

7.0

Groundwater quality monitoring and hydrochemistry program



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Condition 49d, 52, 62 and 65

Hydrochemical studies are a key component of QGC's wider aquifer connectivity studies and longer-term hydrochemistry programs will inform our understanding of water chemistry and water rock reactions in aquifer systems.

7.1 HYDROCHEMICAL TESTING PROGRAM

Discernible differences may exist in the hydrochemical signatures of water from different aquifers in the Surat Basin aquifer system. Significant differences in adjacent layers (e.g. aquifer against aquitard) allow calculation of vertical mixing rates where natural and/or induced vertical pressure differentials induce flow between underlying and overlying hydrochemical systems. This yields vertical leakage rates.

In the Stage 1 WMMP, QGC committed to a preliminary hydrochemical study, groundwater sampling, and a detailed analysis to define a hydrochemical model for establishing leakage rates and potential connectivity.

7.2 PROGRAM OBJECTIVES

The programs primary objective is to use available hydrochemical datasets to assess potential aquifer connectivity and this, in turn, rests on fulfilling these key secondary objectives:

- To evaluate hydrochemistry as a means of identifying specific water 'signatures' for each aquifer of interest
- To identify possible areas of preferential groundwater migration (highlighted by chemistry)
- To determine water quality as an accurate measure of K_v/K_h or, ultimately, flux
- To use hydrochemistry results to identify possible salinity changes within aquifers due to migration of adjacent poorer quality groundwater
- To determine groundwater ages in different aquifers via isotope fingerprinting.

7.3 SCOPE OF WORKS

To meet the objectives defined above the following scope of work has been proposed, namely:

- Hydrochemistry data compilation
- Desktop hydrochemistry study
- Preliminary hydrochemistry conceptual model
- Isotope studies
- Integrated hydrochemistry study/report.

7.4 HYDROCHEMISTRY DATA COMPILATION

Hydrochemistry information is being compiled using these water chemistry datasets:

- Datasets from previous reports
- Existing water analysis results from QGC CSG wells in the WCM
- Analysis of results from farm bore assessments on both QGC and non-QGC owned land
- Analysis of results from QGC's monitoring bores
- Analysis of results from other relevant QGC programs – pond monitoring, shallow aquifer works, etc.
- Analysis of results from springs assessments and rainfall chemistry data (towards establishing water inflow/outflow characteristics)
- Aquifer water chemistry analysis results from other industry proponents
- Analysis of results from relevant DNRM monitoring bores.

Datasets need to be verified, validated and evaluated for accuracy and reviewed for limitations on applicability. Collection methodology, bore knowledge, field and laboratory QA/QC processes and data processing need to be considered. Preliminary datasets from QGC's Stage 1 monitoring bores have been compiled and a brief analysis completed and reported in Section 3.16.

7.5 DESKTOP HYDROCHEMISTRY STUDY

A desktop hydrochemistry study will use compiled and validated datasets along with other validated reports:

- To determine if sufficient chemical differentiation between aquifers can be identified
- To identify key individual parameters for use as aquifer 'signatures'
- To identify and discuss spatial and temporal trends occurring within and between aquifers
- To determine if migration of poorer quality groundwater into adjacent better quality aquifers might be an issue. This involves an assessment of possible mechanisms for groundwater salinisation and of the timing and magnitude of any possible changes. Results will feed into the groundwater quality response plan described in Section 12.0.

7.6 PRELIMINARY HYDROCHEMISTRY CONCEPTUAL MODEL

As part of the previously developed regional conceptual hydrogeological model (Golder Associates, 2011), QGC will develop a basin-wide hydrochemistry conceptual model using data and results from studies already completed. Data from other studies will also be used, including available springs water chemistry data (for 'start' points for water chemistry at discharge/recharge environments).

Conceptualisation begins with a series of key cross sections running throughout the basin. These will be selected to characterise basin hydraulic regimes and include any significant structural or geologic features. This will potentially enable water to be traced 'hydrochemically' from inflow/recharge zones (streams, creeks and springs) through the basin and water chemistry results from various aquifers and surface water bodies. Graphical representations include Stiff/Piper and Durov plots. This cross section study will be expanded as part of an integrated program.

7.7 ISOTOPE STUDIES

Groundwater isotope analysis is a long lead-time activity, with laboratory analysis taking three to six months from the time of sample collection. So a staged approach has been adopted, with initial studies to be completed without isotope data. In this way, preliminary hydrochemical conceptual models can be developed and isotope work brought into models to support and define conceptualisation.

Isotope studies involve defining data sources and raw results, detailing the analysis method(s) and processing the data to determine water ages. Reports are then generated detailing this process and presenting a discussion and interpretation of age results.

7.8 INTEGRATED HYDROCHEMISTRY STUDY

This study will link the isotope works to ongoing water sampling programs and associated hydrochemistry studies and bring the programs together. The aim is to generate an integrated hydrochemical conceptual model for the basin supported by water chemistry and isotope data.

7.9 PROGRAM PROGRESS

The following hydrochemistry following tasks have been completed:

- Water samples collected and analysed from the first 13 Stage 1 (shallow aquifer) bores installed Q3/Q4, 2011
- A preliminary hydrochemistry assessment of the water chemistry results. This assessment is discussed further in Section 3.16.
- Water samples collected from the first 13 Stage 1 (shallow aquifer) bores for isotope analysis with results pending
- Water samples collected and analysed from farm bores located on QGC-owned land. This data will be analysed as part of the Stage 2 WMMP.
- Water samples collected and analysed from a number of private bores throughout the tenements.

7.10 IMPLEMENTATION SCHEDULE

The hydrochemistry program implementation schedule is:

- Ongoing water sampling: Q1, 2013
- Preliminary Hydrochemistry Model: April 2013 in line with GEN3
- Isotope Studies: April 2013 – April 2014
- Integrated Hydrochemistry Study: October 2014 (including update of relevant datasets).

7.11 PROPOSED ANALYTICAL SUITES

The current hydrochemical analytical suite comprises:

- Field Suite: Physical measurements and observations during routine field (on-site) monitoring; and,
- Groundwater Baseline Suite: Field parameters and laboratory analyses including volatile and semi-volatile organic compounds. These results enable definition of groundwater characteristics.

Analytical suite details are shown in Tables 14 and 15. Sampling and analysis frequency is bi-annually.

Field suite	
Odour	Carbon Dioxide (CO ₂) ¹
Appearance/colour	Methane (CH ₄) ¹
Temperature	Hydrogen Sulphide (H ₂ S) ¹
Electrical Conductivity (EC)	Oxygen (O ₂) ¹
pH	Carbon Monoxide (CO) ¹
Redox potential (Eh)	Peak LEL ¹
Dissolved Oxygen (DO)	
Depth to Water	

1. Gas concentrations, can be monitored using a calibrated gas meter.

Table 14 – Field suite

Groundwater baseline suite
Lab pH
Lab Electrical Conductivity (EC), Lab Total Dissolved Solids (TDS)
Total Alkalinity, Bicarbonate/carbonate (HCO ₃ ⁻ /CO ₃ ²⁻)
Sodium (Na ⁺), Potassium (K ⁺), Calcium (Ca ²⁺), Magnesium (Mg ²⁺)
Chloride (Cl ⁻), Sulphate (SO ₄ ²⁻)
Fluoride (F ⁻)
Sodium Adsorption Ratio (SAR)
Ionic Balance
Metals (dissolved): aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, vanadium, zinc, uranium
TPH, BTEX, PAH, including naphthalene, benzo(a)pyrene, VOCs, Phenols

Table 15 – Groundwater baseline suite

7.12 ISOTOPE PROGRAM

Groundwater was sampled at selected wells during 2011 for a series of naturally occurring isotopes. This will yield the age and origin of groundwater and becomes an important tool in identifying potential cross-aquifer leakage.

Isotope suite	Purpose	Application
Carbon-13 / Carbon-14	Provides age of groundwater, up to approximately 40,000 years.	Indicates residence times and hence recharge rates can be inferred.
Chlorine-36	Provides age of groundwater, from approx 100,000 to 1 million years.	Indicates residence times.
Deuterium	To characterise groundwater from specific aquifers.	Usually used in conjunction with Oxygen-18. Varies due to evaporation upon recharge.
Oxygen-18	To characterise groundwater from specific aquifers.	Usually used in conjunction with Deuterium. Varies due to evaporation upon recharge.
Strontium-86 / Strontium-87	May provide a 'signature' for groundwater coming from specific aquifers.	May indicate leakage between aquifers.

Table 16 – Environmental Isotopes

QGC has made arrangements with APLNG and the CSIRO for isotope sampling across a number of bores for the next two years. The company also has an agreement with the University of Queensland to fund isotope analysis of 50 samples from various aquifers in selected bores.

7.13 GROUNDWATER MONITORING PLAN

QGC provided an initial Groundwater Monitoring Plan as part of its Stage 1 WMMP (Appendix D). This plan was amended and resubmitted with Stage 2 WMMP (Appendix G.1). The plan will be further upgraded as part of Stage 2 activities with two upgrades coinciding with new groundwater data available from bore construction and baseline bore assessment programs. The first upgraded plan is scheduled for April 2013 with the final version planned for April 2014.

The interim Groundwater Monitoring Plan will be prepared in April 2013. At this time, QGC is of the view that the ongoing groundwater sampling program will comprise down hole data loggers with continuous (i.e. hourly) logging temperature and EC (if technically feasible) in all QGC monitoring bores. A telemetry system will be used to transmit this data. This will be underpinned by six-monthly sampling of the groundwater baseline suite. A review of existing groundwater quality data by APLNG, as shown in Appendix G.2, shows that for a sample of seven bores from various Surat Basin formations that have multiple laboratory water quality analyses available on the DNRM database, there is an average coefficient of variation (i.e. standard deviation/mean) of only 6% for total dissolved ions and only 4.2% for total dissolved solids. This data, which has been collected over decades, demonstrates that the water quality does not change greatly over the long term. Hence it is considered that very frequent sampling (e.g. monthly) is not necessary. The groundwater quality data will be evaluated and reported on an annual basis.

Many of the sub-programs detailed in Revision 0 of the GWMP (e.g. subsidence monitoring program, and springs monitoring program) are now covered under separate QGC monitoring plans developed during 2011 and 2012. As such, Revision 1 of the GWMP (April 2012 – Appendix G.1) is significantly revised from Revision 0. The GWMP is a live document and will be updated on an annual basis to account for the development of CSG field activities and regulatory changes. A number of the monitoring locations included within the current plan are still 'proposed'. Optimisation of the monitoring programs (the programs developed in the GWMP) will be carried out with consideration of the ongoing monitoring results.

Various modifications have also been made to the GWMP, including to the number and location of proposed groundwater monitoring bores, to take into account factors such as the latest numerical modelling results, directives from regulatory bodies, and land access, technical and geological constraints.

The Interim Groundwater Monitoring Plan will include monitoring bore and VWP locations as agreed in the Monitoring Network Implementation (MNI) Report in February 2013. Any proposed changes agreed for the MNI will be incorporated in the Stage 3 WMMP.

7.14 SUMMARY

The following hydrochemistry programs are proposed for the WMMP:

- Ongoing water sampling
- Preliminary hydrochemistry model
- Integrated hydrochemistry study
- Isotope studies.

Upgrades of the Groundwater Monitoring Plan are proposed for April 2013 and April 2014 as monitoring programs are implemented and new data collected, processed and assessed.

Commitments	Target completion date
Completion of interim Groundwater Monitoring Plan. QGC will continue to monitor the Walloon Coal Measures, Springbok and Gubberamunda Formations. Monitoring of the Mooga Sandstone where appropriate.	April 2013
Collection and analysis of six-monthly groundwater quality samples	Bi-annually
Implementation of the telemetry system for continuous groundwater level monitoring	Bores brought online progressively from March 2013
Completion of preliminary hydrochemistry conceptual model. Justification of water quality trend indicators	April 2013
Completion of Isotope studies	April 2013 / April 2014
Submission of integrated hydrochemistry report. Commitment to provide baseline definition of groundwater quality in the Northern Gas Fields.	October 2014

The above commitments are aimed at satisfying Conditions 49b and 52c (i) - (iv).



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