CSG wells are the lifeblood of the CSG industry. They are critical to identify, test and produce CSG. They are designed and constructed using proven procedures and equipment, and represent a major investment by CSG companies. A great deal of effort goes into their construction to ensure that wells are isolated from overlying geological strata, including overlying aquifers.

Broadly speaking, there are three phases of CSG operations: exploration, pilot testing, and production.

Exploration aims to identify gas bearing coals and wells are generally widespread, with approximately one well per 30 km² depending on the area.

If exploration indicates the potential for gas production, pilot wells may be drilled. A pilot test is essentially a small scale production trial, with associated water and gas handling facilities.

If pilot testing indicates that commercial quantities of gas can be produced, full scale production may commence. Production wells are generally spaced at some 600m–1200m or more, and may operate for several years.

All activities conducted in association with petroleum tenements are subject to government environmental approvals.
Exploration drilling

**Basic principles**

During the exploration phase of a project, companies drill exploration holes to determine the location and extent of various geological formations. Of particular interest is the extent and thickness of coal seams, since they are reservoirs of coal seam gas. Once the extent of a coal formation has been determined, the next step is to understand the reservoir character of the coals of which the gas content, gas composition, and permeability are key parameters.

The main steps involved in drilling wells, either exploration of production, are:
- site identification and location
- site (or ‘lease’) preparation
- drilling
- testing and completion
- well sealing and rehabilitation.

During the normal course of any drilling program there will be various company and contractor personnel who will need to travel to the drill site. These people are required for:
- site checks and surveying
- earthworks (e.g. for access to site and to clear the drill pad area)
- drill rigs and support vehicles
- water carting
- specialist testing service providers
- well site supervision and geological personnel
- cement and casing deliveries.

**Site identification and location**

Potential exploration hole sites are first planned in a desktop process to identify places that will best define the geology of an area, and within known constraints such as tenement boundaries, topographic constraints and environmental restrictions. It is essential to then ‘ground-truth’ the proposed site, and at this stage it is critical that consultation with the relevant landholder takes place to choose the most appropriate site and consider other constraints (e.g. access routes).

In most cases there is reasonable flexibility in locating proposed wells so as to be able to avoid particular sites. As a general rule there is more flexibility to move exploration wells than production wells. Well sites can generally be identified that present least impact to the environment and existing land use.

Petroleum companies are required by law to conduct various checks on any site where works are proposed. These checks are either office or field based, and include:
- environmental checks (e.g. distance from specific vegetation communities)
- cultural heritage inspections (particularly with regard to indigenous cultural heritage)
Site access and preparation

Once agreement is reached on the location of a well, the primary considerations in preparing a drill site are safety and the environment.

For safety to both site personnel and landholders, an area of about 75m by 75m, referred to as a lease, is cleared. The site is cleared both to allow for movement of drilling vehicles, and also to provide a barrier to bush or grass fires. Sites may also be fenced for safety and to provide a barrier to cattle.

The environmental protections used in preparing the site include the stockpiling of topsoil, which is kept separate for rehabilitation. In most cases ground pits (or sumps) are excavated to hold drilling water, but tanks also may be used in some cases. Up to three sumps may be dug with a total capacity of approximately 30 000L for exploration wells, and potentially ten times this amount for production wells. These may be lined with heavy grade plastic if needed.

Depending on the safety requirements and type of rig used to drill the well, it may be necessary to dig a ‘cellar’, which is approximately 2m square and 2m deep, to house a Blow Out Preventer (BOP) which is a safety mechanism which seals the well in case of a build up of pressure.

Each drilling rig has a unique lease design that allows for safe, efficient operation while minimising the environmental footprint of the site.
Exploration hole design

Each core hole has a specific design that complies with the relevant regulations, and integrates the expected core point and total depth of the finished hole. CSG companies use an exploration core hole design that isolates aquifers behind one or two layers of steel casing held in place with pressure tested cement.

A core hole between 10cm and 30cm in diameter is drilled through alluvial and weathered material until it reaches solid rock. Depending on the core hole design, one or two layers of steel casing are run from the surface through the alluvial and weathered material to the competent rock, then cemented in place. The casing is pressure tested to ensure seal. A single casing is used if the distance from surface to competent rock is short, and double casing is used if the distance is further. The casing is strong enough to handle subsurface pressures.

Aquifers used by farmers are generally shallower than the coal seams targeted by the CSG industry. It is therefore important to ensure the steel casing and cement form a barrier that prevents drilling mud and water from lower aquifers mixing with water in upper aquifers. This isolation technique has been standard practice in the oil and gas industry for decades.

Once casing has been installed, a BOP may be mounted at the top of the core hole if needed. The BOP sits in the cellar and seals the well in the event of excess pressure, allowing drilling engineers to assess the situation before taking further action. However, it is important to note that CSG wells do not normally show high pressures.

After solid rock is reached and the BOP has been installed, the drilling method switches to coring. Six-metre long cylinders of rock and coal are extracted and tested on site before being sent off site for further testing. This continues until the hole reaches basement, the point at which all known formations have been found.
Drilling fluids

The standard drilling fluid currently used in the CSG industry is water-based and uses two main drilling additives. Potassium chloride is used as a weighting agent and to help control swelling clays when drilling through upper layers of alluvial and weathered material. Cuttings (earthen fragments) are brought to surface suspended in the drilling fluid.

During coring, a biodegradable polymer is used to stabilise reactive clays and shales, lubricate the drill and lift cuttings to surface.

After use, drilling fluid is returned to the drilling sumps where the solids settle to the bottom of the sump, the liquid can then be recirculated.

Losing drilling fluids down hole is undesirable as they are the primary means of controlling the core hole. As soon as a loss is detected, a loss circulation material (LCM) is fed into the hole with the drilling fluid. LCM is made of cellulose material and looks like sawdust. It prevents fluid loss by blocking the pores in the host rock with cellulose particles.

In cases where loss prevention additives do not work, the hole is completely sealed with a cement plug which is re-drilled.

Drilling site supervision

CSG drilling rigs operate under legislation which governs well design and site rehabilitation. CSG rigs are normally hired from external companies and staffed by trained and qualified personnel. Drilling is a highly skilled profession and extensive on-the-job and off-the-job training is required to become fully qualified.

Plug and rehabilitation

Once drilling is completed to the required depth, the hole is tested and logged, and then ‘abandoned’, a process which involves shutting down the well and rehabilitating the site. This involves sealing the hole completely from bottom to surface using a series of cement plugs. The cement seal prevents any cross-flow of water and gases between underground layers, as well as isolating all down hole zones from the surface.

The steel casing (filled with cement) is cut off 1.5m below surface level, sealed with a metal identification plate and buried.

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1 For example in Queensland the Petroleum and Gas (production and safety) Act 2004, and in NSW the Petroleum Act (onshore) 1991.
Pilot testing

Basic principles

Pilot tests are done to gather additional information (permeability, reservoir pressure, gas and water production and composition) about gas-bearing coal seams. Pilot testing is carried out in areas where exploration has shown that the coal seams have indicated potential to produce gas.

Pilot test results help CSG companies to understand the information from the exploration core holes in more detail. It also allows for trials of water handling methods which may vary from region to region.

Pilot testing involves drilling a well to just below the coals of interest and using a downhole pump to extract water from the coal seam. When enough water has been removed from the coal seam the pressure holding the gas in place is reduced, allowing the gas to flow from the seam. The test finishes, and the hole is sealed at the well head, when sufficient data has been obtained from the well.

Site build

Methods used for a pilot test site build are similar to an exploration site build, but in some cases the area cleared may be larger. Site identification, land access and site supervision are the same as for core hole drilling.

Production/pilot well design

Pilot well design follows the same construction design principles as those used in core holes. There may be one, three, or five wells for each pilot test. Closer spacing that for production wells allows data to be gathered more quickly. Water pumped from the coal seam is tested for volumes and quality, which helps identify options for putting the water to beneficial use. If gas is produced it is also extracted and tested.

Production wells have the same design, but more wells are spread over a wider area.

Well site equipment

The well is lined with pressure-rated steel casing from the surface to just above or below the coal seams and cemented in place. The casing is pressure tested to ensure that it can tolerate higher pressures than the pressures expected over the life of the well.

A BOP may be installed in the cellar to ensure that, in the unlikely event of unexpected water or gas pressures, the drilling rig can shut the well in.

At surface level, a wellhead is installed. It ensures that all produced water and gas is safely handled. Inside the well head is a steel tubing hanger — the tubing hangs inside the steel casing with the pump at the bottom.

The test string (all components of the pumping mechanism) comprises a PCP pump, a rod string which rotates inside the tubing and transmits power from the motor at the well head to the downhole progressive cavity pump (PCP), which is just above the coals of interest. This pump pushes water from the coal seam to the surface.

Just below the PCP is the torque anchor, which fits against the inside of the casing. The anchor prevents the tubing from being twisted out of place by the constant rotation of the sucker rod. Below the anchor is the tailpipe and pump intake. It is designed to assist with downhole separation of gas and water, and prevents gas being pulled through the
pump. The lighter gas rises and is trapped between the tubing and the steel casing, while the heavier water falls to the bottom of the well and is pumped up inside the tubing string by the PCP.

The well head equipment performs all functions required to carry water from the coal seam to the surface and is powered by a motor on site. The drivehead powers a pulley system which drives the rod string and the PCP. There are three outlets on the well head. There is one tubing outlets to carry water from the well to allow water testing. The two casing annulus outlets enable gas to flow from the well to the flare line, and fluid levels in the well to be measured.

The stuffing box provides a seal between the rotating rod string and atmosphere. This prevents water and gas leaking from the wellhead. During a pilot test, pressures and water volumes will be monitored by a flow meter. The results are reported in accordance with regulatory obligations.