3. PROJECT DESCRIPTION

Arrow's field development planning and the basis of design for the project have advanced since submission of the Surat Gas Project Environmental Impact Statement (EIS) (Coffey Environments, 2012b) to the Queensland Government in March 2012. These advancements are the result of ongoing exploration activities that have improved Arrow's understanding of the gas resource. Refinements to the basis of design, including revised typical or expected arrangements, configurations, construction methods and coal seam gas infrastructure design, have allowed Arrow to prepare for the front-end engineering design (FEED) phase and incorporate new design elements to reduce the project's footprint.

Project-specific design details will be determined during the FEED phase, expected to commence in mid-2013. Until such time, the project description remains conceptual.

This chapter describes the changes to the project description, as well as the rationale for these changes.

3.1 Overview of Changes

Table 3.1 presents a summary of the changes to the project description since publication of the EIS. Further details regarding these changes are provided in the following sections of this chapter. While the development case described in this SREIS is appropriate for assessing the maximum potential impact of the project, the project's development case will continue to be refined over the life of the project to recognise emerging policy, evolving industry best practice, the project's business case and operational experience.

Table 3.1 Summary of key project description components and changes

Component	EIS Chapter 5 Project Description	SREIS Project Description Refinements
Project Development Area		
Project development area	• Project development area of 8,600 km^2. • Five development areas (each with approximately 1,500 wells).	• Project development area of 6,100 km^2. • 11 drainage areas (each with varying numbers of wells), which take advantage of natural topography, encouraging flow of gas and water to natural low points.
Field Production		
Sustained production estimate	• 80 TJ/d of gas for supply to the domestic gas market and 970 TJ/d of gas for export overseas (including 10% feed gas). • Sustained gas production aimed at 1,050 TJ/d.	• 80 TJ/d of gas for supply to the domestic gas market and 1,135 TJ/d of gas for export overseas. • Sustained gas production aimed at 1,215 TJ/d.
Coal seam gas water production estimate	• Average production 22 GL/a. • Peak production 43 GL/a. • Total production 694 GL (over 35 years).	• Average production 13 GL/a. • Peak production 34 GL/a. • Total production 510 GL (over 40 years).
Wells and Facilities		
Well number	Well count approximately 7,500.	Well count approximately 6,500.

Table 3.1 Summary of key project description components and changes (cont'd)

Component	EIS Chapter 5 Project Description	SREIS Project Description Refinements
Wells and Facilities (cont'd)		
Well type	Vertical production wells.	• Production well types include vertical (single-well pad) and deviated (allowing for multiple wells located at a central surface location (multi-well pad)). • Maximum of 12 production wells on a multi-well pad. • Multi-well pad will typically contain nine production wells. • Groundwater monitoring bores in accordance with Arrow's statutory obligations.
Integrated processing facilities	• Six integrated processing facilities producing 30 to 150 TJ/d of gas.	• No integrated processing facilities.
Central gas processing facilities (CGPFs)	• Six CGPFs producing 30 to 150 TJ/d of gas. • Conceptually located somewhere within a 12-km-radius area.	• Eight CGPFs producing 75 to 225 TJ/d of gas. • Properties where CGPFs will be located in drainage areas DA2, DA7, DA8 and DA9 (see Section 3.5) have been identified.
Field compression facilities	Six field compression facilities processing 30 to 60 TJ/d of gas.	No change. Potentially six field compression facilities operating at 30 to 60 TJ/d (if required).
Water treatment facilities	Six water treatment facilities with 60 ML/d capacity.	Two water treatment facilities, one at CGPF2 and one at CGPF9, with 35 ML/d and 90 ML/d capacities, respectively.
Power Requirements		
Power generation	• Primary power requirements fulfilled through self-generation. • Alternate power supply option as connection to Queensland's electricity grid.	• Primary power requirements fulfilled through connection to Queensland's electricity grid. • Self-generation option maintained as per EIS. Temporary self-generation may support facilities during initial production for a period until an electricity grid connection is established (not expected to exceed two years) and with a maximum capacity of temporary self-generation of 50 MW for each CGPF.
High-pressure Gas Pipeline		
Right of way (ROW)	25- to 30-m-wide construction ROW.	Up to 40-m-wide construction ROW.
Supporting Infrastructure and Logistics		
Workforce	• Peak construction workforce estimated at 710. • Peak operations workforce estimated at 460.	• Peak construction workforce estimated at 2,300. • Peak operations workforce estimated at 400.

Table 3.1 Summary of key project description components and changes (cont'd)

Component	EIS Chapter 5 Project Description	SREIS Project Description Refinements
Supporting Infrastructure and Logistics (cont'd)		
Temporary workers accommodation facilities (TWAFs)	• Each TWAF typically accommodates between 200 and 350 personnel. • Five TWAFs. • Co-located with an integrated processing facility; maximum travel distance of approximately 30 km for the facilities construction team.	• Each TWAF typically accommodates between 450 and 1,050 personnel. • Six TWAFs. • Property for siting TWAF-F identified. Remaining five TWAFs to be located within the same property as the nearest CGPF (Section 3.6.8).
Coal Seam Gas Water Management		
Discharge to watercourses	Emergency discharge to watercourses when the structural or operational integrity of dams is at risk.	Emergency discharge to watercourses when the structural or operational integrity of dams is at risk. Operational discharge to watercourses to distribute water to managed schemes, or to dispose of water when: • Constraints to supply for beneficial use occur. • Unforeseen events occur such as significant weather events. • Operational upset conditions necessitate discharge.

3.2 Project Development Area

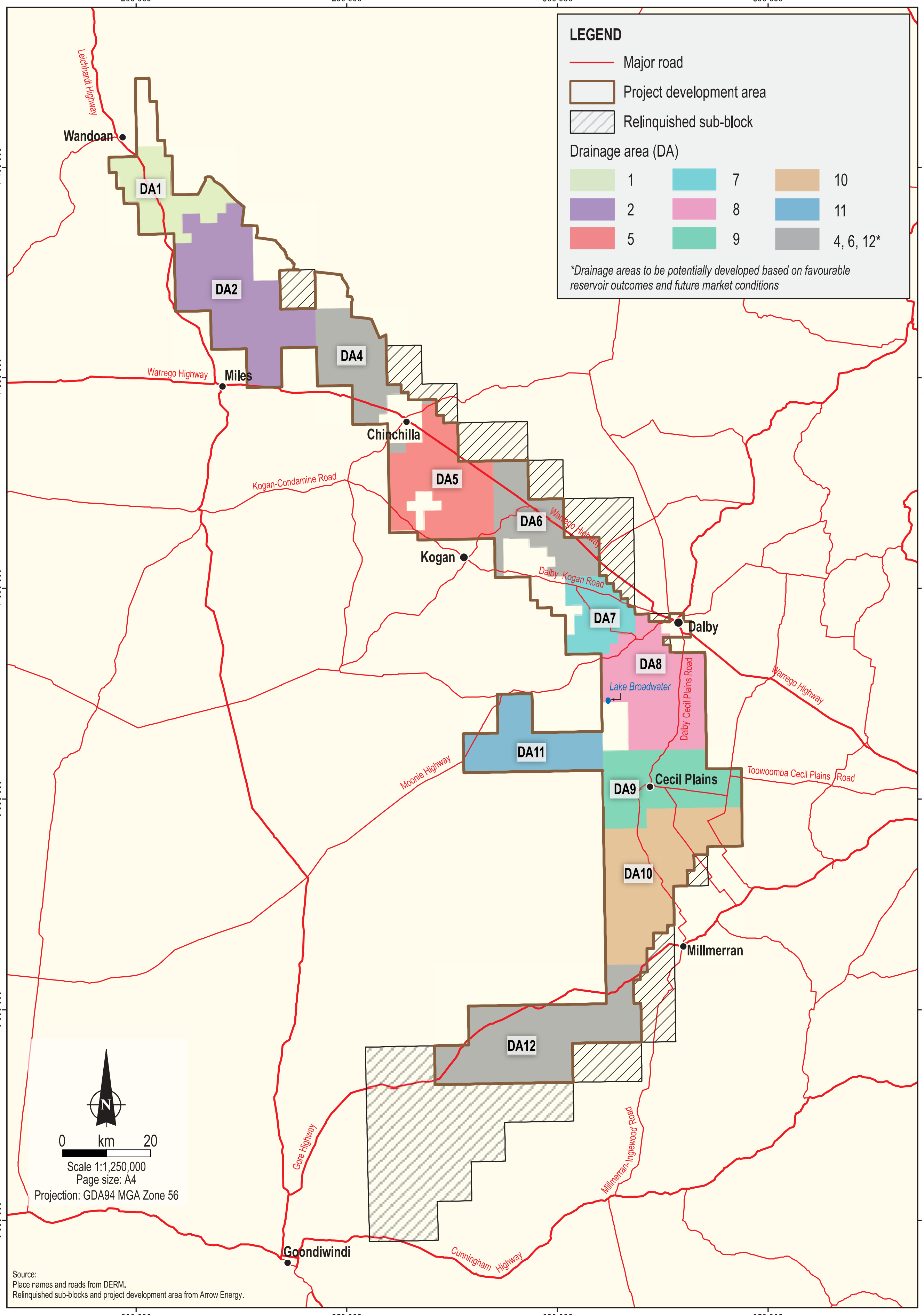
Some petroleum tenement sub-blocks within Arrow's project development area, primarily in the Goondiwindi development region, have been relinquished as a result of ongoing exploration and improved knowledge of coal seam gas reserves.

Figure 3.1 shows the sub-blocks that have been relinquished, where no project activities will occur. The relinquishments have reduced the overall size of the project development area to approximately 6,100 km^2 from the 8,600 km^2 presented in the EIS.

Field development planning has been refined to take advantage of the natural topography across the project development area, encouraging the flow of gas and water to natural low points. The project development area has been separated into 11 drainage areas (see Figure 3.1) that correspond with the gas reserves that will be fed into the CGPF located within each drainage area. The project development sequence presented in Section 3.5 is discussed in terms of drainage areas (DA1, DA2 and DA4 to DA12).

3.3 Description of the Gas Resource

The gas resources 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 (Goescience Australia & ABARES, 2010). The annual coal seam gas review by Energy Quest reported Australian gas reserves in the Australian Coal Seam Gas 2011: From Well to Wharf Report (Energy Quest, 2011). The report stated that 2P gas reserves in Queensland were rising steadily since the reporting period began in 2000. In 2011 the Surat Basin 2P reserve estimates were 23,354 PJ (Energy Quest, 2011).



coffey environments	Date: 05.06.2013 MXD: 7040AE_12_GIS054_v1_1 File Name: 7040_12_F03.01_GIS_VS	Arrow Energy Surat Gas Project	arrow energy go further	Drainage areas and relinquishments in the project development area	Figure No: 3.1

Ongoing exploration and proving of coal seam gas resources has resulted in revision of the gas composition produced in the Surat Basin. The revised coal seam gas composition is presented in Table 3.2.

Table 3.2 Typical Surat Basin coal seam gas composition

Component	Coal Seam Gas Composition (%)	
	EIS	SREIS
Methane	98.75	96.99
Ethane	0.01	0.01
Carbon dioxide	0.19	1.00
Nitrogen	1.05	2.00

3.4 Project Components

The main infrastructure components of the Surat Gas Project include:

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

Figure 3.2 provides a schematic diagram of the gathering network systems transporting coal seam gas and water from the production wells to the production, treatment and storage facilities.

Changes to the project components include revised typical or expected arrangements, configurations, construction methods and coal seam gas infrastructure design. Details of these changes are described in the sections below.

3.4.1 Production Wells and Groundwater Monitoring Bores

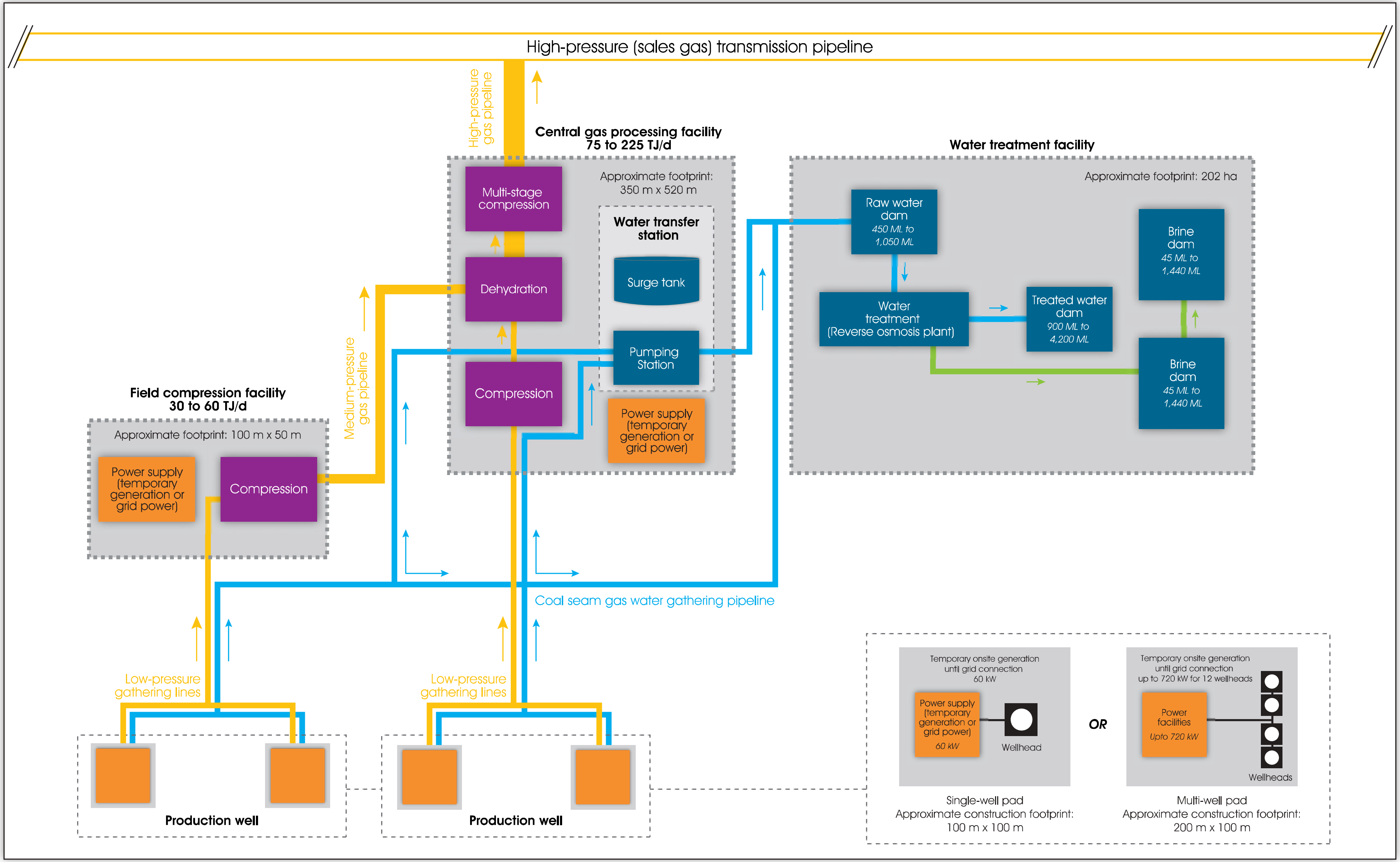
Production wells and groundwater monitoring bores are required as part of Arrow's statutory obligations and to inform gas field planning and design. This section describes changes to the number and type of production wells required for the Surat Gas Project, as well as the requirements for groundwater monitoring bores.

Production Wells

The anticipated number of production wells has reduced to 6,500 over the 35-year project life through the relinquishment of 29% of the project development area.

Arrow has introduced deviated drilling into its design basis. This component is in addition to the traditional vertical production wells presented in the EIS, whereby a single well is drilled vertically from the ground surface to the target coal seams.

Deviated drilling involves drilling the top of the well vertically down from the ground surface to a designed 'kick-off point', from which point a deviated well profile is drilled, using directional drilling technology, to intersect the target coal seams at an angle.



Source: Coffey 2013.

coffey environments	Date: 06.06.2013	Arrow Energy	arrow energy go further	Gas and water production and treatment	Figure No: 3.2
	File Name: 7040_12_F03.02_GL	Surat Gas Project			

The planned well path intersects the target coal seams at subsurface distances up to 800 m from the well entry at the surface. Deviated drilling technology is limited by the geology and depth of the target coal seam. Coal seams deeper than 400 m are typically suitable targets for deviated drilling.

Production wells will generally range from 300 m to 750 m in depth, depending on the depth of the target coal seams.

Details are provided below on the well life cycle, single- and multi-well pad sites, well pad spacing, and surface facilities.

Well Life Cycle

The physical life cycle of a well site remains as described in the EIS and comprises:

- Civil construction (site preparation).
- Drilling (drilling of wellbores).
- Facilities (installation of pad surface production equipment).
- Completions (installation of subsurface artificial lift (pump) systems).
- Connection (wells connected to surface production equipment).
- Production (wells online).
- Well intervention (maintenance, including workovers).
- Repeat production and well intervention cycle.
- Well plug and abandonment (end of well life).
- Pad site remediation.

Once a well is in production, access to it will be required for maintenance activities (at variable frequencies) by the well intervention team. Well sites will require access throughout the life cycle of the well.

Single- and Multi-well Pads

Wells will be drilled from both single-well pads (as described in the EIS) and multi-well pads. The single-well pads will typically be vertical production wells, while the multi-well pads will comprise vertical and deviated production wells. Multi-well pads will be comprised of up to 12 wells per pad (most commonly comprising 9 wells per pad), with wells spaced approximately 8 m apart. A likely configuration will comprise one central vertical production well, with the remainder of the wells being deviated production wells.

The multi-well pads consolidate a group of wells at one surface location, reducing the total number of well pad sites and the individual pad area required per well, and increasing the distance between adjacent multi-well pad sites. Overall, the total disturbance area resulting from well pads will be reduced. An example of what a multi-well pad facility may look like is shown in Plate 3.1.

Approximately 30% of wells will be conventional vertical wells drilled from single-well pads, with the remaining 70% expected to be arranged in multi-well pads, and installed by vertical and deviated drilling techniques.

Well Spacing

The spacing between wells will vary according to the coal depth and permeability. The inclusion of deviated well technology and the use of multi-well pads may increase the separation distance between adjacent wells.

Photo credit: www.usa.autodesk.com

Plate 3.1
Example of a multi-well pad facility

Photo credit: Arrow

Plate 3.2
Typical surface facility infrastructure for a high-point vent in the water gathering pipeline

Arrow aims to be flexible in siting well pads, targeting areas that will have minimum impact on the land use (e.g., farming practices) of the identified pad locations and surrounding land.

Well development around a CGPF typically occurs radially, with production wells progressively drilled at increasing distances from the facility in order to keep the facility 'full'. The timing of well development therefore depends on a well's distance from the facility and the overall production performance in the area. Initially, wells are typically drilled at double the in-coal well spacing which is nominally 800 m i.e., at approximately 1,600 m intervals. Subsequent wells will be drilled between the initial wells, in a practice sometimes known as infill drilling. The later stage of drilling completes the production well coverage of the target coal seams of the drainage area servicing the CGPF.

Land access negotiations with landholders will be based on the initial and subsequent drilling programs i.e., the ultimate arrangement of wells required to service the CGPF. Arrow has committed to an average well spacing of at least 800 m on intensively farmed land over the life cycle of development. This might result in individual wells being closer than 800 m when landholder requirements for the siting of wells are taken into consideration. Notwithstanding such situations, the average spacing of wells on intensively farmed land will not be closer than 800 m.

Surface Facilities

Surface facilities associated with a production well will be as described in the EIS and will include the well's artificial lift system (pump), metering skid, separation equipment, telemetry system and power supply. It is expected that wells that form part of a multi-well pad will be aligned at the surface in a row. All the wells in the pad will likely share the power supply and telemetry system, while maintaining their individual artificial lift system and metering skid. Such wells may also share common separation equipment.

Artificial Lift System. The artificial lift system will pump water from the coal seams to the surface, thereby reducing the hydrostatic pressure head on the coal seam. The reduced pressure allows the methane gas in the coal seam to be released into the well and subsequently produced through the wellhead at the surface. The system will consist of a subsurface pump, driven (from either at or below the surface) by electrical power.

Metering Skid. The metering skid at each well will house the metering equipment to measure produced gas and produced water from each well.

Telemetry System. Remote telemetry units (wellhead communications) installed at well sites will transmit data to the main control system at the respective CGPF (within the same drainage area), via either fibre optic cable laid with the gathering system or via a wireless network connection.

Separation Equipment. Depending on the rate of production from a well, wells may comprise a gas separation vessel to separate entrained water from the produced gas before it is fed into the gas gathering system. Similarly, a well may require a water separation vessel to separate gas from the produced water to reduce the build-up of gas in the water gathering system. Separation may also involve removal of solids from the gas and water streams.

Power Supply. The artificial lift system and telemetry require approximately 60 kW of peak power per well. The power is planned to be distributed at 22 kV (although 33 kV may be required depending on the final design configuration) from the relevant CGPF to the well site via an overhead line or underground cable (as required) or produced on site by coal seam gas–fired engines driving electrical generators.

Groundwater Monitoring Bores

The Underground Water Impact Report for the Surat Cumulative Management Area prepared by the Office of Groundwater Impact Assessment (formerly Queensland Water Commission) (QWC, 2012) requires Arrow to monitor and report groundwater levels in the project development area. Arrow will design and implement groundwater monitoring programs in accordance with the Office of Groundwater Impact Assessment requirements and conditions of environmental authorities.

The groundwater monitoring program developed for each environmental authority will be based on the findings of a specific risk assessment that considers the risks to groundwater associated with the project activities. The risk is determined by consideration of the site setting, authorised petroleum activities, pathways for groundwater impact, the consequence and likelihood of the impact, and control measures.

On the basis of the risk assessment, groundwater monitoring programs will be designed to detect any impacts from authorised petroleum activities which pose a significant risk to groundwater quality and seepage from any regulated dam.

The groundwater monitoring program will include the design and installation of a network of groundwater monitoring bores in areas of identified significant risk and if required, around specific infrastructure as required by the conditions of the applicable environmental authority. The program includes:

- Identification of background groundwater quality.
- Monitoring points, parameters to be measured, frequency of monitoring, and monitoring methodology.
- Trigger values, or the process for developing trigger values, for the measured parameters.
- Assessment of the potential for and level of impact caused in the event of contamination to underlying groundwater from the monitored infrastructure.
- Details of additional hydrogeological investigations to assess the extent and significance of potential contamination e.g., geodetic survey, aquifer testing, groundwater flow mapping.

Groundwater monitoring will also include interconnectivity investigations which will involve a series of bores drilled into the Walloon Coal Measures and over and underlying aquifers. Pump tests and long term monitoring will provide information on connectivity between the formations.

The location of groundwater monitoring bores will be determined, in part, by the predicted areas of greatest drawdown but also be planned to provide an overall understanding of groundwater behaviour in the project development area. Local biological, groundwater and surface water conditions will be considered in identifying sites for coal seam gas water and brine storage dams and the location of any groundwater monitoring bores.

Groundwater monitoring bores will be drilled using conventional groundwater drilling rigs and comprise a casing and downhole instrumentation including piezometers which record the piezometric head or water level in the target aquifers. Surface infrastructure typically comprises a capped casing, telemetry equipment for remote retrieval of data, a small hardstand area and fencing to protect the bore from disturbance or accidental damage. Telemetry systems are typically powered by solar panels and rechargeable batteries.

3.4.2 Gas and Water Gathering Systems

Gas and water gathering systems will be used to collect and transport the gas and water from the production wells to the production facilities. Gas and water gathering system pipelines will be made from high-density polyethylene (HDPE). The design pressure will be around 600 kPag for the gas gathering system and 1,000 kPag for the water gathering system, both of which are classified as 'low pressure' for pipelines. Where possible, pipeline routes will follow fence lines, roads or tracks to minimise disturbance, especially on intensively farmed land.

The low-pressure gas and water gathering pipelines will transport gas to a CGPF (or to a field compression facility where the distance from the well to a CGPF is too great) and produced water to a water transfer station or directly to a water treatment facility.

Gas and water gathering systems include the components described in the EIS (as summarised below), as well as gas and water nodes, which have been included through further development of the gathering system design and are also described below. Reticulated power will be installed in conjunction with the gas and water gathering systems (either as underground cables or overhead distribution lines in the same right of way, wherever possible).

Low-point Drains. As gas flows through the gas gathering pipeline, water will condense and collect at low points, potentially impeding gas flow. Collected water will be removed using low-point drains and then transferred into the adjacent water gathering pipeline as shown in Figure 3.3.

Surface facilities for the low-point drains will occupy an area of up to approximately 5 m by 5 m. The intent is to design pipelines to minimise the number of low-point drains and maximise the distance between low points by using the natural gradient of the ground surface.

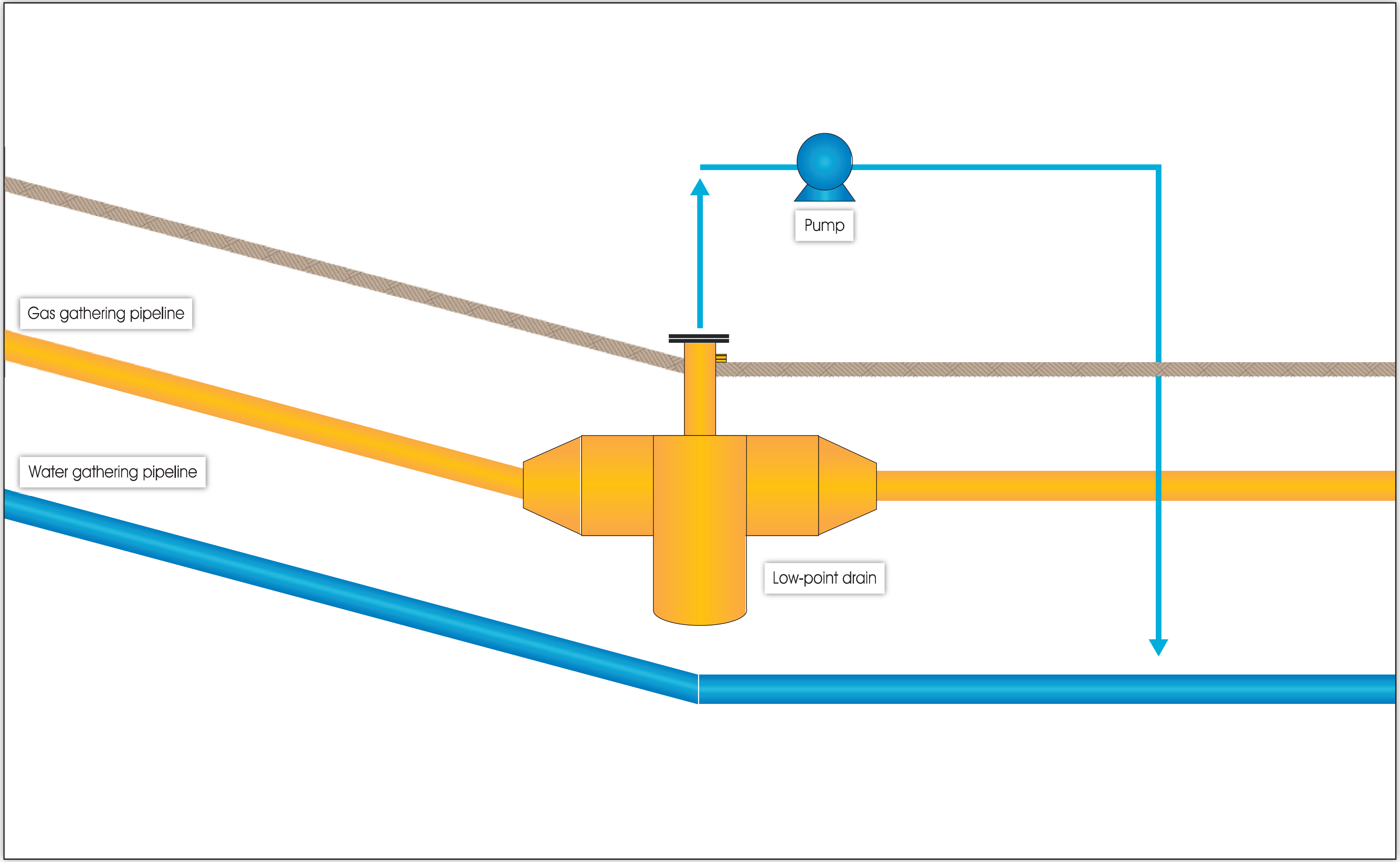
High-point Vents. In instances where water pipelines peak at the top of a slope, dissolved gases that have vapourised within the water pipeline have the potential to collect at high points, creating a partial water flow blockage. High-point vents allow collected gas to be released to the atmosphere (or in some cases directed to the gas gathering pipeline), resulting in restored water flow. The high-point vent surface facilities (Plate 3.2) will occupy an area of approximately 3 m by 3 m.

Pump Transfer Stations. Water pumping stations will be installed in low-lying areas to increase the pressure of the water collected in the gathering network, allowing the water to reach the water treatment facilities. The stations will occupy an area of up to approximately 50 m by 100 m.

Gas and Water Nodes at Major Watercourse Crossings. Gas and water nodes will be constructed adjacent to major watercourse crossings to consolidate multiple pipelines in one crossing. The nodes will incorporate a collection sump on the gas gathering pipeline to capture water entrained with the gas, which will be pumped into the adjacent water gathering pipeline.

3.4.3 Production Facilities

CGPFs will be established across the project development area to achieve compression and dehydration of gas for input to the sales gas pipeline. The sales gas pipeline will transport the processed gas from the CGPFs to the domestic gas market or to a liquefied natural gas (LNG) plant prior to shipment to overseas gas markets. Field compression facilities will improve compression at sites where wellhead pressure is not sufficient to transport the gas directly from the wells to a CGPF. The requirement for field compression facilities will depend on improved knowledge of coal seam gas reserves and field development planning.



Based on Figure 5-6 from Arrow PD

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Arrow Energy

Surat Gas Project

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Low-point drain in gas gathering line

Figure No: 3.3

Facilities included in the SREIS are referred to by their function rather than their location (or co-location with other facilities), e.g., CGPF and water treatment facility. Therefore, the co-location of a water treatment facility with a CGPF (as described in the EIS) is no longer referred to as an 'integrated processing facility'.

Central Gas Processing Facilities

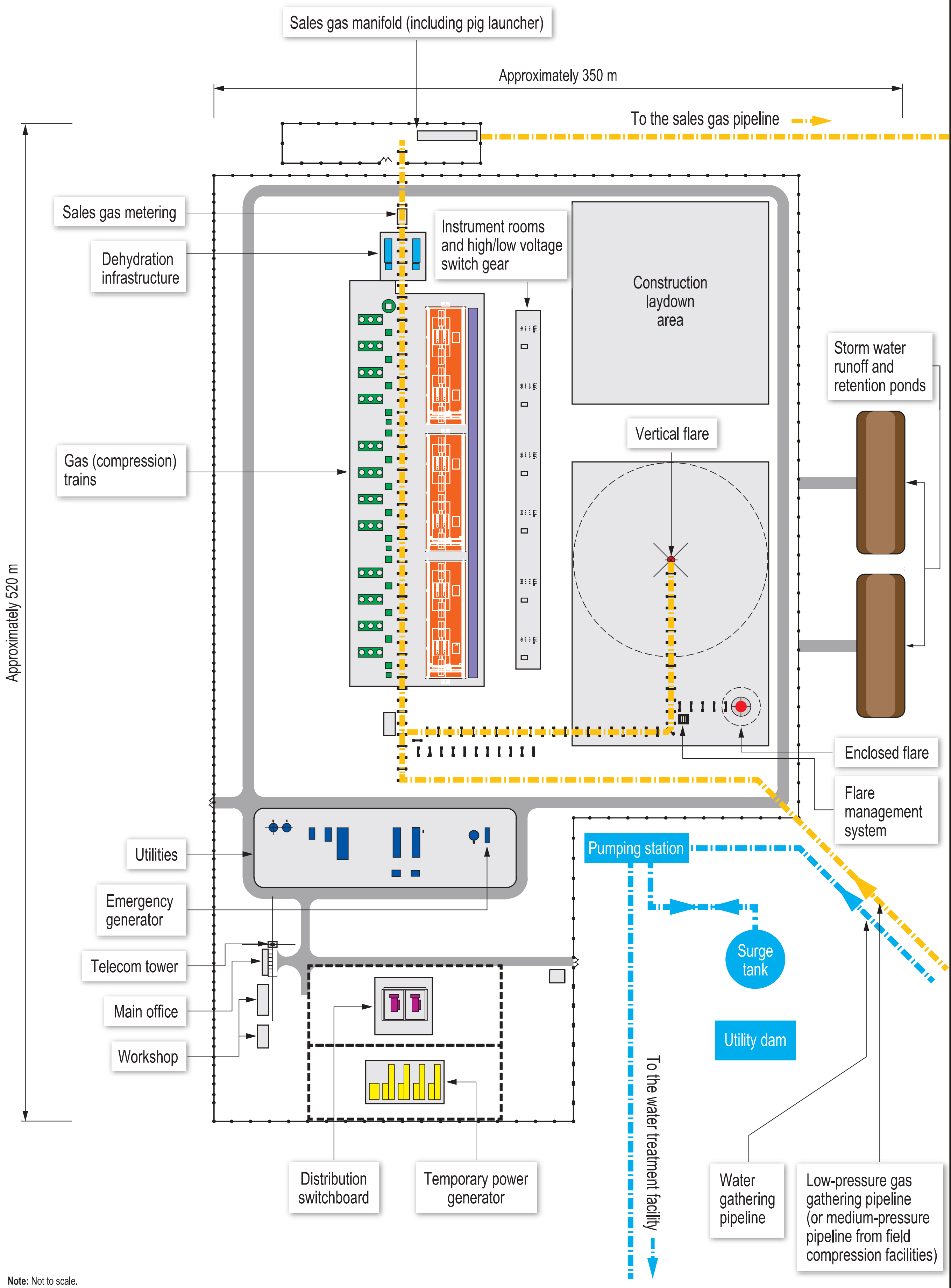
Gas collected in the gathering systems will be piped to one of the eight planned CGPFs. The CGPF's functions remain as described in the EIS and are to:

- Receive gas from wells located within the facility drainage area.
- Remove any bulk water remaining in the gas through a slug catcher. Bulk water in the gas is removed through the use of low-point drains along the gathering system, with bulk water described as free water. The slug catcher is a vessel at the CGPFs, which has sufficient buffer volume to trap the largest slugs of free water expected to arrive at the CGPFs, allowing removal from the gas.
- Compress and cool the gas 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 at the facility and at the associated wells.
- Flare gas in the event of plant upset conditions or control failure. During normal operation, coal seam gas is constantly flowing through the CGPFs. Whenever there is an interruption to the usual operation of the facility, such as an equipment or power stoppage, the constant flow is interrupted and any excess coal seam gas is sent to the flare. Burning the excess gas through combustion ensures the gas is managed safely and does not escape into the atmosphere as methane.
- Receive high-voltage power from the grid, step down the voltage and distribute power to users within the facility and to water treatment and wellhead facilities.

CGPFs will typically receive gas from the low-pressure gas gathering systems, however CGPFs may also receive gas from medium-pressure gas gathering systems, should the contingency option of field compression facilities (from which gas is transported at medium pressure), be adopted. Medium-pressure gathering lines may require a slightly wider construction right-of-way than the low-pressure gathering lines (20 m) of up to 25 m.

The EIS explained that these facilities would dehydrate and compress between 30 and 150 TJ/d of gas to 10,200 kPa, using electrically driven compressors, with each compressor module having the capacity to dehydrate and compress 30 TJ/day gas. It was also proposed that screw and reciprocating compressors would be used.

Development of the basis for design currently proposes that each facility will comprise between one and three compressor trains, each of which will have the capacity to process 75 TJ/d of gas. The CGPFs will typically compress 75 to 225 TJ/d of gas (in contrast to between 30 and 150 TJ/d of gas presented in the EIS). A sparing capacity of one additional train may be adopted at each facility (or 75 TJ/d). Each train will compress the gas from 70 kPag to the sales gas pipeline pressure of 10,200 to 13,500 kPa, using electrically driven centrifugal compressors. A typical CGPF arrangement is shown in Figure 3.4, including the location of stormwater runoff retention and sediment control ponds.



Note: Not to scale.

coffey environments	Date: 25.06.2013 File Name: 7040_12_F03.04_HB	Arrow Energy / Surat Gas Project	arrow energy go further	Typical CGPF arrangement	Figure No: 3.4

The design considerations to be addressed in FEED, which were explained in the EIS, are presented below:

- **Modularisation.** Method for minimising onsite construction periods and associated disturbance through use of similarly configured facilities.
- **Layout.** The specific orientation and layout of each facility, dependent on site-specific conditions and the proximity to sensitive receptors. The footprint for a CGPF will be approximately 350 m by 520 m.
- **Compression.** Centrifugal compressors will be used at the CGPFs. These compressors require less maintenance and are quieter than screw and reciprocating compressor options. Each compressor train will contain inlet separation to remove any water from the gathering system and inter-stage separation to remove water vapour condensed by compression of the gas. Air-cooled heat exchangers (four per compressor train) will cool the processed gas.
- **Dehydration.** The gas will require dehydration at each CGPF to remove water using triethylene glycol. The dehydration unit will be installed immediately upstream of the sales gas metering equipment within the CGPF.
- **Supporting Infrastructure**. Supporting infrastructure associated with the CGPFs includes:
  - Utility dams: for storage of contaminated water, which may contain dilute solutions of chemicals used in the operation and maintenance of the compressors and triethylene glycol units.
  - Power generation facilities: may be constructed during the initial phase of operation until the CGPFs are connected to grid power.
  - High voltage substations and high voltage transformers: to receive power from the electricity transmission grid.
  - Water transfer stations: located at each CGPF and comprising a surge tank (degassing tank) and pumping station. They transfer water from the associated gathering network to one of the two water treatment facilities.

Field Compression Facilities

Field compression facilities described in the EIS have been retained in the revised project description, as a contingency option. Should field compression facilities be required, the location would be considered in accordance with Arrow's commitment to avoid major infrastructure on intensively farmed land (see Chapter 7, Agriculture for further discussion on intensively farmed land). Field compression facilities would likely be located between production wells and the CGPFs. The maximum number of field compression facilities (six) and approximate footprint (100 m by 50 m), has not changed from the EIS.

3.4.4 Water Treatment and Beneficial Use Network

The EIS presented the concept of integrated processing facilities which comprised gas compression, power generation and water treatment facilities. Six integrated processing facilities were proposed at conceptual locations presented in Figure 5.11 of the EIS. Refinement of the project description has resulted in the number of water treatment facilities being reduced from six to two, to be located adjacent to CGPFs.

The northern water treatment facility will be co-located with CGPF2 and is located north of Miles, adjacent to Bottle Tree Creek. This facility is planned to have the capacity to treat approximately 35 ML/d of coal seam gas water.

The southern water treatment facility will be co-located with CGPF9 and is located near Cecil Plains on the Condamine River floodplain. This facility is planned to have the capacity to treat approximately 90 ML/d of coal seam gas water.

The water treatment facilities may be connected by a pipeline to enable the transfer of water to meet the variable demand for beneficial use expected at each location, and to address operational and environmental requirements for discharge (distribution or disposal) of coal seam gas water.

Beneficial use of coal seam gas water is the preferred management option. Beneficial use options include the distribution of coal seam gas water for substitution and augmentation of existing groundwater allocations and new water-dependent uses, and the treatment of brine to produce commercial products.

The water and brine treatment facilities are described below along with the water and brine storage requirements, and the beneficial use network for distribution of coal seam gas water to end users.

Water Treatment Facility

Coal seam gas water will be treated through desalination via reverse osmosis, producing a low salinity (treated water) stream, as well as a high salinity (brine) stream that then requires further treatment. Several pre-, post- and ancillary treatment processes that support the reverse osmosis process will optimise the performance of the water treatment facility.

The area required to establish a water treatment facility (approximately 202 ha) has not changed from that presented in the EIS. The capacity of the raw and treated water and brine dams is dependent on the coal seam gas water and salt management strategy. The ranges of dam sizes being investigated, which incorporate those presented in the EIS, are as follows:

- Raw (untreated) water dams with a capacity of approximately 450 ML to 1,050 ML.
- Treated water dams with a capacity of approximately 900 ML to 4,200 ML.
- Brine dams with an overall capacity of approximately 90 ML to 2,880 ML.

A number of options are available for the end use or disposal of treated coal seam gas water each requiring infrastructure that is specific to that option. Further details on the coal seam gas water and salt management strategy are presented in Section 3.7, Water and Brine Management.

Brine Treatment Facilities

The preferred management option for the brine by-product that results from treatment of the coal seam gas water is recovery of salt for beneficial use. A selective salt recovery plant operated by either multiple coal seam gas industry proponents (producing multiple salt products) or by Arrow (producing a single salt product) is being considered. In both instances, brine concentrators located either at the water treatment facilities or with the selective salt recovery plant and transfer pipelines would be required. The transfer pipeline would transport brine produced at the water treatment facilities (either as brine or concentrated brine, depending on the location of the brine concentrators) to the selective salt recovery plant.

Arrow is actively involved in an assessment of the feasibility of both the joint-industry and Arrow-only brine management options. The selected facility option and its supporting infrastructure will be subject to a subsequent approvals process.

Section 3.7.5, Brine and Salt Management Options, describes the other brine management options that Arrow is investigating. If any of these options were to be carried forward, it would also be addressed through a subsequent approvals process.

Beneficial Use Network

Treated and untreated coal seam gas water will be distributed to end users for beneficial use as a preference to disposal. A beneficial use network will be established from either or both water treatment facilities to deliver water to the agreed delivery point where the end user will take responsibility for the water and its use.

The beneficial use network will comprise a trunk pipeline from the water treatment facility to the reticulation network that will deliver water to the delivery points. The trunk and distribution pipelines will typically be constructed from HDPE pipe and include stop valves, scour valves, air vents and meters.

Where practicable they will be co-located with gas and water gathering lines. Construction and operation of the beneficial use network will be consistent with the methods and procedures adopted for construction and operation of the water gathering lines. Therefore, reference to and the assessment of gas and water gathering systems in the SREIS includes the beneficial use network.

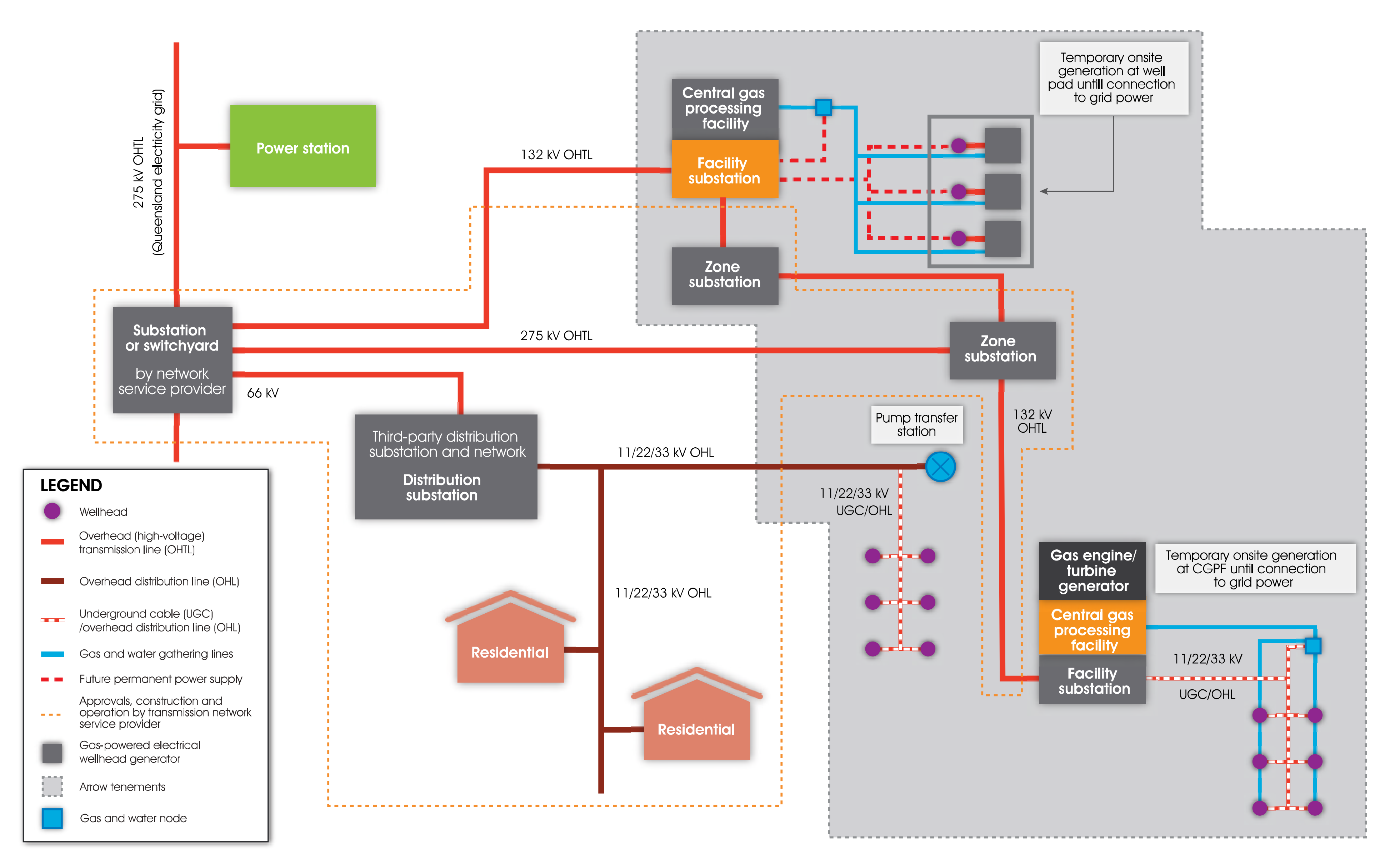
3.4.5 Power Requirements

Power is required to operate production wells, production facilities and associated infrastructure 24 hours per day, 365 days per year except during periods of scheduled and unscheduled maintenance. Electricity and other energy sources (e.g., natural gas or solid and liquid fuel) will be required throughout the life of the project. Arrow therefore seeks to conserve energy in line with government policies through consideration of energy efficiency in the design and procurement of electrical equipment.

The project description presented in the EIS proposed a combination of mechanical and electrical power, with all electric power identified as an alternative option under consideration. Electric power sourced from the Queensland electricity grid is now Arrow’s preferred power supply option. However, onsite power generation may be temporarily required in the initial phase of operation until production facilities, production wells and associated infrastructure are connected to the electricity transmission grid.

Electricity transmission infrastructure required to connect supply points to the Queensland electricity grid will be subject to subsequent environmental approvals processes by the transmission network service provider. Environmental impacts associated with the construction and operation of Arrow’s electricity distribution infrastructure will be assessed as part of environmental authority applications, as the location and configuration will be resolved in conjunction with finalisation of the location of production facilities, production wells and the associated gas and water gathering systems.

The proposed arrangement of electricity transmission and distribution infrastructure and the temporary power generation requirements are described in the following sections. The proposed power supply arrangement from the electricity grid is shown in Figure 3.5.



coffey environments	Date: 26.06.2013	Arrow Energy	arrow energy go further	Proposed power supply arrangement (from electricity grid)	Figure No: 3.5
	File Name: 7040_12_F03.05_GL	Surat Gas Project			

Power Supply Arrangement

Electricity will be supplied to the project by the transmission network service provider from the electricity transmission grid and, as required, distribution networks. High-voltage transmission lines (to be constructed and operated by the transmission network service provider) will transmit power from switchyards or substations in the Queensland electricity transmission grid to zone or Arrow substations, respectively, to be established in the vicinity of or adjacent to CGPFs. A high-voltage overhead transmission line will transmit power – at the required voltage (typically 132 kV) – to an Arrow substation located within each CGPF either from the substation via a zone substation or directly from the switchyard.

Arrow will construct, own, operate and maintain the substation at each CGPF. All other transmission infrastructure will be constructed, owned, operated and maintained by the transmission network service provider.

Arrow will establish an electricity distribution network that will take supply from the Arrow substations and transmit electricity to production facilities, production wells and associated infrastructure, including water treatment facilities.

In some instances (where extension of the Arrow distribution network is not feasible or economical), electricity may be supplied directly to production wells and associated infrastructure by a distribution network service provider via extension of its electricity supply network. Electricity within Arrow's electricity distribution network will be distributed through overhead power lines or underground power cables, as required.

Emergency diesel engine generators will be installed at each CGPF to maintain power supply in the event of a trip or fault on the electricity grid. The emergency generators will automatically cut in to maintain power to essential services at the CGPF.

Transmission Lines

Predominantly, 132-kV overhead transmission lines will be used to connect the transmission network supply point (substation or switchyard) to the zone substations, which will be owned and operated by the network service provider, or to the substations at the CGPF, which will be owned and operated by Arrow. In some instances, it may be necessary for the installation of 275-kV overhead transmission lines. If the network service provider installs a zone substation in the vicinity of a CGPF, a transmission line will connect the zone substation to the substation located within the CGPF.

The transmission lines will comprise single and double circuits, with conductors suspended on steel lattice towers or guyed steel lattice towers or poles spaced at approximately 120 m to 400 m intervals depending on the type of tower or pole. Access tracks to and in some instances between the towers will be required to construct, inspect and maintain the transmission lines.

The network service providers will be responsible for seeking approvals, permitting, construction and operation of electricity supply infrastructure required to enable connection of the substations or switchyards and the zone substations to the electricity grid, including any new substations, transmission lines, system control and integrity equipment, and access tracks.

The network service providers responsibilities will also include selection of the alignment for transmission lines, and placement of substation equipment based on their planning and environmental constraints. The type, spacing and height of towers or poles will be determined by the transmission network service provider.

The typical easement width required for 132-kV overhead transmission lines is up to 60 m depending on the number of circuits. A typical easement width required for 275-kV overhead transmission lines is up to 120 m. Vegetation on the easement will be cleared in accordance with the applicable policies of the network service provider. Typically, an access track will be maintained along or adjacent to the centreline of the transmission line for operations and maintenance purposes.

Zone Substations and Facility Substations

Zone substations are required where there may be more than one CGPF in the region requiring power from the electricity transmission grid. In this case, the network service provider will develop a zone substation in the vicinity of the CGPF.

The zone substation will then provide power to the adjacent CGPF substation by a short length of transmission line (typically 132 kV) and also continue the transmission network (typically 132 kV transmission line) to the next CGPF location.

Some CGPFs will not require an adjacent zone substation to be installed, because there is no requirement to transmit power beyond that point. In this case the transmission lines will be connect directly to the substation at the CGPF and not to a zone substation.

The substations at the CGPF will provide power to the production facilities, production wells and associated infrastructure, including the water treatment facilities proposed at CGPF2 and CGPF9.

A 330-m by 280-m footprint is typically required to establish a 132-kV zone substation. A 500-m by 500-m footprint is typically required to establish a 275/132-kV zone substation. The Arrow substations will be incorporated within the footprint of the CGPFs.

Arrow will own, operate and maintain all power distribution lines or underground cables (132 kV, 66 kV, 33 kV, 22 kV or 11 kV) required to provide power from the substation within each CGPF to the field compression facilities, production wells and other infrastructure, as determined by load requirements. Voltage levels will be selected as appropriate.

Arrow's Distribution Network

Electricity supplied to facility substations will be distributed to production facilities, production wells and associated infrastructure via a network of overhead distribution lines and underground cables.

Typically, the production facilities and water treatment facilities will be supplied by 66-kV or 132-kV power lines, with production wells, water transfer stations, and field compression facilities supplied by 11-kV, 22-kV and 33-kV power lines or underground cables depending on their location relative to the zone or Arrow substation, the expected load, land use, landholder requirements, and site conditions.

Underground cables to production wells will have a typical burial depth of 1.2 m and will be laid in the same trench or easement as the gas and water gathering systems. The final burial depth will be determined by the surrounding land use, landholders' requirements and other subsurface features, such as pipelines.

By exception, production wells remote from production facilities will be powered by gas-engine generators or with power from a third-party distribution substation and network.

Temporary Power Generation

Temporary power generation may be installed to provide power during commissioning and in the initial phase of operation, to accommodate potential delays in the connection to grid power. It is not expected that temporary generation would be required for a period longer than two years. A maximum capacity of 50 MW of temporary power generation has been allowed for each CGPF.

Several options have been investigated for providing the temporary generation capability at CGPFs. The generator units considered range from 1.1-MW, high-speed reciprocating gas engines to 5.7-MW gas turbines (requiring a footprint of up to 150 m by 160 m within the overall CGPF footprint).

The number of generating units will be determined by the power demand in the initial phase and may include a sparing configuration to achieve the estimated maximum capacity of 50 MW per facility.

Wellhead Power Supply

The wellhead equipment for a single-well pad, comprising artificial lift system (pump) and other electrical equipment, requires approximately 60 kW of peak power (which means that the peak power requirement for a multi-well pad with up to 12 wellheads is approximately 720 kW). Typically, the power is distributed at 22 kV (33 kV may be required depending on the final design) from the relevant CGPF to the well site via an overhead distribution line or underground cable as required or produced on site by coal seam gas–fired engines driving electricity generators. In some cases, it will be distributed directly from a third-party distribution substation and network via an 11/22/33-kV overhead transmission line.

3.4.6 Supporting Infrastructure and Logistics

Changes to the main supporting infrastructure and logistics required to operate the various extraction, gathering and production facilities are outlined below.

Depots

Depots will accommodate areas for administration, engineering and production, supervisory support, occupational health and safety management, stores, workshops and laboratories and the associated personnel. The depots are likely to be located in the township of Dalby, servicing the Dalby and Kogan regions, and the township of Miles, servicing the Wandoan and Chinchilla regions. A depot is not expected to be required in Millmerran as originally proposed.

Aggregate

The project construction activities will require foundation aggregate for the construction of camps, access tracks, wells and other facilities. The estimated aggregate volume has been revised to capture changes to the project design (e.g., the reduction in the anticipated total number of wells), temporary aggregate requirements for construction (which expand on the hardstand material footprint), multi-well pads and provision for access roads based on nominal lengths and widths (which will be verified once well and facility locations are known). Aggregate or hardstand material is not required for the entire construction footprint of a particular well pad or facility. The revised aggregate volumes are presented in Table 3.3.

Table 3.3 Indicative aggregate volumes

Drainage Area	CGPF (m^3)	Water Treatment Facilities (m^3)	Field Compression Facilities (m^3)	Camps (m^3)	Single-well Pads (m^3)[1]	Multi-well Pads (m^3)[1]	Access Roads	Total Aggregate (m^3)
1	27,300	3,150	1,500	–	25,164	23,051	95,064	175,229
2	27,300	3,150	1,500	24,000	43,092	39,474	162,792	301,308
4	–	–	–	–	32,400	29,680	122,400	184,480
5	27,300	3,150	1,500	13,500	33,048	30,274	124,848	233,620
6	–	–	–	13,500	25,920	23,744	97,920	161,084
7	27,300	3,150	1,500	–	15,336	14,049	57,936	119,271
8	27,300	3,150	–	–	49,734	45,559	187,884	313,627
9	27,300	3,150	–	13,500	46,008	42,146	173,808	305,912
10	27,300	3,150	1,500	13,500	25,110	23,002	94,860	188,422
11	27,300	3,150	1,500	–	35,478	32,500	134,028	233,956
12	–	–	–	–	19,710	18,055	74,460	112,225
Total	**218,400**	**25,200**	**9,000**	**78,000**	**351,000**	**321,533**	**1,326,000**	**2,329,133**

[1] The estimated aggregate requirements for the single well and multi-well pads within each drainage area, considered an estimated distribution ratio for the number of single well pads compared to multi-well pads, of 3:7 (e.g., if there were 100 wells in a drainage area, it was estimated that 30 were to be drilled on single well pads and 70 to be drilled on a multi-well pad typically comprising 9 wells, resulting in 8 multi-well pads). It should also be noted that a multi-well pad has a far smaller footprint (and thus aggregate requirement) than that for the same number of wells drilled on single well pads.

Accommodation Facilities

Accommodation for the construction and operations workforces for the Surat Gas Project will include a combination of temporary construction camps and permanent housing, as described in the EIS. Further details on the construction and operation of accommodation facilities are provided in Section 3.6.8, Workforce and Accommodation.

Potable Water

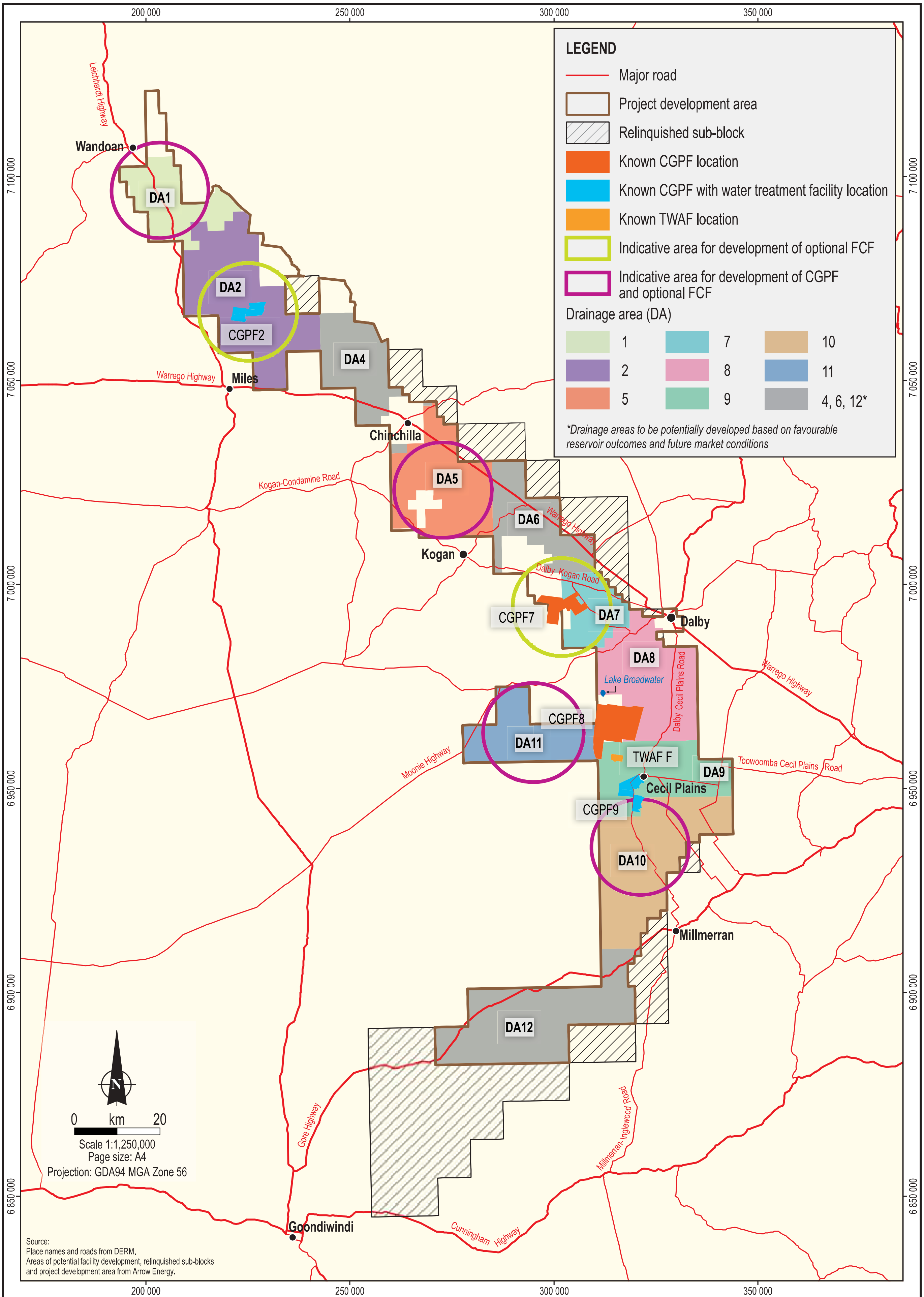
Potable water will be sourced from existing town water supplies and groundwater bores as presented in the EIS, as well as third party reticulated water supply networks.

Other Supporting Infrastructure and Logistics

Other supporting infrastructure and logistics requirements, including telecommunications, remain unchanged from the description provided in the EIS.

3.5 Conceptual Development Sequence and Infrastructure Location

Greater understanding of the gas resource and of options for field optimisation has resulted in changes to the number and arrangement of facilities, including CGPFs and production wells. Eight CGPFs, each with its own drainage area of wells and associated gas and water gathering lines, will be developed initially, with a further three CGPFs potentially being developed based on favourable gas reservoir outcomes and future market conditions (Figure 3.6). Two of the eight CGPFs (CGPF2 and CGPF9) will be co-located with water treatment facilities.



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Arrow Energy

Surat Gas Project

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Conceptual location of production facilities

Figure No: 3.6

Field compression facilities were proposed to be located within their own 12-km-radius areas in the EIS. These facilities may now be located between production wells and the CGPFs to improve compression at sites where wellhead pressure is not sufficient to transport gas to the larger production facilities. Field compression facilities, if required, are expected to be located within a 12-km radius of a CGPF; however, the ultimate location will depend on field development planning. Up to six field compression facilities may be required and are most likely to be located in drainage areas DA1, DA2, DA5, DA7, DA10 and DA11 in the later stages of the development of each area.

Since the EIS was published, Arrow has identified properties on which to site four CGPFs and one temporary workers accommodation facility (TWAF). It is intended that all properties identified for major facilities (i.e., CGPFs, water treatment facilities, TWAFs) will either be owned by Arrow, or leased under a long-term arrangement. The specific locations within the properties identified for each of the CGPFs will be guided by site-specific technical, environmental and social features, including ground stability, elevation, remnant vegetation, topography, and proximity of sensitive receptors. These four CGPFs are central to development of drainage areas DA2, DA7, DA8 and DA9. The remaining four CGPFs will be located in drainage areas DA1, DA5, DA10 and DA11, somewhere within the 12-km-radius areas of indicative development locations shown on Figure 3.6.

An indicative sequence for development of the production facilities within each drainage area is shown in Table 3.4. The estimated construction timeframe for a CGPF is 55 weeks. If a water treatment facility is co-located with a CGPF, the overall construction timeframe extends to 60 weeks. A two-year window for construction is shown to account for the situation where construction starts in one calendar year and finishes in another.

Table 3.4 Indicative development sequence for production facilities

Year	**Production Facility Construction**							
	DA9	**DA2**	**DA8**	**DA1**	**DA7**	**DA5**	**DA10**	**DA11**
2014								
2015	**CGPF9**	**CGPF2**	**CGPF8**					
2016				**CGPF1**	**CGPF7**			
2017								
2018						**CGPF5**	**CGPF10**	**CGPF11**
2019								
2020								
2021								
2022								
2023		FCF*		FCF*				
2024					FCF*			
2025						FCF*		FCF*
2026							FCF*	

* FCF = field compression facilities if required.

The revised rate of development for the Surat Gas Project is faster than that which was presented in the EIS. Commissioning of eight CGPFs is anticipated to occur over six years from the commencement of the project. This compares with the indicative development sequence that was proposed in the EIS, which predicated that only six CGPFs would be commissioned over the same period. Sequencing will be modified according to subsurface performance of wells and the status of the receiving LNG plant facilities. The development sequence of wells and the associated gathering systems aims to keep gathering lines and CGPF compression trains full, by developing progressively out from CGPFs.

Arrow operates existing gas fields, facilities and infrastructure in the area surrounding Dalby. Production facilities are located at Daandine, Kogan North and Tipton West. The Surat Gas Project will supply a sustained gas production of 1,215 TJ/day, of which 1,135 TJ/day will be exported as LNG and 80 TJ/day will continue to be used for domestic consumption under existing gas sales agreements. Sustained production at this rate is expected to continue for approximately nine years, during which time wells will be drilled at an average rate of approximately 400 wells per year, before starting to decline.

The time it takes for the sustained production target to be achieved reflects the rate at which:

- Production facilities can be constructed (including approvals).
- Wells can be drilled and completed (including approvals).
- Gathering systems and power lines can be installed (including approvals).

Other factors include:

- Subsurface performance of the gas field.
- Possible constraints on the end use of water.
- Logistics constraints on the delivery of hardware or services.
- Cost constraints.

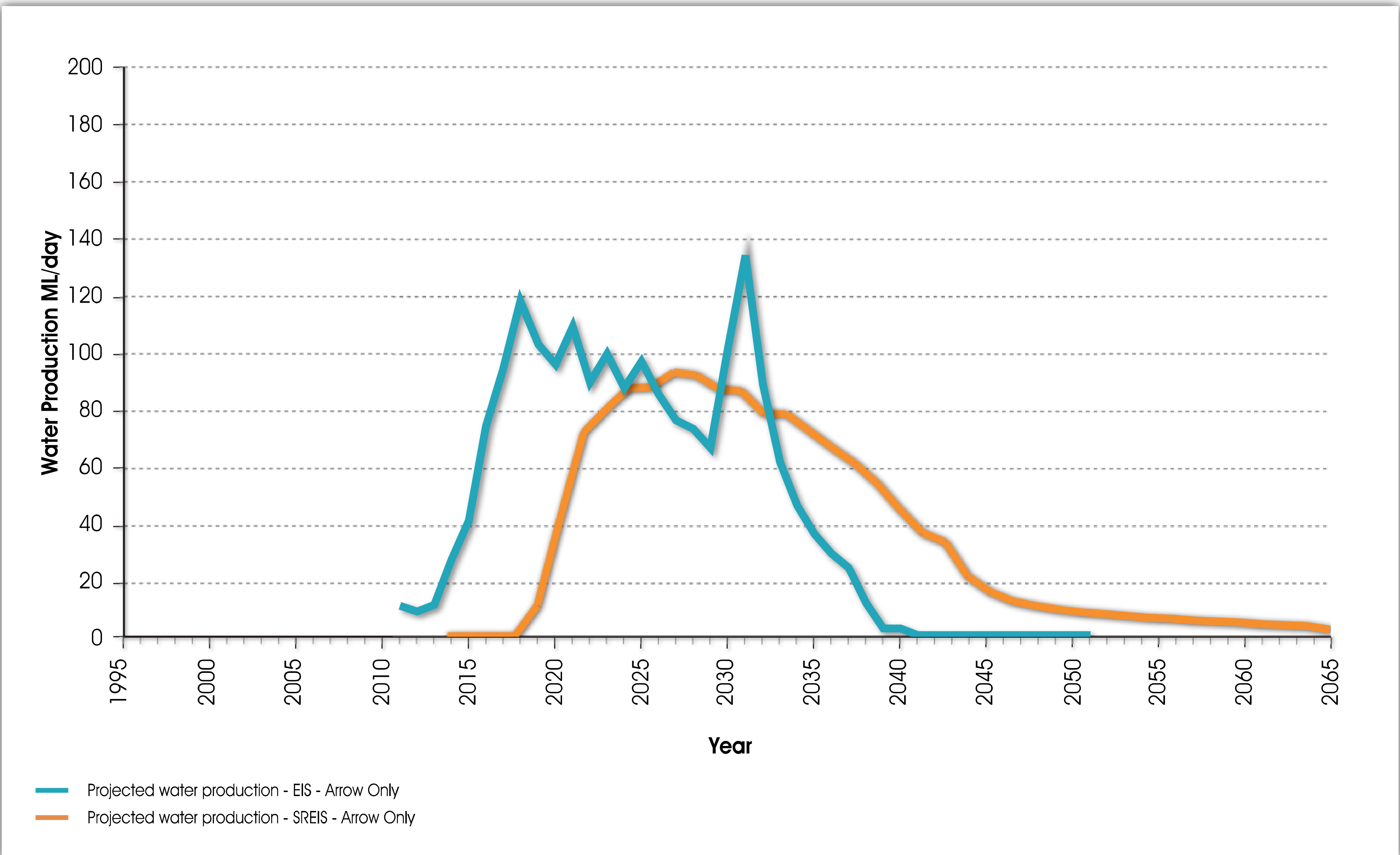
The revised development case changes the coal seam gas water production profile and estimated average, peak and total volumes of water produced over the life of the project. The revised coal seam gas water production profile is shown in Figure 3.6a[1]. Based on the current development case, average coal seam gas water production is estimated at 13 GL/a, with peak production estimated at 34 GL/a, a reduction from the average (22 GL/a) and peak (43 GL/a) production estimates reported in the EIS. The total production has decreased from 694 GL over 35 years used in groundwater modelling for the EIS, to 510 GL over 40 years. Despite production being estimated over a longer timeframe, total production has reduced due to the relinquishment of tenure and subsequent reduction in the number of wells.

The expected sequence of development over the life of the project is shown in Figure 3.7 recognising that the project's development case will continue to be refined over the life of the project to address emerging policy, evolving industry best practice, the project's business case and operational experience.

3.6 Construction, Operation and Decommissioning

This section describes instances where the SREIS development case and design basis have altered the activities associated with the construction, operation or decommissioning of the project components.

[1] Figure 3.6a is a new figure inserted to include additional information. It does not relate to the content of Figure 3.6.



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Date: 25.06.2013

File Name: 7040_12_F03.06a_JO

Arrow Energy

Surat Gas Project

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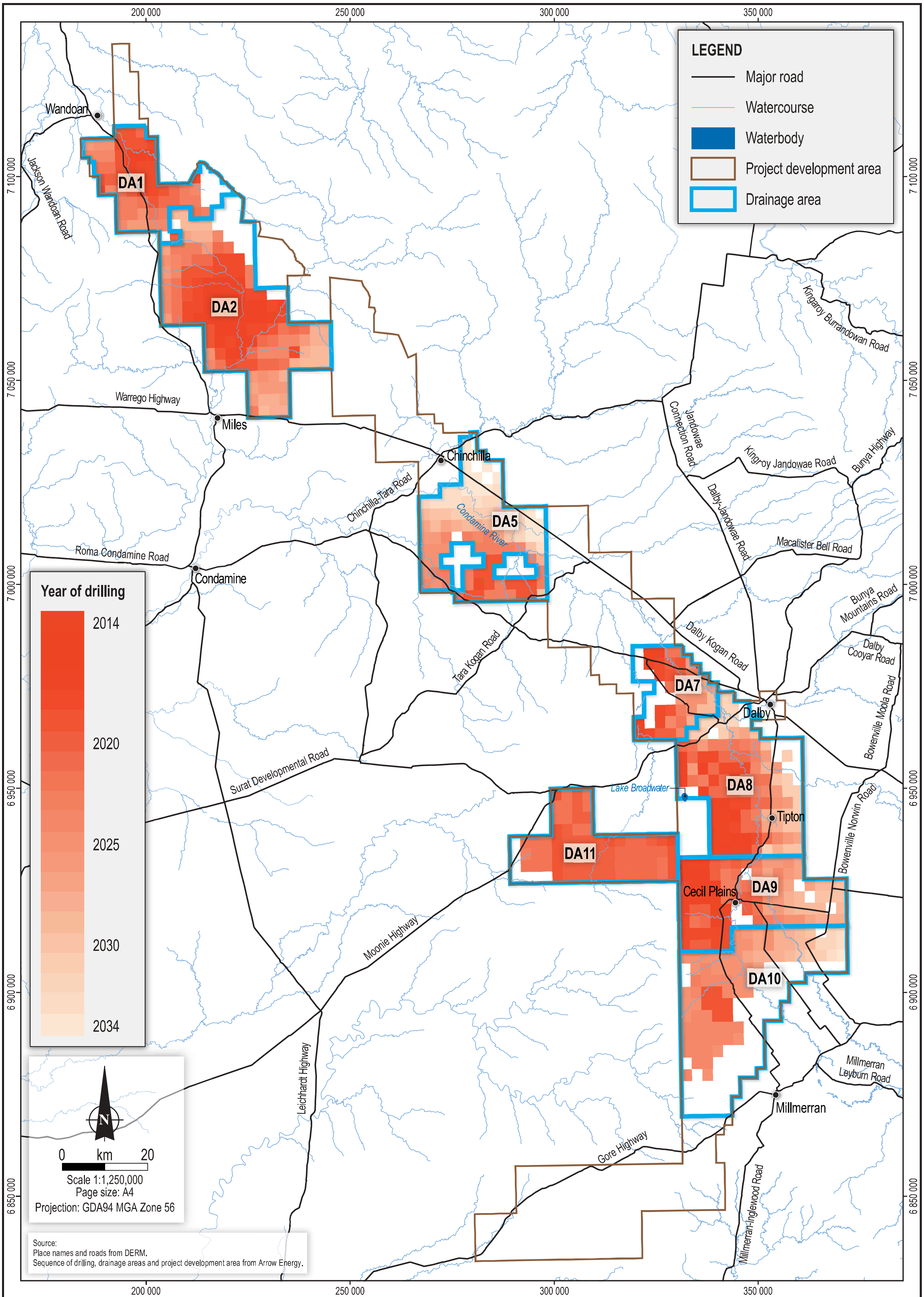
Comparison of estimated water production for the current development case and the EIS development case

Figure No: **3.6a**



coffey environments	Date: 14.06.2013 MXD: 7040AE_12_GIS064_v1_2 File Name: 7040_12_F03.07_GIS_VS	Arrow Energy Surat Gas Project	arrow energy go further	Development sequence for the first 20 project years	Figure No: 3.7

3.6.1 Production Wells

Well sites will be assessed on an individual basis to establish the drilling lease footprint, with the aim of reducing the footprint as much as practicable. The drilling lease footprint required for a single-well pad, including associated sediment and erosion controls and temporary aggregate storage, has been revised to 100 m by 100 m (or 1 ha).

Multi-well pad drilling lease footprints will vary to some extent depending on the type of drilling rig used but will largely be affected by the number of wells installed. The drilling lease footprint for a large multi-well pad containing up to 12 wells may be up to 100 m by 200 m (or 2 ha), including associated sediment and erosion controls and temporary aggregate storage.

Well Installation

Well installation (and abandonment) will be carried out in accordance with strict well design and management procedures, which will be compliant with Queensland regulations, including the Code of practice for constructing and abandoning coal seam gas wells in Queensland (Queensland Government, 2011), a code that was finalised after the EIS was prepared.

The well installation process described in the EIS has been changed to take account of the code and to further describe the method Arrow will use to achieve aquifer isolation (for both vertical and deviated wells). Improved techniques for managing drilling fluids are in the process of being tested.

Wells drilled into the target coal seams will pass through shallower aquifers. Aquifer isolation in vertical and deviated wells will be achieved by lining the well with a steel casing and cement to form a physical barrier between the coal seam producing zones and the identified aquifers. Multiple steel casings and cement may be used depending on individual well requirements to provide a physical barrier between the producing zones through to the surface.

During drilling, drilling fluids (also known as mud or drilling mud) are pumped down the drill string for the primary purposes of lubrication, removal of formation cuttings and provision of a primary barrier for well control. The EIS explained that, during and after drilling, the drilling fluids would be collected at the surface either in small pits or, where wells are constructed on intensively farmed land, in surface tanks (i.e., pitless drilling), following which the fluids would either be removed from site for disposal at a licensed facility or stored in purpose-built containment structures for treatment and reuse in future drilling activities.

Arrow has further investigated pitless drilling and has completed trials in six demonstrations, including on black soils. The demonstrations aimed to enable the project to remove, wherever feasible, the requirement for the excavation of small pits at the well pad locations. In the instances where pitless drilling can be employed, Arrow will be able to:

- Remove all drilling waste from the site.
- Use less water. The demonstrations have shown that up to 75% of the water will be suitable for recycling.
- Reuse drilling waste. For example, as part of the demonstrations, potassium sulfate (commonly used in fertilisers) was added to drilling fluid, making it suitable to be used for compost.

Ongoing Access Requirements

Maintenance of production wells entails well integrity testing, maintenance of wellhead infrastructure and well workovers for maintenance of downhole infrastructure and the well casing. Collectively, these activities ensure the integrity of the well over its life. Manual well integrity testing is expected to be progressively replaced by remote control using supervisory control and data acquisition (SCADA) systems. Regular maintenance of wellhead engines (where temporary power generation is required) and water pumps is carried out in accordance with manufacturers' recommendations. The frequency of well workovers largely depends on differences in the geology of the target coal seams (e.g., the amount of coal fines that may be drawn through the pump) and in the loads placed on the pump due to different well geometry, particularly where directional drilling is used to install deviated wells.

Workovers involve cleaning the production zone by high-velocity air or water jetting, repairing or replacing the downhole pump assembly and, if necessary, replacing the well tubing and rods to ensure continued flow of gas and/or water from the coal seam. Workovers are also required to seal off a production interval when it has no further economic value or to bring into production another, as yet unproduced, interval in the well borehole.

The introduction of deviated wells at multi-well pads has resulted in revision of the frequency of workovers to an expected range of six months to two years, as multi-well pads are expected to require proportionately more workovers than single-well pads. However, technology improvements are expected to result in an increase in pump life, thereby reducing the frequency of workovers. Workovers required to clean the production zone, repair a failed well or change the targeted production interval are rare.

The workspace required for workovers is a similar area to that required to establish the well, i.e., 100 m by 100 m (or 1 ha) for a single-well pad and 100 m by 200 m (or 2 ha) for a multi-well pad. This requirement forms the basis for compensation.

The footprint of well pads will be reduced between workovers to accord with the strategic cropping land standard conditions code for resource activities (DNRM, 2012a) or as agreed for multi-well pads. In either instance, each well site will be rehabilitated after final abandonment activities.

3.6.2 Gas and Water Gathering Systems

The description of activities associated with the gas and water gathering systems remains largely unchanged from that provided in the EIS. Additional information is presented below for hydrostatic testing, marking of the pipelines, valves and signage, and pigging.

Hydrostatic Testing

Pipelines that form part of the gas and water gathering system will be integrity pressure-tested with water or air prior to commissioning. Hydrostatic testing involves filling the pipelines with water and applying higher than normal operating pressures. Water used for hydrostatic testing will be diverted to holding dams for reuse or treatment and discharge. Water quality will be tested prior to discharge.

Water for the hydrostatic testing is normally obtained from existing sources in proximity to where the testing will occur, such as property dams and local watercourses. Where required, environmental approvals will be obtained from the government or the owner of the water. Options from which to source and dispose of the water will be explored with the aim to maximise efficiency of testing, reduce the timing of construction and commissioning and exhibit environmental good practice. If required, the biocides and oxygen scavengers selected for hydrostatic water tests will be those which can be neutralised, are biodegradable, and do not bio-accumulate in the soil.

Marker Posts, Tape and Trace Wire

After a gas and water gathering system is installed, the ground will be compacted to a level consistent with the surrounding land use. As explained in the EIS, marker posts, marker tape, trace wire and 'as-built' surveys will be used to identify the location of the buried gathering lines. A trace wire suitable for direct burial with the gathering system pipelines will be installed to allow gathering systems to be detected and traced from the surface without ground disturbance. Marker post placement will comply with relevant legislation, including the APIA code of practice; Upstream PE gathering networks CSG industry version 2 (APIA, 2013). Underground warning tapes (referred to in the EIS as 'marker tapes') are coloured and are printed with a warning message to identify the gathering system pipes and cables. Underground marker tape is laid in the trench over the pipelines, halfway between the pipeline and the surface, to provide a warning during an excavation before any damage to the pipeline is caused.

Valves and Signage

The placement of valves and signage will be determined during the detailed FEED phase, expected to commence in mid-2013.

Pipeline Inspection Gauge (PIG) Testing

If a field compression facility is deemed necessary as part of the field development plan, the medium-pressure gas pipeline required to transport gas to a CGPF would collect water. This water would be removed by pigging to allow the unrestricted flow of gas.

Pigging stations (launching and receiving) comprise aboveground pipework that allows the 'pig' to be launched (injected) into the pipeline by gas and then retrieved. The pig launching station would be on the pressurised (downstream) side of a compressor at the CGPF to provide adequate pressure to launch and push the pig through the pipe to the receiving station at the adjacent CGPF. Pigging infrastructure will be housed within the security fence of the CGPF and operated as part of the facility.

Water purged by pigging will be of the same quality as the produced water from wells that feed the gathering system serviced by the field compression facility. Sludge will comprise water, coal fines and other impurities produced from the well. The water and sludge will be collected in a chamber at the CGPF and then disposed of to a regulated waste facility or treated at the CGPF and disposed of along with the other waste streams generated at the facility.

3.6.3 Production Facilities

The activities associated with the construction, operation and decommissioning of the production facilities are consistent with those presented in the EIS. Some refinements have been made to the configuration and capacity of the CGPFs and to the operational staffing of production facilities and field compression facilities (if any), which is described below.

CGPF Configuration and Capacity

The refined basis for design includes a shift in the configuration of a CGPF. The CGPFs will now include between one and three compression trains, each with the capacity to compress gas at 75 TJ/day. Therefore, the expected maximum gas compression at a CGPF has increased from 150 TJ/day to up to 225 TJ/day.

The revised estimated total installed capacity for the initial eight CGPFs is presented in Table 3.5.

Table 3.5 Estimated total installed capacity for CGPFs

Facility	Estimated Compression Capacity (TJ/d)
CGPF1	150
CGPF2	225
CGPF5	150
CGPF7	75
CGPF8	225
CGPF9	225
CGPF10	75
CGPF11	150
Total	**1,275***

* Note that whilst the total installed capacity is 1,275 TJ, the expected sustained gas production across the field will be less (1,215 TJ/day).

'Not Normally Staffed Operations'

Arrow has refined its approach to the staffing of CGPFs and field compression facilities. Control of the production facilities will be managed centrally from the Brisbane Central Control Room 24 hours a day, 7 days a week. The production facilities will therefore incorporate a high level of monitoring, automation and communications.

The revised approach introduces the concept of 'not normally staffed operations', which involves staffing facilities on an as-needed basis. Instead of staff being assigned to a particular facility, staff will only visit facilities if and as required. Initially, operations staff will work 12-hour day shifts, with shift rosters planned to ensure 7 days per week coverage of facilities. Staffing levels are planned to gradually move towards 'not normally staffed operations' as operating reliability and confidence is established. Staff will be progressively redeployed to new facilities as they are brought on line and existing facilities transition to 'not normally staffed operations'. The staffing concept and levels will continue to be reviewed as operating experience grows.

The facilities will require periodic visits (e.g., fortnightly for operators and quarterly for maintenance contractors) to carry out inspections or other scheduled maintenance activities. Any work intervention required outside the normal working hours will be attended to by an established on-call roster.

'Not normally staffed operations' require remote exception-based surveillance monitoring and control for all critical process and condition parameters. These operations will be remotely monitored and controlled from the Brisbane Central Control Room.

3.6.4 Water Treatment Facilities

The layout and infrastructure associated with water treatment facilities were described in the EIS. Additional information on operation and maintenance of the facilities is now available and is presented below.

Water treatment facilities are expected to have a 25-year life and operate 24 hours per day, seven days per week. They will be fully automated and designed for minimal operator intervention. The facilities will be controlled and their integrity remotely monitored by a computer-based integrated control system that includes process and safety controls. Operators will be notified by warnings and alarms of changes in key operating parameters.

Typical operations and maintenance tasks at the water treatment facilities will include:

- Routine inspection.
- Minor maintenance (cleaning, lubrication and replacement of filters).
- Chemical delivery.
- Solid waste disposal.
- Monitoring and sampling activities.
- Emergency repairs, as necessary.

Regular maintenance is required to sustain plant performance and will include backwashing of the filter membranes, regeneration of the cation and anion exchangers, and the cleaning of internal surfaces to remove scale, without the need for disassembly (i.e., clean-in-place). These regular maintenance processes will be fully automated. Major maintenance (outages or overhauls) will be undertaken as required in accordance with manufacturer specifications.

3.6.5 Power Transmission and Distribution Facilities

Construction, operations and decommissioning activities for power transmission and distribution facilities are described below.

Construction

High-voltage transmission lines and zone substations will be designed and constructed by the transmission network service provider in accordance with relevant electricity supply, design and safety standards, using typical construction methods.

Arrow's substations at the CGPFs and overhead power lines in Arrow's distribution network will be designed and constructed in accordance with relevant electricity supply, design and safety standards, and using typical construction methods. Underground cables in Arrow's distribution network are intended to generally follow the gas and water gathering network and will be installed using methods in accordance with relevant electricity design and safety standards.

Operation

High-voltage transmission lines and zone substations will be operated and maintained by the transmission network service provider. Maintenance activities are expected to include inspection of the lines to check that vegetation (regrowth) and activities on the easement do not breach electrical safety requirements and that the transmission towers or poles are in good working order.

The distribution network comprising facility substations at CGPFs, overhead power lines and underground cables will be operated and maintained by Arrow. Maintenance activities will include inspection of the power lines to check that vegetation (regrowth) and activities on the right of way do not breach electrical safety requirements and that the power poles are in good working order.

Decommissioning

Decommissioning requirements for transmission lines and zone substations (constructed, operated and maintained by the transmission network service provider) will be determined at the time and will depend on whether the facilities supply or have the capacity to supply other users.

Arrow's distribution network 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 landholders.

Landholder requirements will be taken into account in deciding whether or not to remove the poles and conductors from properties. These facilities may be useful for reticulation of power within the property. If not required, the poles, insulators and conductors would be removed and reused or recycled. Typically, underground cables would be made safe and left in-situ.

3.6.6 High-pressure Gas Pipelines

The diameter and maximum operating pressure of high-pressure gas pipelines is being reviewed. Large-diameter pipelines require a larger right of way to construct. The nominal right of way for construction of high-pressure gas pipelines has been revised by Arrow to 40 m from the 25 to 30 m presented in the EIS.

The minimum depth of cover required by AS 2885, Pipelines: gas and liquid petroleum (Standards Australia, 2008a), is 750 mm. The ultimate depth of cover will be determined through a risk assessment that takes into consideration land use. The ultimate depth of cover may be greater than 750 mm (1,200 mm to greater than 1,500 mm) in specific areas, such as crossings of railways, state-controlled roads and major watercourses. Pipelines will be buried to a depth that minimises the risk of damage to the pipeline and interference with existing land uses, including farming practices. Landholders will be consulted when determining appropriate minimum burial depths. Warning signs will be placed along the easement to indicate the presence of the buried high-pressure pipeline, and marker tape will be buried halfway between the pipeline and the surface to provide a warning should excavation occur above the pipelines.

3.6.7 Construction Water Supply

The volumes and sources of water required for construction have been estimated and identified, respectively. Arrow does not plan to source water from town water supply networks. Construction water supply infrastructure is intended to be independent of existing water supply infrastructure.

Approximately 450 ML of water will be required in the first few years of construction, with the volume of water reducing after the CGPFs and water treatment facilities have been constructed. Estimates of the volumes of water required for construction are:

- Dust suppression and watering for bulk earthworks for construction of dams at the water treatment facilities to be established at CGPF2 and CGPF9. Approximately 120 ML will be required to construct the dams at each site at a rate of 4 ML/day at peak. This equates to a total requirement of 240 ML.
- Dust suppression and watering for bulk earthworks to establish the benches for the CGPFs. About 20 ML of water at a rate of about 1 ML/day at peak construction will be required for construction of a bench, equating to 160 ML in total.
- Dust suppression and watering for bulk earthworks required to construct benches for the water treatment facilities at CGPF9 and CGPF2. Approximately 3 ML will be required for dust suppression and watering at each site, equating to a total requirement of 6 ML.
- Dust suppression and watering for road and track construction. Volume to be determined based on local soil type and seasonal weather conditions.
- Dust suppression on roads and tracks and plant benches. Volume to be determined based on local soil type and seasonal weather conditions.
- Fire water supply at accommodation villages, with the first fill estimated at 0.10 ML.

- Irregular use for hydrostatic testing of high-pressure pipelines. Volume to be determined based on future design parameters.

Construction water supplies will be obtained from the following sources:

- Existing and future facilities owned by Arrow and other coal seam gas proponents. Treated and untreated water will be assessed for its suitability.
- Exploration or appraisal dams.
- Watercourses, bores and farm dams, where approvals are in place to extract water.
- Local, licensed water service providers, where practical.

3.6.8 Workforce and Accommodation

Changes to the development sequence and the timing of drainage areas coming on line has changed the anticipated peak for the construction workforce and the year in which Arrow anticipates it will be reached. The project construction workforce is projected to peak at approximately 2,300 workers in 2017, an increase of 1,590 personnel from the estimated peak presented in the EIS. In contrast, refinement of the expected peak operations workforce has seen a decrease of 60 personnel, to the new expected peak of 400. The decommissioning workforce remains as was presented in the EIS.

Construction Workforce

Key activities for which the construction workforce requirements have been revised since preparation of the EIS, include CGPF construction and the duration for which well and gathering line crews will be required. The revised CGPF construction workforce comprises a peak workforce of up to 450 personnel as compared to the 140 personnel peak presented in the EIS. The revised duration expected for well installation, which includes drilling, completion works and connection of the well, is an average of between 10 and 15 days. For installation and commissioning the gathering networks, the revised estimate allows 8 days per 1 km stretch of the gathering network (which includes a 1 km length for the gas and an additional 1 km length for the water gathering pipeline).

From 2016 to 2019, the average daily workforce is expected to be between 900 and 1,700 personnel, which coincides with the period during which construction of up to eight CGPFs will be under way. The average daily construction workforce will reduce to between 500 and 700 personnel from 2021 to 2029 and then will further reduce to approximately 300 personnel from 2030 onwards.

The estimated construction workforce is summarised in Table 3.6.

Table 3.6 Estimated construction workforce

Year	Average Daily Workforce	Peak Daily Workforce	Year	Average Daily Workforce	Peak Daily Workforce
2015	770	1,100	2026	500	600
2016	1,300	1,200	2027	700	700
2017	1,700	2,300	2028	600	700
2018	900	1,100	2029	700	900
2019	1,200	1,400	2030	300	800
2020	900	1,400	2031	300	300

Table 3.6 Estimated construction workforce (cont'd)

Year	Average Daily Workforce	Peak Daily Workforce	Year	Average Daily Workforce	Peak Daily Workforce
2021	600	800	2032	300	300
2022	700	800	2033	300	300
2023	700	800	2034	300	300
2024	700	1,000	2035	300	300
2025	700	800	–	–	–

Operations Workforce

The numbers of operations and maintenance personnel stationed in the Surat region will vary as required to support operation of the production facilities and will reflect the proposed 'not normally staffed operations' approach to the production phase of the development (see Section 3.6.3, Production Facilities). As a consequence, peak staffing is expected to be 400 down from the 460 presented in the EIS. Notwithstanding the reduction in overall numbers, operations personnel and contractors engaged on well workovers are expected to range between 33 and 230 personnel over time, with an average onsite well workover workforce of 130 personnel.

Operations and maintenance personnel will be stationed at the support depots, proposed to be established in Dalby and Miles.

Accommodation

Arrow's accommodation strategy to house the majority of the construction workforce (i.e., those that are not local to the area) in TWAFs remains the preferred option. The strategy has been revised to include larger facilities and an additional TWAF to take account of the revised construction workforce numbers. The additional TWAF will be located on a property owned or secured under a long-term lease arrangement by Arrow. The property is central to several CGPFs and will negate the need to develop TWAFs at those CGPFs. Elsewhere, TWAFs will be located adjacent to the CGPFs, as presented in the EIS.

Table 3.7 shows the estimated maximum peak and long-term average number of beds required for each TWAF.

Table 3.7 Approximate location and estimated number of beds for each TWAF

TWAF	Maximum Number of Beds Required	
	Peak	Long-term Average
A – Between Wandoan and Miles	575	300
B – Near Miles	800	300
D – Near Kogan	575	300
E – Near Daandine	700	200
F – Near Cecil Plains	1,050	500
G – Between Cecil Plains and Millmerran	450	200

The long-term nature of the project requires that the TWAFs provide accommodation for a wide range of workforce disciplines and skills. TWAFs will typically occupy an area of around 500 m by 500 m. As presented in the EIS, small mobile drilling camps (less than 20 person capacity per drill rig) located near production well drilling operations may also be established. Their location will be agreed with the landholder if not located on Arrow-owned or leased properties.

3.7 Water and Brine Management

The extraction of water is required to depressurise coal seams and allow gas to flow at production rates. The latest version of Arrow's Coal Seam Gas Water and Salt Management Strategy, which applies to its Surat and Bowen basin developments, is presented in Attachment 5. Changes to the strategy since the EIS was published that are relevant to the Surat Gas Project are presented below.

3.7.1 Coal Seam Gas Water Management Policy

A revised Coal Seam Gas Water Management Policy was prepared by the Department of Environment and Heritage Protection (EHP) and released in December 2012. The objective of the policy document is to encourage the beneficial use of coal seam gas water and brine/salt in a way that protects the environment and maximises the productive use of these resources. Although coal seam gas water is considered a waste under the *Environmental Protection Act 1994* (Qld), the government may approve, as a condition of an environmental authority, its use as a 'resource' on a case-by-case basis if the water has a beneficial use that would negate the need for disposal.

The policy identifies priorities for the management of coal seam gas water and brine/salt and states that the management and use of coal seam gas water should be consistent with the following priorities:

- Priority 1. Coal seam gas water is used for a purpose that is beneficial to one or more of the following:
  - The environment.
  - Existing or new water users.
  - Existing or new water-dependent industries.
- Priority 2. After feasible beneficial use options have been considered, treating and disposing coal seam gas water in a way that first avoids and then minimises and mitigates impacts on environmental values.

The policy states that the management and use of brine/salt should be consistent with the following priorities:

- Priority 1. Brine or salt residues are treated to create useable products wherever feasible.
- Priority 2. After assessing the feasibility of treating the brine or solid salt residues to create useable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment.

3.7.2 Arrow's Coal Seam Gas Water and Salt Management Strategy

The Coal Seam Gas Water Management Policy (EHP, 2012) has informed Arrow's management strategy for coal seam gas water and brine/salt. Arrow's Coal Seam Gas Water and Salt Management Strategy (Attachment 5) aims to maximise beneficial use of coal seam gas water and brine/salt and to reduce the environmental impacts associated with their use or disposal.

Management of coal seam gas water will consist of a combination of management options which address Arrow's statutory obligations and commitments within the context of the key assumptions. The field development plan, which is refined over time to incorporate learnings and improvements as the project develops, and the development sequence for the Surat Gas Project will determine the timing, combination and implementation of the management options.

Arrow will seek to beneficially use or dispose of coal seam gas water in the most cost effective manner that limits its exposure to residual liability. This necessitates that supply or disposal of water is managed in proximity to the point of treatment.

Management options for treated and untreated coal seam gas water are shown in Figure 3.8 and described below. Untreated water may be suitable for any of the identified beneficial use options, depending upon the water quality requirements of the end user or receiving environment.

Beneficial Use

Beneficial use is defined in EHP's Coal Seam Gas Water Management Policy (2012) as the use of coal seam gas water for a purpose that is beneficial to one or more of the following:

- The environment.
- Existing or new water users.
- Existing or new water-dependent industries.

In this context, treated and untreated coal seam gas water can be supplied to end users or a receiving environment via a range of mechanisms for a variety of uses including:

- Agricultural uses including irrigation and livestock watering.
- Industrial uses including power station cooling, coal washing and use by Arrow for construction and operational purposes.
- Domestic uses.
- Urban uses such as potential water supply to towns e.g., Dalby.
- Injection into depleted aquifers for recharge purposes.

Opportunities afforded by collaboration with other coal seam gas developers or service providers will be maximised where they result in a material benefit to Arrow, and such opportunities have the potential to reduce costs and the lead time to obtain approval for, and establish, the infrastructure required.

Coal seam gas water will be supplied to the end user under the following framework:

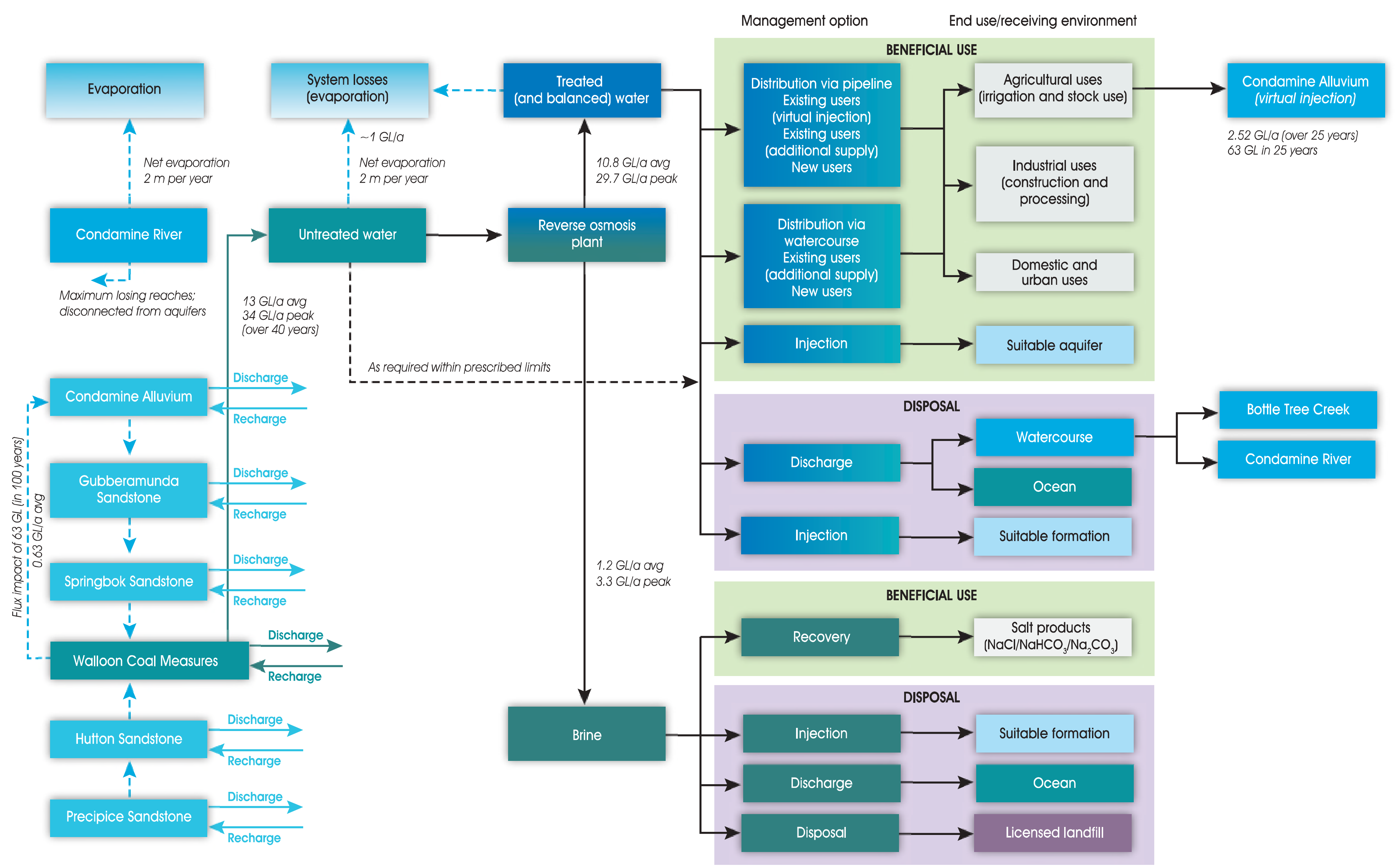
- Environmental Authority under the *Environmental Protection Act 1994* (Qld).
- General or specific beneficial use approval under the *Water Act 2000* (Qld).
- Water supply licence under the Water Act.
- Water supply agreements.

The mechanisms for supply of coal seam gas water to end users for beneficial use are distribution via pipeline and distribution via watercourses. These mechanisms are discussed below along with injection of coal seam gas water into a suitable aquifer which is also recognised as a beneficial use in the Coal Seam Gas Water Management Policy (EHP, 2012).

Distribution of Coal Seam Gas Water via Pipeline (Beneficial Use Network)

A beneficial use network involves the construction of pipelines from water treatment facilities to agreed end user delivery points where the user will take delivery of the water for the approved use. The coal seam gas water beneficial use network will facilitate supply for:

- 'Virtual injection' to substitute existing users' groundwater allocations in the Condamine Alluvium in the project development area.



coffey environments	Date: 25.06.2013 File Name: 7040_12_F03.08_GL	Arrow Energy Surat Gas Project	arrow energy go further	Conceptual coal seam gas water and brine management overview	Figure No: 3.8

Figure 3.8: Conceptual coal seam gas water and brine management overview

- Additional supply to existing users beyond the volumes required to satisfy 'virtual injection', where economically and technically feasible.
- New uses over and above the volumes supplied to existing users, where economically and technically feasible.

Distribution of Coal Seam Gas Water via Watercourse (Managed Schemes)

This option involves supply of coal seam gas water via watercourses to existing and future managed water supply schemes. Coal seam gas water would be distributed to end users of the scheme via offtakes along the pipeline to the watercourse and downstream of the release point into the watercourse. Such schemes are generally managed by an established entity.

Distribution of coal seam gas water in this way, where economically and technically feasible, would involve:

- Additional supply to existing users of managed schemes.
- Supply to new users (for volumes over and above those supplied to existing users) of managed schemes.
- Supply to new users (for volumes over and above those supplied to existing users) of managed schemes yet to be established.

Injection of Treated Coal Seam Gas Water into a Suitable Aquifer

Injection into suitable aquifers whether depleted due to coal seam gas activities or for other reasons such as non-coal seam gas groundwater extraction is recognised as a beneficial use and a further option for management of treated coal seam gas water.

However, it is currently not considered feasible for the following reasons:

- An appropriate regulatory framework is not in place, including approvals process and provision of an indemnity framework.
- The timeframe for approvals, including completion of trials, would significantly delay project schedules.

Arrow has carried out an injection feasibility study for injection of treated coal seam gas water into the Precipice Sandstone, and has submitted environmental authority amendment applications to conduct aquifer injection trials. The purpose of the trials is to understand the suitability of the Precipice Sandstone for injection and to determine the potential volumes and rates of treated coal seam gas water that could be injected.

If the issues mentioned above can be addressed, and these trials prove promising, Arrow will consider further works to define the extent and feasibility of injection over the project development area.

Disposal of Coal Seam Gas Water

Disposal of coal seam gas water may be necessary when beneficial use options are not economically and technically feasible, or in the case of residual volumes which are those volumes of coal seam gas water that cannot be feasibly managed through beneficial use due to operational, technical, environmental or economic constraints. Disposal options include discharge to watercourses, injection into suitable formations and discharge to the ocean. They are described below.

Discharge of Coal Seam Gas Water to Watercourses

Management of residual volumes via discharge to a watercourse will be necessary to ensure that coal seam gas production can continue during times where:

- Constraints to supply for beneficial use occur.
- Unforeseen events occur such as significant weather events.
- Operational upset conditions necessitate discharge.
- The structural and operational integrity of dams is at risk.

Discharge to watercourses would occur within environmental flow requirements and in accordance with the relevant approval. Potential discharge locations are at the water treatment facilities planned to be located with CGPF2 and CGPF9. Site specific assessments of the discharge points will be undertaken to determine the appropriate discharge regime to minimise impact on the environment.

Injection of Coal Seam Gas Water into a Suitable Formation

Disposal of treated or untreated coal seam gas water via injection is only an option if a suitable formation can be identified. To date, the only suitable formations that have been identified in the project development area are aquifers which fall into the beneficial use category. Therefore, injection as a disposal option has currently been ruled out for the Surat Gas Project.

If Arrow considers that injection is the appropriate management option based on the identification of a suitable formation and economics, an injection trial would be conducted. The purpose of the trial would be to understand the suitability of the formations for injection and to determine the potential volumes and rates of coal seam gas water that could be injected.

Discharge to the Ocean via a Pipeline and Outfall

Discharge of coal seam gas water to the ocean via a pipeline and ocean outfall is considered an option in the absence of an approved alternative. For example, when:

- Beneficial use (including injection) is not approved or economically or technically feasible.
- Discharge to watercourses is not approved or feasible due to environmental flow requirements.

3.7.3 Implementation of Arrow's Coal Seam Gas Water and Salt Management Strategy

Table 3.8 sets out the beneficial uses of coal seam gas water identified and being investigated by Arrow.

Table 3.8 Potential beneficial uses of coal seam gas water

Potential Beneficial Use	Description
Agriculture use (Theten demonstration project)	Arrow has purchased a property on the Condamine River floodplain to demonstrate coal seam gas water management for agriculture. The Theten property is being supplied with treated and amended coal seam gas water from the Daandine water treatment facility. The project is taking place on land classified as good-quality agricultural land and potential strategic cropping land due to the vertosol and dermosol soils (black soils or cracking clays).
Agricultural use (irrigation)	Irrigation is the predominant water use within the project development area. Options to substitute and augment existing groundwater allocations from the Condamine Alluvium and supply water to new irrigation schemes are being investigated. Key considerations for providing coal seam gas water to third parties for irrigation include:

Table 3.8 Potential beneficial uses of coal seam gas water (cont'd)

Potential Beneficial Use	Description
Agricultural use (irrigation) (cont'd)	• The ability of the third party to take large volumes of water regularly and reliably. Arrow would install sufficient buffer storage and disposal capacity to cater for instances where water could not be used by the third party due to exceptional circumstances, 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 long distances. • The point of transfer of responsibility. Arrow would be responsible and liable for water pipelines from a water treatment facility to a defined transfer point where responsibility of the water would change hands. The third party would accept responsibility for the water (and any associated impacts of its use) once the water was in their possession as Arrow has no control over how the water was used.
Other agricultural use	Other potential agricultural beneficial uses include provision of water for livestock watering purposes including feedlots.
Industrial use	Depending on water quality, treated and untreated coal seam gas water may be used for industrial purposes in Arrow's operations e.g., dust suppression, drilling, construction water supply and power station cooling. Arrow will continue to supply third-party industrial users and look for further opportunities to do so.
Domestic and urban use	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; and for the Dalby supply, it would also facilitate natural recharge of the aquifers from which supply is currently sourced.
Aquifer recharge	In 2010, Arrow conducted an injection feasibility study and has submitted environmental authority amendment applications to conduct aquifer injection trials. The purpose of the trials is to identify the volumes and rates of water that can be sustainably injected. The injection trials will be conducted under strictly controlled conditions to ensure that the tests have no material impact on the target aquifers. The injection trials would typically run for 12 months, including preparation, data collection and data evaluation. The proposed trials involve drilling injection and monitoring bores into the Precipice Sandstone. The bores will be used to collect geological data and characterise the water geochemistry of that aquifer. In the event that these trials were successful, Arrow will consider further works to define the extent and feasibility of injection over the project development area. Furthermore, the results from the trial could be used to prepare an application for an environmental authority or environmental authority amendment for injection.

While the Coal Seam Gas Water Management Policy (EHP, 2012) promotes substitution or 'virtual injection' as a recognised management option, there is currently no regulatory framework for substitution of groundwater allocations. Consequently, Arrow has developed a commercial framework to support the supply of treated and untreated coal seam gas water to groundwater users who hold allocations from the Condamine Alluvium.

Under the proposed framework, end users would receive and utilise water supplied by Arrow in lieu of utilising their groundwater allocations. Third-party users would be expected to accept legal and practical responsibility for the impacts of their use of the delivered coal seam gas water.

Arrow will be responsible for ensuring that coal seam gas water provided to third party users meets relevant water quality guidelines with quality to be confirmed at monitoring points within Arrow's control. Water quality requirements will be determined by the end use of the water and recognised standards for that use.

3.7.4 Coal Seam Gas Water Management Options at the Planned Water Treatment Facilities

Two potential sites for water treatment facilities have been identified, one adjacent to CGPF2 north of Miles and one adjacent to CGPF9 south of Cecil Plains. Land use and water demand for beneficial uses vary between the potential locations necessitating different management options at the locations. Further flexibility is proposed through interconnection of the facilities to enable local variations in demand to be managed. The following sections describe the land use and water demand profile for each location, and likely management options.

Conceptual Water Management at Water Treatment Facility at CGPF9

Land use in the vicinity of the water treatment facility located in proximity to CGPF9 near Cecil Plains on the Condamine River floodplain, is dominated by irrigated cropping land. The demand for water is higher in the summer months and lower in the winter months based on the cropping cycles and the availability of water through allocations from the Condamine Alluvium. Currently, third-party bore owners access and use their groundwater allocation as required in accordance with the cropping cycles. This practice reduces extended periods of water storage in farm dams and associated losses to evaporation.

Arrow has committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown, as a result of coal seam gas water extraction from the Walloon Coal Measures. Modelled likely flux impacts are defined as those extracted from the calibrated OGIA Surat CMA Groundwater Model realisation occurring over the period referred to in the UWIR for the Surat CMA (QWC, 2012) i.e., the next 100 years.

A beneficial use network will distribute water to the groundwater users within the area of greatest drawdown to mitigate the modelled likely flux by substitution of their allocations. These users and new users may be offered excess water to augment existing allocations to provide a more reliable supply that addresses seasonal variations thereby reducing fluctuations in demand. As a result, the beneficial use network will need to have a higher capacity than the expected annual average water demand.

Residual volumes of coal seam gas water will be discharged to the Condamine River in accordance with environmental flow requirements and site specific water quality guidelines to reduce potential impacts to aquatic ecosystems. Variation in demand and environmental flow requirements will necessitate onsite storage at the water treatment facility to manage periods of low demand and constraints on discharges to the Condamine River. Extended storage periods will increase system losses from evaporation and seepage. Chapter 9, Surface Water and Chapter 10, Aquatic Ecology present the findings of a preliminary environmental flows assessment and the potential volumes of water that might be discharged to the watercourses.

Injection of coal seam gas water into the Precipice Sandstone (and potentially other aquifers, if suitable) is a potential management option but is currently not considered feasible because an appropriate regulatory framework is not in place, including an approvals process and provision of an indemnity framework. Further, the timeframe for approvals, including completion of trials, would significantly delay project schedules. If legislative changes and proposed injection trials subsequently find this to be an appropriate management option the potential volumes and rates of treated coal seam gas water that could be injected would determine the proportion of residual volumes managed by this option at this location.

Conceptual Water Management at Water Treatment Facility at CGPF2

Land use in the vicinity of the water treatment facility at CGPF2 is predominantly grazing land and forested areas, with resource industry facilities including coal mines located in the area. The demand for water is consequently less seasonal than at the location of the water treatment facility at CGPF9.

Beneficial use options include supply to industry or to managed irrigation schemes downstream of the site. Supply to these end uses would be at a constant rate over the year, as they are less exposed to seasonal variation in demand. Further management options are available in the case where coal seam gas water is transferred from this facility to the facility located adjacent to CGPF9.

The ephemeral nature of Bottle Tree Creek and Dogwood Creek into which it flows, limit the opportunity for discharge to these watercourses from the water treatment facility at CGPF2. Environmental flow requirements and site specific water quality guidelines will determine the residual volumes that can be discharged to these watercourses to reduce potential impacts on aquatic ecosystems. Chapter 9, Surface Water and Chapter 10, Aquatic Ecology present the findings of a preliminary environmental flows assessment and the potential volumes of water that might be discharged to the watercourses.

Injection of coal seam gas water into the Precipice Sandstone (and potentially other aquifers, if suitable) is a potential management option but is currently not considered feasible because an appropriate regulatory framework is not in place, including an approvals process and provision of an indemnity framework. If legislative changes and proposed injection trials subsequently find this to be an appropriate management option the potential volumes and rates of treated coal seam gas water that could be injected would determine the proportion of residual volumes managed by this option at this location.

3.7.5 Brine and Salt Management Options

Brine is a significant by-product of the water treatment process and requires specific measures to manage its storage and subsequent use or disposal. Coal seam gas water quality varies across the project development area from high-quality water to highly saline water. 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 treated.

Arrow's preferred management option for brine is to produce salt products for beneficial use. The brine management option selected will be dependent on both the concentration and the total volume of water expected for that development, as well as the feasibility of processing the brine to produce beneficial or saleable products. Figure 3.8 presents the brine management options and the expected average and peak annual volumes of brine production. The brine management options being considered are as follows:

- Selective salt recovery at a joint-industry facility.
- Selective salt recovery at an Arrow-only facility.

- Injection into a suitable formation.
- Discharge to the ocean.
- Disposal to landfill.

The management options for end use or disposal are described in the following sections.

Beneficial Use (Selective Salt Recovery)

Brine produced through water treatment is comprised of sodium chloride or common salt (NaCl), sodium bicarbonate ($NaHCO_3$) and sodium carbonate or soda ash (Na_2CO_3) which, when recovered by a process known as selective salt precipitation, can be used beneficially in industrial processes.

Selective salt recovery is based on evaporative processes that occur within engineered vessels fabricated from specialist steels. Gas is used to fire a boiler to generate steam that is used to drive water evaporation. Alternatively, electricity is used to drive a compressor that heats a steam recirculation unit to drive water evaporation. The process is generally conducted within one or more buildings to protect the equipment and manage emissions, such as noise and dust. Supporting infrastructure and equipment required as part of the selective salt recovery process include pumps, pipework, chemical dosing equipment, salt dewatering and drying infrastructure, and packaging equipment and materials. Chemicals utilised in the process include anti-scalants to manage the selective salt recovery process and the functionality of the required equipment. Caustic soda is commonly used to convert native bicarbonate to carbonate for enhanced production of soda ash (sodium carbonate).

The salts and soda ash produced would be stockpiled on site. Stockpiles would typically be contained in a covered area to manage the environmental conditions and ensure appropriate quality control. If the stockpiles were not covered, they would likely have a dust suppression system installed. The size and configuration of stockpiled salt and soda ash would depend on the logistical requirements for transportation of the material to beneficial users i.e., delivery to commercial enterprises or to ports for shipping.

The selective salt recovery process also produces high-quality distilled water that can be beneficially used for a range of industrial purposes. The other primary by-product of the process is a waste salt. The volume of waste salt produced would depend on the chemical characteristics of the brine processed at the selective salt recovery facility. The waste salt stream would typically form approximately 5% of the total salt produced. The waste salt would be dried through a dedicated waste salt production process and transported offsite to a regulated waste facility. The location of the regulated waste facility would be subject to further investigation and a subsequent approvals process.

Arrow is consulting with commercial enterprises to investigate viable opportunities for the beneficial use of brine. As part of this process, Arrow is commissioning selective salt recovery 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.

Opportunities afforded by collaboration with other coal seam gas developers or service providers will be maximised where they result in a material benefit to Arrow, and such opportunities have the potential to reduce costs and the lead time to obtain approval for, and establish, the infrastructure required for the management of brine/salt.

Brine produced as part of the coal seam gas water treatment process would be transported from the water treatment facilities to the selective salt recovery plant via a pipeline for treatment. The pipeline and selective salt recovery facility would be assessed under subsequent approvals processes.

Disposal

Three options for disposal of brine are under consideration with the base case being disposal to a regulated waste facility (suitably-licensed landfill). The options are described below.

Disposal to a Regulated Waste Facility (Suitably-licensed Landfill)

Since publication of the EIS Arrow has committed not to dispose of brine (as a salt concentrate) to the regulated waste facility at Swanbank. Although disposal to a suitably-licensed landfill remains the base case for brine and/or salt management, this option would only be pursued if beneficial use options were proven infeasible or uneconomic. Arrow expects other suitably licensed landfill sites to be developed in response to the demand created by the coal seam gas industry and to be available to accept brine (as a salt concentrate) produced in its operations.

For the purpose of assessing the maximum expected vehicle movements (and associated emissions from vehicles), the EIS assumed transport to and disposal of brine at Swanbank. To facilitate assessment of the transport of brine (as a salt concentrate) from the planned water treatment facilities at CGPF2 and CGPF9 to a suitably-licensed facility, a conceptual location in the eastern part of the project development area was adopted as the worst-case for transport and disposal of brine. The revised assessments are presented in Chapter 6, Greenhouse Gas Emissions and Chapter 12, Roads and Transport.

Injection into a Suitable Formation

Arrow will consider disposal of brine via injection should a suitable geological formation be identified during the exploration phase of the project. 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 formation has been identified in the project development area.

Discharge (Ocean Outfall)

Disposal of brine to the sea via an ocean outfall pipeline is recognised as a feasible option and is undergoing evaluation as part of the detailed design of the gas field and facilities. If carried forward, this option would be assessed under a subsequent approval process. In the event that an ocean outfall pipeline was constructed, brine would be transported to the coast where it would be discharged into the sea via an outfall pipeline. A diffuser at the end of the pipe would allow for appropriate mixing and dispersion of the brine entering the sea.

3.8 Preliminary Constraints Mapping

The environmental framework presented in Chapter 8, Environmental Framework of the EIS incorporates constraints mapping which is a planning tool used by Arrow to guide site and route selection for coal seam gas infrastructure. Preliminary constraints maps were presented in Attachment 10, Preliminary Constraints Maps to the EIS. The constraints mapping was based on publicly available Australian and Queensland government datasets whose accuracy is determined by the scale at which the data was captured or digitized.

The preliminary constraints maps have been updated as part of the SREIS to capture the information collated and presented in the EIS. The updated maps are presented in Attachment 8, Constraints Mapping Update. The maps have been updated to include the findings of ecological surveys undertaken for the EIS, the outcome of sensitivity assessments carried out by technical specialists, and analysis of high resolution imagery to improve the accuracy of identification of houses in the project development area. Constraints previously shown in relinquished sub-blocks which no longer form part of the project development area are not shown in the updated maps.

The current version of the preliminary constraints mapping adopts the example regulated buffer distances for ESAs proposed in the Model Conditions for Level 1 Environmental Authorities for Coal Seam Gas Activities (DERM, 2011d). It is noted that regulatory policy is evolving to an outcome-based approach and that subsequent updates to the constraints mapping will reflect the regulatory requirements at the time of the update.

Constraints to development are maintained in the project Geographic Information System (GIS), a live system, used by Arrow in gas field planning. The constraints mapping will be periodically updated to include revisions to Australian and Queensland government GIS data, the results of ecological and preconstruction clearance surveys, landowner negotiations and any subsequent environmental impact assessment processes.

The constraints maps are indicative and need to be used in conjunction with other information (e.g., mapping of potential SCL and the results of detailed ecological surveys) to provide a meaningful understanding of the type and level of constraint across the project development area. Gas field planning will also be informed by landowner and regulatory authority negotiations and ongoing community consultation including such initiatives as Area Wide Planning.