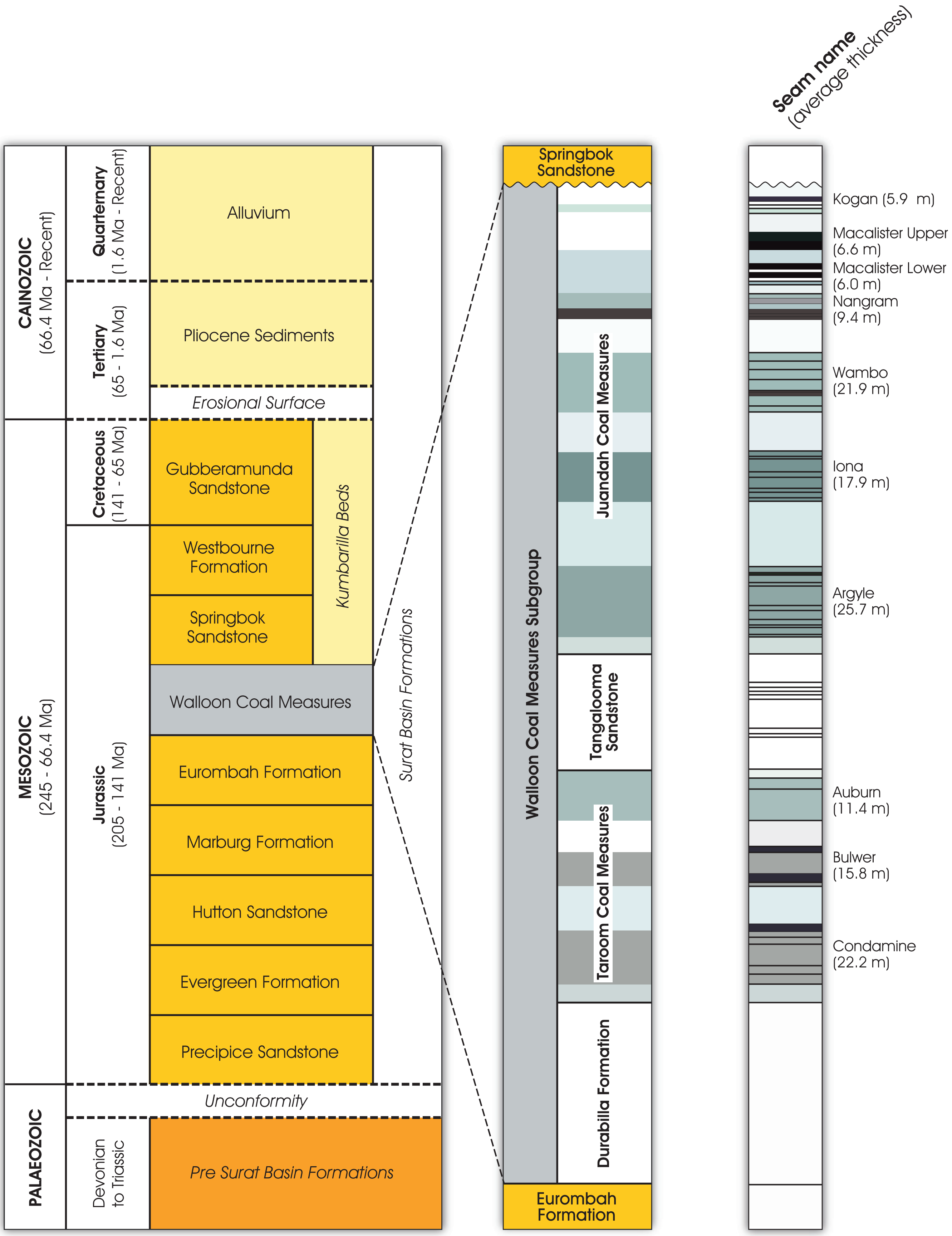
Location of the Surat and Clarence-Moreton basins

Figure No: 5.2



Source: Data form Arrow Energy
Scott et al (2004)

coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Project development area stratigraphic profile	Figure No: 5.3
	File Name: 7040_04_F05.03_GL	Surat Gas Project			

5.1.4 Coal Seam Gas Composition

The coal seam gas composition within the project development area has been characterised from Arrow's existing exploration and production (Table 5.1).

Table 5.1 Typical coal seam gas composition

Component	Typical Quantity (%)
Methane	98.75
Ethane	0.01
Carbon dioxide	0.19
Nitrogen	1.05

5.2 Project Components

Development of the coal seam gas reserves in the Surat Basin will require significant infrastructure to extract and transport the gas for production and sale. Arrow proposes that numerous production wells be installed firstly to remove the water from the coal seams and then to extract the gas for processing at a number of production facilities. Production facilities will dehydrate and compress the gas for transport to market, as well as treat and store the coal seam gas water. Power generation facilities will be required as will various supporting infrastructure.

The main infrastructure components of the Surat Gas Project are:

- Production wells.
- Gas and water gathering systems.
- Production facilities.
- Water treatment and storage facilities.
- Power generation facilities.
- High pressure gas pipelines.
- Supporting infrastructure and logistics.

Figure 5.4 provides a schematic diagram of the Surat Gas Project production infrastructure.

This section provides a detailed description of the major infrastructure components and the workforce required to construct, operate and decommission this infrastructure. Additional details regarding the construction, operation, and decommissioning of these components are provided in Sections 5.5, 5.6 and 5.7, respectively.

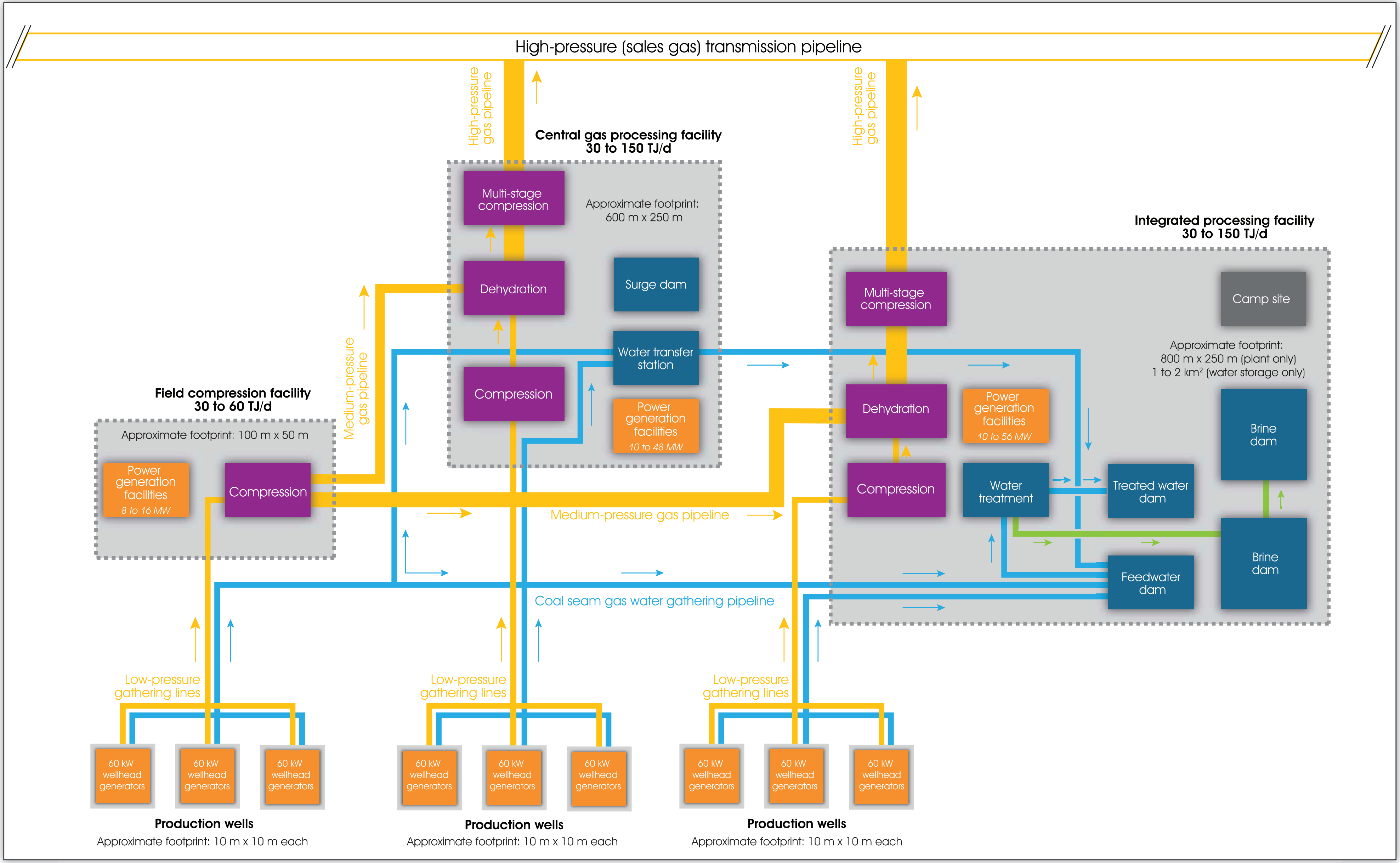
5.2.1 Production Wells

Throughout the life of the project (35 years expected), about 7,500 production wells will be drilled across the project development area at a rate of approximately 400 wells per year.

Figure 1.2 portrays the expected number of proposed production wells in each of the five development regions over the life of the project.

Production wells will generally be 300 m to 750 m deep depending on the depth of the coal seams. Extremely shallow or deep coal seams typically do not contain economically viable coal seam gas reserves.

Arrow proposes to install production wells on an 800-m-grid spacing. This equates to an indicative density of one well per 65 to 130 ha (160 to 320 acres).



Source: Coffey 2010.

coffey environments	Job No: 7040	Arrow Energy	Gas and water production and treatment
	File Name: 7040_04_F05.04_GL	Surat Gas Project	Figure No: 5.4

arrow energy go further

Based on a 65-ha-block-centred layout (approximate 800-m-grid spacing), this equates to indicative production well densities of:

- Forty wells in an area 5 km by 5 km.
- One hundred fifty wells in an area 10 km by 10 km.
- Three hundred wells in an area 14 km by 14 km.

Wells do not need to be placed on a precise grid and may be spaced as far apart as 1,500 m depending on such constraints such as environmental and social values, economics, reservoir characteristics and existing land use. As gas production ramps down, in-fill wells may be drilled between existing well locations to improve gas recovery and production.

The life of a production well will vary in accordance with the density of wells, the gas extraction rate and the production performance of the well. Production performance is predominantly dependent on the physical characteristics of the coal. Modelling of well life is based on probabilities and averages and Arrow's current modelling suggests an average well life of 15 to 20 years.

Surface facilities associated with a production well include a water pump, a generator and separation equipment. Construction and operation of production wells are described in Section 5.5, Construction, and Section 5.6, Operations and Maintenance, respectively.

A typical production well is depicted in Figure 5.5.

5.2.2 Gas and Water Gathering Systems

Upon completion of a production well, coal seam gas and water are produced at low pressures of approximately 100 kPa. Gas and water gathering systems are required to collect and transport the gas and water to production facilities.

Gas and water gathering systems may include:

- Wellhead facilities such as a water and gas separator vessel, water pump, electrical generator, electrical control panel, instrumentation, piping and valving at the wellhead to control the flow of the gas and coal seam gas water from the well to the gathering system.

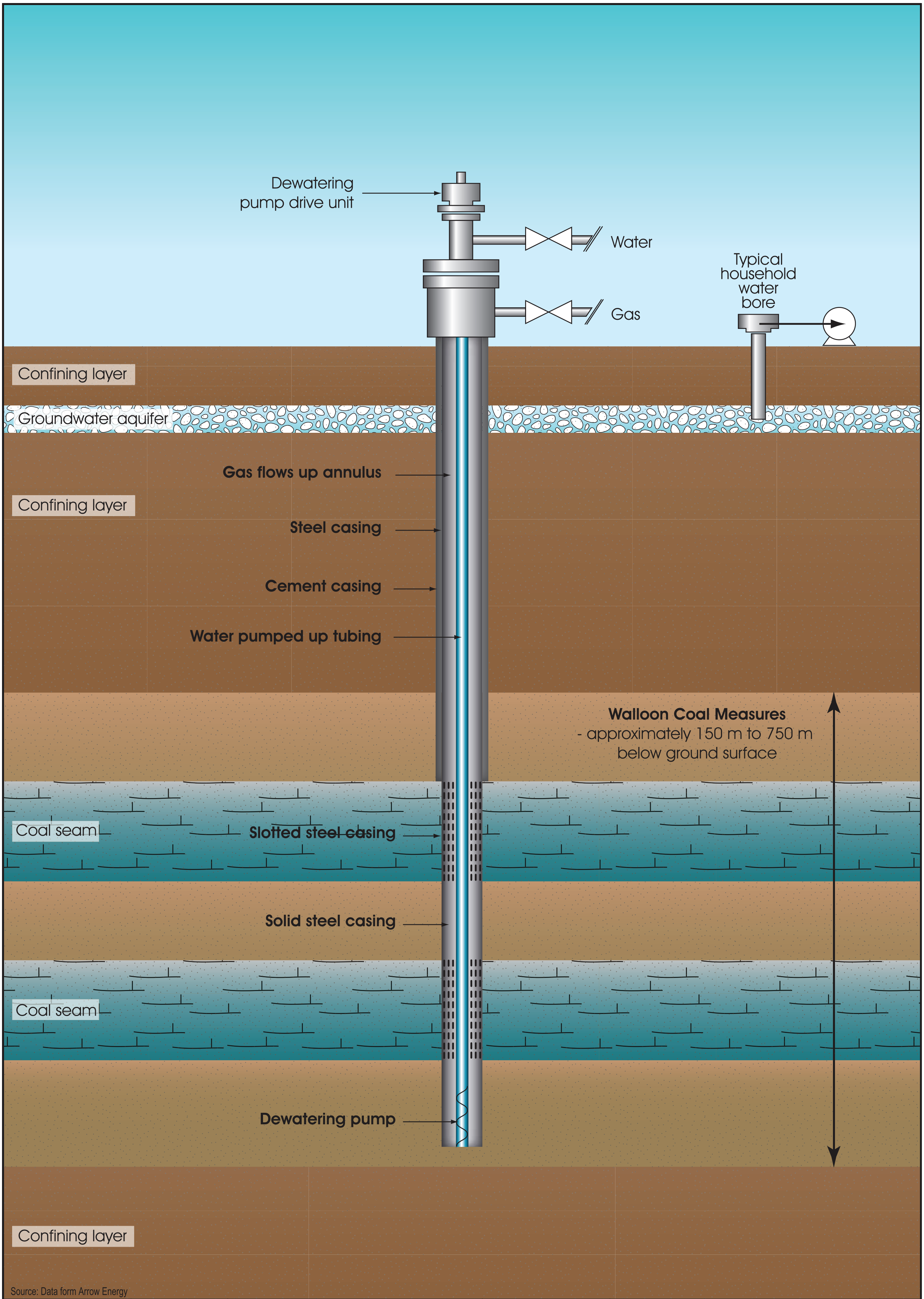
- Low-pressure gas and water gathering pipelines to transport gas and water from the wellhead to the production facilities. These low-pressure pipelines will be 100- to 630-mm-diameter, high-density, polyethylene buried pipelines.

- Medium-pressure pipelines to transport gas between production facilities. Medium-pressure pipelines will be buried and constructed of lightweight, plastic-composite, glass-reinforced epoxy or steel.

5.2.3 Production Facilities

Gas and water collected in the gathering systems will be transported to production facilities located at approximately 25-km intervals. Production facilities primarily:

- Receive gas from wells located within reasonable proximity to the facility.
- Remove any bulk water remaining in the gas through a slug catcher.
- Compress gas through multiple stages to achieve sales gas pipeline pressure.
- Dehydrate gas to sales gas pipeline quality.
- Meter and control gas flow from the wells and to the sales gas pipeline.
- Provide a control centre for activities in the facility and the associated gas fields.
- Flare gas in the event of plant upset conditions or control failure.



Source: Data form Arrow Energy

coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Typical production well	Figure No: 5.5
	File Name: 7040_04_F05.05_GL	Surat Gas Project			

- Vent process gas in emergency situations.

A combination of three types of production facilities will be required:

- Field compression facilities will provide between 30 and 60 TJ/day of gas compressed to 1,000 kPa for production wells that are located within a 12-km radius of the facility. Field compression facilities will be located between wells and larger production facilities where wellhead pressure is not sufficient to transport to the larger production facilities. The compressors (Plate 5.1) will be electrically driven and require a large amount of power, which may be generated onsite. The approximate footprint for a field compression facility is 100 m x 50 m.
- Central gas processing facilities will receive gas from both low- and medium-pressure gathering systems. These facilities will dehydrate and compress between 30 and 150 TJ/d of gas to 10,200 kPa using electrically driven compressors before transporting the gas to market. A water transfer station comprising a water transfer dam and pumping station will be located at each central gas processing facility. The water will be transferred to a water treatment and storage facility located at or near an integrated processing facility (see below). Power generation facilities will also be included at these facilities. Central gas processing facilities may serve as a field base for operations personnel and could incorporate such facilities as offices, maintenance shops and storage. The approximate footprint for a central gas processing facility is 600 m x 250 m.
- Integrated processing facilities are much the same as central gas processing facilities with dehydration, compression and power generation; however, they also have facilities for coal seam gas water treatment and storage. The term ‘integrated’ implies both gas processing and water treatment facilities. Integrated processing facilities also receive gas from both low- and medium-pressure-gathering systems and transport the processed gas to market at high pressures (10,200 kPa). Similar to central gas processing facilities, integrated processing facilities may also have operations offices, maintenance rooms and storage. The approximate footprint for an integrated processing facility is 800 m x 250 m for plant and associated buildings and one to two km^2 for water storage.

Figure 5.6 provides a conceptual layout of an integrated processing facility.

Detailed components for each type of production facility are listed in Table 5.2 below.

Table 5.2 Typical production facility components

Production Facility	Typical Equipment	Compression Details	Power Generation	Water Treatment and Storage
Field compression facility	• Gas powered engines. • Electric motors. • Compressors. • Cooling fans. • Separators. • Control and safety systems. • Electrical panels. • Station pipework. • Supervisory control and data acquisition system.	• Electric drive compressors. • Discharge gas pressure: 1,000 kPa. • No dehydration.	Low NOx, gas engine power generation facility: 8 to 16 MW.	No coal seam gas water storage or treatment onsite.

Table 5.2 Typical production facility components (cont'd)

Production Facility	Typical Equipment	Compression Details	Power Generation	Water Treatment and Storage
Central gas processing facility	As per typical equipment for the field compression facility with the addition of: • Dehydration with the compressors. • Supervisory control and data acquisition system and control rooms and ancillary systems.	• Electric drive compressors. • Discharge gas pressure: 10,200 kPa. • Dehydration units.	Low NOx, gas engine power generation facility: 10 to 48 MW.	• Pumping station. • 600-ML transfer dam.
Integrated processing facility	As per typical equipment for central gas processing facility.	As per typical equipment for central gas processing facility.	Low NOx, gas engine power generation facility: 10 to 48 MW for compressors and 4 to 8 MW for water treatment facilities.	• Reverse osmosis water treatment capacity of 30 to 60 ML/d requiring two 1,440-ML brine dams. • Water storage facilities to include: – 840-ML feedwater dam. – 960-ML treated water dam.

Arrow intends to develop similarly configured production facilities for the purpose of minimising on-site construction periods and associated disturbance. Similarly configured facilities will include modularised equipment that can be transferred easily from one site to another. Importantly, this will also allow both expansion and reduction of facility capacity as specific areas of the gas field ramp-up and deplete over the project life.

The specific orientation and layout of each production facility will depend on site-specific land and environmental features, such as remnant vegetation, topography, soil and the proximity of sensitive receptors.

Standardisation and modularisation of plant items is planned and will include such items such as:

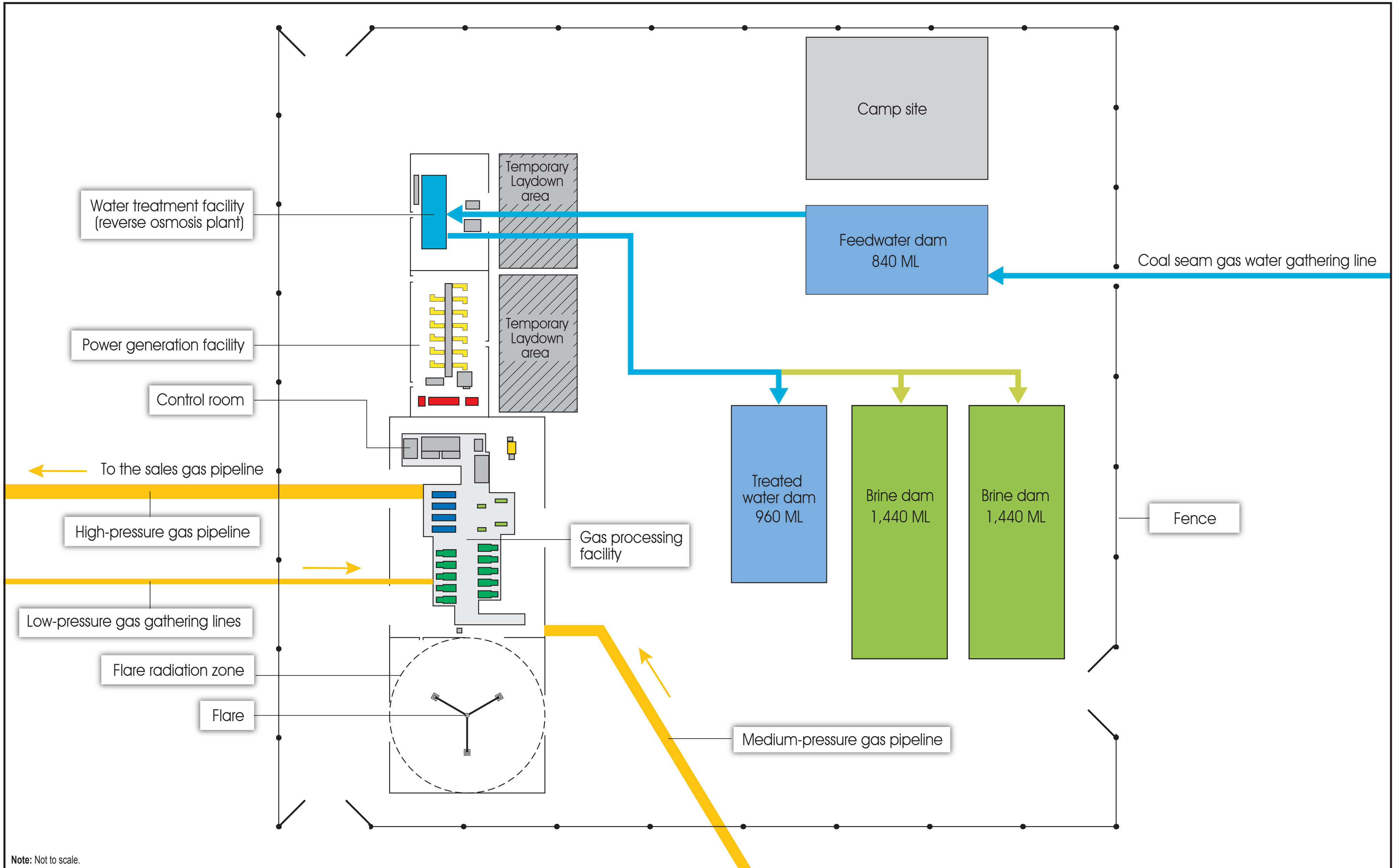
- Flare systems.
- High-voltage substations.
- Variable-speed drives for compressors.
- Oily water handling and loading facilities (if required).
- Instrument and plant air equipment.
- Control and communications equipment.
- Fire and gas detection and protection equipment.

Additional refinement of production facility configuration and equipment will be completed in pre-front-end engineering design (pre-FEED) and FEED stages.

Plate 5.1
Gas compression facility

Plate 5.2
Water treatment facility
(reverse osmosis plant)

Plate 5.3
Well site generator



Note: Not to scale.

coffey environments	Job No: 7040 File Name: 7040_04_F05.06_HB	Arrow Energy Surat Gas Project	arrow energy go further	Typical integrated processing facility arrangement	Figure No: 5.6

5.2.4 Water Treatment and Storage Facilities

Coal seam gas production often requires the removal of large quantities of water to depressurise coal seams to allow the gas to flow. Dewatering can take weeks or up to several years, depending on the characteristics of the coal seam. Typically, Arrow has observed a six-month timeframe to dewater a production well before gas will flow and 18 months for a well to reach peak gas production. A typical gas versus water production curve is shown in Figure 5.7.

Coal seam gas water production across the project development area is variable but is estimated to average 22 GL per annum and peak at about 43 GL per annum over the life of the project. The predicted annual average coal seam gas water production rates over the life of the project are presented in Figure 5.8.

Arrow maintains water balance models for long-term planning and management of coal seam gas water in connection with its existing production wells in the Walloon Coal Measures. The modelling is reviewed and updated quarterly in alignment with the production-forecasting schedule. Such models and modelling will be applied to the planning and management of coal seam gas water across the Surat Gas Project development area.

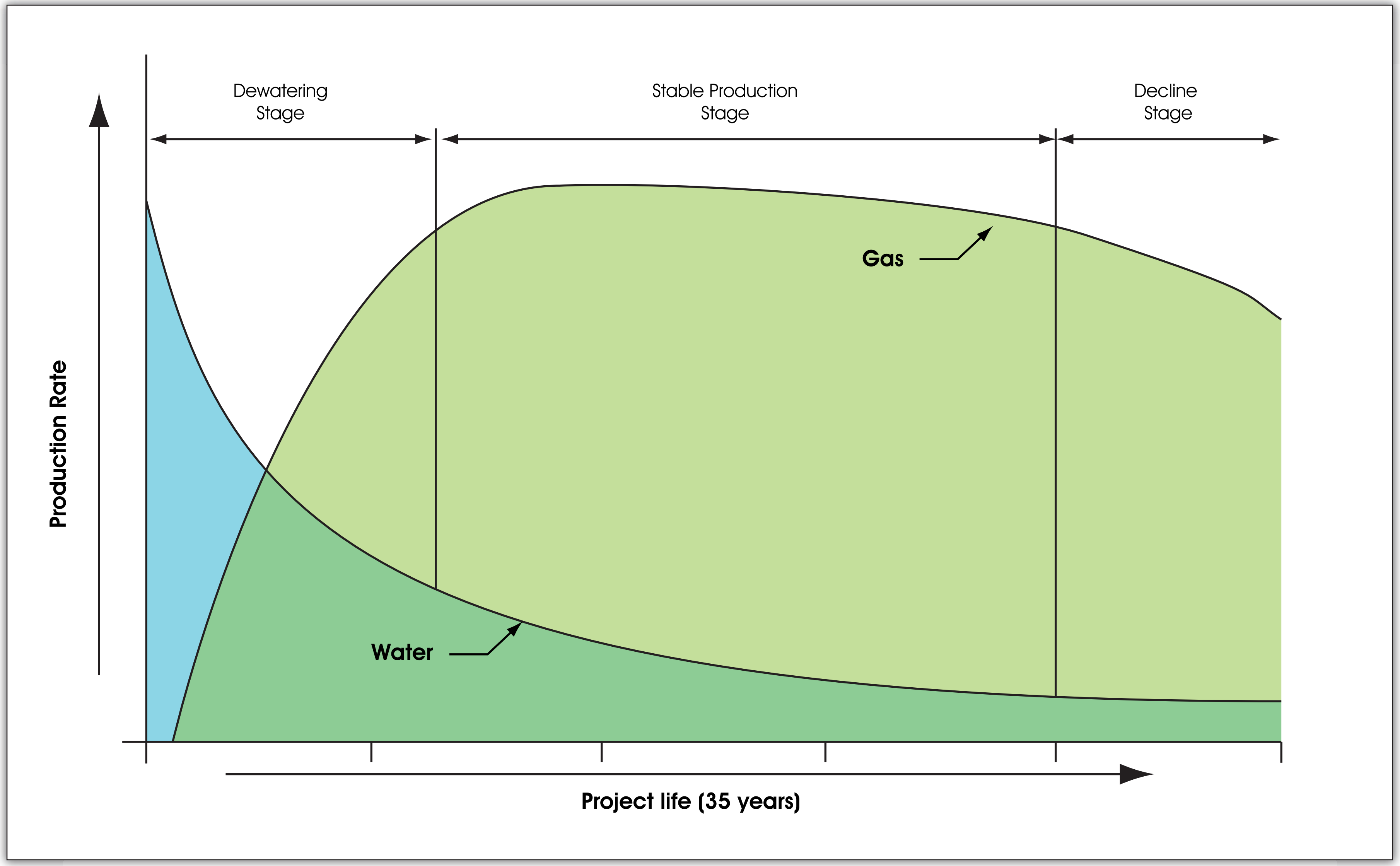
The coal seam gas water quality from the Walloon Coal Measures can vary from fresh water (water with very few other elements) to saline or highly turbid water. Coal seam gas water from the Surat Basin typically has the following characteristics:

- pH of approximately 7 to 11.
- Salinity in the range of 3,000 to 8,000 mg/L (i.e., brackish) and total dissolved solids (TDS) including sodium salts, bicarbonate salts and others.
- Suspended solids from the well that will usually settle out over time.
- Other ions including calcium, magnesium, potassium, fluoride, bromine, silicon and sulphate (as SO_4).
- Trace metals and low levels of nutrients.

Table 5.3 presents the range of coal seam gas water quality concentrations from samples taken at 67 existing production wells currently drawing coal seam gas water from the Walloon Coal Measures. These results have been used as the basis for the impact assessment in this EIS.

Table 5.3 Groundwater quality in the Walloon Coal Measures

Water Quality Parameter	Unit	Minimum	Maximum	Mean
pH		7.1	11.4	8.1
Conductivity (a measure of salinity)	µS/cm	830	31,000	7,223
Total dissolved solids (TDS)	mg/L	534	20,150	4,694
Calcium (Ca)	mg/L	4	1,160	136
Magnesium (Mg)	mg/L	2	850	113
Sodium (Na)	mg/L	135	6,950	1,420
Chloride (Cl)	mg/L	65	12,770	2,280
Bicarbonate (HCO_3)	mg/L	5.2	1,980	561
Sulfate (SO_4)	mg/L	0	355	43



Source: Data from Arrow Energy

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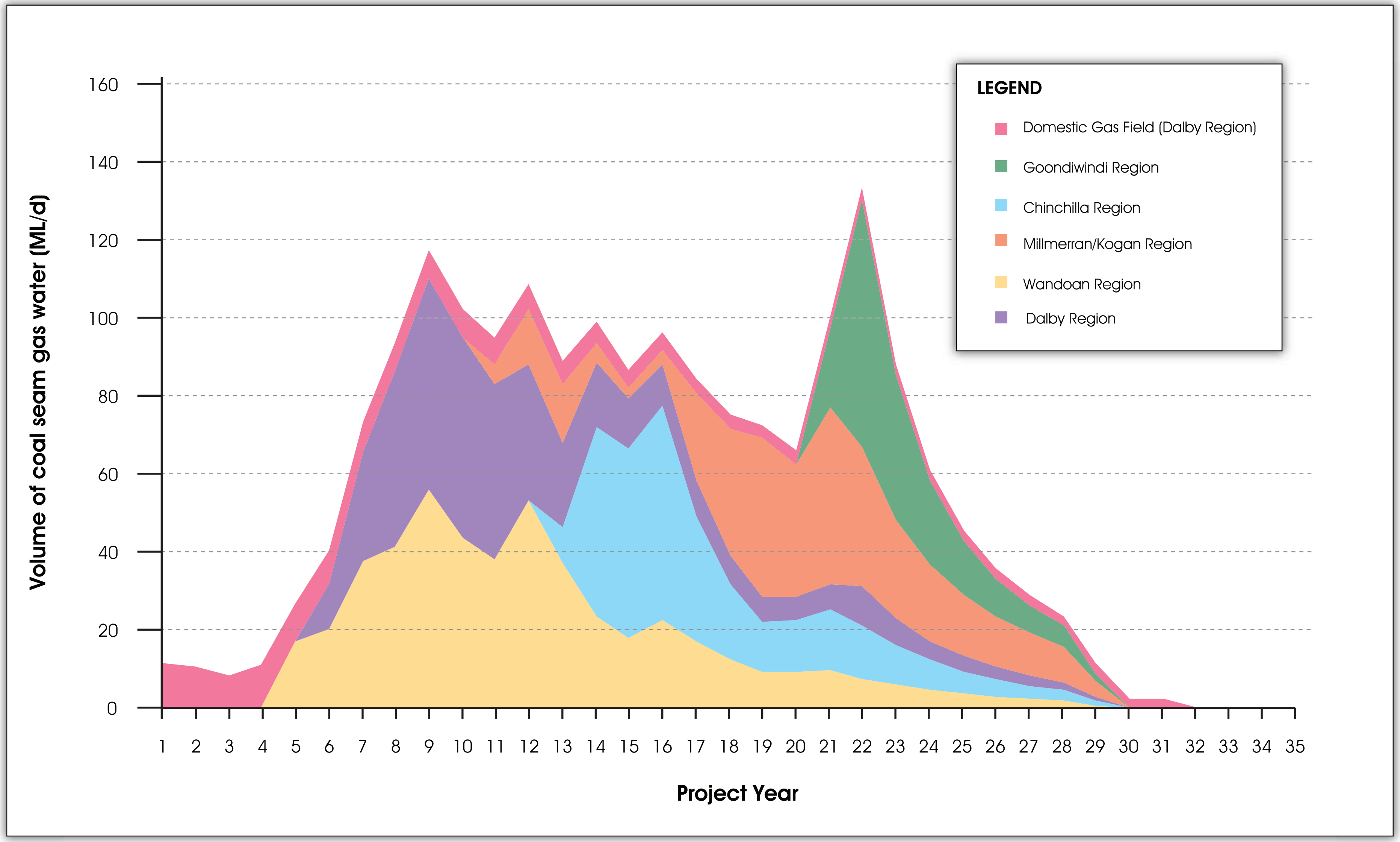
Job No: 7040	Arrow Energy	arrow energy go further	Typical gas and water production curve	Figure No: 5.7
File Name: 7040_04_F05.07_GL	Surat Gas Project			



coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Estimated cumulative annual average production of coal seam gas water for the Surat Gas Project	Figure No: 5.8
	File Name: 7040_04_F05.08_GL	Surat Gas Project			

The design of water treatment and storage facilities will consider Queensland's Coal Seam Gas Water Management Policy (June 2010).

Infrastructure required for the treatment and storage of coal seam gas water includes:

- Feedwater and treated water storage dams.
- Treatment facilities for coal seam gas water.
- Brine storage dams.
- Treated coal seam gas water and brine distribution infrastructure.

Water Storage Dams

Central gas processing facilities will each require a transfer dam in the order of 600-ML capacity. Integrated processing facilities will each require dams in the order of 840 ML for feedwater dams and 960 ML for treated water dams.

Coal seam gas water storage dams will be assessed using the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams prepared by DERM (2011a). If a dam is in the significant or high-hazard category, it is considered a regulated dam and detailed dam design reports must be submitted to DERM following grant of the EA that provides in principle approvals to construct dams.

The following will apply with respect to any regulated dams connected with the project:

- Arrow will design dams in accordance with relevant legislation and Queensland standards and DERM guidelines.
- Arrow will submit dam designs separately and specifically for registration.
- An independent third party will certify dams to ensure design, construction and hydraulic performance meet design plan.
- Dams will be constructed under the supervision of a suitably qualified and experienced person, and in accordance with in accordance with the relevant DERM schedule of conditions relating to dam design, construction, inspection and mandatory reporting requirements.
- Arrow will install groundwater monitoring wells near dams as a leak detection measure.
- Arrow will routinely monitor water quality in dams.
- Arrow will monitor dam levels to provide early warning of overtopping.
- Arrow will monitor the integrity and assess the available storage of dams annually.

Any low-hazard dams required for coal seam gas water storage will be designed in accordance with accepted engineering standards. The dams will be designed with a floor and sides made of material capable of containing the water for the life of the project.

Water Treatment Facilities

Arrow has undertaken a comprehensive assessment to evaluate the various technologies available for the treatment of coal seam gas water. At the time of writing, reverse osmosis had been selected as the treatment technology of choice; however, Arrow will continue to investigate new and emerging technologies to evaluate their applicability to operations based on economics, energy consumption, brine recovery and environmental footprint of the technology.

Each integrated processing facility will contain a reverse osmosis water treatment plant with 30 to 60 ML/d of modular water treatment capacity (Plate 5.2).

Brine Storage Dams

The reverse osmosis treatment of water will produce concentrated brine. Each integrated processing facility will contain two 1,440-ML brine dams. Brine dams are considered regulated dams and will be constructed accordingly.

Water and Brine Distribution Infrastructure

Other infrastructure associated with the treatment and storage of coal seam gas water may comprise:

- Interconnection between the water treatment facilities. The linking of facilities will provide additional flexibility to cope with variations or spikes in water production across the development regions.
- A network of distribution pipelines to transport treated water to end users (for substitution of existing allocations, for new uses or for make-good measures to ensure ongoing water supply to landholders with impaired bore capacity). The network location and its extent will be dependent upon location(s) of the end user market.
- A selective salt precipitation plant. Arrow is consulting commercial enterprises to investigate viable opportunities for the beneficial use of brine. Infrastructure required to convert brine to salt for beneficial use would include a salt storage area with a concrete apron, process building, bunding and roof. This area is expected to be in the order of 150 m by 150 m for each facility, keeping in mind that the facility would require heavy articulated vehicle access and loading facilities.

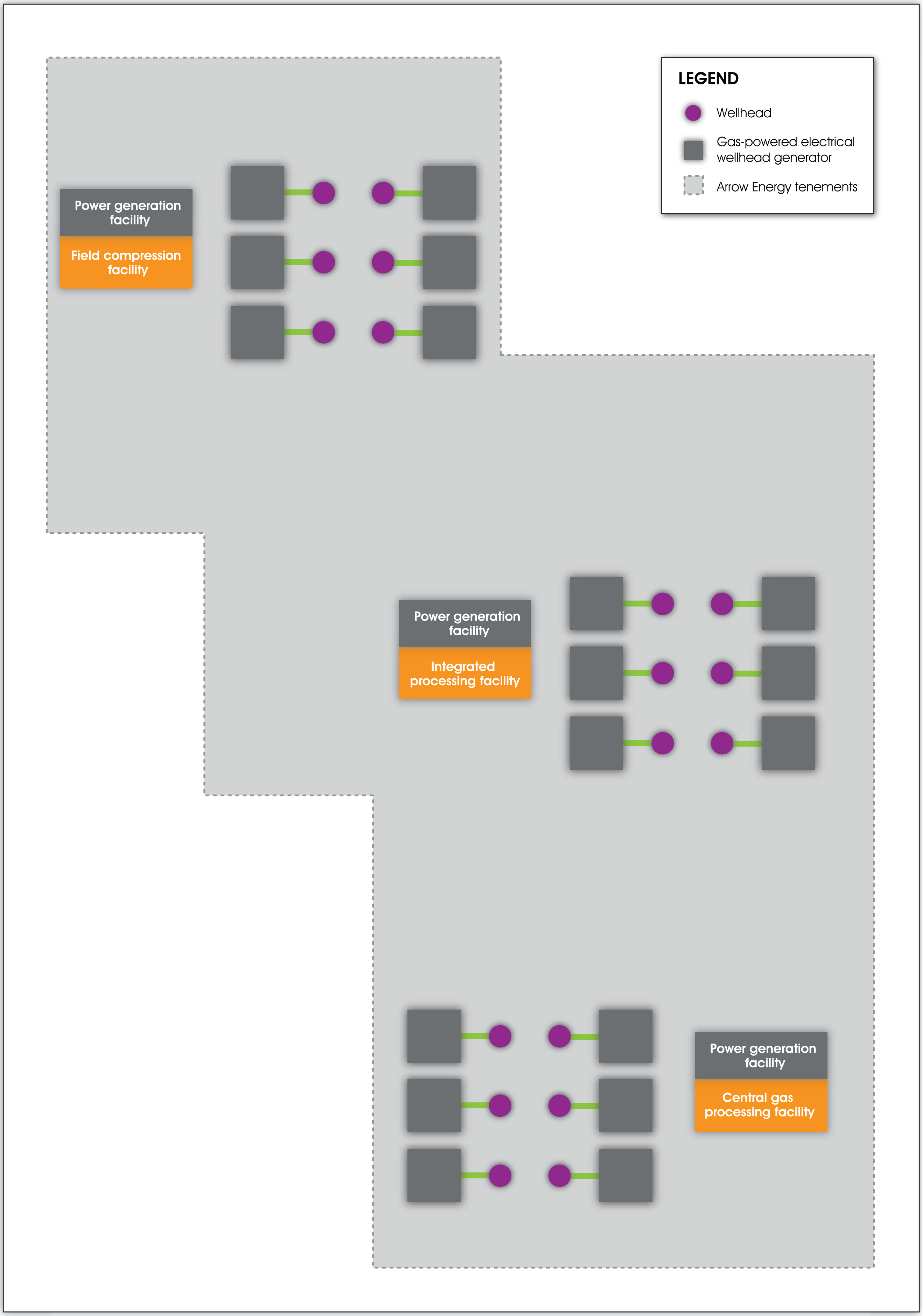
Management of coal seam gas water and brine is further discussed in Section 5.6, Operations and Maintenance.

5.2.5 Power Generation Facilities

Power is required for the extraction, transport and production of coal seam gas and water. The conceptual project design assumes power generation facilities are required at both the production wells and production facilities (Figure 5.9). These facilities are expected to generate electricity continuously 24 hours a day, 365 days a year except for scheduled and unscheduled maintenance.

A power generation facility will likely comprise a series of high-efficiency, coal-seam-gas-fired reciprocating engines with lean burn technology to achieve high efficiency generation (greater than 40%) with reduced emissions (low nitrogen oxide combustion technology). Each engine will be coupled to alternators generating directly at 11 kV. Power generation facilities will be located within or in close proximity to production facilities. An estimated 80 m by 150 m footprint will be required to accommodate a power generation facility. These facilities will supply power for gas compression, dehydration and water treatment.

The number of electrical generators for each production facility will be based on the facility load requirements, the size of each generator and the required redundancy (normally expected to be one engine). Power generation requirements will range from a minimum of 8 MW for a field compression facility to a maximum of 56 MW for an integrated processing facility.



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Power supply conceptual design

Figure No: 5.9

The generators will be housed in an acoustic enclosure, complete with fire and gas detection and emergency shutdown systems. The electrical output from each generating set will be transmitted to switchgear, which will distribute it to the compression equipment, water treatment facilities and ancillary facilities and equipment.

Approximately 60 kW of power will be generated at the production wells using coal seam gas-fired generators (Plate 5.3) to operate the water pumps and other electrical equipment.

The project is carrying out studies to assess the viability of an alternative power supply option that would draw power from the national electricity network where existing or proposed power transmission infrastructure can be easily accessed. The alternative power supply option is further discussed in Section 5.8, Alternative Power Distribution.

The demand on electricity and other energy sources (e.g., natural gas and/or solid and liquid fuel) from the production wells, production facilities and associated infrastructure will be significant throughout the life of the project. Arrow will endeavour to conserve energy in line with relevant government policies, through consideration of energy efficiency during the design and procurement of power generation facilities. Project-related equipment will be inspected and maintained regularly to ensure efficient operation.

5.2.6 High-pressure Gas Pipelines

High-pressure gas pipelines (10,200 kPa) will transport gas from the outlet of central gas processing facilities and integrated processing facilities to the main Arrow Surat Pipeline, Surat Header Pipeline or Daandine gas hub. High-pressure pipelines will be buried and constructed of steel.

Pipeline route selection will be informed by environmental and social considerations in addition to constructability, technical and cost constraints.

5.2.7 Supporting Infrastructure and Logistics

The development of the Surat Gas Project, which will require supporting infrastructure to construct and operate the various extraction, gathering and production facilities, will occur over a large and diverse area. Where existing infrastructure is not in place, additional supporting infrastructure will be constructed to facilitate project development requirements.

The main supporting infrastructure for the project is expected to include depots, borrow pits, accommodation facilities, telecommunications facilities and potable water supplies.

Depots

Depots are likely to be located in:

- The township of Dalby servicing the Dalby and Kogan regions.
- The township of Miles servicing the Wandoan and Chinchilla regions.
- The township of Millmerran servicing the Millmerran region and possibly the northern portion of the Goondiwindi region.

The depots will accommodate administration, engineering and production, supervisory support, occupational health and safety management, stores, workshops, laboratories and associated personnel.

Borrow Pits

The project construction and operations activities will require foundation aggregate for construction of camps, roads and production facilities. The estimated volumes of aggregate required throughout the construction period are provided in Table 5.4. Volumes are based on the number of production facilities throughout the development regions and the total distance of access roads to be constructed.

Table 5.4 Aggregate volumes

Development Region	Integrated Processing Facilities (m^3)*	Central Gas Processing Facilities (m^3)*	Field Compression Facilities (m^3)*	Camps (m^3)	Production Well Access Roads and Pads** (m^3)	Total Aggregate (m^3)
Dalby	10,000	2,500	1,500	2,000	207,000	223,000
Wandoan	5,000	5,000	0	2,000	207,000	219,000
Chinchilla	5,000	2,500	0	2,000	207,000	216,500
Millmerran /Kogan	5,000	2,500	6,000	2,000	207,000	223,000
Goondiwindi	5,000	2,500	1,500	2,000	207,000	218,000
Total	**30,000**	**15,000**	**9,000**	**10,000**	**1,035,000**	**1,099,500**

* Production facility construction aggregate volumes based on the following: integrated processing facility = 5,000 m^3, central gas processing facility = 2,500 m^3, field compression facility = 1,500 m^3, camps = 2,000 m^3.

** Assumes that there will be 1,500 production wells in each development region.

Where approved by the relevant government agency, existing quarries and borrow pits will be used for rock, gravel, sand and soil. If unavailable, alternative sources of quarry and borrow pit materials will be sought from more remote sources or through the identification and development of new borrow pits. Proximity to production facilities will be a key factor in investigating alternative borrow pit sites. Borrow pit site selection will primarily be informed by quality of material, access to resource, environmental and social constraints and consultation with landowners and relevant government agencies.

Accommodation Facilities

Accommodation for the construction and operation of the Surat Gas Project will include a combination of temporary construction camps and permanent housing.

The construction workforce will be accommodated primarily in self-contained temporary accommodation facilities that contain a canteen, fitness facility, laundry, vehicle parking, fuel handling and storage area, and a camp waste management and storage area. These accommodation facilities will typically occupy an area located in the vicinity of a central gas processing facility or integrated processing facility.

Small mobile camps to house drilling staff may also be required in a location central to the drilling activities. These camps would contain a small canteen, vehicle parking areas and waste collection and storage areas.

Operations staff will be accommodated in permanent housing within the project development area.

Additional details on the construction and operation of accommodation facilities are provided in Section 5.5, Construction, and Section 5.6, Operations and Maintenance, respectively.

Telecommunications

Telecommunications for the project will make use of the latest proven technology and connection techniques. It is envisaged that the following systems will be required:

- Well site telemetry systems.
- Mobile, wireless communications (e.g., mobile phones and two-way voice communications such as handheld radios and vehicle-mounted radios).
- Vehicle tracking systems (e.g., vehicle location, speed, braking force).
- CCTV for security and site monitoring (e.g., water dam levels).
- Intruder detection systems for either perimeter (fence-line) mounted or subsurface 'listening' devices.
- Access to company's corporate voice and data network from manned locations and remote offices.

These systems will be supported by a combination of a high-speed networks and secure wireless solutions. The high-speed network would interconnect the production wells and production facilities. The fibre optic cables will be placed in the same trenches as the low- and medium-pressure gas-gathering pipelines. The secure wireless system will provide coverage across the gas field and provide telecommunications to the wells for telemetry and CCTV.

Potable Water

Potable water is required during construction and operational activities. Water will be sourced and trucked from existing town water supplies, groundwater bores or treated coal seam gas water depending on the location of the activities and production facilities.

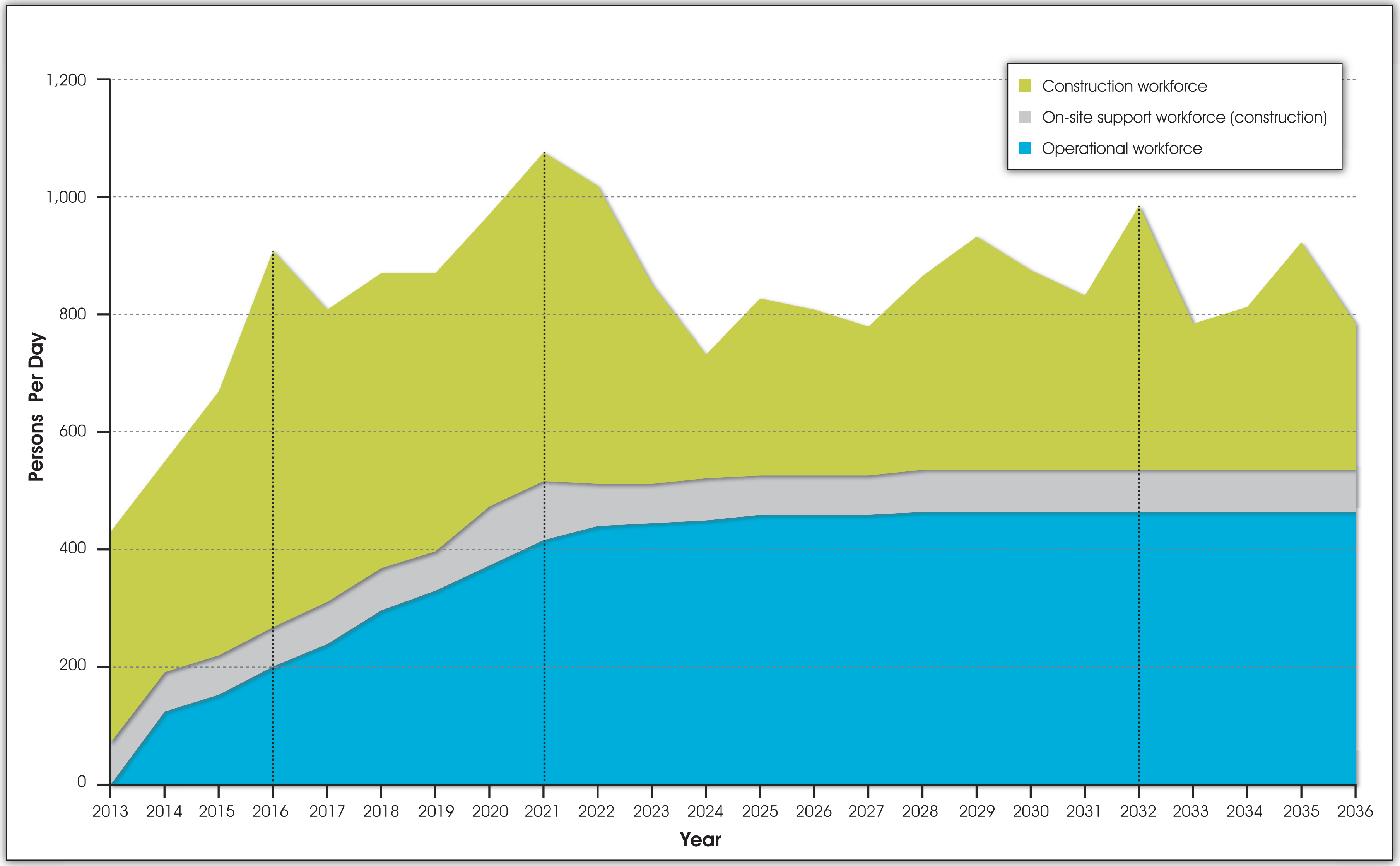
The expected volume of potable water consumed during construction and operations will be approximately 7 ML per annum and 12 ML per annum, respectively.

Logistics

Arrangements for the transport of plant, equipment, products, wastes and personnel will be required over the full life cycle of the project. A logistics plan will be developed during FEED when potential locations of the major project infrastructure are identified. Traffic movements will be planned to take place as efficiently as possible, with minimal handling, e.g., bulk transport. The frequency of trips to project facilities will be minimised where possible.

5.2.8 Workforce

A significant workforce will be required for the development of the Surat Gas Project. Figure 5.10 shows the anticipated project development workforce required for the project. A peak workforce of approximately 1,000 personnel is predicted in years 2021 and 2032. Workforce predictions will be influenced by the contractual volumes of sales gas and may increase or decrease with the rate of development.



coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Forecast project workforce
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A range of qualified and unqualified labour will be required for the project as per Table 5.5.

Table 5.5 Skill requirements

Workforce Category	Construction of Production Facilities	Construction of Wells and Gathering Lines	Operations	Decommissioning
Project management	2%	5%	5%	2%
Engineering	3%	3%	10%	2%
Supervision	0%	7%	5%	2%
Administration	2%	5%	10%	4%
Human resources	1%	1%	5%	2%
Health and safety	2%	5%	5%	4%
Security	2%	1%	1%	2%
Engineering Procurement Construction				
Skilled labour	73%	0%	0%	0%
Management (e.g., HSE, human resources, industrial relations, engineering)	15%	0%	0%	0%
Drilling Contractor				
Skilled labour and operators	0%	50%	0%	0%
Management (e.g., HSE, human resources, industrial relations, engineering)	0%	8%	0%	0%
Pipeline Contractor				
Skilled labour and operators	0%	13%	0%	0%
Management (e.g., HSE, human resources, industrial relations, engineering)	0%	2%	0%	0%
Maintenance				
Maintenance contractors	0%	0%	14%	0%
Arrow field staff: well operators	0%	0%	18%	0%
Arrow field staff: workover crew	0%	0%	12%	0%
Arrow facility staff: superintendents and operators	0%	0%	15%	0%
Decommissioning Crews				
Wells	0%	0%	0%	14%
Facilities	0%	0%	0%	68%

Arrow prefers to recruit its workforce from the local area. This includes candidates without the necessary industry-specific skills, who show a strong willingness to be trained. An overview of Arrow's staff training and development programs is provided in Table 5.6.

Table 5.6 Staff training and development programs

Program	Details
Competency-based training for field operators	Arrow has developed a competency-based training program for the field operators. New staff are assessed against the competency framework and training needs are identified and a training plan developed. Arrow's senior operators and field supervisors are accredited as trainers and assessors in order to provide recognised training to junior staff.
Certificate II Process Plant Operations (Dalby State High School)	Under a joint agreement between Arrow and the trade centre at Dalby State High School*, Arrow undertakes a pilot program to provide 12 traineeship positions for senior Dalby State High School students in Certificate II Processing Plant Operations, the qualifications of which pertain to coal seam gas field operations. Presently 11 students are involved in the program. Twelve places will be offered each year. Under this traineeship, students are engaged as casual employees of Arrow with an opportunity to gain work experience during school holidays. Trainees who excel and exhibit a keen interest in the coal seam gas industry may be offered positions within Arrow upon completion of schooling.
Indigenous traineeships in Certificate II Engineering (Dalby State High School)	As part of a joint coal seam gas industry Indigenous employment initiative, Arrow has two Indigenous senior students from the Dalby State High School undertaking Certificate II Engineering traineeships. Students may be offered positions within Arrow upon completion of schooling.
Certificate III Process Plant Operations (Southern Queensland Institute of TAFE, Toowoomba)	Queensland-registered training organisations presently do not offer recognised processing plant operations training, and a number of coal seam gas operators use interstate registered training organisations for validating assessments and issuing qualifications. Arrow assists the Southern Queensland Institute of TAFE (SQIT) to gain scope of registration for this qualification in Queensland. A co-provider agreement is now in place between SQIT and Arrow to enable Arrow to provide training and on-the-job assessment that result in a trainee being issued with a national qualification.
Graduate development program	Arrow has a graduate development program for young engineers in the petroleum engineering and geology disciplines; currently, there are eight graduates in the program. The program covers the first three years and includes field experience, office-based supporting studies, active mentoring by senior staff and formal classroom training.
Vacation employment program	In September each year, Arrow offers 12-week vacation employment opportunities to students who are completing their penultimate year of undergraduate study. The program aims to provide students with exposure to the coal seam gas industry. Study disciplines likely to be sought include geology, petroleum engineering, chemical engineering, mechanical engineering, civil engineering and finance. Students are located in either the Brisbane office, or at Arrow's field operations in Dalby or Moranbah.

* Dalby State High School acts as the lead school for cluster schools including Bell State School, Cecil Plains State School, Dalby Christian School and Jandowae State School.

5.3 Conceptual Development Sequence and Infrastructure Location

Arrow currently operates existing gas fields, facilities and infrastructure in the area surrounding Dalby. Production facilities are located at Daandine, Kogan North, Stratheden and Tipton West. Under existing gas sales agreements, Arrow currently supplies approximately 80 TJ/day of gas to the domestic market for power generation and other domestic uses. These agreements will not expire until between 2020 and 2025 and it is anticipated that the Surat Gas Project will maintain the domestic gas supply.

Over the 35-year life span of the project, production will ramp up from 2014 to 2019, reaching a sustained production rate of 1,050 TJ/d in 2019, of which 970 TJ/day will be exported and 80 TJ/day will be used for domestic consumption. Following approximately 20 years of sustained production, production is expected to decline.

This section describes the conceptual sequence and rate of development (Section 5.3.1), the proposed method for managing ramp-up gas (Section 5.3.2) and the key influences on the sequence and rate of development (Section 5.3.3).

5.3.1 Sequence and Rate of Development

The conceptual field development sequence for each development region across the project development area, as described in Section 1.2.3, Project Phasing (see Figure 1.2), is provided in Table 5.7.

Table 5.7 Conceptual field development sequence

Year	Development Region				
	Dalby	Wandoan	Chinchilla	Millmerran/Kogan	Goondiwindi
2013					
2014					
2015					
2016					
2017					
2018					
2019					
2020					
2021					
2022					
2023					
2024					
2025					
2026					
2027					
2028					
2029					
2030					
2031					
2032					
2033					
2034					
2035					

Note: Shaded area denotes the regions being developed.

Approximately 1,655 wells will be required in the first five years of development to achieve the required production rate of 1,050 TJ/d. As the gas production of early wells decreases and wells are decommissioned, additional wells will be drilled to maintain the required production rate.

To conceptualise the well development sequence, the development areas have been divided into parcels, each containing a nominal 100 production wells. The final number of production wells in each parcel will ultimately depend on the economic resource potential of the parcel, the environmental and social constraints within the parcel and the outcomes of landowner negotiations. Production wells will be located geographically close to each other with common access and/or gathering systems where possible. Parcels of wells within a development region will be developed concurrently (i.e., wells drilled and gathering systems installed) with the construction of production facilities and water treatment facilities. More than one region will be developed at a time.

Approximately 18 production facilities will be constructed across the project development area as summarised in Table 5.8. For the purposes of this EIS, production facility locations were assumed to be located somewhere within a 12-km radius that allowed flexibility for environmental and land use constraints. Conceptual production facility locations are depicted in Figure 5.11. The locations are indicative only and final locations will be determined at the completion of FEED.

Table 5.8 Summary of expected facilities by development region

Development Region	Integrated Processing Facilities	Central Gas Processing Facilities	Field Compression Facilities	Total
Dalby	2	1	1	4
Wandoan	1	2	0	3
Chinchilla	1	1	0	2
Millmerran/Kogan	1	1	4	6
Goondiwindi	1	1	1	3
Total number of facilities	**6**	**6**	**6**	**18**

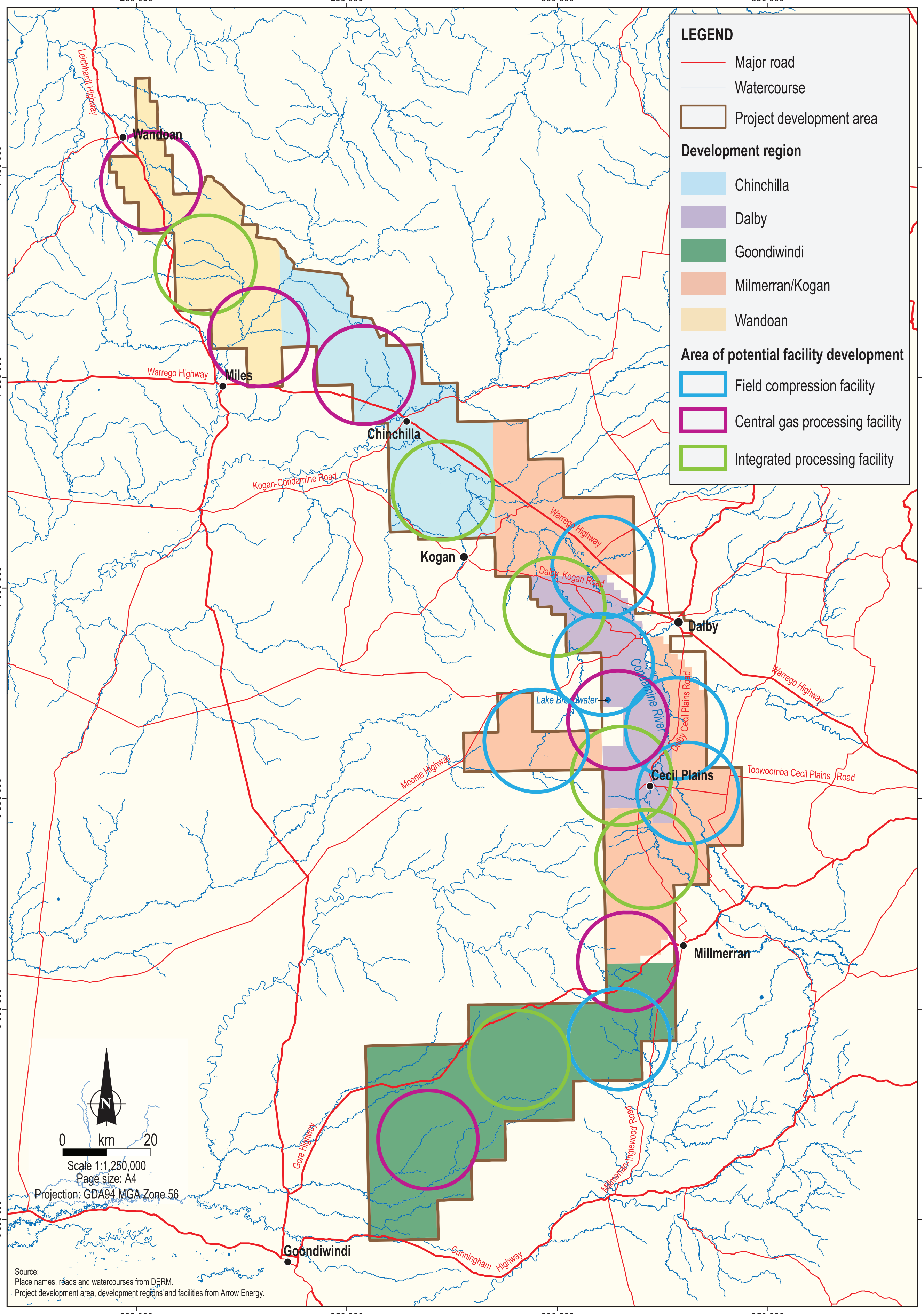
The expected sequence of development over the life of the project is shown in Figure 5.12.

5.3.2 Ramp-up Period Conceptual Gas Management

The ramp-up period is defined as the time when gas is first produced to the time in which sustained production is reached (1,050 TJ/d). Sustained production correlates with the start-up of the receiving LNG plant. The ramp-up period is also contingent upon the Arrow Surat Pipeline being commissioned.

Significant gas is produced during the ramp-up period and it will be managed in order of the following preferences:

- Directed to Arrow’s existing gas-fired power generation facilities (e.g., Daandine, Braemar 2).
- Sale on the gas ‘spot’ market for supply of electricity and gas to domestic markets.
- Flared at production facilities. Gas will be flared only as a last resort. Arrow is investigating options other than flaring to assist in managing ramp-up gas. This includes design options such as increased well spacing and selective well start-up.



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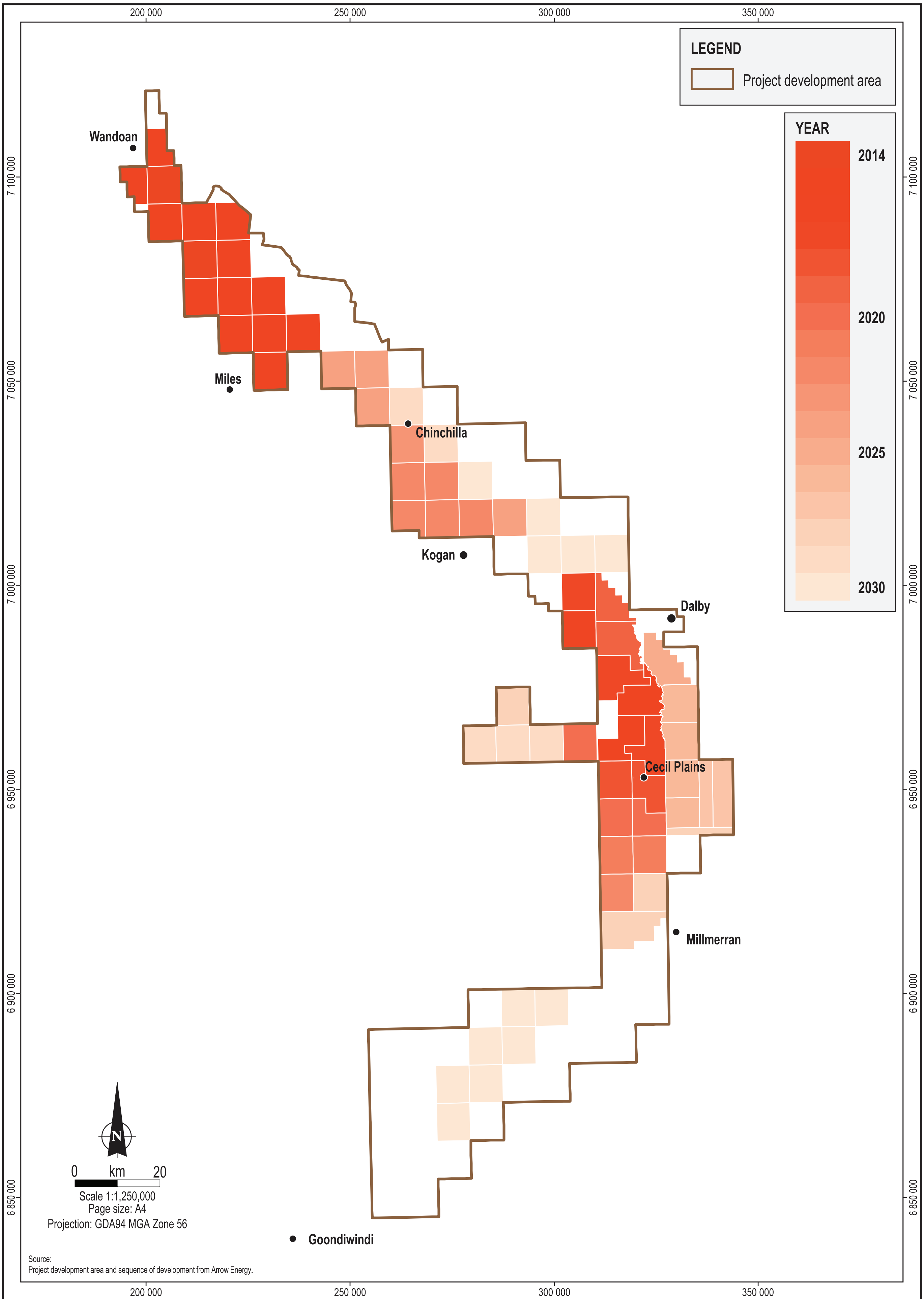

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Sequence of development

Figure No: 5.12

5.3.3 Factors Influencing the Sequence and Rate of Development

The conceptual sequence and rate of development is only indicative as a number of factors can influence the development. Factors include:

- The supply requirements of long-term gas agreements.
- Confirmation of production rates through exploration and pilot well programs.
- Land access agreements.
- Execution capacity (drilling and construction resources).
- Capital cost of new infrastructure and access to existing infrastructure.
- Operating costs.
- The resolution of environmental and social issues.
- The development of the more productive parts of the field.
- Planning well depressurisation and developing infrastructure to manage the produced water.
- Completion of the Arrow Surat Pipeline and the Arrow LNG Plant.
- The availability of supporting services (such as accommodation), as these factors can encourage faster development, while others can constrain the speed of development.

5.4 Development Planning

The Surat Gas Project spans an area of approximately 8,600 km^2 with significant infrastructure and workforce requirements. Development planning will be ongoing throughout the life of the project. Development plans will be produced for each development region, guided by the results of exploration as well as environmental and social constraints. A development plan describes (but is not limited to):

- The exploration and appraisal history and status.
- Geological and reservoir modelling and subsurface development schemes.
- The number of wells to be drilled, their location, sequencing and spacing to meet the required production rates.
- The location, quantity and size of production facilities.
- The quantity of water produced and subsequent treatment and storage requirements.
- The pipeline networks needed to transport gas and water.
- The high-level operations philosophy for the field layout.
- Capital and operating expenditures as well as schedule estimates.
- Risk and opportunity register.

5.4.1 Exploration

Arrow has conducted significant exploration across the project development area. In many areas, exploration is at a mature stage with extensive 2P and 3P reserve coverage. Future exploration will focus on collecting data on the lesser-explored areas in the northwest and south of the project development area and upgrading 3P reserves to 2P reserves. Assessment and approval of exploration activities is governed by existing approvals covering tenures across much of the project development area. Expected exploration activities within the petroleum tenures of the project development area are summarised in Table 5.9.

Table 5.9 Planned Surat Basin exploration 2011 to 2013

Petroleum Tenure	Area (km^2)	No. of Historical Drillholes*	Drillhole Intensity	Planned Coreholes/ Exploration Wells	Planned Pilot Wells
PL 194	196	0 (n/a)	n/a	1	1
PL 198	259	0 (n/a)	n/a	5	0
PL(A) 185	236	0 (n/a)	n/a	1	0
ATP 676	5,520	15	1/368 km^2	<15	<3
ATP 683	8,960	42	1/218 km^2	<25	<10
ATP 689	4,720	6	1/787 km^2	<15	<5
ATP 746	3,044	0	n/a	<10	<1
ATP(A) 687	6,650	0	n/a	<10	<1
ATP(A) 747	3,553	0	n/a	<20	<3
ATP(A) 810	749	8	1/94 km^2	<5	<5

* This refers to the number of core holes or exploration wells previously drilled in the petroleum tenure by Arrow or another explorer.

The majority of work being undertaken in the next three years is part of a de-risking exercise that delineates geological anomalies and reduces geological uncertainties surrounding coal seam extent, gas content and permeability. These results will influence the sequence of field development and inform the regional development plan. Once Arrow has 2P reserve coverage across the area, the requirement for additional exploration may cease.

Exploration typically begins with geophysical activities that characterise the geologic environment and identify potential coal seams. Drilling is then required to verify the geologic setting, determine coal seam properties such as thickness, permeability, gas content and gas quality, and test the production potential of the target reservoir.

A three-phased approach is generally employed for exploration drilling:

- **Phase 1 (Stratigraphic Holes).** Stratigraphic holes (also referred to as chipholes) are drilled to test for the presence, depth and lateral extent of coal. A rotary rig drills a hole and cuttings (chips) are used to identify subsurface lithologies and coal seam thickness.
- **Phase 2 (Core Holes).** Core holes are required to determine the permeability and gas composition of coal seams. The drilling of core holes involves cutting a solid piece of rock from the well bore and desorbing gas from the coal in a laboratory to determine permeability and gas composition. A core rig is shown in Plate 5.4.
- **Phase 3 (Pilot Wells).** Pilot wells are drilled and a test is conducted to rapidly assess the production potential of the gas reserve being targeted. Pilot well tests involve the installation of 5 to 6 wells spaced up to 200 m apart on a diamond-shaped layout, followed by dewatering and gas production tests. Pilot well tests typically last for a period of 6 to 24 months and are conducted at approximately 10 to 20 km intervals. Test results improve the accuracy of reserve calculations and are integral for field development planning.

Plate 5.4
Core rig

Plate 5.5
Well site pump

Plate 5.6
Lowering-in pipe

The location of exploration wells is flexible and is guided by physical, environmental, social and landowner constraints. Arrow will seek to establish approximate 5 km spacing between exploration wells, with closer spacing in areas that exhibit characteristics inconsistent with regional norms.

As stated in Chapter 1, Introduction, exploration activities throughout the project development area are governed under existing approvals (Environmental Authorities) and are subsequently not within the scope of this EIS.

5.4.2 Environmental and Social Constraints

Development planning within the project development area is also guided by potential environmental and social constraints. Environmental and social constraints have been considered in the preliminary design of the project and form the conceptual design from which potential impacts were assessed in this EIS. Arrow's health, safety and environmental management system (HSEMS) inherently includes a number of design specifications (Table 5.10) that aim to minimise environmental and social impact, and hence inform the development plans.

Table 5.10 Environmental and social design specifications of Arrow's HSEMS

Aspect	Design Specification
Air quality	• Reduction of nitrogen dioxide emissions through selection of low NOx gas engines for power generation. • Minimisation of flaring by selling ramp up gas to domestic markets.
Greenhouse gas	• Reduction of greenhouse gas emissions through selection of high-efficiency drivers for compressors. • Minimisation of greenhouse gas emissions through the use of flares rather than venting.
Geology, landform and soils	• Avoid unstable slopes where possible, or design to address slope and soil stability issues.
Groundwater	• Avoid natural springs. • Construct dams using material capable of containing the water and brine and any contaminants.
Surface water	• No discharge of coal seam gas water during normal operations. • Avoid wetlands.
Aquatic ecology	• No discharge of coal seam gas water during normal operations.
Terrestrial ecology	• Avoid Category A* environmentally sensitive areas. • Avoid national parks. • Avoid wetlands (e.g., Lake Broadwater). • Minimise construction footprint through centralisation of water treatment facilities. • Minimise construction footprint through placement of gas and water gathering lines within the same trench.
Social	• Manage impacts on local communities through the construction phase by using fly-in, fly-out workforces and accommodating them in camps. Maximise employment of local people and minimise fly-in fly-out arrangements for operations. • Avoid locating wells and infrastructure within 200 m of residences.
Cultural heritage	• Avoid significant heritage sites.
Hazard and risk	• Fire and gas detection systems. • Emergency shutdown systems. • Emergency pressure release systems. • Fire suppression systems in high-risk locations.

* Category A environmentally sensitive areas are all areas designated as national park under the *Nature Conservation Act 1999* as well as conservation parks, forest reserves, and the Wet Tropics World Heritage areas.

Relevant environmental and social design specifications have been included in constraints mapping that forms the basis of the framework established by Arrow to address uncertainty about the location of infrastructure. The framework approach analyses potential constraints and consists of constraint maps and environmental controls that inform site selection and development plans, as well as the environmental management of construction, operation and decommissioning activities. Further details on the framework approach are provided in Chapter 8, Environmental Framework.

5.5 Construction

Construction activities for the Surat Gas Project will essentially occur over the expected 35-year project life at a rate that maintains plateau gas production. Across the project development area which spans 8,600 km^2 (or 860,000 ha), the 7,500 production wells and 18 production facilities will require a footprint in the order of 5,155 ha, requiring a workforce of more than 300 people.

The following sections describe the planning requirements, construction methods for major infrastructure, the workforce required to construct the infrastructure and associated accommodation to house the workforce. The wastes generated during construction are also discussed.

5.5.1 Production Wells

Production wells will be installed progressively throughout the project life starting in 2014 and ending in 2035. It is expected that up to 18 drilling rigs will be used to install the 7,500 wells. The short-term construction footprint for each production well is approximately 0.5 ha, equating to a total footprint of about 3,750 ha for the 7,500 planned wells. It is important to note the construction footprint will significantly reduce following construction with an estimated 0.01 ha (10 m x 10 m) per well required for operations. The total operational footprint for the 7,500 wells is estimated to be only 75 ha.

Production well construction is conducted in the following stages:

1. **Site Preparation.** Access to a well site will be via existing tracks where possible; otherwise, a track will be cleared and graded. A drilling area measuring about 0.5 ha for a truck-mounted drilling rig is prepared by vegetation removal, stripping and stockpiling of topsoil, grading and compaction, fencing, excavation of small pits for drilling fluids and ground flares. Wells constructed on intensively farmed land will have surface tanks rather than pits for drilling fluids. Arrow will undertake site preparation works using earthmoving equipment such as graders, excavators and bulldozers.

2. **Production Well Drilling and Well Site Completion.** Arrow intends to use 50-t, truck-mounted drilling rigs or hybrid rigs to drill wells. A completion rig is used to install a downhole pump and stimulate the well as required. The top section of each well between the targeted coal seam and the surface is cased and cemented through the non-gas producing strata to prevent cross-contamination between aquifers. To promote gas and water flow in the well, a special rotating blade is used to ream out the producing coal seams. Drilling fluids are used in the rotary drilling process during the construction of production wells.

   The production zone is lined with alternating slotted and blank steel casing (see Figure 5.5). An electric, top-drive, variable-speed pump (Plate 5.5) is installed to extract water though an 80-mm tube installed inside the well casing. This limits the amount of water entrained with the gas. In some cases, Arrow will construct wells with more than one production zone in order to produce from multiple coal seams.

Approximately 200, 000 L of drilling fluid will be used to drill a production well. Drilling fluids (also known as mud or drill mud) are pumped down the drill pipe to lubricate and cool the drill bit and flush out the drill cuttings. Arrow's preference is to use an inert, water-based drilling fluid largely comprised of fresh water and 2% to 3% of salts, which increases the mud weight and prevents natural clay in the formation from swelling. A small amount of bentonite (a clay-based product) may be added to coat the bore hole to stabilise the formation and prevent the loss of fluid.

Drilling fluid will be collected in surface tanks or in pits and will be either removed from site for disposal at a licensed facility or stored in purpose-built containment structures on the property. Arrow's current activities use drilling fluids comprised of clay stabilisers (calcium chloride, calcium chloride anhydrous and potassium chloride), cement additive (bentonite and calcium sulphate), disinfectant (biocide), viscosifier (FS2000, XCD polymer and NIF 20 liquid), foaming agent (Tuff-Foam Ultra) and fluid loss prevention (Tuff-Loss).

3. **Progressive Rehabilitation.** Following completion of drilling, the rig and pits will be removed and the well site footprint reduced to a sufficient size to accommodate surface equipment. Typically this is less than 10 m by 10 m. The construction site footprint outside the 10 m by 10 m area will be rehabilitated and contoured as soon as practicable to pre-existing conditions or to a standard agreed with the landowner.

   The operational well site will be fenced to exclude stock and unauthorised access. A 2-m safety exclusion zone within the fence will be implemented.

   In addition, well workovers may be required during the well life that will require a rig to replace or repair the downhole pump. Any disturbance during workover operations will be progressively rehabilitated as soon as practicable.

Wastes generated during the construction of production wells include:

- Solid wastes (general trash, scrap metal, cleared vegetation, cut and fill material, empty drums and containers, timber, drill cuttings, cardboard and other packaging materials, wood pallets, soil contaminated with chemicals/oils).
- Liquid wastes (drill fluids, residual drilling mud, coal seam gas water, filters and filter media, used lubricating oil and filters, acids and caustics, unused or spent chemicals/oils/solvents, grey water, stormwater).
- Gaseous waste (coal seam gas and engine emissions).

With the exception of drilling mud, waste liquids will typically be removed by a tanker to nearby integrated processing facilities for treatment. Solid wastes will be removed offsite to an appropriate waste facility.

Additional details of the expected waste types, quantities and waste management practices are provided in Chapter 26, Waste Management.

5.5.2 Gas and Water Gathering Systems

The gas and water gathering systems will consist of surface equipment for production wells and subsurface low- and medium-pressure pipelines.

Following the completion of drilling, surface equipment such as the wellhead, dewatering pump, wellhead gas/water separator, control valve, metering and telemetry/communications equipment will be installed. Gas-driven electric generators will be required at wellheads to power the dewatering pumps and ancillary equipment until the gas free-flows, after which production wells will be powered by solar panels where possible.

Low-pressure gathering lines will be used to deliver gas directly from production wells to production facilities. Medium-pressure gathering lines deliver gas from field compression facilities to both central gas processing and integrated processing facilities.

The location of the gathering pipelines will be informed by technical, environmental, social and landowner constraints.

The gathering lines will be constructed in four stages:

1. **Site Preparation.** A right-of-way (ROW) of up to 20 m will be prepared including vegetation removal and stockpiling, topsoil stripping and stockpiling and grading where required. In environmentally sensitivity areas, the ROW may be narrowed for short distances. Markers will be placed along the route to identify the pipeline centreline and the edge pipeline ROW. Temporary fencing may be established around sensitive areas occurring along the ROW to ensure they are not disturbed during construction.

2. **Trenching and Laying Pipe.** Separate gas- and water-gathering pipelines will be buried below ground in a commonly excavated trench to minimise surface land use disturbance. Trench spoil is stockpiled for backfilling.

   Breaks in the trench will be installed to facilitate stock and wildlife crossings. There will be locations where trenching is not a suitable construction method, for example, due to river or road crossings and other potential environmental constraints. Techniques such as thrust boring or horizontal directional drilling may be selected to minimise environmental impact (see Section 5.5.6, High-pressure Gas Pipelines, for construction crossing methods).

   The depth of pipeline burial will conform to acceptable industry practices but will ultimately depend on the existing land use. As a minimum, the pipeline depth will be 750 mm from the top of the pipe. Landowners will be consulted to determine land use practices and pipelines will be buried to a depth that minimises risk of damage.

   The pipe will be lowered into the trench using side-boom or all-terrain vehicles (Plate 5.6). Other equipment used to trench and lay the pipelines include graders, excavators, tip trucks, low loaders, ploughs, trenchers, backhoes, fuel delivery trucks, and 4WD coaster buses.

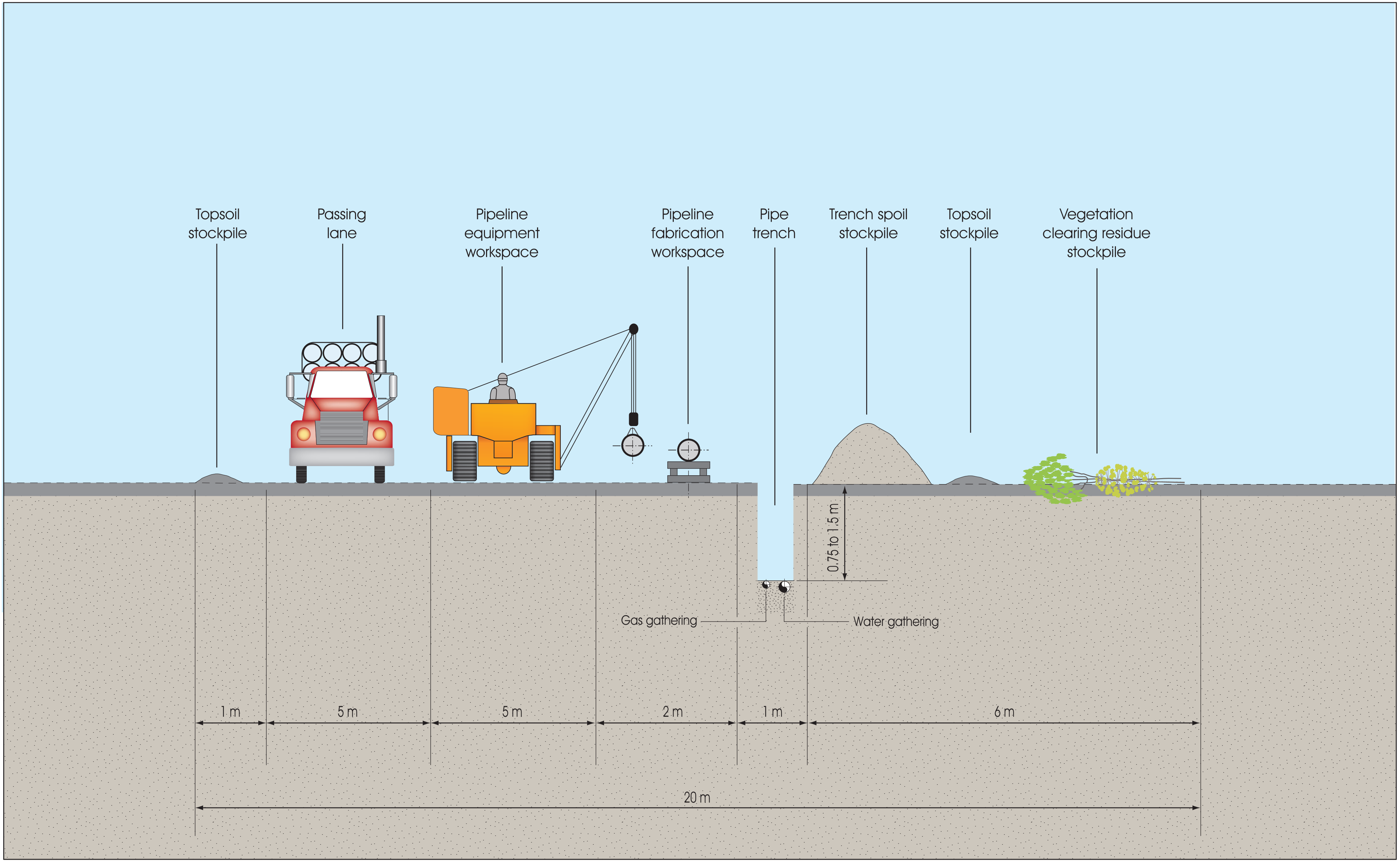
   Figure 5.13 exhibits the typical layout used for the construction of the gas and water gathering lines.

3. **Hydro-testing.** Gathering pipelines are integrity tested by hydro-testing or pneumatic pressure testing prior to commissioning. Pipelines are filled with water and subjected to higher than normal operational pressures. Water used for hydro-testing will be diverted to holding dams for re-use or treatment and/or discharge. Water quality will be tested prior to release.

Plate 5.7
Backfilling trench

Plate 5.8
Production well surface facilities

Plate 5.9
Production well in cultivated land



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Typical gas and water gathering line ROW layout

Figure No: 5.13

4. **Progressive Rehabilitation.** Once the gathering system is installed, the trench will be backfilled (Plate 5.7) and the ground compacted to a level consistent with the surrounding land use. The surface will be stabilised using the stockpiled vegetation and the disturbed area will be contoured, topsoil respread and revegetated to a standard consistent with surrounding land use. In most instances, gathering lines will be capped with a crown of topsoil to compensate for potential subsidence. Breaks in the crown will be constructed to prevent channelling of surface drainage. Marker posts, marker tape, trace wire and 'as-built' surveys will be used to identify the location of the buried gathering lines.

Wastes generated during the construction of gathering pipelines include:

- Solid wastes (general trash, scrap, cleared vegetation, excess trench soils and rock, empty drums and containers, timber, plastic pipe, steel pipe offcuts, cardboard and other packaging materials, soil contaminated with chemicals/oils, x-ray film).
- Liquid wastes (hydrostatic-test water, filters and filter media, used lubricating oil and filters, unused or spent chemicals/oils/solvents, paints and paint wastes, grey water).
- Gaseous waste (vehicle air emissions).

As with the production wells, waste liquids will be removed by a tanker for treatment at nearby integrated processing facilities. Solid wastes will be removed offsite to an appropriate waste facility.

5.5.3 Production Facilities

The specific location, orientation and layout of the proposed 18 production facilities will be guided by site-specific technical, environmental and social features, including ground stability, remnant vegetation, topography, proximity of sensitive receptors and landowner consultation. Facilities will be designed and constructed to minimise footprint.

The following activities will occur for the construction of new production facilities:

- **Preconstruction Clearance Survey.** All sites proposed for development of production facilities will be subjected to a preconstruction clearance survey by a combined team of environment specialists, project engineers and surveyors. The purpose of the survey will be to identify site-specific technical, environmental, social and cultural heritage sensitivities, and to develop measures to avoid or mitigate the potential impacts on these sensitivities once the preferred location of the facility has been identified. Preconstruction clearance surveys will be conducted during detailed design and prior to ground disturbance.
- **Surveying.** All sites will be surveyed and pegged to demarcate the construction footprint and any site-specific sensitivity that requires avoidance.
- **Geotechnical Investigation.** The physical and chemical properties of the subsurface materials will be assessed to determine suitability and type of facility foundations.
- **Vegetation Clearing.** The site will be cleared and grubbed within the surveyed footprint. The cleared vegetation will be used for stabilisation or rehabilitation works.
- **Erosion Control.** Surface water drainage systems and stormwater diversions will be constructed. The objective will be to reduce the potential for soil loss and degradation and to limit the discharge of sediment-laden water to local watercourses. Clean surface water run-off will be diverted away from disturbed areas, while runoff from the disturbed areas will be collected and transferred to Arrow's water treatment facilities, if necessary.

- **Grading and Foundation Excavation.** Sites will be graded, excavated and compacted to the designed level and slope to provide a base for the infrastructure. Excavated cut material will be used for fill where suitable. Surplus soil will be deposited in designated areas and used for bunding and landscaping as required.
- **Progressive Rehabilitation.** Progressive rehabilitation will occur both within and surrounding the facility site. Any temporary areas cleared for construction will be contoured, topsoil respread and revegetated. Production facilities will be fenced to maintain a secure site.

Construction equipment is likely to include graders, dozers, excavators, tip trucks, low loaders, trenchers, backhoes, heavy lift cranes 80 t to 150 t, fuel delivery trucks, concrete trucks, concrete pumps, welding machines, portable generators, piling rigs, 4WD coaster buses and passenger buses. Some of this equipment will also be used for progressive rehabilitation of the area surrounding the site.

Construction will involve the transportation of large items of plant and equipment to the site, such as compressors and gas-engine generators. Further details of logistical arrangements are provided in Section 5.5.7, Supporting Infrastructure and Logistics. Construction equipment will be moved to successive production facility sites as the need arises.

Wastes generated during construction of a production facility could include:

- Solid wastes (filter cartridges, batteries, concrete, general trash, scrap metal, cleared vegetation, cut and fill material, empty drums and containers, timber, plastic pipe, sandblast grit, cardboard and other packaging materials, wood pallets, oily rags and sorbents, electrical cable and tyres).
- Liquid wastes (cleaning acids, domestic cleaners, fuel, greases, lube oils, glycol, paint waste, wash-out liquids, hydro-test water, sewage from amenity blocks, contaminated stormwater runoff, radioactive wastes from integrity testing, pesticides and herbicides).
- Gaseous waste (vehicle air emissions).

5.5.4 Water Treatment and Storage Facilities

Water treatment facilities will be located within integrated processing facilities using similar construction methods as for production facilities.

Construction of water storage facilities includes dams for coal seam gas water (treated and untreated) and brine. Dams will be constructed in accordance with DERM guidelines using equipment such as graders, dozers, excavators and tip trucks.

All untreated coal seam gas water and brine storage dams will contain impermeable liners to prevent impacts on groundwater.

Wastes from the construction of water treatment facilities are similar to that of the production facilities.

5.5.5 Power Generation Facilities

Power generation facilities will located within the production well sites and production facility sites and the subsequent construction methods are similar to those described for construction of wells and facilities, respectively (see Section 5.5.1, Production Wells, and Section 5.5.3, Production Facilities).

5.5.6 High-pressure Gas Pipelines

High-pressure gas pipelines will be designed and constructed in accordance with Australian standards and the Australian Pipeline Industry Association code of environmental practice (APIA, 2009). With the exception of the pipeline ROW width and the depth of the trench, the process for high-pressure gas pipeline construction is similar to the method used for medium-pressure gas pipeline construction as described in Section 5.5.2, Gas and Water Gathering Pipelines. The ROW required for high-pressure gas pipeline construction is 25 to 30 m wide and the trench depth is usually 750 mm to 1,500 mm, depending on the land use. Warning signs will be placed along the ROW to demarcate the buried high-pressure pipeline.

Waste generated during the construction of high-pressure pipelines is similar to that of the gathering lines.

The high-pressure gas pipelines may have to cross roads, pipelines, railway tracks, utilities and/or watercourses. The construction of these crossings will be undertaken in accordance with Australian Standard AS 2885.1 for the design and construction of gas and liquid petroleum pipelines (Australian Standards, 2008a), Australian Pipeline Industry Association's code of environmental practice for onshore pipelines (APIA, 2009), and the requirements of asset owners and/or operators.

Pipeline Crossing Construction Methods

Depending on the nature of the crossing, the following types of construction may be used:

- **Open Cut.** Open-cut methods are used to cross small waterways and small roads. In this method, a trench is excavated using a trenching machine or an excavator. Open-cut construction involves the continuation of normal pipeline trench construction methods through the waterway or road (Figure 5.14). Trench material is placed adjacent to the road or on each waterway bank. Crossings are kept open for the minimum amount of time to limit disruption of stream flows or vehicle traffic.

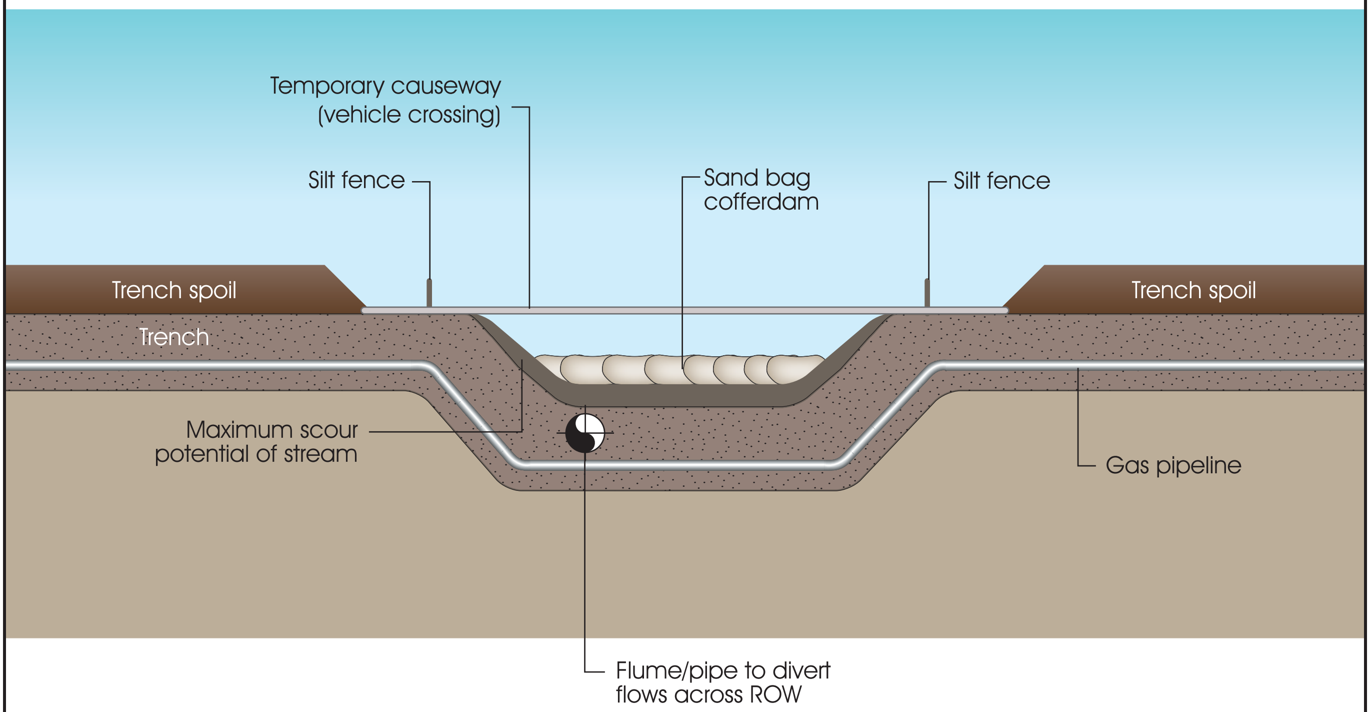
  Open-cut waterway crossings are most suited to ephemeral or low-flow waterways. Typically, flows are maintained during open-cut construction; however, for waterways with high flow rates or volumes, flow diversion may be required. Flow diversion can be achieved by installation of flumes, pumping of water around the worksite or cofferdams. Cofferdams would be constructed using very large sandbags, water-filled bladders or steel sheet piles to divert flow around the worksite. Typically, only half of a major watercourse is diverted at a time.

  Open-cut methods may be used for watercourse crossings where rapid construction is considered the best means of minimising environmental impact (APIA, 2009).

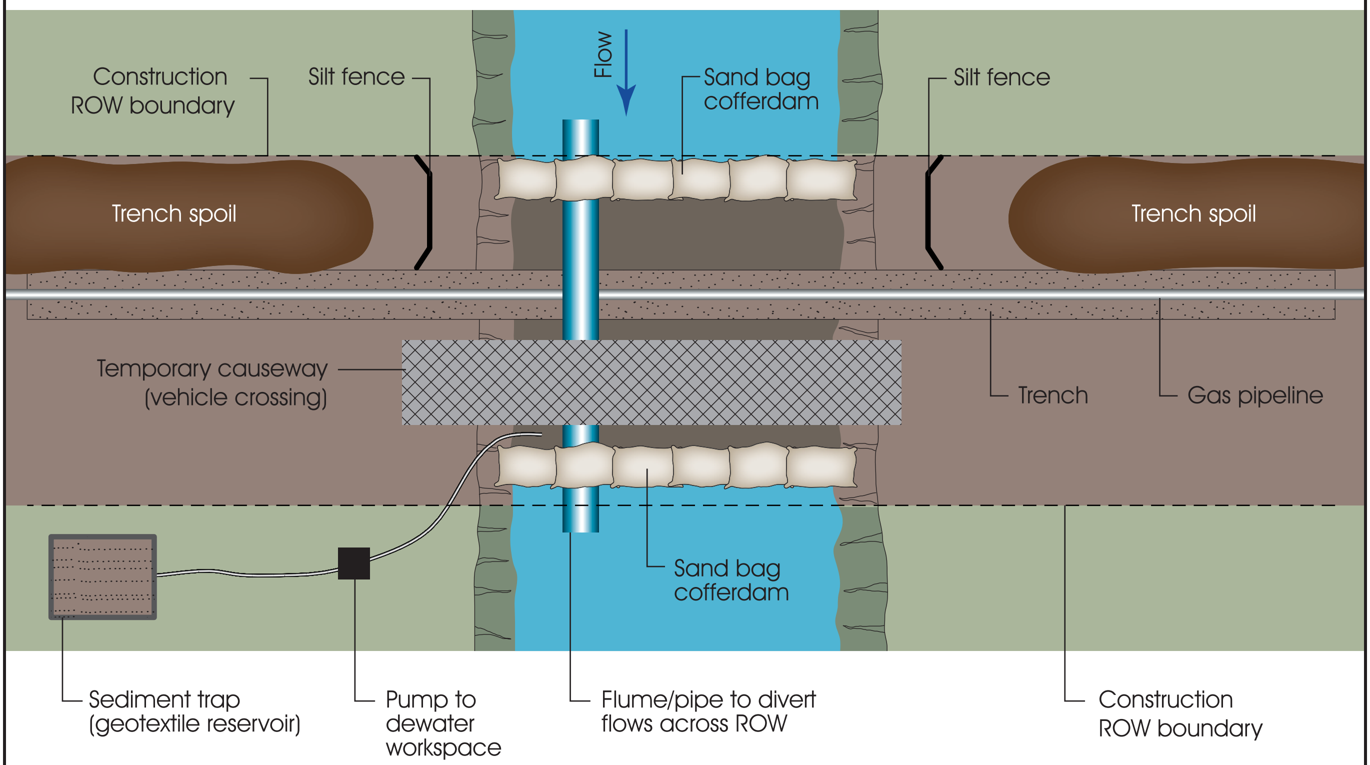
  Machinery will cross waterways in a manner that minimises further disturbance. Sediment control measures will be installed to minimise sediment transport and construction methods will minimise riverbed scouring.

- **Horizontal Directional Drilling.** This method is used to drill under large waterways, large roads and, where necessary, railway lines. The aim is to reduce above-ground environmental impacts and reduce disruption to vehicle traffic or train movements. This method involves drilling a curved hole at a shallow angle under the feature, through which the pipeline is pulled or pushed. Once a pilot hole is established, it is then reamed or enlarged to approximately 1.25 times the diameter of pipe. The borehole may be cased or uncased depending on the geology of the area. The pipe is then pulled through the casing or borehole. Figure 5.15 shows a schematic of a horizontal directional drilled crossing.

Cross section

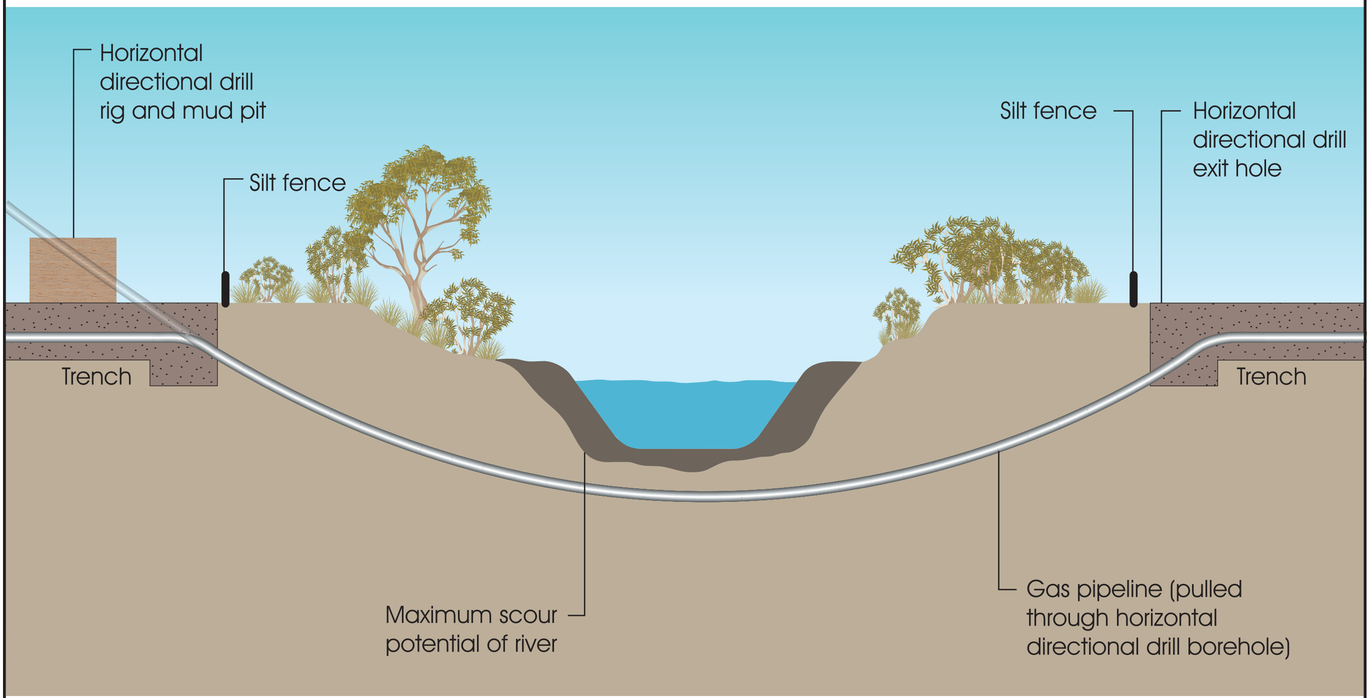


Plan



coffey environments	Job No: 7040 File Name: 7040_04_F05.14_GL	Arrow Energy Surat Gas Project	arrow energy go further
Schematic of an open cut crossing method	Figure No: 5.14		

Cross section



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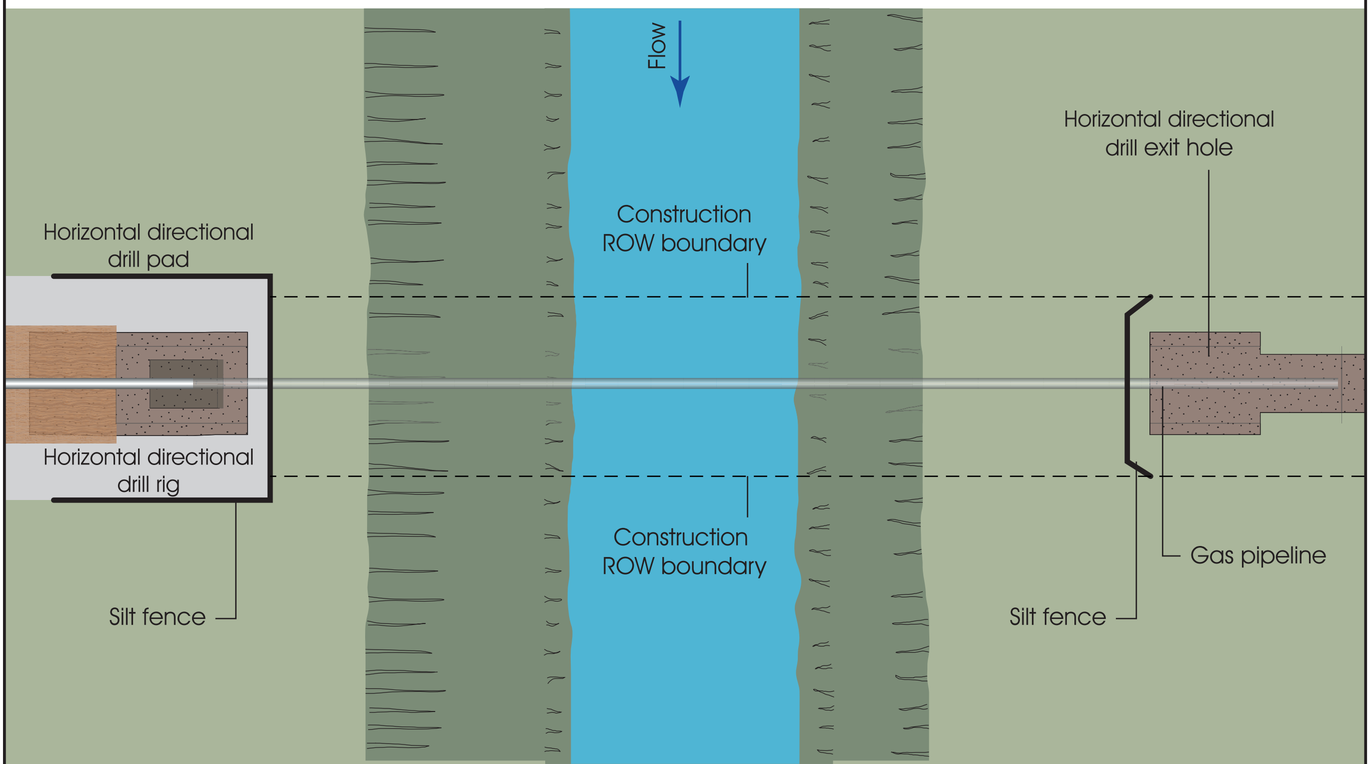


coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Schematic of a horizontal directional drilled crossing method	Figure No: 5.15
	File Name: 7040_04_F05.15_GL	Surat Gas Project			

- **Bored.** Boring involves the drilling of a short borehole to install pipelines beneath larger roads, railway lines and buried utilities. In order to drill the borehole, bore pits are constructed within the ROW on both sides of the road, railway line or utility. A thrust bore drilling rig is placed in the pit to drill a hole that is typically 10 m long by up to 4 m in diameter. Bored crossings are limited by the depth, width and length of crossing, geology and presence of groundwater. Small amounts of shallow groundwater can be temporarily drained from the work area during construction.

  Boring significantly reduces environmental impacts and does not disrupt traffic flows. Figure 5.16 shows a schematic of a bored crossing.

5.5.7 Supporting Infrastructure and Logistics

Supporting infrastructure includes town depots, telecommunications and borrow pits. Construction of depots and telecommunications will follow standard industry practices and comply with building codes.

Borrow pit establishment will include the following:

- Vegetation will be cleared and stockpiled for use in rehabilitation. Where appropriate, clearing residue will be mulched. Vegetation and mulch will be stockpiled separate to topsoil and overburden.
- Topsoil will be stripped and stockpiled prior the start of extraction activities.
- Sediment and erosion control structures will be installed to limit sediment transport.

5.5.8 Construction Workforce and Accommodation

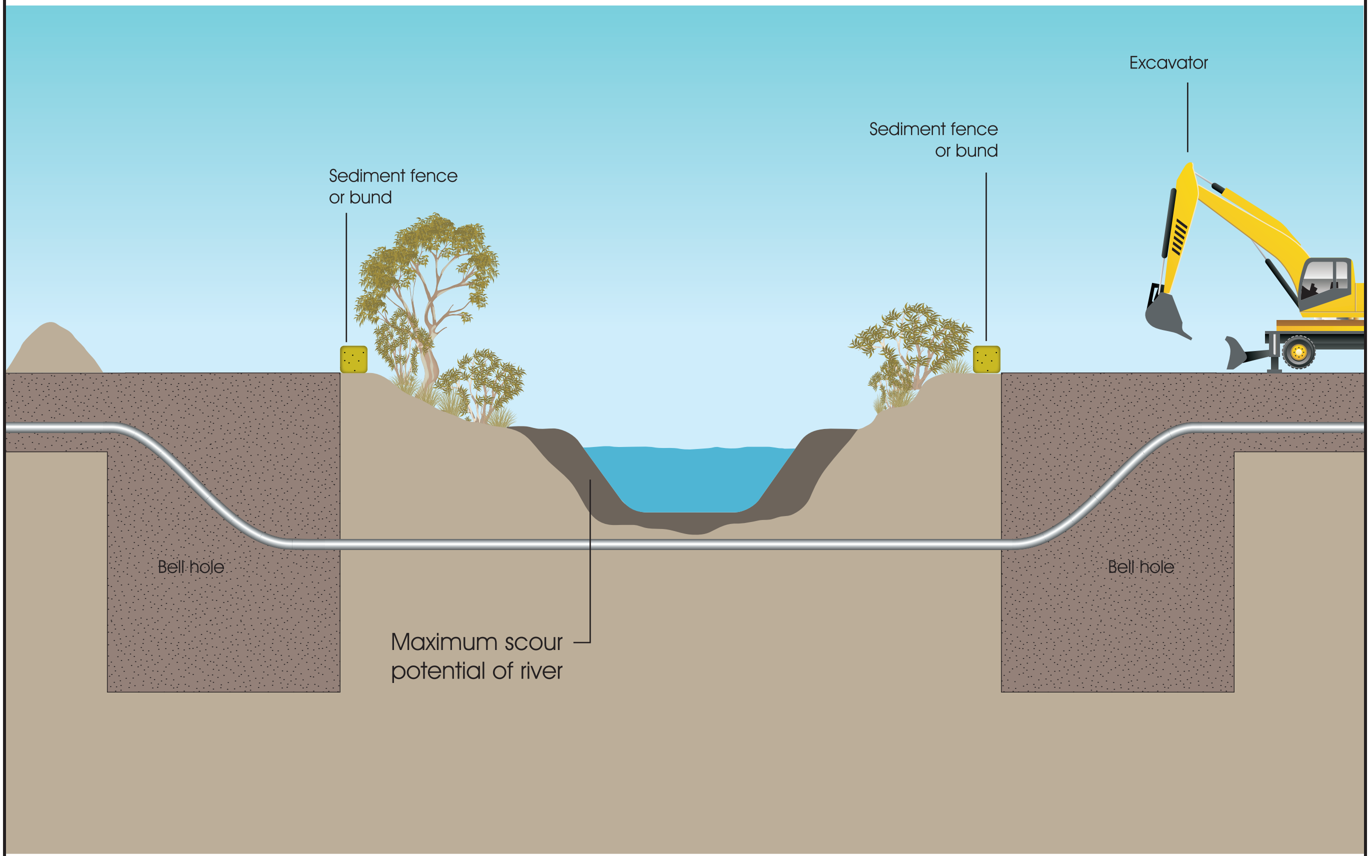
The development of workforce numbers has assumed that similarly configured infrastructure will be constructed where possible. Major components including compressors, power generating units, gas metering equipment and water treatment units will typically be supplied as modules assembled on skids to facilitate quick construction and easy relocation to other sites.

Construction Workforce Roles

The predominant construction workforce roles will include the following functions:

- Direct construction labour required to construct all infrastructure.
- Direct construction management calculated as a percentage (15%) of the direct labour requirement.
- Well and gathering system installation and commissioning personnel including:
  - Well site preparation.
  - Well drilling and completions (i.e., the completion of the subsurface aspects of the well and the deployment of down-hole equipment).
  - Surface equipment installation.
  - Connection of wells to gathering systems.
  - Installation of low-pressure gas pipelines and water gathering systems and infield medium-pressure gas pipelines.
  - Testing and commissioning.

Cross section



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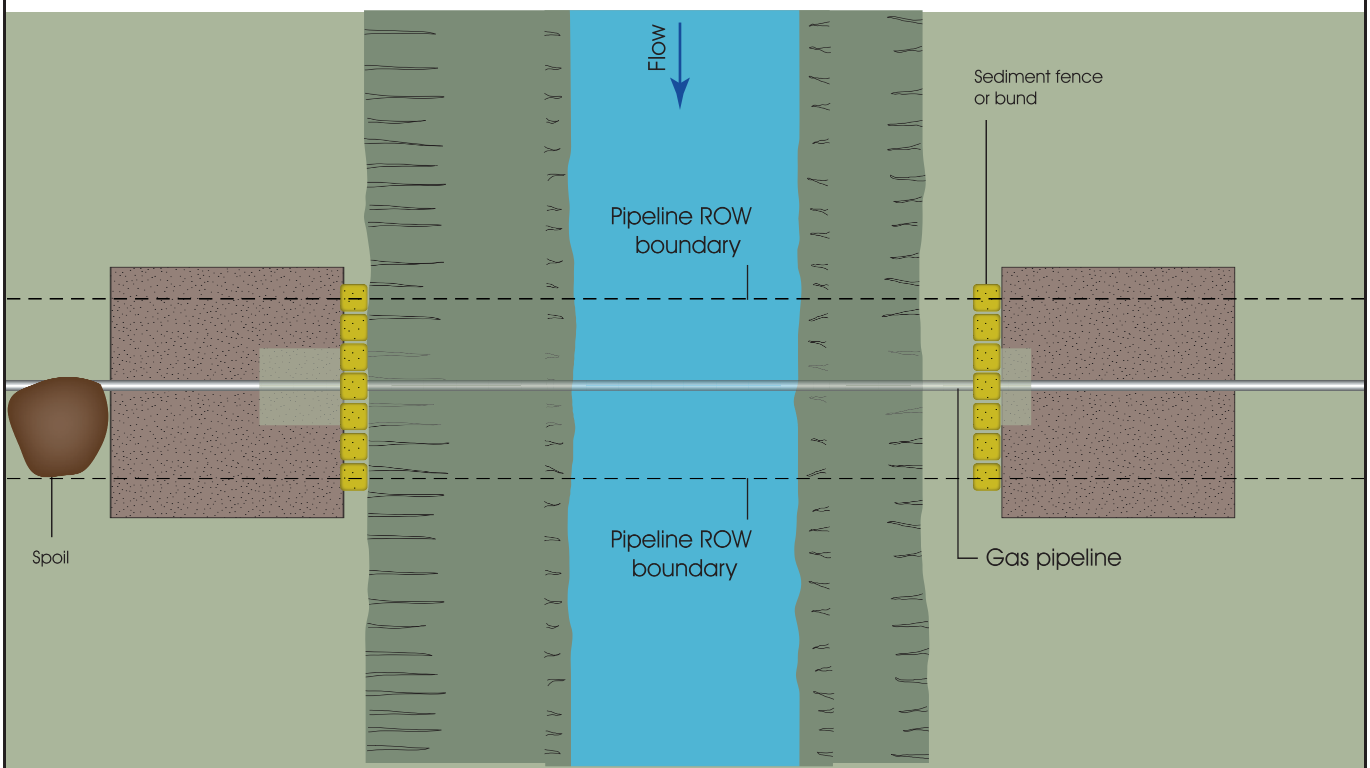


coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Schematic of a bored crossing method	Figure No: 5.16
	File Name: 7040_04_F05.16_GL	Surat Gas Project			

- Earthworks crew assumed to comprise an earthmoving/site preparation team that is deployed to clear, grade, fence and excavate all roads, pads, facilities and dams required for the development of production facilities and water treatment facilities (excluding wells and pipelines).
- Camp operations staff responsible for running the construction camps.

Construction Workforce Assumptions

The construction workforce has been estimated in consideration of the following:

- The design of the compressors is made up of components common to each production facility type that includes piping, electrical and instrumentation components suitable for a 30 TJ/day compressor module. Additional capacity will be provided by means of additional modules (trains), each adding another 30 TJ/day capacity to the production facility.
- Construction downtime due to adverse weather conditions is estimated at 10% for facilities and 30% for gathering lines.
- The construction crew roster will be a 21-day-on and 7-day-off cycle, with a 10-to 12-hour-day roster, for 24 hours per day (i.e., there will be two 10- to 12-hour shifts each day) with multiple offset cycles to ensure continuous construction.
- The production facility construction crew is scheduled on one cycle. No smoothing through multiple cycles or scheduling on a functional crew level (e.g., civil crew) has been included.
- Field teams responsible for installation and commissioning of wells and gathering lines are expected to be placed on a continuous work cycle.
- Estimated workforce numbers for the installation of the high-pressure gas pipelines and connection of production facilities to the sales gas pipelines (i.e., Surat Header Pipeline) have not been included as the work will likely be completed by the Surat Header Pipeline workforce.
- Should the alternative power supply option become the preferred option, the workforce required to install powerlines and the associated substations is estimated to be generally equivalent to, if not smaller than, the workforce estimated to construct onsite power generation. Connections to the existing distribution network would be coordinated and approved by the relevant transmission and/or distribution network service provider.

Construction Workforce Requirements

The results of Arrow's construction workforce modelling are summarised in Table 5.11. A peak construction workforce of 710 personnel is predicted to occur in 2016 when two major production facilities will be constructed concurrently (see Figure 5.10). The construction workforce will reduce to approximately 660 personnel in 2021, after which it will further reduce and fluctuate between 250 and 500 personnel with peaks coinciding with overlapping production facility construction programs.

Table 5.11 Construction workforce requirements

Activity Type	Size of Workforce	Source of Workforce	Accommodation
Well and gathering line installation and commissioning team	***Construction Workforce***		
	• 17 persons for a single shift drilling crew and 30 persons for a double shift. • Estimated peak workforce: 370 persons (year 2020). • Average workforce: 250 persons (from years 2012 to 2030).	• 20% local area. • 80% from elsewhere; travelling to site for each shift.	• 100% of drilling workforce accommodated at site camps. • Small (<20 person) mobile drilling camps may occur depending on drill site and proximity to site camp. • Some local residences.
	Local Support Staff		
	• 70 site-based support staff on average. Peak of an estimated 100 personnel in year 2020.	• 20% local area. • 80% from elsewhere who purchase/rent accommodation and live locally.	• 20% existing local residences. • 80% renting or purchasing locally.
	Brisbane-based Support Staff		
	• 30 support staff on average, per annum. • Peak workforce of 45 persons occurring in years 2016 and 2019 (when 2 facilities are brought online in each of those years) and in year 2020.	• 100% from Brisbane who travel as required.	• Drive to/from Brisbane.
Field compression facility	• 5- to 7-month construction duration (dependant on facility capacity). • 40 to 60 persons for construction of 30 and 60 TJ/d facilities, respectively.	• 20% local area. • 80% from elsewhere; travelling to site for each shift.	• 20% local residences. • 80% construction camp.
Production facilities	• 9- to 15-month construction duration (dependant on facility capacity). • 70 to 140 persons for construction of 30 and 150 TJ/d facilities, respectively.	• 20% local area. • 80% from elsewhere; travelling to site for each shift.	• 20% local residences. • 80% construction camp.

The workforce will comprise permanent and temporary positions, with workers employed and contracted directly by Arrow, and by other organisations contracted to Arrow. These positions include:

- **Short-term Contract Positions.** Short-term contracts will involve employment for 5 to 15 months.
- **Medium-term Contract Positions.** Approximately 380 positions will be available as part of the well and gathering line installation, along with commissioning teams required during ramp-up for about 5 years from 2014.
- **Long-term Contract Positions.** Following ramp-up, approximately 200 people will be required periodically over 15 years to install and commission wells and gathering infrastructure.

Approximately 300 permanent positions will be available from 2014, largely involving indirect employment through contractors.

Arrow's preference is to provide employment to people sourced locally (within the Darling Downs regional area); however, due to the high demand by other coal seam gas proponents and low unemployment rates, Arrow recognises that labour will likely need to be sourced from further afield. Arrow's aim, in this regard, is to implement a hierarchy of preferred employment and contractor candidates based on the employees'/contractors' home or source location. The order of preference is as follows:

1. Local (live within the Darling Downs regional area).
2. Regional (live within southern and central Queensland).
3. National (live in Australia).
4. International (live outside Australia).

Construction Accommodation

Table 5.12 provides a summary of Arrow's accommodation strategy for the construction of the project.

Table 5.12 Accommodation strategy

Accommodation Aspect	Strategy
Site selection	Purpose-built accommodation will be constructed at an integrated processing facility central to each development region. This will minimise commute times, with an average travel distance of approximately 20 km (and a maximum of 40 km) for the well installation team and a maximum travel distance of approximately 30 km for the facilities construction team, while working on adjacent facilities. Design, environmental, social and cultural constraints will guide site selection of construction camps. Similarly, any pipeline construction camps would be selected in line with Arrow's framework approach, if required.
Camp size	The final size and number of construction camps will be influenced by: • The rate of project development. • The distance between nearby central gas and integrated processing facility sites. • Opportunities for efficient use (or reuse) of camp infrastructure and resources. Construction camps will be sized to accommodate: • 100% of the peak construction workforce (nominally, accommodation for 140 workers for the construction of one facility). • 100% well and gathering line installation construction team (accommodation for 368 workers across each of the 5 regions). Based on the above assumptions, each construction camp will typically accommodate between 200 and 350 personnel, depending on the number of processing facilities that are constructed concurrently and the number of production wells drilled each year. The estimated maximum camp sizes for each of the five regions are shown in Table 5.13.
Construction camp facilities	Construction camps will include: • Individual sleeping quarters. • Catering services, commercial kitchen and dining area. • Recreation facilities such as a television room. • Ensuite facilities. • Laundry facilities. Onsite couple and family accommodation is not anticipated.

Table 5.12 Accommodation strategy (cont'd)

Accommodation Aspect	Strategy
Establishment	The 'pioneer' workforce required to establish construction camps will be housed in existing local accommodation until sufficient units are constructed. Construction camps are expected to take approximately four weeks to establish. Arrow expects that camp sizes will increase as the workforce increases. Where travel time is practicable, housekeeping and catering staff will be accommodated in communities close to the construction camp worksite.
Short-term accommodation	In addition to the construction workforce, Arrow anticipates a constant stream (average of 20 persons, 5 days a week) of management personnel and specialist consultants who may visit the project development area. Where possible, these personnel will be accommodated in construction camps. However, during peak activities, it is likely these personnel will seek motel or similar accommodation in towns.
Ongoing accommodation for drilling crews post facility construction	There are two options for accommodating the well and gathering line installation and commissioning team after construction of all gas processing facilities are completed and associated construction camps demobilised: • Small mobile drilling camps located near drilling operations might be established, as is Arrow's current practice. • A small section of an integrated processing facility construction camp might be retained for the purpose of accommodating well installation and commissioning crews.

Table 5.13 outlines the estimated construction camp sizes for each development region.

Table 5.13 Estimated construction camp sizes for each region

Construction Camp Location	Maximum Number of Beds Required	Year(s) Maximum Number of Beds are Required
Wandoan	320	2016 to 2018
Chinchilla	310	2020 to 2022
Millmerran	275	2019 to 2020
Dalby	300	2015 to 2019
Goondiwindi	290	2030 to 2031

5.6 Operations and Maintenance

5.6.1 Production Wells

Production wells (Plate 5.8) generally will be remotely operated and monitored from central locations at the production facilities. Wells will be remotely monitored for pressure as well as gas and water flow rates. Regular visits will also be conducted by field operators and maintenance personnel to inspect and maintain surface facilities.

Regular maintenance of production wells includes:

- **Wellhead Engine and Gas Wellhead Generator Maintenance.** Daily field operator visits will occur until such a time that production stabilises and telemetry is established, after which visits will be weekly.
- **Downhole Water Pump Maintenance.** Downhole pumps, which usually include flushing, will be maintained as required throughout the project. Periodic maintenance will be based on the downhole pumps selected during detailed engineering design, and will be conducted based on usage according to manufacturer's guidelines.

Plate 5.10
Production well in grazing land

- **Well Workover.** Well workovers are generally required every three years, with some wells requiring more frequent maintenance. Workovers involve the cleaning the production zone by high-velocity air or water jetting, maintaining or replacing the pump and, if necessary, replacing the well tubing and rods to ensure continued flow of gas and/or water from the coal seam. A workover drilling rig is required for well maintenance.

With the exception of a small safety exclusion zone, farming and grazing activities can continue around established well sites (Plates 5.9 and 5.10).

Operation and maintenance waste associated with the production wells is limited to well workover drilling fluids.

5.6.2 Gas and Water Gathering Pipelines

Operation of gas and water gathering pipelines is limited to remote flow rate monitoring. Regular inspections and maintenance are conducted by field operators.

Gathering system maintenance includes:

- **Regular Inspections.** Regular inspections will be conducted along the gathering line routes to observe and manage vegetation, subsidence, erosion and to ensure appropriate bushfire protection.
- **Maintenance of Valves, Vents and Drains.** Valves periodically require inspection and maintenance to ensure effective and safe operation. Water pipelines contain high-point vents to release accumulated gas and low-pressure gas pipelines have low-point drains to allow the accumulated water to drain. Inspection and maintenance of the vents and valves are required to maintain flow.
- **Pigging.** Gas from field compression facilities will be saturated with water, which can collect in low points of the medium-pressure pipelines. This water is removed by pigging. Pigging is accomplished by inserting a plug (pig) in one end of the pipeline and allowing the pressure of the gas in the pipeline to push it along the pipe until it reaches a receiving station. Pigging ensures unrestricted gas flow in the gas pipelines.

Other than pigging debris, the operation and maintenance of the gas and water gathering pipelines will generate negligible volumes of waste. Pigging wastes will include water and possibly sludge.

5.6.3 Production Facilities

The operational life of production facilities is expected to be approximately 30 years and will be operated 24 hours a day, 7 days a week. Production facilities will be fully automated and designed for minimal operator intervention. They will be controlled and their integrity monitored by a computer-based integrated control system that includes process and safety controls as well as a fire and gas systems. Operators are notified through warnings and alarms of changes in key

operating parameters. Additional details on operational safety and security systems are provided in Section 5.6.9, Operational Security and Safety.

Field compression facilities will be operated remotely with manning for maintenance purposes only.

Typical operational tasks for production facilities will include:

- Regular operation and maintenance.

- Major shutdowns in the order of eight hours per year for servicing critical equipment (e.g., gas compressors).
- Monitoring activities.
- Emergency repairs if required. Gas flaring will be undertaken during unplanned shutdowns.

Wastes generated during the operation and maintenance of a production facility could include:

- Solid wastes (filter cartridges, activated carbon, membrane modules, batteries, general trash, scrap metal, empty drums and containers, sandblast grit, cardboard and other packaging materials, wood pallets, oily rags and sorbents, electric cable, spent filter media bulk bags and tyres).
- Liquid wastes (cleaning acids, domestic cleaners, fuel, greases, lube oils, glycol, paint waste, water treatment chemicals, sewage from amenity blocks, triethylene glycol, brine, coal seam gas water, contaminated stormwater runoff, pigging waste, pesticides and herbicides).
- Gaseous waste (air emissions).

Chapter 26, Waste Management, details production facility waste types, quantities and management measures.

5.6.4 Coal Seam Gas Water and Brine Management

As described in Section 5.2.4, Water Treatment and Storage Facilities, the removal of large quantities of water is required to depressurise coal seams and allow gas to flow at production rates. Coal seam gas water management is addressed in Arrow's Coal Seam Gas Water Management Strategy (Attachment 9). The strategy addresses aspects of Arrow's operations that extend beyond the Surat Gas Project. The aspects of the strategy that are directly relevant to the Surat Gas Project are presented below.

Coal Seam Gas Water Management Strategy

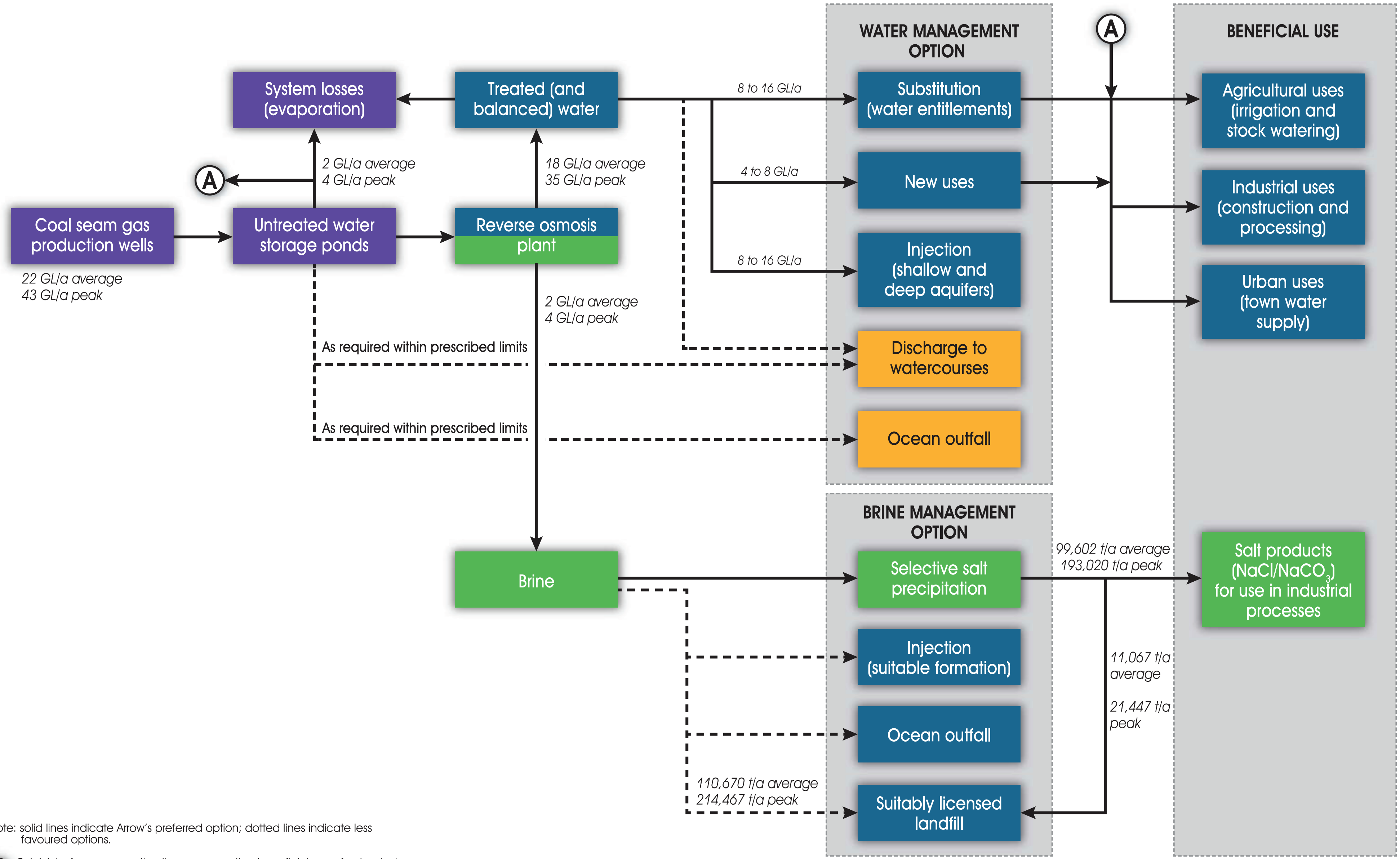
Arrow's Coal Seam Gas Water Management Strategy seeks to maximise beneficial use of coal seam gas water and minimise the environmental impacts associated with water use and disposal. It also seeks (where possible) to manage coal seam gas water in such a way as to mitigate the impacts of groundwater depressurisation.

The application of the strategy for the project is represented in the conceptual coal seam gas water management overview (Figure 5.17), which identifies the preferred and potential management options for coal seam gas water and associated brine/salt, including treatment, storage, beneficial use and disposal. The substitution and injection options are also proposed as effective means for managing groundwater depressurisation impacts.

The water balance is based on a 1,050-TJ/day production profile and provides both the average and peak expected volumes per annum. The distribution of coal seam gas water to the different management options will be continually reviewed as planning for field development evolves and opportunities for beneficial use present themselves.

Coal Seam Gas Water Management Options

Management of coal seam gas water during operations includes both beneficial use and disposal options as shown in Figure 5.17.



Note: solid lines indicate Arrow's preferred option; dotted lines indicate less favoured options.

(A) Point A to A are connecting lines, representing beneficial use of untreated coal seam gas water within prescribed limits.

coffey environments	Job No: 7040 File Name: 7040_04_F05.17_GL	Arrow Energy Surat Gas Project	arrow energy go further	Conceptual coal seam gas water management overview	Figure No: 5.17

Although coal seam gas water is considered a waste under the *Environmental Protection Act 1994* (Qld), the government may approve its use as a 'resource' on a case-by-case basis if the water has a beneficial use that would negate the need for its disposal. When used beneficially, coal seam gas water ceases to be defined as a waste.

Wastes generated during the operation of water treatment and storage facilities include filters, brine, water treatment chemicals and chemical containers.

The management options presented below apply to treated and untreated water. Untreated water may be suitable for any of the beneficial use options identified in Figure 5.17, depending upon the water quality requirements of the end user. Investigations indicate that there is limited demand for the beneficial use of untreated coal seam gas water in the project development area.

Substitution of Allocations

Arrow’s preferred approach is to beneficially use coal seam gas water by substituting existing water allocations in the area, i.e., the volumes of groundwater and surface water currently extracted by third parties in accordance with existing allocations will be replaced with coal seam gas water provided by Arrow. The strategy proposes substitution of water allocations for the duration of the project, until the production of coal seam gas water ceases.

Arrow has commenced discussions with relevant regulatory bodies regarding the appropriate legislative framework that would facilitate this component of Arrow’s Coal Seam Gas Water Management Strategy. It is expected that the third-party users will accept responsibility (legally and practically) for the impacts of their use of the water.

New Uses

Over the course of the project, it is anticipated that new opportunities for use of treated and untreated water will emerge and be investigated.

Injection

The benefits of injecting water are to offset the impacts of groundwater depressurisation and to provide a disposal option for any water that cannot be accommodated through beneficial use.

Arrow conducted an injection feasibility study in 2010 and is preparing environmental authority applications to conduct shallow and deep aquifer injection trials. The purpose of the trials is to identify the volumes and rates of water that Arrow can sustainably inject.

An injection trial would typically run for 12 months including preparation, data collection and data evaluation. Initial trials would involve drilling a single injection bore into each target aquifer. The bores will be used to collect geological data and characterise the water geochemistry of those aquifers.

Further works will be required to define the extent and feasibility of injection over the project development area. The Surat Gas Project EIS assumes that the legislative framework to enable injection of coal seam gas water into shallow and deep aquifers will be developed.

Disposal to Watercourses

Disposal to watercourses will be considered in the event that beneficial uses of coal seam gas water are temporarily unavailable or the demand for water decreases and alternative disposal options are required to maintain dam integrity and safety, e.g., due to adverse climatic conditions such as prolonged rainfall or severe storms.

Coal seam gas water may be discharged, subject to holding or obtaining relevant approvals, to watercourses in a controlled manner, taking the sensitivity of the receiving watercourse into consideration. Appropriate monitoring will be required to ensure the released water adequately dilutes and does not cause any adverse effects on the receiving aquatic environment. At this stage it is anticipated that discharge to watercourses will only be conducted under emergency situations.

Ocean Outfall

Disposal of coal seam gas water to the sea via an ocean outfall pipeline is recognised as a feasible option, however it is not the preferred option. In the event that preferred coal seam gas water management options do not eventuate, the feasibility of an ocean outfall, as an emergency or alternative disposal option for coal seam gas water, will be evaluated This evaluation will be conducted at the time of detailed design of the field and facilities.

Beneficial Uses of Coal Seam Gas Water

Implementation of the proposed coal seam gas water management options will result in the distribution of coal seam gas water to the following beneficial uses:

Agriculture

Irrigation Trials. Arrow holds a specific beneficial-use approval for an irrigation trial on Arrow's Theten property. Further specific beneficial use applications are being considered. These trials will occur on land classified as good quality agricultural land.

It is Arrow's intention over the next three to five years to develop a ‘showcase’ farming operation using treated coal seam gas water as a substitute for water drawn from aquifers and establish a framework for supply to third parties. It is not Arrow’s intention to operate farms in the medium to long term.

Irrigation. Irrigation is the predominant water use within the project development area. Arrow is pursuing the options to substitute existing allocations and supply water to new irrigation projects, both of which may include flood irrigation. Key considerations for providing coal seam gas water to third parties for irrigation include:

- The ability of the third party to take large volumes of water regularly and reliably (the third party will need to have buffer storage in the event that water cannot be used daily, such as during and following storm events or prolonged periods of rainfall).
- The location of the third party in relation to the water treatment facility (due to the cost of transporting water over large distances).
- The point of transfer of responsibility (Arrow is responsible and liable for water pipelines from a water treatment facility to a defined transfer point where responsibility of the water changes hands. Arrow intends that the water and the implications of its use will be the responsibility of the third party once the water is in their possession as Arrow retains no control over how the water is used beyond the transfer point.)

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

Industrial Uses

Coal seam gas water may be used for industrial purposes in Arrow’s operations, e.g., dust suppression, drilling and construction water supply and power station cooling. Arrow will also continue to supply third party industrial users and look for further similar opportunities.

Urban Uses

Arrow has undertaken a preliminary analysis for augmentation of the Dalby town water supply. On 25 November 2010, the *Water Supply (Safety and Reliability) Act 2008* (Qld) was amended to include the requirement that coal seam gas producers must develop an approved recycled water management plan if they propose to release water into a watercourse, aquifer or town drinking water supply. Recycled water management plans are designed to integrate into council drinking water management plans and deal principally with monitoring and communication. Augmenting town water supplies would decrease reliance on potable aquifers.

Brine Management Options

Brine is a significant by-product of the water treatment process, which also requires specific measures to manage its storage, use and/or disposal.

Assuming an average salt concentration of 4,500 mg/L, Arrow expects that treatment of coal seam gas water will generate in the order of 4.5 t of salt per megalitre of coal seam gas water. Arrow will continue to monitor coal seam gas water quality as the development progresses; however, development is planned with the assumption that similar water quality and salt concentrations will be observed across the entire project development area.

Figure 5.17 displays the brine management options and the expected average and peak annual volumes of salt production.

Although beneficial use is the preferred option for brine management, for the purposes of this impact assessment it is assumed that brine will be stored in dams and disposed to a suitably licenced landfill.

Selective Salt Precipitation

The concentrated brine produced through water treatment is comprised of sodium chloride (salt), carbonate and bicarbonate salts (soda ash). Arrow is consulting commercial enterprises to investigate viable opportunities for the beneficial use of brine. As part of this process, Arrow will commission selective salt precipitation trials to:

- Understand the chemical composition of the brine.
- Identify methods to enhance precipitation of the brine.
- Identify viable chemical processes to transform the brine into commercial products.

Brine Injection

Should Arrow identify an appropriate formation during the exploration phase of the project, disposal of brine via injection will be considered. A criterion for injection is finding a target formation where the water quality is lower than that of the brine. To date, no such target formations have been identified.

Ocean Outfall

Disposal of brine to the sea via an ocean outfall pipeline is a feasible option that is being investigated by Arrow. As with coal seam gas water the viability of an ocean outfall will be evaluated at the time of detailed design of the field and facilities.

Suitably Licenced Landfill

An assessment of waste disposal facilities indicates that suitably licenced facilities exist in the region. It is assumed that other commercial operations will be developed to capitalise on this waste stream. Arrow will develop appropriate storage capacity to manage brine until such time as permanent disposal solutions are operational. The closest currently available suitably licenced waste disposal facility is located at Swanbank, near Ipswich. This EIS has assumed that all brine concentrate will be trucked to Swanbank.

5.6.5 Power Generation Facilities

Power generation facilities (see Figure 5.9) will be located at production wells and production facilities and operated and maintained as per those facilities.

Waste generated from power generation facilities will include glycol and lubricating oil from the gas-fired engines.

5.6.6 High-pressure Gas Pipelines

For the most part, high-pressure gas pipelines will be operated and maintained similarly to the medium-pressure pipelines. Mandatory signage to identify the pipeline location will be visible above ground. Regular patrols, inspection and maintenance will be carried out to manage weeds, ensure vegetation is not encroaching on the pipeline centreline, check for subsidence or erosion, test and inspect valves and conduct integrity testing. The frequency of inspections will be the highest in the first 12 months after construction as the ROW rehabilitates. Intrusive investigations (excavation) to address pipeline coating defects or other upset conditions are not a common occurrence.

Pipeline pressure and gas volumes in the pipe will be remotely monitored. Pipelines will be constructed with automatic inlet valves that shut off or isolate sections of pipe if a large pressure change is detected.

Wastes generated from the operation and maintenance of high-pressure pipelines is similar to that of the gathering system pipelines.

5.6.7 Supporting Infrastructure and Logistics

Operation of supporting infrastructure, such depots and borrow pits, will be conducted during daylight hours only. Management of operational logistics from any borrow pits will be minimal as only small volumes of material will be shipped to production facilities.

5.6.8 Operations Workforce and Accommodation

The life of the Surat Gas Project is nominally 35 years, during which time an operational workforce of around 400 personnel will be required, including Arrow’s existing personnel. The operational workforce is expected to increase by approximately 50 people for short durations for planned maintenance.

Existing Operations Workforce

As of 2011, Arrow had an operations workforce of approximately 100 staff supporting the current field development and operating facilities in the Dalby region. Operations staff members are based either at existing production facilities at Kogan North, Daandine and Tipton West or at Arrow’s office and stores in Dalby. Most staff members currently reside in Dalby, with a small contingent travelling from such towns as Chinchilla, Cecil Plains, Millmerran, Nanango and Toowoomba on weekdays. Table 5.14 provides a breakdown of Arrow’s employees according to role type.

Table 5.14 Dalby operations workforce

Type of Role	Number of Staff
Administration and stores	15
Drilling	10
Engineering and production including: • Construction management. • Engineering. • Field assistance. • Geology. • Production and field operation. • Technical assistance. • Well site completion and development.	64
Land negotiations and management	4
Environmental, occupational health and safety	5
Training and development	2
Total	**100**

During periods of increased activity, Arrow engages contractors to supplement its core staff. A number of these contractors travel from outside the project development area to work. In addition, Arrow contracts personnel to assist with drilling services. Drilling service contractors are Dalby based.

Surat Gas Project Operations Workforce Requirements

Approximately 300 new operations personnel will be required for the Surat Gas Project. It is expected that project operations will commence in the Wandoan region in 2014, when the first integrated processing facility and associated production wells are commissioned.

Arrow proposes to establish a local operations workforce by filling approximately 50% of the 300 new positions (in addition to the 100 existing personnel) from towns within or close to the project development area. The remaining 50% of staff are expected to move in to the area where they will rent or purchase homes and become part of the local community. Some staff may elect to base themselves in Toowoomba and drive to places of work daily, particularly if they are engaged in activities in the southern development regions. There are no plans to establish fly-in/fly-out or drive-in/drive-out operations.

Where personnel cannot be sourced locally, the following recruitment hierarchy will be applied:

- Regional (lives within southern and central Queensland).
- National (lives in Australia).
- International (lives outside Australia).

The forecasted operations workforce is expected to peak at about 460 personnel in 2025 and remain relatively constant thereafter. The operational workforce will be centrally based at central gas processing and integrated processing facilities with support staff, depot personnel and administration centralised in town(s).

Operations workforce requirements are provided in Figure 5.10 and summarised in Table 5.15.

Table 5.15 Operations workforce requirements

Activity Type	Size of Workforce	Source of Workforce	Accommodation
Development region administration and management	Up to 200 personnel (including 50 existing persons) will be 3 based at 1 of the depots (Dalby, Miles or Millmerran) from year 2022 onwards for various roles, including administration, engineering and production, supervisory, OHS and stores.	• 50% local area. • 50% from elsewhere who move to the area to live.	• 50% existing local residences. • 50% renting or purchasing locally.
Field compression facility operation	No designated workforce. Staff from the associated central gas processing or integrated processing facilities will remotely operate and maintain the field compression facilities.		
Central gas processing and integrated processing facilities operations (including water treatment and power generation)	Approximately 7 to 9 persons per production facility. From year 2022, over 70 persons may be required.	• 50% local area. • 50% from elsewhere who move to the area to live.	• 50% existing local residences. • 50% renting or purchasing locally.
Field operators	It is estimated that there will be approximately one field operator per 50 wells. As more wells are brought on-line each year during ramp-up, the number of field operators increases; however, a maximum number of operators are reached in year 2025 when 80 personnel are expected to be responsible for well operations across the project development area.	• 50% local area. • 50% from elsewhere who move to the area to live.	• 50% existing local residences. • 50% renting or purchasing locally.
Well workover crews	Similar to the well operators, there will be a peak workforce of 100 workover staff and this number plateaus from year 2022 onwards. It is estimated that a production well will require: • One workover every 3 years. • A nominal 7 days per workover. • Five people per workover crew.	• 50% local area. • 50% from elsewhere who move to the area to live.	• 50% existing local residences. • 50% renting or purchasing locally.

Operations Workforce Roles

Local operations personnel will be responsible for the following:

- **Land Access.** Including land agents, cultural heritage monitors and environmental staff.
- **General Support.** Construction superintendents, field engineers, quality assurance engineers, occupational health and safety specialists.

- **Earthworks.** Earthworks supervisors.
- **Pipelines.** Pipeline supervisors.
- **Drilling.** Arrow supervisors, geologists, site drilling and completions engineers.

Brisbane-based operations staff will typically include:

- **Access.** Land access, cultural heritage and environment managers.
- **Management and Engineering.** Project management, project engineering, controllers, schedulers, GIS staff and contract administrators.

Working hours will depend on the employee's operational role and are expected to include the following:

- Production staff will work 10-hour shifts during daylight hours, 5 days per week. Production facilities run 24 hours a day, 7 days a week but staff will be on call to respond to emergencies.
- Support staff, depot personnel, engineering and administration will generally work 8- to 10-hour shifts during daylight hours, 5 days per week.

5.6.9 Operational Security and Safety

Protection of assets, workforce and public safety is paramount to Arrow's operations. Utilising qualified personnel and through implementation of Arrow's comprehensive and integrated health, safety and environmental management system, the potential security and safety risks will be minimised.

Below is a brief summary of key security and safety features employed during operations. A detailed discussion of security and safety is provided in Chapter 25, Preliminary Hazard and Risk, and Appendix S, Preliminary Hazard and Risk Assessment.

Site Security

Site-specific security measures will be risk-based and determined during FEED. Common security features include the following:

- **Production Wells.** Completed well sites will be fenced to prevent access. The height of the fence will be dependent upon the location and risk of unauthorised access.
- **Production Facilities.** Production facilities will be enclosed by a perimeter security fence. The facilities will have 24-hour lighting and security monitoring equipment.

Safety

Production wells, pipelines and production facilities have numerous safety systems that maintain the integrity of the facilities. Systems include:

- Fire detection and fire suppression systems that consist of active and passive fire protection systems such as flame, smoke and heat detectors.
- Gas detection systems.
- Automatic alarm systems.
- Emergency shutdown systems in the event of an upset or emergency. Emergency shutdown systems will be both automatic through the integrated control system and manual through operator call points and pushbuttons.

- Automated overpressure protection systems on high-pressure pipelines, remote-controlled isolation valves on medium-pressure gas pipelines and manual isolation valves on low-pressure gas and water pipelines at each of the well heads.

In the event of an emergency, Arrow will implement their emergency response plans as described in Attachment 5, Environmental Management Plan.

5.7 Decommissioning and Rehabilitation

The project infrastructure has a design life ranging between 15 and 35 years and decommissioning and rehabilitation will progressively occur throughout this period. Final decommissioning and rehabilitation will occur at the end of individual infrastructure life and will be done in accordance with the relevant approvals and regulatory requirements of the day.

The goals of decommissioning and rehabilitation are to ensure that the project development area is:

- Safe to humans and wildlife.
- Non-polluting.
- Stable (landforms).
- Able to sustain a useful land use project.

Prior to decommissioning, detailed objectives, criteria and performance indicators will be developed for each of the above goals in consultation with the appropriate regulatory agency and landowners.

Decommissioning and rehabilitation involves three key tasks:

1. **Progressive Rehabilitation.** This is undertaken postconstruction, to stabilise the land and reduce the construction footprint for operations. The period of time between construction and rehabilitation will be minimised to prevent degradation and loss of exposed soils. Surface structures, equipment and waste materials from the construction area will be removed prior to rehabilitation.

2. **Decommissioning.** At the end of the project infrastructure life or when no longer required, infrastructure will be decommissioned by removal of surface facilities and waste from site. In some cases, subsurface infrastructure may remain in situ. Any contaminated soils present will be remediated or removed to a licensed disposal facility.

3. **Final Rehabilitation.** This involves the final reinstatement of topography, reprofiling and revegetation of the site (where required) to return the disturbed land to as near as possible the predisturbance state. Compacted areas will be ripped or scarified and topsoil will be respread to encourage natural revegetation. In some cases, stabilisation measures will be used to ensure topsoil remains intact. Site-specific rehabilitation plans will be developed for areas where natural vegetation regeneration may be problematic. The final rehabilitation will be determined in conjunction with the landowner.

During decommissioning Arrow will aim to:

- Reuse accommodation blocks, offices, pumps, tanks and components of production facilities.

- Recycle steel, piping and fencing.

- Dispose of general waste from camps, brine residue from dams and liners in accordance with the waste hierarchy described in Chapter 26, Waste Management.

Decommissioning and final rehabilitation methods for major project infrastructure are described below.

5.7.1 Production Wells

Progressive rehabilitation after installation of wells will result in an operational footprint area of approximately 10 m by 10 m per well. When the wells reach the end of their production life (approximately 15 to 20 years), the wells will be decommissioned in accordance with the Petroleum and Gas Act requirements.

These requirements include the removal of all surface equipment including fencing, cutting off the well casing and the gathering line connections below ground surface, and using a drilling rig to plug the well with concrete to isolate formations and prevent gas leakage to the surface. A statutory signpost will be erected on a nearby fence or other suitable location.

Well sites will then be rehabilitated to a standard consistent with the surrounding land use, or as agreed with the landowner. Rehabilitation may involve recontouring, replacing topsoil and re-establishing drainage lines and pasture species.

5.7.2 Gas and Water Gathering Systems

Decommissioning of gathering lines will involve:

- Depressurisation of the pipeline.
- Isolation of pipelines from wells and/or above ground facilities.
- Purging the gas pipelines, filling with an inert gas or water, then capping the ends.
- Leaving the gathering lines in situ (removing the pipes from the ground would result in additional and unnecessary environmentally impacts).
- Where necessary, filling the pipe with a stabilising material such as concrete to prevent subsidence under roads, utilities or railway lines.
- Removal of surface infrastructure and signage.

Rehabilitation of the gas and water gathering line easement would return it to the surrounding land use, or as negotiated with the landowner.

5.7.3 Production Facilities

Arrow may undertake decommissioning of production facilities as a combined project, or may progressively decommission and rehabilitate individual components. Given that the production life of facilities is approximately 30 years, decommissioning and rehabilitation works may not occur for 15 to 30 years.

Major production facility equipment such as compressors and gas engines, as well as ancillary equipment such as flares, tanks, piping, electrical and other utility systems, will be isolated, drained, purged of gas and removed from site. Where practical, the major equipment will be re-used elsewhere in Arrow’s developments.

Any potentially contaminated soil will be remediated onsite or removed to an appropriate treatment or disposal facility.

Rehabilitation of production facilities may involve recontouring, topsoil replacement and revegetation. Rehabilitation will be done in consultation with the landowner.

Any infrastructure, such as roads, tracks or dams, that remains onsite for the landowner will have a written agreement in place that will be submitted to DERM with the final rehabilitation report.

5.7.4 Water Treatment and Storage Facilities

Water treatment units will be drained and removed from site with a priority to re-use these elsewhere on Arrow developments.

Dams may be left in situ if agreed with landowners. The water reticulation potential may be considered a beneficial end use for the land. However, if this is not possible, dams will be removed. Any brine residue will be removed as waste and disposed of at an appropriately licensed facility.

5.7.5 Power Generation Facilities

Power generation facilities will be decommissioned and rehabilitated similarly to the production facilities. Overhead transmission lines would be isolated from the distribution system and will be either removed or left in situ, if agreed with landowners.

5.7.6 High-pressure Gas Pipelines

The Australian Standard AS 2885 for gas and liquid petroleum pipelines (Australian Standards, 2008a) provides guidance on the abandonment of pipelines.

High-pressure gas pipelines will be either suspended for future use or decommissioned. Suspending a pipeline would involve filling it with inert gas (e.g., nitrogen) or water containing corrosion-inhibiting chemicals and capping the ends. Decommissioning of high-pressure pipelines would be consistent with the gas gathering pipelines methods described in Section 5.7.2, Gas and Water Gathering Systems.

In either case, a detailed rehabilitation plan will be developed in consultation with landowners.

5.7.7 Supporting Infrastructure

Accommodation camps were constructed in modules and therefore can be removed easily from any site and reused elsewhere.

Decommissioning and rehabilitation of borrow pits will involve ripping of the pit floors, slope stabilisation, contouring, respreading of topsoil and, if practicable, revegetation.

Depots and offices blocks in regional centres will be left in place.

5.7.8 Decommissioning Workforce and Accommodation

Arrow will progressively decommission production wells and production facilities over the life of the project. The assumptions used to determine decommissioning workforce requirements are:

- Most production wells will be decommissioned after 15 to 20 years.
- Decommissioning of production facilities is dependent on the life span of the wells that feed the particular facility.
- An approximate 5-year gas tail-off and decommissioning period.

A summary of the decommissioning workforce is provided in Table 5.16.

Table 5.16 Decommissioning workforce requirements

Infrastructure Type	Size of Workforce	Source of Workforce	Accommodation
Decommissioning wells and supporting infrastructure	Year 2030 to 2048: 2 by 8 person crews.	• 100% local.	• Existing staff housing.
Field compression facility	Up to 25 persons for a period of 4 months.	• 90% local. • 10% specialist skills from outside area.	• 90% existing staff housing. • 10% motels or similar.
Central gas processing facility	Up to 50 persons for a period of 8 months.	• 90% local. • 10% specialist skills from outside area.	• 90% existing staff housing. • 10% motels or similar.
Integrated processing facility	Up to 160 persons for a period of 8 months.	• 90% local. • 10% specialist skills from outside area.	• 90% existing staff housing. • 10% motels or similar.

Arrow expects most personnel involved in decommissioning to be sourced locally. These activities are scheduled many years in the future allowing adequate skills development in the local employment base.

It is expected that decommissioning activities would be undertaken in 10- to 12-hour shifts, up to 7 days per week.

5.7.9 Decommissioning Waste

Wastes generated during the decommissioning and rehabilitation may include:

- Solid wastes (general trash, concrete, electrical cables, fencing, piping, gas compressors, scrap metal, production wellheads, power generators, pumps, sewerage, sludge, storage tanks and soil contaminated with chemicals/oils).
- Liquid wastes (brine, triethylene glycol, lube oil, spent chemicals).
- Gaseous waste (vehicle emissions to air).

5.7.10 Financial Assurance

Financial assurance for the project is required by the DERM Guideline for Financial Assurance for Petroleum Activities (DERM, 2011d). It is a security held to meet any potential costs or expenses incurred by the Queensland Government in taking action to rehabilitate or restore the environment.

Arrow will calculate financial assurance required for the project based on the maximum area of disturbance. The financial assurance will be provided to DERM and reviewed throughout the life of the project.

5.8 Alternative Power Distribution

The Surat Gas Project has reviewed a number of potential technical alternatives in the preliminary design. Of the alternatives reviewed, an alternative power distribution within the project development area has been considered a viable option as were alternative coal seam gas water and brine management measures. These have therefore been included within the scope of this EIS and are discussed below.

An alternative option to the EIS conceptual design of generating power onsite is to connect particular production facilities to existing electricity supply networks. This would result in a combination of onsite power generation and grid power. Connection to existing electricity supply networks would be based on the production facility proximity to the supply network. Connections would be coordinated and approved by the relevant transmission and/or distribution network service provider.

The alternative power supply option would include the installation of zone substations and new transmission lines as represented in Figure 5.18.

5.8.1 Zone Substations

Grid power will be supplied to production facilities via high-voltage transmission lines connecting zone substations established adjacent to the central gas and integrated processing facilities to substations operated as part of the electricity grid. The number and location of zone substations will be determined by the electricity load at the central gas and integrated processing facilities, and the proximity of these facilities to existing electricity grid substations and transmission infrastructure. A typical footprint of up to 200 m by 150 m is required to establish a zone substation, which, if selected as an option, may be incorporated in the design of the central gas or integrated processing facility.

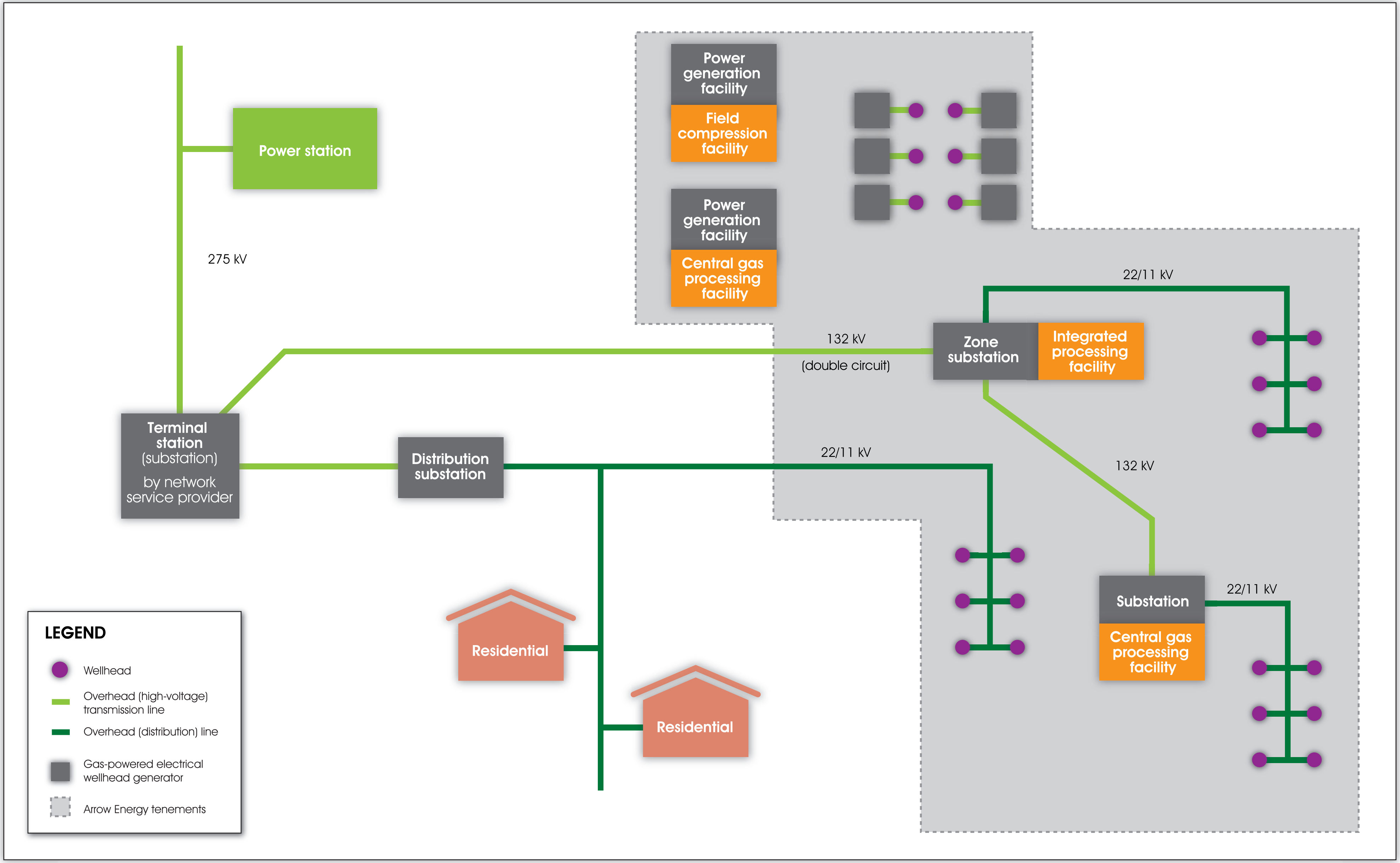
Network service providers may be responsible for permitting, construction and operation of electricity supply infrastructure required to enable connection of the zone substations to the electricity grid, including any new substations, transmission lines, system control and integrity equipment and access tracks.

5.8.2 Transmission Lines

Overhead 132-kV transmission lines will connect the zone substations to the network service provider-owned and provider-operated substation. The alignment of transmission lines will be informed by physical, environmental, social and landowner constraints. The type, spacing and height of poles will be determined during the detailed design, where span lengths and pole height will be optimised to reduce the number of poles and achieve the required safety clearances to the ground, roads, structures and vegetation. Farming practices and equipment (e.g., irrigators) will be considered in the detailed design.

The typical easement width required for the 132-kV overhead lines will be 45 m to 60 m. Vegetation on the easement will be cleared in accordance with the applicable electricity line safety clearance requirements. Typically, a 10-m-wide access track will be maintained along or adjacent to the centreline of the transmission line for operation and maintenance purposes. Existing formed roads and tracks will be used to access transmission lines to minimise disturbance, where possible.

Distribution lines (132 kV, 33 kV, 22 kV or 11 kV) will provide power to adjacent production facilities and other infrastructure, as determined by load requirements. Voltage levels will be selected as appropriate.



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Arrow Energy

Surat Gas Project

arrow energy go further

Alternative power supply option

Figure No: 5.18