GasFields Commission Queensland

Collation of Water-Related Science and Research Activities in the **Queensland Coal Seam Gas Sector**

COLLATION OF WATER-RELATED SCIENCE AND RESEARCH ACTIVITIES IN THE QUEENSLAND COAL SEAM GAS SECTOR

A total of 188 water-related science and research projects linked to the Queensland coal seam gas sector have or are being carried out by universities, government agencies and coal seam gas (CSG) proponents.

INTRODUCTION

Effective water management is fundamental to minimising the environmental impact of CSG operations and improving its co-existence with rural industries. While industry and government agencies have been involved in undertaking research in relation to the impact of CSG activities in all aspects of water management, it has been difficult for stakeholders to identify the range of research activities that have been, or are currently being, undertaken. This report seeks to provide an initial collation of water-related science and research activities being undertaken in relation to the Queensland CSG industry. The GasFields Commission's objective is to provide stakeholders with a better awareness of both previous and current research activities as well as stimulate discussion regarding future science and research directions.

EXECUTIVE SUMMARY

- This collation of water-related science and research activities was undertaken to provide stakeholders with greater awareness of research activities and to stimulate discussion on future science and research directions.
- The Commission requested information in August 2012 from major CSG companies, State and Australian government agencies and Queensland universities about water-related science and research activities they were undertaking in connection with the CSG sector in Queensland.
- Any science and research activities undertaken in relation to Queensland which were focused on CSG water, or considered relevant to CSG water and salt management were within scope.
- A total of 188 research activities or projects were identified within the scope of the inquiry.
- Preliminary analysis of these activities was undertaken to identify trends pertaining to geographic locations, research theme and source of funding.
- Geographical analysis showed that the science and research are heavily focused within the Surat Basin with only limited activities being undertaken in other geological basins.
- The majority of science and research activity has been directed towards understanding and managing groundwater hydrology including investigations of hydrogeology, groundwater impacts and injection activities.
- Surface water management (including water treatment, irrigation and discharge) was identified as the second major area of activity.
- Industry has funded the majority of the science and research activities with Government (both State and Federal) funding the next biggest group of activities.
- This collation is a snapshot of research activities being undertaken, completed or planned as at October 2012. This collation is therefore a baseline to which further science and research information can be added as it becomes available.

The majority of science and research activity has been directed towards understanding and managing groundwater hydrology

METHODOLOGY

The Commission sent information request letters in August 2012 to CSG companies, Queensland and Australian government agencies and universities (listed in Appendix 1, page 5), which were identified as the major institutions potentially undertaking or commissioning relevant research. Whilst it was acknowledged that there may be other organisations undertaking relevant research, it was expected that this list would capture most of the relevant research which has been completed or is under way or planned within Queensland.

Information was requested on key research activities, studies and investigations that pertained to water management where CSG activities are undertaken. To assist the organisations in providing details of research activities that met the scope of the request, the information request letter listed the following areas of interest:

- CSG water treatment and management
- Salt management and disposal
- Systems for groundwater monitoring
- Impacts of CSG extraction on groundwater drawdown
- Groundwater contamination and inter-aquifer leakage associated with CSG bore construction, integrity and decommissioning
- Potential for, and/or impacts associated with re-injection of CSG water into aquifers
- Water quality and management guidelines for beneficial use of CSG water
- Characterisation of aquifer properties
- Impact on springs
- Any other areas that were considered relevant to CSG water and salt management within Queensland.

To facilitate subsequent collation of the information, the organisations were requested to provide it in the following prescribed electronic format:

- Organisation: organisation which has commissioned/undertaken the research
- Project title: title of the research
- Time frame: expected time frame the research will be completed or undertaken in
- Funding source: source of funding for the project
- Funding amount: monetary investment in the project
- Summary: a short summary of the project, kept to less than 200 words.

The information provided by the respondents was screened to ensure activities reported were consistent with the scope. Activities were classified as out of scope if they met one of the following criteria:

- Geographically located outside Queensland;
- Key focus was not on water research, or considered relevant to CSG water and salt management within Queensland
- The activity was identified as being a technical assessment or documentation required as part of an approval process.

A total of 271 individual activities were detailed by the respondents. However, 83 of the reported activities were clearly outside the scope of the report and were omitted from further study. The remaining 188 activities were included in the collated list of activities in Appendix 2, pages 6-37.

It should be recognised that no additional screening or investigation of the reported activities was undertaken and hence, the list may be expected to contain activities which fall outside the scope (in particular, activities that are technical rather than research by nature) and that there may be individual activities which have been reported by more than one respondent.

The information provided by the organisations has been included in the list without alteration. However, due to the lack of detail and consistency submitted in relation to the funding amount, this information has been omitted from the list and where appropriate noted as 'commercial in confidence'.

A preliminary analysis of the collated list was conducted to provide summary information in relation to geographic locations, research theme and source of funding. For the purposes of the analysis, the reported activities were categorised into the following research themes:

RESEARCH THEME	REPORTED RESEARCH ACTIVITY
Groundwater hydrology	Hydrogeology Impacts Response Injection Springs Visualisation/3D modelling
Water management	Environmental impact Irrigation Surface water Discharge
Waste and brine management	Brine management Salt recovery Salt management

KEY OBSERVATIONS

A range of key observations can be made about the water-related science and research activities, including common research themes, funding sources and stages of work.

STAGE OF RESEARCH

- Approximately half of the activities where date data was provided are currently being undertaken
- Seven per cent of the reported activities where date data was provided are yet to start.

ACTIVITY STATUS	COUNT
Completed	67
Currently being conducted	72
Yet to start	10
Date data not provided	39

SOURCE OF FUNDING

- Industry currently funds more than 70% of the activities (by number) with government funding approximately 20% of the activities.
- Insufficient data was provided by respondents to quantify the total investment in science and research activities.

FUNDING SOURCE	COUNT
Industry	129
Industry/government	8
Government	37
Government/university	1
University	9
Industry/university	4

GEOGRAPHIC LOCATION

- The majority of the activities (57% by number) were either non-specific to a particular region or not able to be assigned to a particular region.
- More than 80% of the activities which were identified as specific to a particular region or where a spatial location was provided were in the Surat Basin.
- Approximately 6% of the activities which were identified as specific to a particular region or where a spatial location was provided were focussed on the Bowen and Galilee Basins.

REGION	COUNT
Surat Basin	56
Surat Basin - Condamine Alluvium	12
Surat and Bowen Basins	9
Bowen Basin	2
Galilee Basin	3
Other	106

RESEARCH THEMES

- A total of 44% of the research activities are investigating groundwater hydrology issues with a further 30% of activities focused on water management and 11% on waste and brine management.

RESEARCH THEME	COUNT
Groundwater hydrology	84
Water management	57
Waste and brine management	20
General	27

RESEARCH THEME BY GEOGRAPHIC LOCATION

The research activities being undertaken outside of the Surat Basin region are focused on groundwater hydrology.

BASIN	THEME	COUNT
Surat Basin	Groundwater hydrology	25
	Water management	19
	Waste management	7
	General	5
		Total 56
Surat (Condamine Alluvia)	Groundwater hydrology	9
	Water management	2
	General	1
		12
Surat and Bowen Basins	Groundwater hydrology	7
	Water management	1
	General	1
		9
Bowen Basin	Groundwater hydrology	2
		2
Galilee Basin	Groundwater hydrology	3
		3

APPENDIX 1

LIST OF ORGANISATIONS FROM WHICH INFORMATION WAS REQUESTED AND PROJECT CONTACT (WHERE SUPPLIED)

- Arrow Energy Pty Ltd – tony.knight@arrowenergy.com.au
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) – tsuey.cham@csiro.au
- Department of Agriculture, Fisheries and Forestry (DAFF)
- Department of Environment and Heritage Protection (EHP)
- Department of Natural Resources and Mines (DNRM) – csgwaterstudy@dnrm.qld.gov.au
- Department of Sustainability, Environment, Water, Population and Communities/Office of Water Science
- Gas Industry Social & Environmental Research Alliance (GISERA) – founding members CSIRO and Australia Pacific LNG
- GeoScience Australia
- Origin Energy – a key partner in Australia Pacific LNG, a joint venture project with ConocoPhillips and Sinopec contact@aplng.com.au
- QGC Pty Limited – a key partner in QCLNG, a joint venture project with China National Offshore Oil Corporation rob.millhouse@bg-group.com
- Queensland Chief Scientist, Queensland Government – chief.scientist@premiers.qld.gov.au
- Queensland University of Technology (QUT) – jim.reeves@qut.edu.au
- Queensland Water Commission (QWC) – (07) 3405 4994
- Santos – a key partner in Santos GLNG, a joint venture project with PETRONAS, Total and KOGAS glng.communications@glng.com
- University of Queensland (UQ)/Sustainable Minerals Institute (SMI) – a.innes-walker@uq.edu.au
- University of Southern Queensland (USQ) – jochen.bundschuh@usq.edu.au

APPENDIX 2

LIST OF WATER-RELATED SCIENCE AND RESEARCH ACTIVITIES IN THE QUEENSLAND COAL SEAM GAS SECTOR

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Arrow Energy	Bowen EIS Model		Industry	
Arrow Energy	Brine Injection Exploration basement rocks		Industry	
Arrow Energy	Brine P/L Report Surat		Industry	
Arrow Energy	Concept Select Studies		Industry	
Arrow Energy	Condamine Connectivity		Industry	
Arrow Energy	Condamine Walloon Connectivity		Industry	
Arrow Energy	Data Analysis Hypoth. Testing		Industry	
Arrow Energy	Developing a Water Chemistry Atlas for CSG fields	2012-2015	University of Queensland (UQ)-Sustainable Minerals Institute (SMI)/ Industry	
Arrow Energy	Fault Representation		Industry	
Arrow Energy	Flux Uncertainty		Industry	
Arrow Energy	Geochemistry + Blanding Study - Tipton	August 2012	Industry	
Arrow Energy	Groundwater (GW) Monitoring/ Drilling/ sampling Program		Industry	
Arrow Energy	Herbarium Spring Ecology Study		Industry	
Arrow Energy	Injection FS Stage 1 + 2	2009	Industry	
Arrow Energy	Interactions of CSG Development with Agriculture and Forestry	2012-2014	UQ-SMI/Industry	
Arrow Energy	Ion Exchange Study	Planned	Industry	
Arrow Energy	Management Strategy Report		Industry	
Arrow Energy	Modflow		Industry	
Arrow Energy	Monitoring Vert. Depression Pilots		Industry	
Arrow Energy	PhD Geochemistry		Industry	
Arrow Energy	Review of TP153		Industry	
Arrow Energy	Sensitivity Analysis		Industry	

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Arrow Energy	Spring Hydrog. Study		Industry	
Arrow Energy	Spring I.D Report		Industry	
Arrow Energy	Surat Extension Model	August 2012	Industry	
Arrow Energy	Surat Extension Model V.40		Industry	
Arrow Energy	Surat Model		Industry	
Arrow Energy	Surface Facilities	August 2012	Industry	
Arrow Energy	Sustainable yield - Condamine		Industry	
Arrow Energy	UQ Water Charterisation Project		Industry	
Arrow Energy	USQ Cum. Impact Assessment		Industry	
Arrow Energy	Water Characterisation + Modelling	2011	Industry	
Arrow Energy	Water Concept Select Model	January 2012	Industry	
Arrow Energy	Water Discharge Model Report		Industry	
Arrow Energy	Water Quality Characterisation + Modelling Bowen	2012	Industry	
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Assessing predictive error when up-scaling CSG reservoir models for regional GW model impact assessment	2012-2013	Industry/CSIRO	Determine the predictive uncertainty associated with predictions of drawdown impacts resulting from CSG extraction, within the regional scale context and the best way to upscale from detailed to regional representations.
CSIRO	Critical Review - Bore construction, integrity, monitoring and reporting and decommissioning techniques	June-September 2012	Government	The review includes a critique of existing technologies and regulations for production bore operation and decommissioning. It will also critique existing regulations regarding in-field auditing, monitoring of bore leakages and failures and contingency procedures.
CSIRO	Critical Review - Predicting, monitoring, assessing and remediating subsidence and other movement related impacts associated with CSG and coal mining activities	June-September 2012	Government	This project will collate and provide a critique of the state of the science under-pinning CSG and coal mining impact management. The review will bring together into one document the latest knowledge (separating science from rhetoric and assumptions), better inform Government's decision making processes and identify knowledge gaps which will influence decisions about future targeted research needs.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
CSIRO	Critical review of the science underpinning CSG and coal mining in Australia - Topic 1, Aquifer connectivity within the Great Artesian, Surat, Bowen and Galilee Basins	June-September 2012	Government	The review will include a critique of current knowledge of hydro-geological and geophysical processes regarding aquitard integrity and aquifer inter-connectivity within the Great Artesian, Surat, Bowen and Galilee Basins.
CSIRO	GAB Water Resource Assessment	To be finalised December 2012	Government - Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)/National Water Commission	CSIRO's Water for a Healthy Country Flagship and Geoscience Australia are collaborating on a rigorous and detailed basin-scale investigation of water availability in the Great Artesian Basin (GAB): the Great Artesian Basin Water Resource Assessment. The assessment will conduct a basin-scale investigation of water resources across the GAB. The aim is to assess the status of water resources in the GAB and the potential impacts of climate change and resource development on those water resources and fill knowledge gaps in our understanding of the resource. Geoscience Australia's primary role is to update the conceptualisation of the hydrogeology of the GAB. This includes the development a 3D geological model of the main hydrostratigraphic units within the basin.
CSIRO	Geochemical baseline monitoring	2011/2012 - 2013/2014	Gas Industry Social & Environmental Research Alliance (GISERA)	Characterise the baseline geochemistry of groundwater and formation water prior to and during initial stages of development to understand groundwater age and origin. Outcomes: baseline measures of groundwater quality and protocols for monitoring changes in groundwater quality, during and after development.
CSIRO	Geochemical response to re-injection	2011/2012 - 2013/2014	GISERA	Understand and quantify aquifer reactions occurring due to re-injection of CSG water, and their impacts on water quality. Outcome: methods for predicting water quality changes resulting from CSG water re-injection.
CSIRO	Great Artesian Basin water resource assessment	2009/2010 - 2012/2013	Government	The Assessment is mid-way through the process of reappraising how the whole Great Artesian Basin groundwater system operates. This work is due for completion at the end of 2012.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
CSIRO	High performance groundwater modelling	2011/2012 - 2013/2014	GISERA	Determine the feasibility of large scale re-injection schemes. Outcomes: models that assess the feasibility of large re injection schemes and predict how re injection may reduce impacts from CSG development.
CSIRO	Managed aquifer recharge and reinjection of aquifers	2010-2013	Industry	Evaluating the feasibility of using managed aquifer recharge re-use to treat the produced water from CSG production and re-injecting it into the aquifers beneath Roma in Queensland's Western Downs. If successful, this project will be Australia's largest potable water managed aquifer recharge (MAR) project. The MAR project aims to re-inject over 30,000ML of treated water to re-pressurise the Gubberamunda Aquifer, part of the Great Artesian Basin.
CSIRO	Re-injection of CSG water	2011/2012 - 2013/2014	GISERA	Understand, quantify and manage clogging of injection wells during re-injection of CSG water permeates, brines and blends. Outcome: strategies to manage clogging of re-injection wells to maximise re-injection volumes.
CSIRO	Research project - hydraulic properties of aquifer geology	June 2012 - April 2013	Government	This project will result in a report presenting new hydraulic properties of different rock types associated with CSG prospective areas and the improvements in predicting impacts of de-pressurisation due to CSG extraction. QPED and or PIRSA (SA) databases will be updated with new hydraulic property information. There will also be a report outlining the assessment of current methods for estimating aquifer leakage.
CSIRO	Risks associated with surface handling of chemicals in hydraulic fracturing and flow back/produced water	September 2012 - December 2013	Government	The project represents Stage 1 of an independent national assessment of chemicals associated with CSG extraction activities in Australia. It will determine the potential human health and environmental risks arising from chemicals used in hydraulic fracturing and also naturally occurring chemicals released from coal seams – geogenic contaminants - as a result of CSG extraction. It addresses both direct and indirect exposures arising from normal operational procedures and reported accidents during these procedures.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Department of Natural Resources and Mines (DNRM)	Healthy HeadWaters CSG Water Feasibility Study (consisting of nine activities as described below)	July 2009 - December 2012	SEWPaC/DNRM	The Healthy HeadWaters Coal Seam Gas Water Feasibility Study is analysing the opportunities for, and the risks and practicability of, using CSG water to address water sustainability and adjustment issues in the Queensland section of the Murray–Darling Basin (QMDB). These issues include transitioning irrigation communities to lower water use and securing the viability of ecological assets. This 3.5 year study is being funded by $5 million from the Australian Government's Water for the Future initiative, with support from the Queensland Government as part of the Healthy HeadWaters Program. The study is due to be completed in 2012. The study is being undertaken as a series of activities. Activities 1 to 7 consist of investigations to fill knowledge gaps relating to the risks of extracting and using CSG water, as well as analyses of likely supply and demand. Activities 8 and 9 will assess specific opportunities for using CSG water in the QMDB, subject to the risks being acceptable and reliable supplies being available. For more information visit http://www.derm.qld.gov.au/water/health/healthy-headwaters/feasibility-study/index.html
DNRM	Healthy Headwaters CSG Water Feasibility Study Activity 1.1: Conceptualisation of the Walloon Coal Measures (WCM) beneath the Condamine Alluvium	Completed	SEWPaC	This activity undertook a comprehensive review of all existing data regarding the hydrogeology of the Condamine Alluvium and the underlying and flanking sections of the WCM. It developed a new interpretation of the stratigraphy of the region and assembled a three-dimensional block model. The investigation found that coal seams within the WCM typically lie within the upper half to three quarters of the sequence, and that the Measures are between 300-350m thick along the western margin of the Condamine Alluvium. Extensive weathering of the surface of the coal measures makes it difficult to provide a firm interpretation of the boundary between the alluviums and the coal measures. Available groundwater level data suggests that there is a possible upward hydraulic gradient from the coal measures to the alluvium; however, further data is required to enable a detailed assessment of the degree of hydraulic connection between the two units.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 1.2: Spatial analysis of coal seam water chemistry	Completed (September 2010 - December 2011)	SEWPaC	This activity has collated and analysed water quality data for coal seams and surrounding aquifers in the Surat and Bowen Basins in order to better understand the origins of coal seam waters and their potential interactions with other aquifers. A new database, which integrates all publicly available water quality data for Queensland (as at March 2011) has been constructed as part of this activity. Analyses have identified distinguishing chemical features of formations in the Bowen and Surat basins. The report is currently being edited for publication. The Activity 1.2 database has been provided to the Bureau of Meteorology (BoM), which is undertaking a project on behalf of the Office of Water Science (SEWPaC) to inform the bioregional assessments of the major CSG and coal producing regions.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 1.3: Spatial heterogeneity of the Walloon Coal Measures	Commenced March 2012. To be completed 30 September 2012.	SEWPaC	Understanding the scales of geological heterogeneity within the WCM will improve the static geological models that underpin the dynamic simulations of current and future groundwater flow as a result of CSG exploitation. This activity will produce a geological model showing the general distribution of coals, carbonaceous mudstones, heterolithics and sandstones, and conceptual depositional and structural models for controls on their geometries, lateral continuity and connectivity relative to over and underlying formations. This will reduce the uncertainty surrounding the delineation of areas affected by CSG production, the occurrence of more and less permeable strata within the WCM, and therefore the groundwater flow pathways.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 2 Extension	To be negotiated - yet to commence	SEWPaC	This activity will enhance the existing CSG Water Production Tool developed in Activity 2 of the study. No new or separate tools or models are to be developed. The enhancements relate only to the data used to populate the tool and the way the tool can interface with the user and with GIS platforms. The enhancements will focus on improved salt load forecasting; updated regional coal hydrogeology data; and improved GIS interfacing and industry development scenario customisation.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 2: Forecasting of CSG water production	Pending publication (September 2010 - December 2011)	SEWPaC	This activity has developed a water production forecasting tool capable of representing where, when and how much water will be produced by the CSG industry in the Surat and Bowen basins. The tool has been developed with input from the then DERM and other regulators and with data and information provided by the four main CSG operators. A draft report presenting the tool methodology and initial CSG water production forecasts for a range of industry development scenarios has undergone scientific peer review, and the final report is currently being edited. The preliminary outputs of the tool have provided valuable information for Activities 8 and 9, allowing more detailed CSG water management scenarios to be proposed and assessed. This level of analysis could not have been undertaken with the data available from the CSG industry to date.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 3: Assessment of salinity impacts of CSG water on landscapes and surface streams	Pending publication (May 2009 - December 2010)	SEWPaC	This activity has produced a salinity risk assessment framework for irrigation proposals using CSG water. The framework draws together a wide body of scientific knowledge concerning irrigation and salinity processes as well as best-practice land management principles. It identifies four key components of risk that need to be assessed: (1) the inherent biophysical characteristics of the landscape; (2) the cumulative effects of historic land use management practices; (3) the influence of current land management practices; and (4) the likely post-irrigation land use over a 100-year time frame. The salinity risks associated with specific landscapes in the QMDB are also reviewed. The report and technical notes produced in this activity are currently being finalised for publication.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 4: Stream ecosystem health response to CSG water release	Pending publication (May 2009 - June 2011)	SEWPaC	This activity has produced a decision support system (DSS) to assist the assessment of proposals to discharge CSG water to streams in the QMDB. The DSS features an ecological risk assessment framework which is tailored to the assessment of CSG water releases. It incorporates newly developed ecosystem response models as well as the results of field and laboratory studies which investigated the water quality and flow related risks posed by CSG water to aquatic ecosystems. The DSS recommends guidelines for assessing water quality and flow impacts as well as identifying biological indicators for monitoring the response of aquatic ecosystems to the disposal of CSG water. These reports have been peer reviewed and are currently progressing through the department's publication processes.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 5: Vulnerability of aquifers to CSG water extraction	Commenced November 2011. Undergoing final review.	SEWPaC	This activity will produce a methodology to assess the vulnerability and risk of aquifers of the Surat and southern Bowen Basins to CSG industry development in the Walloon and Bandana coal measures. The activity will then conduct a preliminary risk assessment to determine the probability and severity of impacts of the proposed CSG industry development. Data and knowledge gaps will also be identified. The activity commenced in November 2011 and is planned to be completed in mid 2012. The consultants are currently finalising the draft final report for this project.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 6.1: Feasibility of injecting CSG water into the Central Condamine Alluvium (CCA)	Completed (November 2010 - June 2011)	SEWPaC	This activity has identified and compared appropriate methods, locations and quantities for the injection of treated CSG water into the CCA. The relative merit of different injection technologies was assessed in relation to the physical characteristics of the region. Ten investigation areas were identified for shallow or deep injection targets within the CCA. Recommendations are provided regarding the choice of injection technology and general construction and maintenance requirements that would maximise injection volumes throughout the life of projects.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 7: South West Queensland Water Demand Analysis	Completed (August 2009 - August 2010)	SEWPaC and DNRM 50/50	This activity identified existing water use for the urban, industrial, mining and agricultural sectors in the QMDB and forecast future water demand over the next 50 years, based on projected growth and incorporating efficiency and demand management measures. The analysis predicts urban water demand to increase by approximately 39% over the next 50 years, but suggests that customised demand management measures for each urban location could reduce projected demand by 10%. Non–urban demand currently meets or exceeds supply throughout the region. However, a basic assessment of the capacity of non–urban industries to use treated CSG water indicated that such use would be limited by the lack of appropriate infrastructure to transport and store the water, and uncertainty regarding continuity of supply.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 8.1: Infrastructure options for delivering CSG water to the CCA	Pending publication (August 2011 - June 2012)	SEWPaC	This activity evaluated the feasibility of infrastructure options for delivering treated CSG water to the CCA. It has outlined the infrastructure, associated costs, water delivery volumes and issues associated with eight potential pipeline options. Key conclusions include: 1) the depletion of the CCA aquifer and the licensed water use by the CCA users provide sufficient demand to use all the projected CSG water from the identified source areas; 2) existing water supply infrastructure is unlikely to be of significant assistance in delivery of CSG water to the CCA; 3) the best option is likely to be focused on delivery of water to injection locations, with opportunity provided for direct off-take to farms (substitution) along the pipeline route; 4) lower cost schemes can be constructed using water sources close to the CCA, however these schemes deliver about 15,000 ML/a, while schemes extending further west can deliver up to about 44,000 ML/a; 5) capital costs for the investigated schemes vary from $30M to $530M, with unit cost per ML delivered varying from $397/ML to $783/ML.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibilty Study: Activity 8.2 (Phase 1): CCA Injection - Site Prioritisation	Pending publication (August - September 2011)	SEWPaC	This activity prioritised the deep and shallow injection sites identified in Activity 6.1 and has developed a conceptual work program to guide the design of injection trials.
DNRM	Heathy HeadWaters CSG Water Feasibilty Study: Activity 8.2 (Phase 2): Field program design for injection trials in the CCA	To be completed 30 November 2012	SEWPaC	This activity will firstly design an injection trial field program and an accompanying program of works to implement the field program. This component will review and, if necessary, extend or modify the conceptual field program presented in the site prioritisation report (Phase 1 of Activity 8.2) and then document in more detail how the conceptual field program would be applied to all of the prioritised injection sites identified in the Phase 1 report, having regard to both regulatory requirements and best practice methodology. While the field program is designed primarily to assess the feasibility of injection at each site, consideration must also be given to assessing the hydrogeological relationship between the CCA and WCM. Secondly, the activity will develop indicative design and costing of infrastructure required to undertake long-term injection activities in the CCA. While the State Government currently has no practical plans for injection in the CCA, the assessments in this activity are designed to inform a business case for further consideration of CSG water management options.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 8.3 (Phase 1): Substitution issues	To be completed 30 November 2012	SEWPaC	Activity 8.3 (Phase 1) will provide a detailed assessment of the use of CSG water for groundwater substitution purposes for all pipeline options in the CCA identified in the earlier Activity 8.1 report. This work will develop conceptual designs and associated costings for the substitution scheme (distribution network and storages) for each pipeline option. In addition, this work will describe and analyse the issues associated with the implementation and operation of these schemes. Consistent with the recommendations of Activity 8.1, this body of work assumes that the substitution schemes will be developed in conjunction with injection schemes in order to manage any significant reduction in demand for CSG water for irrigation purposes e.g. due to high rainfall conditions. The activity will involve formal consultation with a Stakeholder Reference Panel comprised of landholders, local government, peak agricultural bodies, environmental groups, departmental officers. Additional consultation with other key stakeholders such as CSG operators may also be required.
DNRM	Heathy HeadWaters CSG Water Feasibilty Study: Activity 8.3 (Phase 2): Governance issues	To be completed 30 November 2012	SEWPaC	This activity will examine suitable governance arrangements for implementing and operating a substitution/injection scheme in the CCA.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 8.3 (Phase 3): Comparative analysis of CSG water use options	To be completed 30 November 2012	SEWPaC	This activity will compare the CSG water use schemes proposed in Activity 8.1 with alternative uses for the same CSG water in order to identify the relative benefits, costs and feasibility issues.
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 8.4 (Phase 4): Business case development	To be completed 31 December 2012	SEWPaC	This activity will synthesise the outcomes of Activities 8.1, 8.2 and Tasks 1-3 of Activity 8.3 in order to develop a business case for the next program of work that will progress option(s) for using CSG water in the CCA.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Heathy HeadWaters CSG Water Feasibility Study: Activity 9: CSG water use proposals in the QMDB (assessing the impact on aquatic ecosystems)	October 2011 - December 2012	SEWPaC	This activity is developing an overarching framework for assessing the cumulative impacts on aquatic ecosystems of the release of CSG treated water at multiple sites into the surface water systems of catchments in the QMDB. To date, it has reviewed existing knowledge (including the outputs from Activity 4) to develop conceptual models of cumulative impacts and recommend interim principles for assessing multiple proposals to discharge CSG water to streams. Current work is focused on modelling water flow impacts associated with a range of cumulative discharge scenarios. The next phase will investigate potential water quality impacts associated with multiple discharges. These investigations will be used to test the conceptual models and develop a firmer understanding of these cumulative impacts. The final assessment framework will also incorporate the results of field and laboratory studies designed to address knowledge gaps about water quality and flow impacts.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
DNRM	Queensland Groundwater Dependent Ecosystems Mapping	February 2011 - October 2012	National Water Commission and Queensland Government	This project is delivering a mapping method as well as digital GDE maps over priority areas in Queensland. The state already has a well-advanced and current wetlands mapping and regional ecosystem (RE) mapping datasets. The GDE mapping dataset will complement the existing mapping and provide valuable additional information about the parts of the ecosystem that are dependent on groundwater. In addition new spatial datasets describing subterranean ecosystems will be initiated. The project is using the following steps: 1. Review and consolidation of current and completed GDE studies in Queensland. 2. Collation of potential source data for GDE mapping and the identification of key spatial datasets. 3. Assessment of available datasets for GDE mapping. 4. Inclusion of local and expert knowledge (obtained through DERM regional consultation and engagement). 5. Application of mapping rule-sets. 6. Continuous refinement of mapping including ongoing feedback from DERM regional consultation and engagement process. 7. Roll-out plan (across Queensland). The maps will be made freely available through WetlandInfo on the EHP website.
Origin Energy	A Common View of the Opportunities, Challenges and Research on Pongamia	2009-2012	Industry	Research on Pongamia (a tree for biodiesel being used in one of the Origin CSG irrigation projects) has been conducted by Origin, CSIRO, Pacific Renewable Fuels and the University of Queensland over three years.
Origin Energy	AGOS network augmentation	Ongoing	Industry/ Government	Installation of survey plinths and periodic 4d (E, W, RL, time) high resolution GPS surveying.
Origin Energy	Aquifer Injection of CSG Production Water, Phase 1 Pre-feasibility Assessment	2009	Industry	The pre-feasibility assessment considered the reinjection of raw and treated produced water into the aquifer system of the Surat Basin. Discussing regulatory, technical and financial constraints, the report provided a summary of the investigations and trials required to implement an aquifer reinjection water option.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Aquifer Injectivity trials	Two years	Industry	Involves four trial sites targeting three different aquifers.
Origin Energy	Biodiversity	Five years initially	Industry	Biodiversity knowledge hub for Queensland – develop an online ecological overview of the region, and use it to discover the kinds of biodiversity information that connects with communities' needs and expectations including: • Fire ecology – understand the impact of fire on species and ecosystems in the region • Threatened species ecology – understand the threats to vulnerable species • Landscape planning – evaluate a range of options for increasing the effectiveness of conservation in the region.
Origin Energy	Brine injection	Q4 2013	Industry	Technical and economic feasibility assessment of injection of brine into fractured basement geological formations.
Origin Energy	Coal Seam Gas – Water Management Study, Agricultural Use	2007	Industry	This study evaluated the potential use and profitability of associated water for agricultural use. The study identified a number of options including: • Irrigated crops: sorghum, maize, wheat, pasture and Lucerne • Horticultural crops: melon, grapes and cotton • Biodiesel from algae and Kalpa/Pongamia plantations • Agroforesty • Feedlots. The study also assessed the suitability of soils for irrigation and the financial benefits of supply of associated water for agricultural uses.
Origin Energy	Coal Seam Gas Water Strategic Options Analysis	2008	Industry	This study used a rapid assessment approach to compare options. The assessment approach referred to as SOAM (Strategic Options Analysis Model) is based on triple bottom line reporting. The approach examines the commercial, environmental and social dimensions of corporate decision making and ranks the water options based on the return and risk perspective of each of these dimensions. The study developed 70 ideas of water management within the 11 categories.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Coal Seam Gas Water Management Study Urban and Industrial	2007	Industry	The purpose of this study was to develop an associated water management strategy to identify potential urban and industrial water users that could benefit from associated water use. Three urban customers and five industrial users were identified that were interested in sourcing associated water.
Origin Energy	Condamine River Seep Investigation	2012	Industry	Collaboration with government and independent consultants to investigate potential sources and mechanisms for gas observed bubbling within the Condamine River, and set up long term monitoring programmes.
Origin Energy	CSG water management optimisation	Q4 2012	Industry	Development of an optimised water strategy to maximise the beneficial use of treated CSG water (via irrigation, aquifer injection and some minor uses such as construction and industrial emergency water supply) with managed discharge to the Condamine River. Release rules for managed discharge have been developed to mimic the natural flows of the river.
Origin Energy	Direct toxicity assessment	Q4 2012	Industry	Direct toxicity assessment of treated CSG water and boron as it relates to the aquatic ecology of the Condamine River.
Origin Energy	Gas Industry Social and Environmental Research Alliance: Subproject Agricultural land management	Five years initially	Industry	Shared space - understand how farmers from a range of production systems (extensive grazing to intensive cropping) perceive and value CSG developments on their and others' farms. Preserving agricultural productivity – understand the impact of landscape change on agricultural productivity at local through to regional scale. Gas farm design – understand how to design farms for a new mixed land use. Making tracks, treading carefully – understand the direct and indirect impacts of tracks and traffic on invasive species and erosion in agricultural landscapes. Without a trace – identify the nature and likely extent of damage to agricultural soils, and methods for avoiding and improving soils.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Gas Industry Social and Environmental Research Alliance: Subproject Surface and groundwater	Five years initially	Industry	Isotope and geochemical groundwater baseline study - characterise the baseline geochemistry of groundwater and formation water prior to and during initial stages of development to understand groundwater age and origin. High performance groundwater modelling – determine the feasibility of large scale re-injection schemes. Geochemical responses to re-injection – understand and quantify aquifer reactions occurring due to re-injection of CSG water, and their impacts on water quality. Re-injection of CSG water – understand and quantify clogging of injection wells and its management during re-injection of CSG water permeates, brines and blends.
Origin Energy	Grass selection for re-vegetation	2011-2012	Industry/Australian Research Council	In response to the challenges in establishing cover vegetation on disturbed land for the control of erosion, work conducted by the Ecoturf project is being applied to the CSG industry trialling varieties of turf on constructed earthen embankments.
Origin Energy	Hydrocarbons in groundwater in the Surat and Bowen Basins	2012	Industry	Collaboration with CSIRO and rest of industry to address public concerns about CSG water quality. Collation of all existing information on hydrocarbon presence in the Surat and Bowen Basin formations, and gathering of additional data where there are data gaps to ensure that there is a scientifically defendable explanation for possible future hydrocarbon findings prior to further expansion of the CSG industry.
Origin Energy	InSAR ground movement	Life of project	Industry	Inferometric Synthetic Aperture Radar satellite based ground movement studies over extent of Surat and southern Bowen basin leases. Base lining completed, operational data being captured for periodic assessment. APLNG is independently undertaking high resolution studies over injection sites.
Origin Energy	Integrated water model	Q3 2012	Industry	To develop an integrated water model to provide deterministic and probabilistic mass balance modelling of hydrological impacts of APLNG CSG water management solutions.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Liner testing	Q2 2011	Industry	An experiment was developed to allow testing of the degradation of pond lining membranes under simulated conditions to be experienced in brine ponds - high temperature and high salinity / pH. Samples of commercially available membranes were subjected to the tests in order to demonstrate which liner materials where appropriate for the application.
Origin Energy	Marine	Five years initially	Industry	Sustaining turtles and dugongs and their habitat – establish baseline data on distribution and abundance of sea grass within Port Curtis. Understand the movement and feeding habitats of turtles and dugongs in Port Curtis and environs. Integrated modelling –understand the local and cumulative effects of discharges and dredging on the visual conditions and sea grass ecosystems in Port Curtis. Marine offsets – Establish links between water quality, threats to food supply and swimming behaviour of turtle and dugongs and, hence, risks to turtle and dugong populations.
Origin Energy	Modelling of drainage and salinity	2012	Industry	Modelling of drainage from irrigation in surface and unsaturated layers to determine impacts of irrigation
Origin Energy	Preliminary Discharge Assessment – Walloons Coal Seam Gas Development	2008	Industry	This study assessed the feasibility of discharging up to 35 ML/d of reverse osmosis (RO) treated water into the Condamine River from the Walloons CSG field. Four potential discharge points were identified and assessed in detail. The most desirable discharge point was found to be Chinchilla Weir, based on minimal impacts and the scale of benefits from discharge at this location.
Origin Energy	Receiving Environment Monitoring Program	2010 - 2014 with the possibility for extension as required	Industry	The receiving environment monitoring program is collecting a significant data set which is used for the monitoring, management and determination of potential impacts (both positive and negative) to aquatic ecology in relation to the release of treated CSG water to river. The program spans 3 watercourses across 2 basins. The CSG context is atypical in that comparatively large volumes of highly purified water is released in comparison to typical industry discharges which could be considered as smaller in volume with a higher overall contaminant load.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Recycled Water Management Plan	2011-2012	Industry	Public health assessment of treated CSG water, operations, and water treatment facility management.
Origin Energy	Reedy Creek to the River Dawson Pipeline	2011	Industry	The pre-feasibility assessment of a pipeline from Reedy Creek WTF adjoining QGC, Xstrata Coal and the Glebe weir. The option considered environmental condition of the pipeline, economic cost/benefit and drafted commercial arrangements.
Origin Energy	Review of Water Quality and Irrigation strategies for CSG Water	2010	Industry	A study involving modelling and review by a panel of experts in soil chemistry, salinity and hydrology, examined the soil and drainage impacts and the sustainability of irrigation with water of different salt contents, which might be used if CSG water was blended with water from RO output.
Origin Energy	River Temperature Environmental Evaluation	Q1 2012	Industry	An Environmental Evaluation was undertaken to determine if the release of treated CSG water to the Condamine River is having an impact on aquatic ecology associated with temperature differentials and to determine the spatial extent of the temperature mixing zone. Overall, the data demonstrates that variation of temperature within the Condamine is natural and ecological communities are tolerant of such variations.
Origin Energy	Saline Water Management Study	2009	Industry	The study investigated opportunities for the disposal of saline water, including non-treated disposal options and brine disposal. Markets for trona, halite, calcium carbonate and combined salt were investigated and economically evaluated with consideration to a range of treatment technologies. The study also considered innovative associated water solutions such as algae and solar heat recovery.
Origin Energy	Selective Salt Recovery Trials	2011-2013	Industry	To identify and confirm the technical and economic viability of potential solutions to convert brine into commercial grade products through a Pilot Project program.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Origin Energy	Socio-economic	Five years initially	Industry	Monitoring regional transition – synthesise existing knowledge on the nature of rural socio-economic transitions occurring as a result of resource developments, and track the social impacts of regional economic change. Community functioning and well-being – identify principal indicators of community function and well-being, the resources and strategies necessary for enabling and enhancing community responses, and how communities respond to major developments in their region. Planning for socially sustainable communities – predict requirements for social services and infrastructure based on population mobility at local, regional and state-wide scales. Understanding community aspirations - identify community aspirations and their overlaps/disparities with existing resources, industry, and policy trajectories.
Origin Energy	Surat Basin Water Grid Briefing Paper	2008	Industry	The water grid option involves the development of a small water distribution network with a major mine being the main user along with other mines, towns and selected agricultural users. This paper details the risks and returns of water grid options: • Two water grid delivery options are identified • Origin as the sole owner, supplier and operator • A commercial joint venture with other major CSG producers.
Origin Energy	Vertical hydraulic connectivity studies	Life of project	Industry	Suite of interconnectivity studies including centrifuge permeameter analysis at UNSW/NCGRT to determine vertical permeabilities and Quarts Helium diffusion studies at CSIRO to determine insitu vertical hydraulic flow velocity.
QGC	A Water Chemistry Atlas for CSG Fields (UQ's Centre for Coal Seam Gas [CCSG]/ Industry)	2012-2013	Industry	Groundwater chemistry data analysis (based on data provided to QWC) and mapping across the Surat basin and development of a portal to allow access to analysis from industry websites.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QGC	Aquifer connectivity	Ongoing	Industry	This study is to assess the magnitude and extent of aquifer connectivity to assist understanding the long term hydraulic behaviour of the Walloon Coal Measures (WCM) and adjacent formations. QGC has established a comprehensive long-term program of investigation, monitoring and analysis to understand the impact of CSG extraction from the WCM on groundwater pressures in adjacent formations. The evolving knowledge will be used in hydrogeological conceptualisation and QGC's GEN3 modelling.
QGC	Aquifer Injection	Mid 2014	Industry	QGC's approach to assessment of aquifer injection and groundwater repressurisation is focused on investigating and trialling cost-effective technologies to maintain groundwater pressures in formations that support MNES springs.
QGC	Australia UQ Walloon Supermodel (UQ/QGC)	2012/13	Industry	Review of parameters and reservoir/aquifer characterisation factors across the Surat Basin. Development of an interactive groundwater model in conjunction with industry, CSIRO and QWC.
QGC	Connectivity between MNES Springs and Walloon Coal Measures (QGC, Santos, Australia Pacific LNG)	Mid 2013	Industry	The three major CSG operators in the southern Bowen and Surat basins (QGC, Santos and APLNG) are working collaboratively to develop a monitoring scheme to address the risk of groundwater drawdown propagating from CSG production and potentially affecting MNES springs. The CSG proponents have jointly defined an integrated and collaborative approach to the early warning and threshold groundwater level change monitoring in the Hutton and Precipice sandstones.
QGC	Ground Motion Studies (QGC, Santos, Australia Pacific LNG, Arrow Energy)	2014/15	Industry	Use of high resolution satellites to evaluate ground motion within QGC tenements. This investigation is part of an industry wide collaborative effort.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QGC	Groundwater monitoring	Ending 2013	Industry	QGC is committed to obtain representative baselining of the Surat Basin aquifers, prior to the commencement of CSG production, through its groundwater monitoring bore program. QGC has started its Stage 2 groundwater monitoring bore program, which will define groundwater baselines in respective aquifers, identify existing (pre-CSG) trends and allow ongoing calibration of QWC's groundwater modelling.
QGC	Interactions of Coal Seam Gas Development with Agriculture and Forestry (CCSG/Industry)	2012/14	CCSG/Industry	Understanding the interactions, impacts and benefits from CSG activities in close proximity to agriculture. Issues of water availability, water quality and water balance.
QGC	Review of QGC groundwater modelling – upscaling Eclipse insight into Modflow for the Surat Basin (CSIRO, QGC)	2012/13	Industry/CSIRO	Comparison and Contrast the differences and limitations between Eclipse (dual flow) and Modflow (single phase flow) modelling for water production from the Gasfields. Development of a useable basin-wide groundwater model based on dual flow regimes (Eclipse) to get a true picture of groundwater movement within the basin.
QGC	Selective Salt Recovery – Brine Management (QGC, Australia Pacific LNG, Arrow Energy)	Mid 2013	Industry	QGC, APLNG and Arrow Energy have formed an alliance to trial four separate pilot plant technologies to separate the various salts to industrial grade purity salts to enable commercialisation. The objective of the pilots is to demonstrate the technical and commercial feasibility.
QGC	Spatial Variability of Methanogenesis in Walloon Subgroup (UQ, QGC, Santos)	2012/14	Industry	Isotopic analysis of groundwater from various aquifers and spatial locations across the basin to assess age and connectivity.
QGC	Toxicity and eco-toxicity testing for stimulation chemicals and flowback waters	Ending 2013	Industry	QGC is collaborating with other proponents on an industry-level total effluent toxicity test program to assess the comparative hazard of pre-stimulation coal seam groundwater and flowback waters. QGC is also doing extensive work on the toxicity and ecotoxicity of individual fracturing agents.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QGC	Understanding origin, recharge and flow regimes of coal seam waters to better constrain aquifer interactions (UQ/QGC)	2012/13	Industry	There is limited knowledge regarding the origins, recharge and flow regimes of coal seam waters. This knowledge is critical to understand the timing and extent of isolation of the coal aquifers from major basin aquifers and whether the coal measures function as relatively continuous or compartmentalised reservoirs. The aim of this work is to provide fundamental knowledge of the nature of coal seam waters and coal seam hydrogeology to allow the local and regional hydrological consequences of gas and coal exploitation to be understood and managed.
Queensland University of Technology (QUT)	3D visualisation of Galilee Basin	2011	Industry	3D conceptual hydrogeological model of Eromanga-Galilee basins with drillholes, and formation surfaces.
QUT	3D visualisation of Surat Basin simulated groundwater levels	2013	Industry	3D visualisation of simulated groundwater surfaces over projected time.
QUT	3D visualisation of Surat-Clarence Moreton Basins	2011-2012	Industry	3D conceptual hydrogeological model of Surat Basin area with drillholes, formation surfaces and preliminary solid geometry.
QUT	Galilee Basin hydrogeology	2012-2014	Industry	PhD scholarship to develop hydrogeology and hydrochemical model of Galilee Basin and interfaces with GAB aquifers.
QUT	Galilee-GAB aquitard properties	2012-2014	Industry/China Scholarship	PhD scholarship to determine aquitard/aquifer properties and model connectivity and interformations flow.
QUT	Groundwater Visualisation Tool (Upper Condamine)	2009	State/ Commonwealth Government	Develop a 3D visualisation and animation model for alluvial groundwater in the Upper Condamine valley, emphasis on groundwater levels and drawdown.
QUT	Honours thesis: identify potential organic constituents present (or absent) in CSG waters and quantitatively/qualitatively describe their relationship to the coal from which these waters are abstracted	2011	University	Honours thesis: identify potential organic constituents present (or absent) in CSG waters and quantitatively/ qualitatively describe their relationship to the coal from which these waters are abstracted.
QUT	Hydrochemistry and alluvial bedrock connectivity, Surat	2012-2014	Industry	PhD scholarship to test connectivity between Condamine alluvium and Walloon Coal Measures using hydrochemistry and isotope hydrology.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QUT	Numerical modelling of flow into wells	2012-2013	Industry	
QUT	Surat-Bowen Cumulative Management Area (CMA) 3D tool	2011-2012	State Government	Build 3D visualisation, animation models and videos for Surat and southern Bowen basins based on geological and simulated data provided.
QUT	Testing application of CSG production waters	2012	Industry	End use application and assimilation of CSG Water.
QUT	Treatment methods for CSG production waters	2012-2013	Industry	Advanced water treatment.
Queensland Water Commission (QWC)	Hydrogeology of the Walloon Coal Measures		Government	Improve understanding of the hydrogeology of the Walloon Coal Measures (WCM) to support future modelling of water level impacts from CSG water extraction. The hydrogeology of the WCM is very complex. The water bearing coal seams comprise numerous thin, non-continuous stringers or lenses separated by bands of low permeability mudstone, siltstone or sandstone. Detailed information on the lithology of the coal measures is only available for producing tenures. There are difficulties in correlating individual coal seams over any significant distance. The complex stratigraphy of the WCM and the presence of dual phase flow have implications for regional groundwater flow modelling.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QWC	Improving knowledge about springs		Government	Improve existing knowledge about the springs in the CMA in relation to their hydrology, ecological and cultural values and improve spring monitoring techniques. The management of potential threats to springs arising from the extraction of groundwater by petroleum tenure holders involves understanding the spring values that could be affected by a reduction in the flow of water to the spring and the interconnection of affected aquifers to springs. The spring survey and connectivity studies carried out by the Commission have largely completed the spring data sets, but some gaps remain. Springs are highly variable in nature and are often in locations that are difficult to access. Remote sensing methods have the potential to improve monitoring efficiency and consistency.
QWC	Influence of geological structures on groundwater flow in the Surat CMA		Government	To improve current knowledge about the influence of geological structures on regional groundwater flow to support future modelling of water level impacts from CSG water extraction. Geologic structures, such as faults have potential to influence groundwater flow either as pathways or barriers to groundwater flow. There are significant regional fault systems within the Bowen and Surat basins. However, they are generally restricted to deeper formations in the Bowen Basin and do not affect overlying Surat Basin formations to the same extent. The exact nature of influence of faults in the Surat and Bowen basins on regional groundwater flows is uncertain. There is a need to assess how structures may influence groundwater flow if large water level differences occur in the future in and around the structures as a result of CSG development.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QWC	Interconnectivity between the Condamine Alluvium (CA) and Walloon Coal Measures (WCM)		Government	Improve knowledge about the interconnectivity between the CA and the WCM to support future modelling of water level impacts from CSG water extraction. The Condamine Alluvium is an important water resource overlying the WCM. Current knowledge has been used to characterise the geological and hydrogeological contact between the CA and the WCM (the contact). That knowledge has been used to construct the regional groundwater flow model. Knowledge about the contact can be improved by: • Collecting new information about the geological and hydraulic nature of the contact • Monitoring hydraulic response across of the contact under stressed conditions that simulate CSG development, in local areas.
QWC	Re-conceptualisation of the groundwater systems in the Surat and Bowen basins in Surat CMA		Government	Improve understanding of the hydrogeology of the groundwater systems in the Surat and Bowen basins to support future modelling of water level impacts from CSG water extraction. The aquifer systems in the Surat CMA are complex. The conceptualisation of the groundwater systems used in constructing the regional groundwater flow model is based on information drawn from published literature, departmental databases and petroleum company drilling data that was available at the time. New knowledge that would improve future modelling include: • Regional and sub-regional water level/pressure maps for key aquifers to establish groundwater flow patterns and hydraulic gradients between aquifers • Hydrogeological characterisation of aquitards • Hydraulic connectivity of coal formations with overlying and underlying aquifers.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
QWC	Second generation regional flow modelling for the Surat CMA		Government	To further refine the prediction of water level impacts from CSG water extraction. The current regional groundwater flow model has been built using currently accepted geologic conceptualisations and currently available regional modelling techniques. The modelling process has highlighted a number of areas where improvement may be possible in the next generation of the regional groundwater flow model.
Santos	2011 Development of Water Portal			The water portal is an Australia-first initiative which will make all of its water monitoring testing results for the Surat and Bowen basins available for the public to view. There the public can also access FAQs and view a document library.
Santos	Arcadia Injection Feasibility Study			Assessment of the feasibility of injection of CSG water and concentrated saline effluent within Arcadia Valley Project Area.
Santos	Bowen Basin Groundwater Model			Numerical groundwater model of the Bowen Basin to allow better understanding of the groundwater system and forecast its behaviour in future due to CSG extraction activities.
Santos	Brine Injection Investigations			To assess the feasibility and risk associated with brine injection in Roma leading into injection trials.
Santos	Brine Options Study			Scoping study for brine management options within Fairview, Roma and Arcadia CSG fields.
Santos	Catchment Impact Subprogam			These studies determine the landscape impact and improve monitoring efficiency of CSG water irrigation projects.
Santos	Dawson River Release Assessments			All facets of the Dawson River Release Scheme have been designed to mitigate any potential impacts of the proposed release on the receiving environment. A suite of assessments has been completed in order to determine the environmental impact.
Santos	Desalinated Water Discharge to Grade - Roma Field			Scoping study of the impacts of discharging desalinated water to streams in the Roma Field.
Santos	Discharges to Lake Cambell			Scoping Study on the potential to discharge desalinated water to Lake Cambell.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Santos	Discharges to Lake Nuga Nuga			Scoping study to assess the viability of discharging treated CSG water to Lake Nuga Nuga.
Santos	Enhanced Evaporation Trials			Trials of the Wind Aided Intensified eVaporation (WAIV) and Solar Environmental Tube System (SETS) as potential alternative enhanced evaporation technologies.
Santos	Fairview Injection Feasibility Study			Assessment of the feasibility of injection of treated CSG water within Fairview Project Area.
Santos	Groundwater and Surface Water Impact Study			Included surface water update and integration of SEWAAL data requirements.
Santos	Groundwater Impact Assessment			Hydrogeological impact study for Fairview, Roma and Arcadia.
Santos	Groundwater Impact Study Update			Comprises redevelopment of groundwater models to predict impact to groundwater from CSG depressurisation, the development of associated water beneficial uses and the development of the groundwater monitoring activities - required by Coordinator General.
Santos	Hermitage MAR Trial			Investigation into feasibility and risk leading into trial injection of treated CSG water (from Walloon Coal Measures) into Gubberamunda Sandstone aquifer.
Santos	Impacts of CSG Water Management on Matters of National Significance			Summary of the potential impacts to Matters of National Environmental Significance (MNES) associated with the production and management of CSG water and outlines the management and mitigation measures.
Santos	Investigation of Potential Discharge Locations - Arcadia and Fairview			Scoping study of the impacts of discharging desalinated water to streams in the Arcadia and Fairview field.
Santos	Irrigated Farming Studies			Studies in this program aim to: maximise water utilization, reduce CAPEX and OPEX, reduce irrigation footprint and maintain regulatory compliance of CSG water irrigation projects.
Santos	Irrigation Research and Development Studies			A range of irrigation studies to improve the sustainability of irrigation projects.
Santos	River Health Assessments			Ecological river health surveys.
Santos	River Health Studies			

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
Santos	RO Treatment Options for Roma CSG Water			Report investigating process configurations options for a RO plant for the Roma gas field.
Santos	Roma Managed Aquifer Recharge Study Report and Risk Assessment			Evaluation of Sector 3 MAR scheme.
Santos	Salt commercialisation feasibility study			Assessment of the feasibility of salt commercialisation.
Santos	Scotia Hydrogeological Conceptual Groundwater Model			Conceptual hydrogeological model for the Scotia CSG Field (PL176).
Santos	Scotia MAR Trials			To assess the feasibility and risk associated with Managed Aquifer Recharge at Scotia.
Santos	Soil Root Zone Program			This program investigates robust and cost effective CSG water treatment methods for agriculture irrigation systems.
Santos	Subsidence Monitoring			Santos has commissioned ALTAMIRA INFORMATION to undertake the baseline assessment (as at Q4 2011/Q2 2012), and estimation of currently ongoing deformations prior to CSG production (as at 2007).
Santos	Surat Basin Groundwater Model			Groundwater model that replicates the hydrogeology of a large portion of the Surat Basin, specifically the Roma CSG field.
University of Queensland (UQ)	1: Field trial to measure and model water use of range of forage crops to be irrigated by CSG water 2: Glasshouse trial to ascertain the root zone salinity tolerance of range of forage crops	14/3/11 - 14/3/13	Industry	
UQ	A Human Health Risk Assessment for developing CSG water resources in Queensland	2/9/09 - 1/9/10	University	
UQ	A Water Chemistry Atlas for CSG fields: discovering value beyond baseline monitoring	30/5/2012 - 31/8/2015	Industry	
UQ	Coal Seam Gas, Coal, and Agriculture: Water Implications	1/10/11 - 30/6/12	Industry	

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
UQ	Compatibility of injected concentrated brines with formation waters and their tendency for scaling	1/10/11 - 30/6/12	University	
UQ	Guidelines for establishing ecologically sustainable discharge criteria in seasonally flowing streams	1/8/10 - 31/1/13	Industry	
UQ	Smart Futures Fellowship (Early): Inorganic membranes of CSG water and brine treatment	1/7/12 - 30/9/15	Government	
UQ	Sustainable use of CSG water	1/1/12 - 31/12/14	Government	
UQ	Treatment of saline water from CSG production using adsorption techniques	7/4/11 - 6/4/12	Government/ Industry	
UQ	Understanding origin, recharge and flow regimes of coal seam waters to better constrain aquifer interactions	11/11/10 - 11/05/12	University	
UQ	Use of CSG Water in Algal systems - Literature/Technical review project	14/12/10 - 24/12/10	Industry	
University of Southern Queensland (USQ)	A review of the potential issues associated with using CSG associated water for dust suppression	2011	Industry	A review of land application of CSG water to soil was undertaken to aid in assessing the potential of using CSG water for dust suppression. An assessment of the use of salts for dust suppression and snow melt was undertaken to investigate movement of ions into the environment from the roadside. Major recommendations were that CSG water is a potentially manageable dust abatement method provided treatment and regulations were considered. Furthermore, the majority of land application was US based and therefore there is a requirement for Australian published data on land application of CSG, and more specifically application of CSG for dust suppression purposes.
USQ	Assessing impacts of CSG amended water application: soil chemistry equilibrium as influenced by solution volume and time	2012	University	Student project investigating the volume and time required for soil equilibration with percolating solutions on the basis of solution concentration and pore volume.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
USQ	Assessing the water use and solute management of Chinchilla White Gum irrigated with amended CSG water	2012-2015	University	This is a PhD project designed to investigate the water use of Chinchilla White Gum irrigated with amended CSG water. This project is just commencing and will use existing stands of White Gum and laboratory controlled White Gum to investigate the water use ability of the plant, its ability to withstand solute concentrations and how these solutes are stored within the root and vadose zone.
USQ	CSG water as a medium to grow microalgae for biofuel production	2012	University	Preliminary investigation to assess the potential of using bicarbonate rich CSG water as a medium for growing salinity tolerant microalgae for biofuel production. Rates of microalgal growth, carbon sequestration, nutrient removal potential and lipid contents were evaluated in a batch reactor.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
USQ	Disturbance and resilience in riparian woodlands on the highly-modified Upper Condamine Floodplain	2004-2011	University/ Government	Riparian woodland remnants on the Upper Condamine floodplain are subject to significant changes in hydrological regimes and land use intensity. They also exhibit dieback and limited recruitment of canopy species, as well as widespread invasion by the introduced perennial herb Phyla canescens (lippia); however, efforts to address these issues have largely failed to curb ongoing degradation, potentially due to a lack of understanding of the key drivers of ecological change operating in this complex socio-ecological landscape. This research addressed questions about the drivers of floristic composition, functional diversity and woodland condition in fragmented riparian woodland communities associated with a regulated dryland river system, and embedded in a production landscape. In particular, it investigated ecological responses to the range of disturbances (including altered hydrology, land use intensity, resource availability, and key species interactions) prevalent in this highly modified landscape. Groundwater decline was found to be the primary predictor of ecosystem response, with lower floristic and functional diversity and more severe dieback associated with increasing depth to groundwater; this result suggests an overarching reliance on shallow groundwater resources for maintenance of ecosystem resilience not previously reported for this ecosystem type in Australia. This research indicates that observed condition in riparian woodlands on the Upper Condamine floodplain is an integrated response to a range of disturbances, but that certain changes (in particular, groundwater decline due to over-extraction in combination with extended drought) may be critical to the long-term persistence and function of these remnants.
USQ	A field study of irrigated soil properties comparing land conditioning of applied coal seam gas (CSG) water, application of chemically amended CSG water and good quality groundwater	2012-2013	Industry/University	This project is just commencing with the experimental design having been initiated in the field. This project is currently commercial in confidence.

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
USQ	Environmental effects of applying coal seam gas associated water to unsealed roads for dust suppression	2011	Industry	Commercial in confidence
USQ	Preliminary assessment of cumulative drawdown impacts in the Surat Basin associated with the CSG industry	2011	Industry	During 2010, the four major CSG companies operating in the Surat Basin identified that there was significant community concern regarding the cumulative groundwater impacts of CSG operations in this area. In an industry first, these companies agreed to pool their resources to review the approaches taken to the individual assessments, and provide a preliminary independent assessment of cumulative groundwater impacts associated with CSG operations. USQ was commissioned in September 2010 to manage this study, with RPS Aquaterra engaged to undertake the independent assessment of cumulative impacts, based on information from published impact assessment reports and other information made available to USQ and RPS Aquaterra by the four CSG companies to undertake the study. The overarching aim was to collate and present the existing groundwater modelling data to provide both the Government and the public with a greater level of understanding and confidence regarding the cumulative groundwater impacts from the development of CSG projects within the Surat Basin.
USQ	Evaluating the effect of bicarbonate in coal seam gas water on soil threshold electrolyte concentration relationships	2011-12	Industry	Commercial in confidence
USQ	Independent groundwater research	2012-2014	USQ	USQ strategic funding for core salaries and infrastructure to enable independent hydrogeological assessments of CSG impacts on groundwater systems in southern Queensland.
USQ	Modelling the change in conductivity of soil associated with the application of saline–sodic water	2007-2009	USQ	PhD Student project to improve quantification of soil structure degradation under sodic conditions and enhance the modelling of water and solute movement under sodic conditions.
USQ	Modified Threshold Electrolyte Concentration analysis for soils from Greenacres	2011	Industry	Commercial in confidence

Organisation	Project title	Time frame	Funding source	Summary (< 200 words)
USQ	Threshold electrolyte concentration relationships for soils from Roleen, Tantatton, Pine Ridge, Ben Bow and Oakleigh	2011	Industry	Commercial in confidence
USQ	Threshold electrolyte concentration relationships for soils from Roma fields Roleen property	2011	Industry	Commercial in confidence
USQ	Threshold electrolyte concentration relationships for soils from the Fairview IR5, IR7 and IR8 irrigation areas	2011	Industry	Commercial in confidence
USQ	Threshold electrolyte concentration relationships for soils from the Roma Fields Angry Jungle property	2011	Industry	Commercial in confidence

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