QGC
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11.0
Re-injection and repressurisation options

11.0 Re-injection and repressurisation options

Condition 49c

11.1 INTRODUCTION

Coal seam gas extraction cogenerates significant groundwater volumes which then need to be managed at surface level. Water treatment and subsequent beneficial use is one solution and injection of treated water into an aquifer is another. QGC is actively investigating water injection as a potential management response alternative. Aquifer injection involves pumping excess water down purpose-built injection wells to a targeted aquifer formation. A program and schedule for field piloting of aquifer re-injection of treated CSG water and other groundwater repressurisation techniques is required under Condition 49c.

A Managed Aquifer Recharge (MAR) Feasibility Assessment was completed by Golder Associates (December 2010) which assessed potentially suitable aquifers for injection and identified possible locations for a trial and for potential future permanent development. Subsequently, QGC has selected a Northern Gas Fields site for its Aquifer Injection Trial and planning and implementation are well-advanced.

11.2 OVERVIEW OF QGC APPROACH TO RE-INJECTION AND GROUNDWATER REPRESSURISATION

QGC's approach to assessment of re-injection and groundwater repressurisation is focused on investigating and trialing those technologies that can be cost-effectively used to maintain groundwater pressures in formations that support EPBC listed springs. Accordingly QGC's strategy consists of:

- Field investigations of Hutton and Precipice Sandstones in the northern tenements west of Wandoan for re-injection potential
- No consideration of repressurisation of shallow aquifers such as Mooga or Gubberamunda Sandstones as these formations are not present at or do not support EPBC listed springs
- No consideration of re-injection to deep aquifers in the Central and Southern Gas Fields due to their long distance from EPBC listed springs. Re-injection in the Northern Gas Fields would be a more effective option given the area's proximity to springs. However, QGC are planning coring studies of Hutton and Precipice formations in the Central and Southern Gas Fields to increase overall knowledge of aquifer characteristics in these areas.
- Coal seam re-injection is not considered to be a viable option for the reasons described below.

11.3 COAL SEAM RE-INJECTION

Re-injection into Walloon Coal Seams has been assessed and is considered unviable for a number of reasons:

- Re-injection into coal seams could not occur until gas extraction had been completed in particular areas
- Depleted gas fields of sufficient area will not become available for many years, whereas peak CSG water production occurs in the early years of gas field development.

11.4 REGULATORY CONTEXT

Australian Government SEWPAC

Under Approval Condition 49c, the Australian Government requires QGC to investigate re-injection of CSG waters as a possible future management action response to protect MNES and groundwater resources and maintain water balance. This requires evaluation of re-injection (one form of Managed Aquifer Recharge) of produced water to deeper aquifers as well as other groundwater repressurisation techniques.

Queensland Government
Queensland's Department Environment and Resources Management (DEHP) (now Department of Environment and Heritage Protection (DEHP)) articulates in its June 2010 Water Management Policy that its preferred water management options are beneficial use and reinjection. DEHP's non-preferred water management options include disposal via CSG evaporation dams and disposal to surface waters.

Under the CSG Water Management Policy the injection feasibility studies need to address the aquifer selection, the properties of the aquifer, and the water treatment requirements to the appropriate standards, (based on the water quality of the target aquifer). At present, there is no re-injection regulation.

Injection trials approvals
Currently QGC has approval under its EA PEN 101741410 for the Woleebee Creek project areas to only undertake a 'Fluid Injection Trial' providing that QGC can comply with the conditions stipulated in the EA. The Fluid Injection Trial involves the reinjection of water withdrawn from an aquifer, in this case the Precipice Sandstone. QGC will seek an amendment with DEHP to its current EA conditions related to aquifer injection to undertake injection trials using CSG treated water. This work is planned to commence in 2013.

QGC will also be required to comply with the requirements of the Queensland Water Supply (Safety and Reliability) Act 2008, to allow the use of treated CSG water as a recycled water source.

Full scale injection using CSG treated water
Currently there is no regulatory framework in place to undertake full-scale injection of CSG treated water. QGC, in collaboration with CSG companies, will work with Queensland regulators to develop a fit-for-purpose regulatory framework under which aquifer injection can be undertaken if required.

The issue of future liability for re-injection needs to be addressed with regulatory agencies.

11.5 OBJECTIVES OF RE-INJECTION PROGRAM WOLEEBEE CREEK BLOCK

On a regional level, the study seeks to predict and verify the spatial extent of regional groundwater level drawdown, groundwater balance and inter-formation leakage estimates in order to estimate the extent to which aquifer repressurisation may be required. The Woleebee Creek Block site was selected for this aquifer injection feasibility study because of its proximity to EPBC springs and the availability of a Water Treatment Plant.

The study plan has three main stages; and prior to moving to a next stage, a review will be made to ensure readiness to move to the next stage:

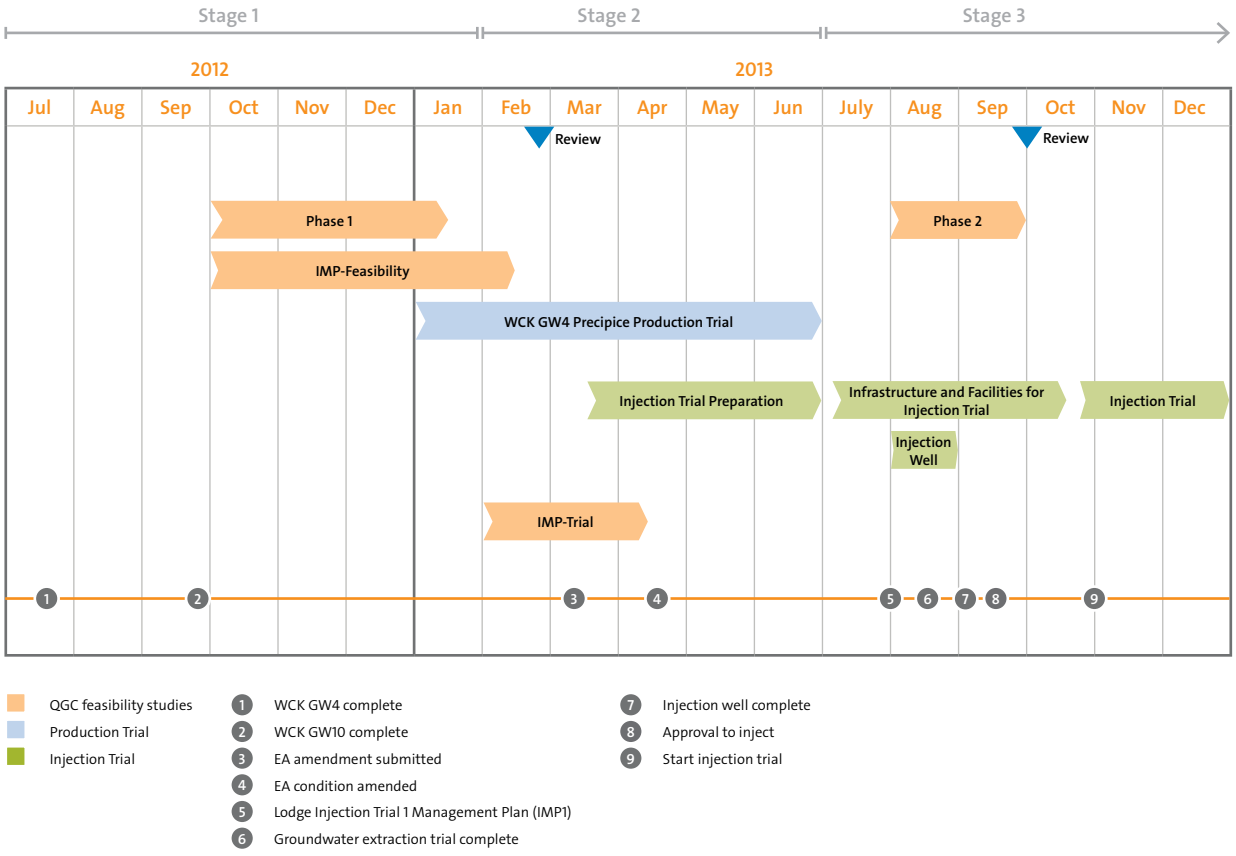
- Stage 1 – Data acquisition, monitoring and trial injection bore construction/conversion
- Stage 2 – Production trials and reinjection preparation
    - First trial to produce Precipice water
- Stage 3 – (Long-term) injection
    - First trial with treated Precipice water
    - Second trial with treated CSG water.

The transition from one stage to another is contingent to getting (i) all regulatory approvals in place, (ii) access to infrastructure and (iii) outcomes of the aquifer injection feasibility assessment from the previous phase, and (iv) company comfort that the next stage can be safely and responsibly executed. The immature regulatory framework and injection into potable aquifers give rise to indemnification concerns.

Forward Schedule

QGC's current schedule for its trial reinjection program is outlined in Figure 38. This indicates that Stage 1 activities (involving construction of monitoring bores GW4 and GW10 and hydraulic testing of bore GW4) as well as the conversion/construction of the injection well will be completed by March 2013.

QGC had originally proposed in its Stage 1 WMMP (Table 16) that the Precipice Formation monitoring bore GW4 would have been constructed over the period Q4 2011 to Q1 2012. This program was delayed due to the availability and contracting of a suitable drilling rig to drill this bore and other monitoring bores at the Woleebee Creek site for the connectivity program. Construction of GW4 was completed in Q3 2012.



QGC feasibility studies
Production Trial
Injection Trial

1 WCK GW4 complete
2 WCK GW10 complete
3 EA amendment submitted
4 EA condition amended
5 Lodge Injection Trial 1 Management Plan (IMP1)
6 Groundwater extraction trial complete
7 Injection well complete
8 Approval to inject
9 Start injection trial

Figure 38 – Aquifer injection feasibility plan

11.6 AQUIFER INJECTION FEASIBILITY ASSESSMENT

The study's objective is to assess the aquifer injection potential of the Precipice Sandstone and the Hutton Formation in the Northern Gas Fields as a mitigation option for potential impacts on EPBC listed springs recharged through both formations. The feasibility study will be developed in parallel with the staged development and implementation of investigations and trials. The feasibility study addresses key technical criteria to determine aquifer injection feasibility including:

- Injectivity: injection rate of water (ML/d) over time
- Capacity: extent of the targeted aquifer where water can be injected over time
- Containment: vertical and lateral water migration and groundwater pressure propogation.

To fulfill this objective, QGC needs to complete a step by step approach to:

- Characterise the geology, hydrochemistry and hydrogeology of the Hutton and Precipice aquifers
- Based on newly acquired data, build hydrogeological and hydrochemical models to assess
    - Projected injection rates and Hydraulic Impact Zone
    - Projected water quality impact zone and
    - Water quality and mineralogical compatibility and any potential impacts to agricultural and potable town water supplies
- A more detailed data acquisition program involving dynamic testing (production tests or/and injection trials) to address injectivity and containment risks as well as the geochemical compatibilty of injected water with the subsurface environment
- Engineering studies to assess injection water pre-treatment requirements, plant layout and footprint size and related infrastructure including requirements for treated water storage at injection facilities
- Preliminary engineering optimization studies to assess feasibility of multiple-well injection.

In summary, QGC has planned the following tasks:

Stage 1 Tasks

- Aquifer appraisal investigations. This will allow an initial assessment of indicative bore injection capacity for both Hutton and Precipice Formations to be developed.
- Trial Injection bore design
- Aquifer injection feasibility based on initial assessment of bore injection rates/volumes
- Precipice water extraction, transfer and storage engineering
- Prefeasibility of injection scheme options which would consider injection water pre-treatment options numbers of injection wells and required spacing, injection pressure, power and related infrastructure requirements
- Collation of available regional data on current bores, geology, groundwater use pressure head and quality within the northern Surat Basin and Dawson River catchment
- Initial impact assessment including bore and aquifer clogging potential, regional groundwater pressure and water quality impacts for a range of injection scheme scenarios
- Review prior to moving to stage 2.

Stage 2 Tasks

- Injection trials (Precipice and treated CSG water) water pre-treatment water requirements and feasibility level design
- Development of injection pre-treatment water requirements
- Impact assessment of various scales of injection
- Infrastructure and power requirements for trials and full-scale implementation
- Economics of various sizes of injection schemes
- Precipice water extraction and simulation and monitoring of resevoir performance
- Review prior to moving to Stage 3.

Stage 3 Tasks

- Injection trials with Precipice water
- (Short term) injection trials with treated CSG water
- Injection trials.

A comprehensive Aquifer Injection Feasibility Study Report considering the above elements will be prepared to:

- Assess technical and non technical risks and propose a program to de-risk aquifer injection
- Provide the basis for developing Injection Management Plans that will support Queensland Government approval requirements
- Comply with EPBC Act approval conditions.

QGC's aim is to submit the Feasibility Study to SEWPAC and the Queensland regulators six months after the commencement of the extended reinjection trial with treated CSG water. However, Injection Management Plans will be submitted prior to the start of each of the injection trials (see below).

QGC's current schedule for its trial reinjection program is outlined in Figure 38.

11.7 PLAN OF ACTION TO DETERMINE FEASIBILITY

QGC's plan of action consists of three Stages:

- Stage 1 – Data acquisition, monitoring and trial injection bore construction/conversion
- Stage 2 – Production trials and reinjection preparation
- Stage 3 – (Long-term) injection trials.

11.7.1 DATA ACQUISITION, MONITORING AND TRIAL INJECTION BORE CONSTRUCTION/CONVERSION

As part of its Stage 2 WMP connectivity studies program, QGC has recently drilled seven groundwater monitoring bores at the Woleebee Creek location targeting various aquifers and aquitards for monitoring purposes during production trials and full-scale production. Two bores have specific focus on the assessment of aquifer injection feasibility:

- Woleebee Creek GW3 Hutton monitoring bore
- Woleebee Creek GW4 Precipice data acquisition and monitoring bore.

Key information for each bore is summarised in Table 18. The Woleebee Creek GW3 and GW4 bores were drilled between March and July 2012 using Atlas #1 rig at the Woleebee Creek Block (ATP 651). Bore locations in relation to major regional structural features and previously drilled oil and gas exploration holes are shown at Figure 39.

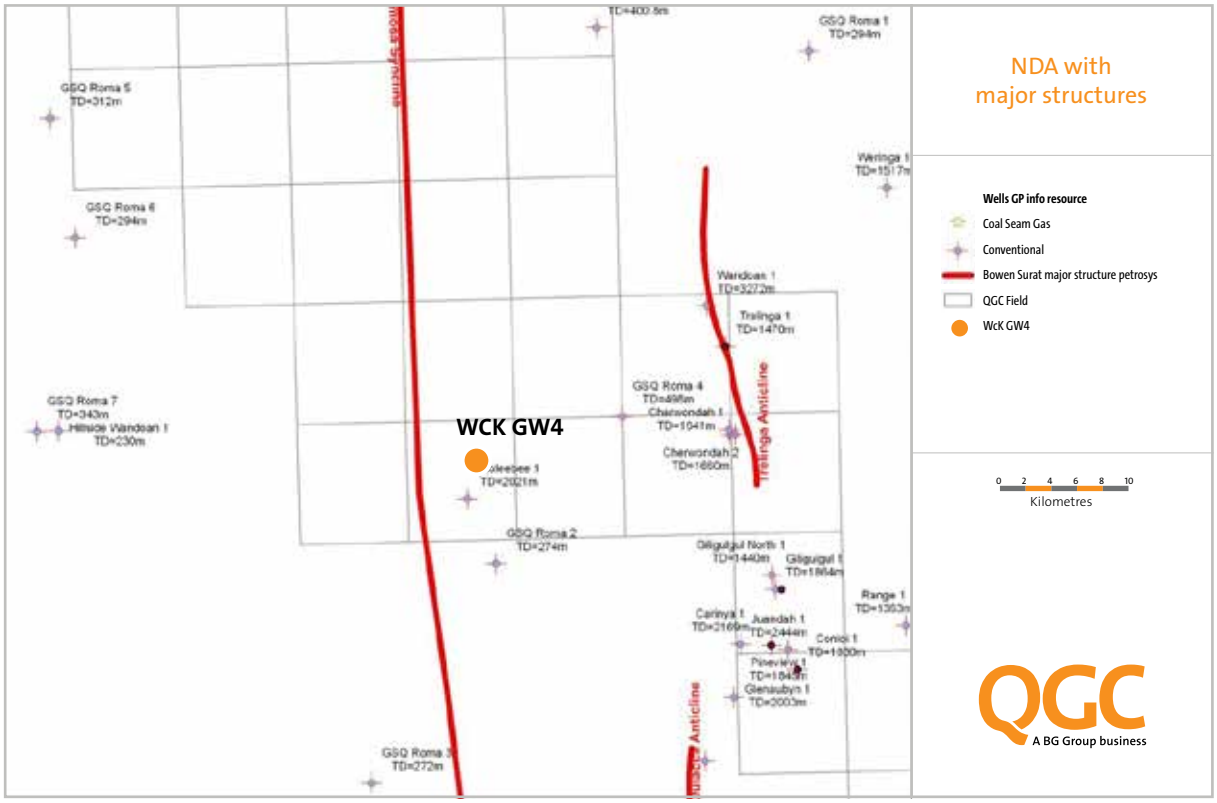


Figure 39 – Location of GW4 bore

QGC has embraced the opportunity to transfer this newly available water source for the benefit of regional communities.

Location	Woleebee Creek	
Well name	WCK GW3	WCK GW4
Targeted Formation	Hutton	Lower Precipice
Interval targeted (m)	1050-1250	1460-1572.5
TD (mblg)	1250	1572.5 (actual depth drilled 1635 m)
Spudded	14/03/2012	11/05/2012
Completed	4/04/2012	
Coring	No coring	~ 1,100m of cores including: • 114m from surface to Gubberamunda Sandstone • 133m of Westbourne Formation • 102m of Springbok Sandstone • 101m of Eurombah Formation • 300m of Hutton Sandstone • 150m of Evergreen Formation • 125m of Precipice Sandstone (including Upper and Lower Precipice) • 50m of Moolayember Formation
MFTs	Springbok, Hutton	Gubberamunda, Springbok, Hutton, Precipice.
Open logs (surface to TD)	Density, Neutron, Resistivity, GR, SP, Image Logs, Cross Dipole Sonic	Density, Neutron, Resistivity, GR, SP, Image Logs, Cross Dipole Sonic
Cased logs	Westbourne and Eurombah	Westbourne, Durabilla and Upper Precipice
DSTs	N/A	Gubberamunda, Springbok, Hutton, Precipice
DFITs	N/A	Westbourne, Durabilla, Evergreen, Moolayember
Monitoring	Target: Hutton Groundwater level – continuous water level recorder installed Water quality (planned)	Target: Precipice Groundwater level – continuous water elvel recorder installed Water quality (planned)

Table 18 – Woleebee Creek monitoring bores GW3 and GW4 summary information

Woleebee Creek GW3 Hutton bore was drilled to:

- Acquire key geological data of the Hutton Formation
- Establish baseline hydrogeological condition of the Hutton aquifer.

Data derived from WCK GW3 drilling and monitoring will be used to assess aquifer injection potential of the Hutton Formation at Woleebee Creek.

The data acquisition program for Woleebee Creek GW3 and GW4 bores included:

- 1,100m coring of the entire Surat geological formations (except the WCM) from surface (Gubberamunda) to Total Depth (TD) into the Moolayember Formation;
- Wireline cased hole logging to assess well integrity (cement and casing) from surface to production casing shoe
- Wireline open hole logging estimating rock properties (GR, resistivity, sonic, neutron) while quantifying stress regimes (CXD) using image logs (CMI) to detect fracture density and orientations
- Measured Formation Testing (MFTs) to assess in situ formation pressure and temperature across these formations
- Drill Stem Testing (DSTs) of the Hutton and Precipice for direct evidence of flow capacity for the tested formations and therefore, direct estimates of transmissivity (permeability-thickness product, or K•H)
- Measurement of in-situ fracture gradients (DFIT) in the sealing formations including the Eurombah Formation, Evergreen Formation and Moolayember Formation to determine fracture pressures.

QGC is currently undertaking a core analysis program on all WCK GW4 cores (including Hutton and Precipice Sandstones) which includes:

- Routine Core Analysis (RCA) to assess rock properties, permeability, porosity and rock compressibility. Comprehensive core data is required to calibrate geophysical logs for a greater understanding of key formation properties. The core data will provide confidence in petro-physical analysis to characterise the formation with permeability, porosity, and lithology, net-to-gross (NTG). Vertical (K_v) and horizontal (K_h) permeability profiles will also be derived from cores.
- Special Core Analysis (SCAL) involving, for each formation:
    - Thin sections and core description to characterise sedimentological and petrographic properties
    - X-RAY Diffraction (XRD) analysis to assess mineralogy
    - Scanning Electron Microprobe (SEM) to determine mineralogical compositions
    - Throughput test to assess brine permeability and overburden porosity
    - Critical velocity to assess fines migration
    - Rock mechanics and sand mobility tests through rock strength analyses and sieve and laser particle size analysis.

Figure 40 – Precipice Sandstone core from Monitoring Bore GW4 Woleebee Creek

The geological, geochemical, hydrogeological and geomechanical data will be integrated into predictive models to 1) understand the general environment that may be impacted by any future aquifer injection development, and 2) assess injection potential to maintain groundwater pressures in formations that support EPBC listed springs.

Progress to date

The preliminary interpretation of the data acquired from the drilling of WCK GW3 and GW4 confirmed the findings of the MAR Feasibility Assessment (Golder Associates, 2010). The Precipice Sandstone, at the Woleebee Block, offers the highest probability of injection feasibility because:

- It is on QGC-owned land close to planned infrastructure (RO treatment plant)
- It is relatively close to springs (about 60 km north-west of the Woleebee Block), which are the potential receptor of impacts from CSG operations that may require mitigation with injection
- It offers good prospects for being able to accept large quantities of water. It is a relatively massive, regionally extensive, and permeable reservoir.
- It is geochemically stable with clean quartzose sandstone, with lesser amounts of kaolinite and trace amounts of pyrite.
- The naturally occurring TDS content of the Precipice water in the Wandoan -Woleebee Creek area is low (approx. 300 ppm). Treated water from the proposed Woleebee Creek RO plant will be designed to produce water of similar salinity.

Initial Woleebee Creek GW4 results from both open-hole wireline logs and a review of the raw core indicate that the entire Lower Precipice is a clean, homogeneous sandstone. Precipcie Sandstone permeability is estimated at 1,630 mD (based on DST testing of a 6 m interval) compared to 750 mD for the Hutton Sandstone.
In summary, the Precipice Sandstone:

- Is quartz dominated coarse grained consolidated sandstone whilst the Hutton tends to be more clay-rich
- Is over 100 m thick
- Has the highest Net To Gross (about 99% of Precipice is sandstone) compared to Hutton NTG of 38%
- Is consistently highly porous (20%) and permeable (exceeding 1D permeability or 10 m/s) where as the Hutton is more heterogeneous with sand intervals
- Is overlain by a thick (180 m) low permeability aquitard sequence – the Evergreen Formation.

On this basis it was decided to proceed with:

- The drilling of the second Precipice monitoring bore GW10
- The planning and design of the Woleebee Creek GW4 Precipice production trial
- The planning of MAR 1 Precipice injection well drilling
- The planning and design of MAR 1 injection trials.

Expected Outcomes (Stage 1)

At the end of Stage 1 of the pilot re-injection program, QGC will better understand Evergreen Formation sealing capacity with data on formation top and sand versus shale, porosity-permeability, MCIP, rock strength and mechanical properties, fracture pressure, and reactivity of minerals. Precipice aquifer performance will be assessed using data on:

- Formation top and sand versus shale
- Porosity/permeability
- Vertical permeability per horizontal permeability (K_v/K_h) Net to Gross (N/G)
- Compressibility
- Groundwater head pressure (via MFT, DST and groundwater level gauges)
- Potential formation reactivity(clogging/scaling).

11.7.2 PRODUCTION TRIALS AND REINJECITON PREPARATION

Woleebee Creek (WCK GW10) Precipice groundwater monitoring

QGC is currently drilling (September 2012) an additional Precipice monitoring bore GW10 on the Woleebee Creek Block, 3.2 km north-west from the Woleebee Creek GW4 bore.

The main purpose of this bore is to measure groundwater pressure changes during the WCK GW4 Precipice groundwater production tests (see next section). Data collected from the bore will also provide additional information on the regional Precipice Sandstone continuity and to confirm Evergreen Formation lithology and geomechanical properties.

Woleebee Creek GW4/GW10 Precipice Production tests

QGC is currently planning a production trial at WCK GW4 to obtain aquifer hydraulic properties through short-term Precipice Formation water production testing and monitoring of ongoing water production for construction purposes. Extracted water will be discharged to one of the nearby Woleebee Creek pond cells.

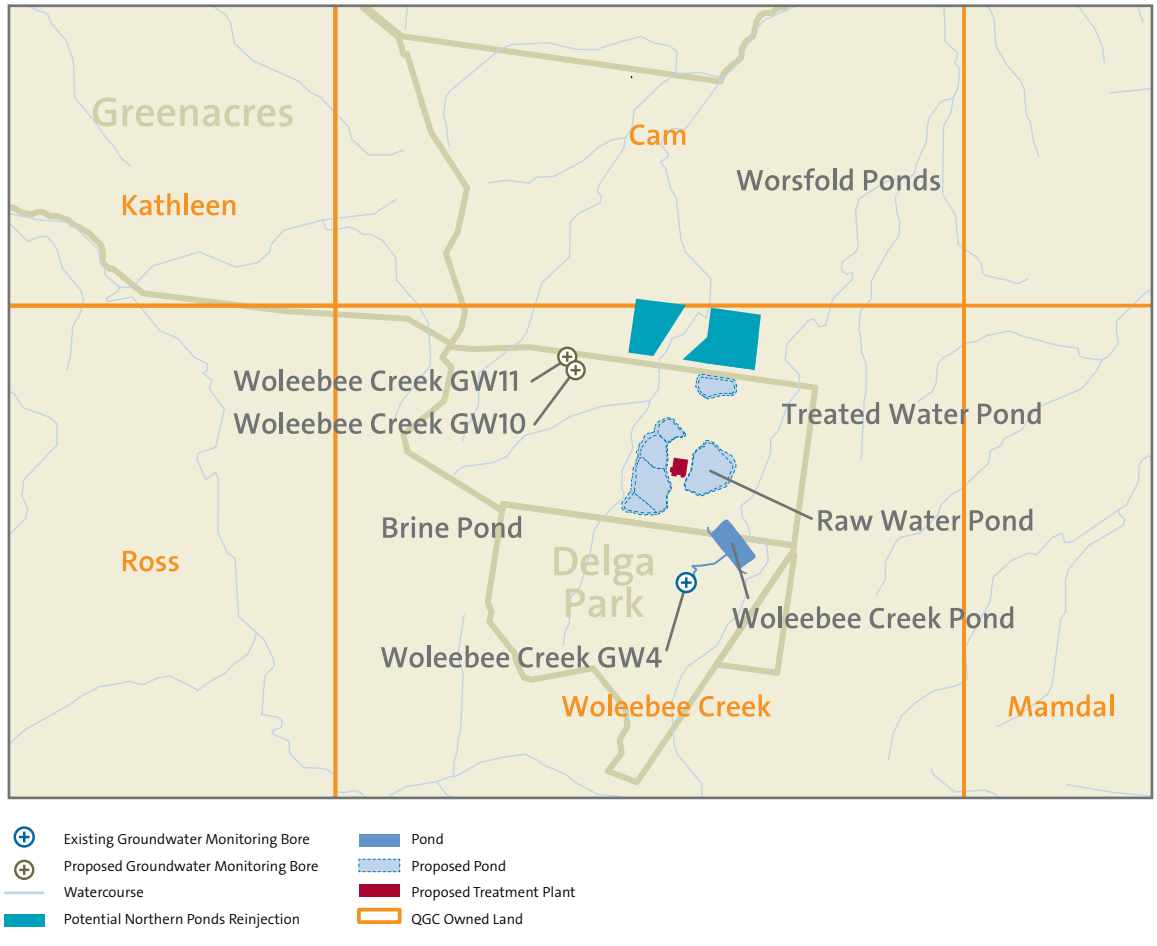


Figure 41 – Potential Northern Ponds

The production trial is currently under final planning and preparation and is due to start November 2012. Ongoing water production will be assessed after four to six months. Test design is limited to a maximum bore pump production rate (3.18 ML/d or 20,000 bbls/d) and available pond storage (total capacity 150 ML).

The testing program will include:

- Short-term pumping tests including:
  - A multi-rate pumping test to assess bore performance
  - A constant rate pumping test at a rate designed to sufficiently stress the aquifer to investigate any close potential boundary or water quality zonation effects
- Long-term test pumping:
  - To evaluate aquifer heterogeneity, lateral connectivity, boundary effects
  - To propagate drawdown to observation bore GW10 if possible for the calculation of aquifer storage parameters
  - To assess vertical connectivity across the Evergreen through a vertical interference test (VIT) using the GW3 Hutton monitoring bore
  - To assess groundwater quality variability.

Groundwater pressure at WCK GW4 and GW10 (Precipice) will be monitored with data loggers for the test period on a continuous basis to assess aquifer performance. Results will help calibrate the dynamic predictive reservoir models which are currently being developed using WCK GW4 core and logging data.

During the production trial period, water samples will be taken on a regular basis to assess formation water quality. QGC has developed a comprehensive groundwater sampling and analysis program which will aim to:

- Establish a hydrochemical and aqueous isotopic baseline for the subsurface system under assessment
- Facilitate geochemical modelling scenarios to assess the impact of treated waste water injection activities on regional groundwater quality and potential aquifer clogging effects.

Laboratory samples are analysed by testing laboratories that are NATA certified to perform the tests (where required).

Parameters tested include a minimum of:

- Physiochemical parameters: pH, EC, oxidation-reduction potential
- Dissolved cations and anions
- Isotopes
- Radiological parameters.

Based on the results of the laboratory testing, a risk assessment will be conducted to assess the compatibility of injection waters with existing groundwater conditions. In addition to the compatibility testing detailed in subsequent sections, the laboratory analyses will be used to assess any potential variations in the quality of in-situ Precipice groundwater.

This new data will allow assessment of injection estimates and provide data to better understand the maximum injection pressures and water chemistry necessary to design and plan the injection trials (Stage 1c).

11.7.3 (LONG TERM) INJECTION TRIALS

It is intended that one injection bore will be completed in 2013. The injector well will be designed and constructed using the data collected and lessons learnt from WCK GW4 and WCK GW10 drilling, and could be a new well (MAR 1) or the conversion of GW4.

All drilling activities will be conducted in general accordance with:

- The Minimum Construction Requirements for Water Bores in Australia
- The Minimum Standards for the Construction and Reconditioning of Water Bores that Intersect the Sediments of Artesian Basins in Queensland
- The Interim Requirements for the Construction of Injection Wells
- MAR 1 will be drilling following BG well engineering standards.

The drilling schedule is subject to rig availability, materials (casing and well heads), site access and regulatory approvals.

Injection trials – parameters

Injection Management Plans to support each of the injection trials will be developed. The initial Injection Management Plan will be revised following the Precipice water injection trial and at the end of Stage 2 following the CSG treated water injection trial. Both Injection Management Plans will address the following key issues:

- Water quality compatibility
- Water quality compatibility will be defined on the basis of the WCK GW4 Precipice water chemistry data which will be acquired during the WCK GW4 production trial. Water quality of the Precipice will be compared to the proposed injectate quality based on the RO product water treatment specifications. Modelling of the expected interactions will be undertaken using geochemical modelling tools.

Initial assessment was made on the compatibility of the RO treated water quality with the expected Precipice water quality (see Table 19).

Analyte	Units	Indicative Precipice Groundwater Quality *	Indicative Treated CSG Water Quality **
pH		6.8 - 7.8	7.5 – 8.5
EC	µS/cm	200 - 290	<300
Sodium	mg/L	30 – 34	<60
Potassium	mg/L	1.3 – 1.8	
Calcium	mg/L	0.14 – 0.46	
Magnesium	mg/L	0.08 – 0.14	
SAR	mg/L	11 - 16	
Chloride	mg/L	10 – 13	50 – 70
Fluoride	mg/L	0.1 - 0.3	< 0.3
Carbonate	mg/L	Nd	
Bicarbonate	mg/L	50 – 75	20 – 50
Hydroxide	mg/L	Nd	
Total Alkalinity	mg/L	50 – 75	20 – 50
Sulphate	mg/L	3 – 14	Nd
TDS	mg/L	110 - 190	
TSS	mg/L	Nd	
Ammonia	mg/L	0.18 - 0.64	< 0.4
NOx	mg/L	Nd – 0.03	
Aluminium	mg/L	Nd – 1.8	Nd
Arsenic	mg/L	0.0005 – 0.0021	Nd
Barium	mg/L	0.015 - 0.017	~ 0.017
Beryllium	mg/L	Nd	Nd
Boron	mg/L	0.017 – 0.022	< 0.5
Cadmium	mg/L	0.0005	Nd
Chromium	mg/L	0.003 – 0.009	Nd
Cobalt	mg/L	Nd – 0.002	Nd
Copper	mg/L	0.015 – 0.5	Nd
Iron	mg/L	1.8 – 5.8	~ 0.001
Lead	mg/L	0.001 - 0.007	Nd
Manganese	mg/L	0.025 - 0.051	Nd
Mercury	mg/L	Nd	Nd
Molybdenum	mg/L	Nd	Nd
Nickel	mg/L	0.017 – 1.1	Nd
Selenium	mg/L	Nd	Nd
Silver	mg/L	Nd	Nd
Strontium	mg/L		0.067
Uranium	mg/L	Nd	Nd
Vanadium	mg/L	0.004 – 0.01	Nd
Zinc	mg/L	0.13 – 0.35	~ 0.004
Total Hardness	mg/L	1 – 2	< 2
Methane	mg/L	0.005 - 4.7	Nd
CO2 Free	mg/L	17 – 23	
Alpha		0.05 - 0.06	
Beta		0.13 - 0.22	
TOC	mg/L	Nd – 1	2
DOC	mg/L	Nd – 1	1
Dissolved Oxygen	mg/L		9

** Wandoan town bores ** QGC basis of design for proposed northern treatment plant*

Table 19 – Indicative Precipice Formation and treated CSG water quality

During the injection trials, water quality data will be benchmarked against results of water quality analyses collected during the test pumping and modelled injectate-groundwater chemical compositions.

This geochemical modelling will be used to estimate the water quality impact zone and assessment of potential impacts to agricultural and potable town water supplies.

Injection pressures

Water injection into aquifers can occur via fracture or matrix permeability. The clear intent of the draft regulatory guidelines in Queensland is to permit only matrix injection, as fracture injection risks uncontrolled injection into other aquifers if fractures propagate through confining layers. A constraint on injection pressure of 90% of fracture pressure has been established in the existing EA. As the matrix fracture pressure of the Precipice Sandstone is difficult to determine. Data obtained from the Diagnostic Fracture Injection Tests (DFIT) in the overlying Evergreen and underlying Moolayember sealing formations can be used to estimate fracture pressures. The ongoing geomechanical testing of core from WCK GW4 will provide definitive fracture pressures for the precipice that will guide the proposed injection trial program.

Laboratory core tests are planned on the core plugs to assess sand mobility and its potential behaviour during injection.

A key risk for matrix injection is the potential for pores to become plugged over time, either with formation fines, chemical scale or corrosion products. Petrographic analysis of core samples from WCK GW4 will be used to determine the clay content and type, as some clay minerals are more likely to be remobilised and to plug pore throats. The potential for chemical scale to be deposited as the treated water interacts with bore screens, the minerals in the sandstone and the formation water will be investigated.

Injection rates and hydraulic impact zone

Indicative injection rates and hydraulic impact zones have been projected based on WCK GW4 data and currently available well data. These will be revisited following the WCK GW4 production trial.

Injection trials – Objectives and Plan

At this stage, QGC is planning two injection trials:

- Re-injection of produced Precipice water
- Injection trial using CSG treated water.

Re-injection of produced Precipice water

The purpose of this trial is to evaluate:

- Injection well efficiency
- Aquifer performance.

Stored Precipice water will be filtered to reduce suspended solids and re-injected. Filtration requirements will be determined following groundwater sample analysis from GW4 and GW10.

The final re-injection test design will be submitted as part of the Injection Management Plan 1.

The well will be monitored for fines migration, and scale build-up in the formation.

Injection trial using CSG treated water

Objectives for the injection trial using CSG water are:

- To estimate injection rates over time
- To assess lateral and vertical migration over time
- To assess reactivity of the Precipice Formation with CSG treated water chemistry
- To integrate subsurface and surface infrastructure
- To estimate costs/economics of aquifer injection into the Precipice
- To confirm the regulatory framework under which an operational injection scheme can be developed.

The Stage 3 (injection trial) plan details are being developed and will build on the data collected from GW4 testwork and the Precipice water injection trial. Currently, the injection trial plan involves:

- A mobile RO plant can be contracted to treat associated water from nearby ponds at Woleebee Creek to produce a high quality permeate stream. RO Plant selection and design are still to be confirmed. Alternatively the plan is to treat water through the Woleebee Creek Water Treatment Facility (WTF) during WTF commissioning and subsequently during operations
- The plan also envisages a pre-injection facility, including a possible pre-treatment facility, pumping, storage tanks, ponds and pipes from the RO facility to the well head.

The design including duration and timing of the injection trial is yet to be confirmed but will be finalised as part of the Injection Management Plan 2.

QGC believes that an injection trial using CSG treated water is necessary to prove the feasibility of aquifer injection before any full scale injection. The decision to proceed to the extended injection trial with treated CSG water will be dependent on the Queensland Government’s approval and resolution of QGC's indemnity concerns.

11.8 SUMMARY

QGC's approach to the assessment of re-injection and groundwater repressurisation is focused on investigating and trialing those technologies that can be cost-effectively used to maintain groundwater pressures in formations that support EPBC listed springs. QGC's trial injection program is a staged approach which is planned to consist of:

- Construction of monitoring/investigation bores into Hutton and Precipice Sandstones in the northern tenements west of Wandoan for re-injection potential
- Hydraulic testing of Precipice monitoring bore (GW4)
- Construction of trial injection bore and second monitoring bore
- Injection trials using Precipice Formation water and treated CSG water
- Long-term injection test.

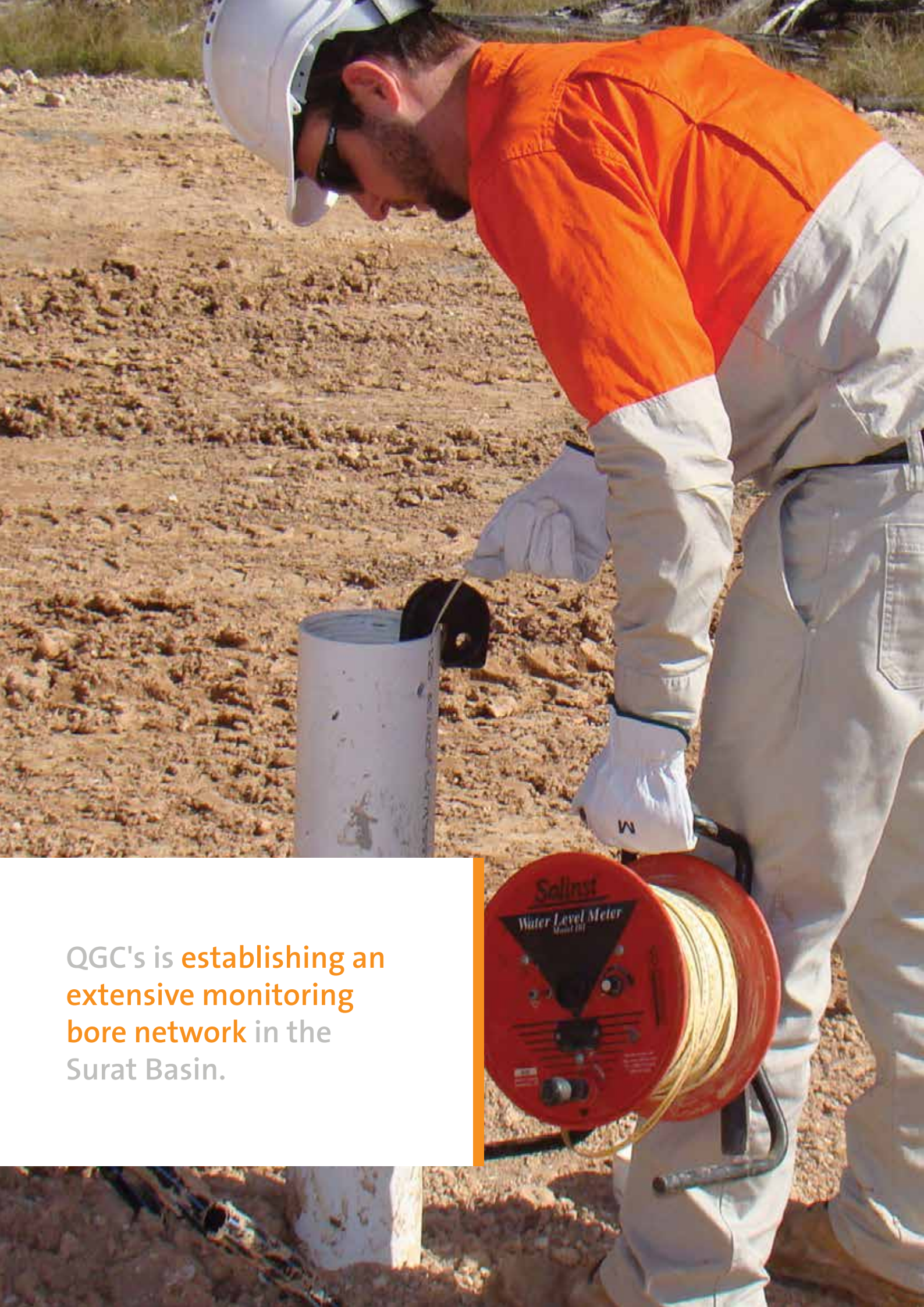
11.9 COMMITMENTS

QGC is committed to the following actions:

- Construction of monitoring bore GW10 and trial injection bore (conversion)
- Test pumping monitoring bore GW4 and monitoring post-test water extraction
- Reporting findings of field and laboratory programs and interpretive studies in an Injection Management Plan for the Precipice water injection trial. Submittal of this report to SEWPAC and Queensland agencies in February 2013
- Reporting findings of the Precipice injection trial and ongoing laboratory programs and interpretive studies in an Injection Management Plan for a treated CSG water injection trial. Submittal of this report to SEWPAC and Queensland agencies in June 2013
- Conducting an injection trial using treated CSG water and reporting the findings of the trial and recommendations for an operational injection scheme in an Aquifer Injection Feasibility Study Report in April 2014.

Commitments	Target completion date
Completion of first Injection Management Plan (Precipice Water)	February 2013
Completion of second Injection Management Plan (Treated CSG Water)	June 2013
Construction/conversion of investigation, monitoring and trial injection production bore	October 2013
Completion of Feasibility Study Report	April 2014

The above commitments are aimed at satisfying Condition 49C



QGC's is **establishing an extensive monitoring bore network** in the Surat Basin.