10 SUMMARY OF RESULTS

To investigate the source, mechanism, and pathways for the gas seeps observed in 2012, Origin and CSGCU jointly developed a list and schedule of tasks (Table A.1) that would be accomplished in phases. Phase 1 included initial field activities and desktop investigations and the development of an initial geologic and hydrogeologic conceptual model. Phase 2 included field activities focused around the four Condamine River gas seeps, the four Orana pilot wells, and areas of stressed or dead vegetation of concern to landowners and additional desktop investigation of similar events and situations elsewhere in Australia and in other parts of the world. Information gathered was used to refine and revise the site conceptual model.

The Tasks were numbered for ease of reference, but were not performed in strict numerical order. The division of Tasks between Phase 1 and Phase 2 was as follows:

Phase	Tasks
1	1, 2, 3, 6, 7, 8, 11, 12, 13, 18
2	4, 5, 9, 10, 14, 15, 17

Task 16 (installation of monitoring bores) is included in Phase 3 (i.e., future work).

The results of Phase 1 and Phase 2 of the Condamine River gas seep investigation are presented in Section 7 and Section 8, respectively. In addition to the tasks agreed to jointly by Origin and CSGCU, information from CSG activities in the Argyle Field was reviewed and the results of the review are presented in Section 9.

Because of the large number of tasks, and the complexity of the activities, the results for all of the tasks have been summarized in Table 10.1. The Argyle Field assessment is included in Table 10.1as an unnumbered Task.

TABLE 10.1
RESULTS BY PHASE AND TASK

Phase	Task	Results
1	Task 1 - Status of Surrounding CSG Wells (see Section 7.1)	1. In 2012, the Orana 8, Orana 9, Orana 10, or Orana 11 pilot wells did not appear to be acting as pathways for gas migration to the ground surface. 2. Orana 8 – cement plugs were placed to isolate the lower formations with the top of the cement at 110.5 mGL. The upper cement plug does not cover several coals in the Upper Juandah and does not extend into the intermediate casing shoe. Coal seams in the Upper Juandah Coal Measures (located from approximately 94 mGL to 103 mGL) were intentionally left open to allow pressure monitoring in this zone. 3. Orana 9, 10, and 11 are constructed with pre-perforated production casing in open-holes.
1	Task 2 – Status of Surrounding Landowner, Government, and Coal Mine Exploration Bores (see Section 7.2)	1. 45 water and coal exploration bores were initially identified, 25 bores considered key to the investigation were located in the field. 2. Most bores are completed in the Springbok Sandstone and/or the WCM. 3. In some cases, it is not known whether a bore is completed in the Springbok Sandstone, WCM, or both; therefore samples collected and measurements made cannot be assigned to a particular formation. 4. Methane was detected in the headspace of 17 bores. 5. Stable isotope analysis indicates that the gas in two water bores is similar to CSG gas and the gas seeping at the four locations in the Condamine River. 6. Baseline (pre-seep) water level and quality data is available for many bores. 7. Assessing whether concentrations of methane change with time and if changes are related to CSG production requires systematic and ongoing monitoring. 8. Water and coal exploration bores that contain methane have a potential to act as conduits for gas migration into overlying aquifers and to the atmosphere. 9. Water and coal exploration bores may contribute to depressurizing the Springbok Sandstone and WCM.

Phase	Task	Results
1	Task 3 – Condamine River Methane Gas – Geochemical Analysis (see Section 7.3)	1. Stable isotope analysis indicates that the gas from the 4 gas seeps and 2 water bores is biogenic from microbial reduction of CO_2, and not from microbial acetoclastic reaction (i.e., "swamp gas" or fermentation). 2. CSG produced from both the WCM and Springbok Sandstone is biogenic from microbial reduction of CO_2 and based upon currently available data it appears to be isotopically similar.
1	Task 6 – Initial Landowner Interviews (see Section 7.4.1)	1. More than 30 landowners were interviewed. 2. Methane seepage and bubbles had not been observed or noticed by those interviewed at the Pump Hole, Fenceline, or Camping Ground seeps prior to the 2012 observations. 3. Bubbles had been observed at the Rock Hole seep prior to the 2012 observations. 4. Methane was known to occur historically in many of the water and coal exploration bores prior to CSG development in the Surat Basin.
1	Task 6 – Field Reconnaissance (see Section 7.4.2)	1. Approximately70 km of Condamine River and 21 km of Charleys Creek investigated. 2. Observations confirmed only 4 seep locations in the Condamine River. 3. Minor bubbling likely due to natural processes, such as bacterial fermentation of organic matter.
1	Task 7 – Additional Landowner Interviews and Literature Review (see Section 7.5)	1. Published documents indicate that methane has been encountered in some bores since the early 1900s and that the eastern edge of the Surat Basin in this area has been the target for gas exploration because of "gas shows" in water bores. 2. Bore card reports indicate that coal seams were encountered in 14 of the landowner bores. 3. Bore card reports for many bores specifically list coals as the aquifer. 4. It is not unexpected that water bores that are completed in coal seams will contain methane. As the bore is pumped and hydrostatic pressure drops, gas desorbs from the coals. When pumping stops and the water level recovers gas desorption may stop.

Phase	Task	Results
1	Task 8 – Additional Review of Government Records (see Section 7.6)	1. There is a significant documented history of shallow methane in the region. 2. Water and coal exploration bores in the area are often completed in the WCM and/or Springbok Sandstone and contain coals. 3. Published documents indicate that methane has been encountered in many bores since the early 1900s.
1	Task 11 – Surface Geology Map (see Section 7.7) and Task 12 – Geologic Cross Section (see Section 7.8)	1. Geologic map, WCM structure map, and cross section will be used and refined in the ongoing investigation of the sources, pathways, and mechanisms of methane seeps.
1	Task 13 – Downhole Video of Water and Coal Exploration Bores (see Section 7.9)	1. Downhole video confirmed the presence of free gas in some water and coal exploration bores. 2. Limited usefulness due to condition of the existing bores (collapsed, bacterial slime, turbidity, etc.), but may be useful in studying new boreholes or boreholes drilled in the future.
1	Task 18 – Review Condamine River Hydrographic Data and Rainfall Records (see Section 7.10)	1. Significant intense rainfall events have occurred at intervals in the project area. 2. Condamine River has a history of periodic high discharge and flood events. 3. January 2011 discharge at Chinchilla Weir was highest recorded since 1966 when records began. 4. Larger rainfall events have occurred prior to the stream flow gauging period, so the 2010-2011 and 2011-2012 discharges may have been exceeded in earlier times. 5. The Pump Hole, Fenceline, and Camping Ground gas seeps were first observed in early 2012, after the 2011-2012 flood event.

Phase	Task	Results
2	Task 4 – Initial Surface Water Quality Sampling (see Section 8.1)	1. Data from limited number of samples from 2 locations represent “initial” conditions only.
2	Task 5 – Aquatic Ecology Assessment (see Section 8.2)	1. Gas seeps are potentially having a minor impact on some water quality parameters. 2. Adverse effects on local flora and fauna are not evident. 3. Lower DO at 2 sites did not appear to have immediate adverse effects on aquatic plants, macroinvertebrates, or fish. 4. Impacts could change over time or with lowering of water levels.
2	Task 9 – Gas Flux (see Section 8.3)	1. CSIRO continues to develop the method and equipment for measuring the flux of methane from the 4 gas seeps and evaluating the analytical results from its surface water sampling.
2	Task 10 – Installation and Operation of Water Level Gauging Stations (see Section 8.4)	1. Water level records provide a good context for the ecological assessment and water quality studies. 2. Measurements from Origin stations are relative, they do not provide elevation; therefore the data cannot be compared with the bathymetric survey (see Section 8.7) or to water levels measured elsewhere e.g. at Chinchilla Weir. They also cannot be used to determine when the river transitions from continuous flow to discontinuous pools and vice versa. Therefore the transducer elevations should be accurately surveyed. 3. Water level and elevation are useful data, but does not address the question of the erosive power of flood events, which is hypothesized as a factor in the appearance of the gas seeps. Erosion effects can be determined from follow-up bathymetric surveys.

Phase	Task	Results
2	Task 14 – Review of CSG Industry and Other Scientific Information Regarding Gas Seepage (see Section 8.5)	1. Information from the CSG industry and other scientific sources were reviewed and used to develop the strategy for Phases 1 and 2 of the Condamine River Gas Seep Investigation. 2. Outside experts with experience in investigating gas seepage in the United States were hired to assist in the investigation.
2	Task 15 – Surface and Shallow Subsurface Soil Gas Survey (see Section 8.6)	1. Established the current extent of the 4 gas seeps, The mapping data will be the baseline against which future mapping will be compared to determine whether changes in extent of the seeps occur. 2. Most methane seepage appears to be coincident with the active channel of the Condamine River and does not extend beyond the adjacent banks. 3. Methane seepage is not occurring at the 3 areas of stressed vegetation of concern to landowners. 4. Methane seepage is not occurring around the 4 Orana pilot wells. 5. Methane was detected at very low concentrations in most of the soil gas probes, therefore stable isotopes could not be analysed. 6. In most of the probes with higher methane concentrations, the isotope ratios have been altered by oxidation and fractionation; therefore, they are not useful in determining the source of the gas in the probes.
2	Task 17 – Bathymetric Survey (see Section 8.7)	1. The bathymetric map and profiles do not indicate a strong relationship between depth of the river bottom and the locations of the 4 gas seeps. 2. Active bubbling occurs in areas where the river bottom is deep “holes”, in areas where the bottom is relatively high, and in areas along the edge of the active channel. 3. The bathymetric survey provided a “snapshot” in time. Erosion effects and other changes can be determined from follow-up bathymetric surveys. 4. Data from this survey can be compared to future data to help determine: whether erosion and redistribution of sediment opens up additional pathways or closes existing pathways for gas migration; what role bathymetry has in the locations of existing gas seepage; and whether bathymetric data can be used for predicting future areas of gas seepage.

Phase	Task	Results
	Argyle Field Assessment	1. Gas was detected in the Westbourne Formation and Springbok Sandstone, but the largest and most numerous gas detections occurred in the WCM. 2. The Springbok Sandstone in the Argyle 4 well contained a significant amount of methane gas and water. 3. CSG wells in the Argyle Field have not been stimulated by hydraulic fracturing. 4. The date on which the Condamine River gas seeps were reported to the CSGCU does not coincide with or follow any unusual production trend, such as a significant increase in water and/or gas production in the Argyle Field. 5. Pressure monitoring and testing data demonstrate that the CSG production is causing depressurisation of the WCM in the Argyle Field, but not necessarily the seep areas. Depressurisation may be in part attributable to production in other fields. 6. Dewatering and depressurization from earlier wells have resulted in increased gas:water ratios in later wells and indicates some degree of continuity across the Argyle Field and perhaps extending into other fields. 7. Permeability of the WMC is generally greater than the Springbok Sandstone. The permeability of the Taroom significantly higher than that of the Upper and Lower Juandah Coal Measures. 8. Stable isotope ratios for QGC WCM gas indicate that it is biogenic methane produced by CO_2 reduction and similar to CSG gas produced elsewhere from the WCM, to the gas discharging from the Condamine River gas seeps, and to gas in the Springbok Sandstone. 9. Baseline landholder water bore sampling showed that there is methane in the Springbok Sandstone.