Australian Government
Department of Agriculture

AUSTRALIAN Pork™

Low Cost Methane Capture and Combustion from a Piggery Effluent Lagoon

Final Report
APL Project 2009/2307

August 2013

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Executive Summary

Installation of an anaerobic lagoon cover, flare and monitoring equipment was installed at Rivalea's Bungonwannah site in February 2010. Monitoring of data began on the 30th May 2010.

The project and data monitoring was progressing well however there were calibration issues with some of the flow monitoring equipment which were resolved by September 2010. Early indications from the data collected showed a daily production of 600-900m^3 of biogas with a concentration of 60-70% methane.

By September 2010, substantial volumes of biogas were accumulating under the cover causing billowing which was subject to wind gusts. The constantly changing shape of the cover caused slippage of the ballast weights from their anchors which led to over inflation of the cover and reduced flow of gas through the flares.

This situation persisted for several months and the contractors were called back to re position the ballasts and service the flares which appeared to have stopped working. The contractors returned to site on the 31st January 2011, however in repositioning the ballasts, the cover was ruptured and a very large plume of biogas was released and caught fire.

The fire only narrowly missed causing major injuries or death to the contractors and Rivalea employees. Substantial property damage including destruction of the cover was the end result.

Following an investigation, Rivalea determined the cause of the fire to be poor design of the cover and ballast system, omission of a gas blower and poor work practices by the contractor on the day.

After an insurance claim, Rivalea contracted JJC Engineering to oversee the installation of a new cover which included a more robust ballast system and a gas blower. The new cover was installed in December 2011 by different contractors with a rigorous commissioning regime put in place to prove the performance of the cover and associated gas evacuation pipe work. An additional bank mounted automatic emergency vent has also been incorporated.

The blower and flare which were installed by Rivalea technical team was commissioned in February of 2012. The operation of the flares with a fan forced blower is somewhat different to the original design and will require fine tuning however we are confident that the biogas system is now much safer than the first installation.

The monitoring equipment from the original installation has been reused however a new PLC controller has been installed to monitor additional information about the status of the gas under the cover and operation of the flare. The new control system was designed to take into account the ability to generate carbon credits under the Carbon Farming Initiative which commenced in December 2011.

Monitoring data included in this report includes data from the first installation as well as data recorded from the new installation commencing in May 2012.

Acknowledgements

This project is supported by funding from Australian Pork Limited and the Department of Agriculture.

Milestones Achieved

Task 1: Development Approval
Task 2: Construction Complete

- Build digester within set budget
- Retrofit a cover to an existing anaerobic effluent lagoon

Task 3: Six Month Progress of Flare Operation

- Progress report dated 15 October 2010

Task 4: Twelve Month Flare Operations

- Data collection for this project has been interrupted due to the fire and lead time to reinstate the cover.
- Data collected in this report is in two separate tranches
    - Pre fire Original Installation – 31/5/2010 -31/01/2011 – 7 months
    - Post fire Second Installation 9/5/2012 -4/06/2012 – 1 month
- Rivalea will continue to collect data and provide an addendum to this report as the necessary data comes to hand in the second half of 2012.

Pre Fire Data Analysis

Data recorded from June 2010 to January 2011 included daily gas volumes flared and the methane percentage of the biogas.

Gaps in the data recording log indicate that the data logger was either not working properly or not restarted after a download. This failure also highlights the need to include alarms in the data recording software.This is a learning experience that data recording equipment needs to operate automatically and alert operators if data loggers fail.

Analysis of this data, outlined in Fig 1, suggests that daily gas volumes in the range of 1200-1400 m^3 per day were achievable with a marked upward trend in the warmer months. . Data between 7th and 25th of December 2010 is not available suggesting that the data recording equipment was not working during this period. This period also coincides with time when the ballasts fell off and gas flow began to reduce. The period between 25th December 2010 and 31st January 2011, clearly shows reduced daily gas flows to between 200-400m3/day. The difference between what would have been expected to be produced, and what was being flared, was accumulating under the cover.

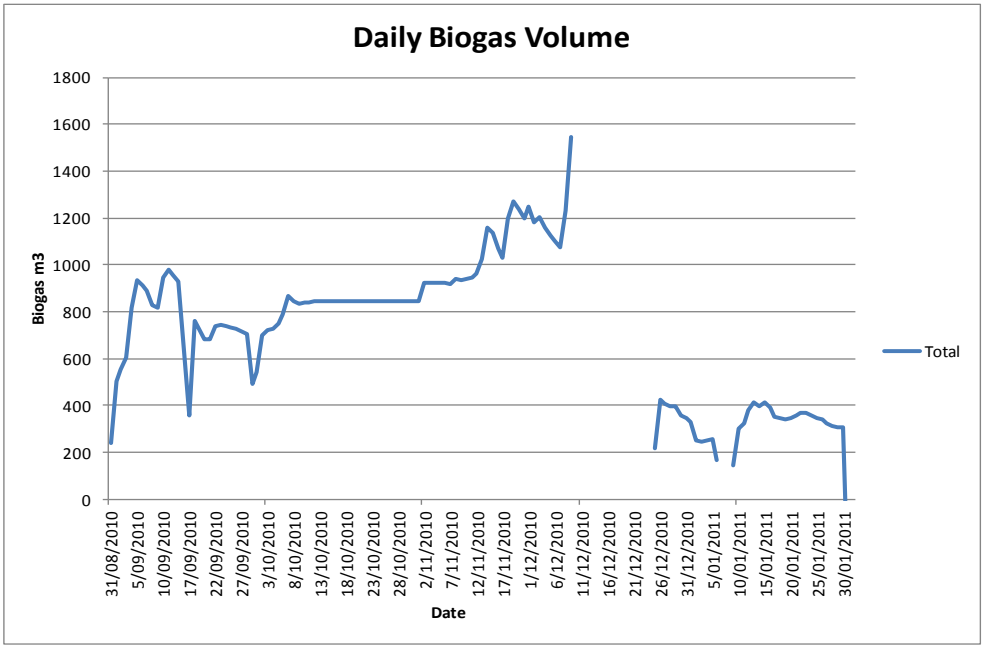

Figure 1

Methane

Biogas generated in the lagoon is a mixture of methane (CH_4), carbon dioxide (CO_2) and other trace gases including hydrogen sulfide (H_2S). Methane is a potent greenhouse gas with a global warming potential 21 times that of CO_2. It is also a potential source of energy so understanding the volume of methane in the biogas is essential to calculate greenhouse mitigation as well as develop strategies for utilizing the energy content on farm.

Data collected to January 2011 (Fig 2) shows that the average percentage of methane drifting down slightly from 70% to 60% around the end of November. It is expected that this drift is caused by increased temperatures which cause volumes of biogas to rise but methane content to fall slightly.

Interruptions to data collection can be clearly seen from December to January and these readings are considered too volatile to be a true indication of gas quality.

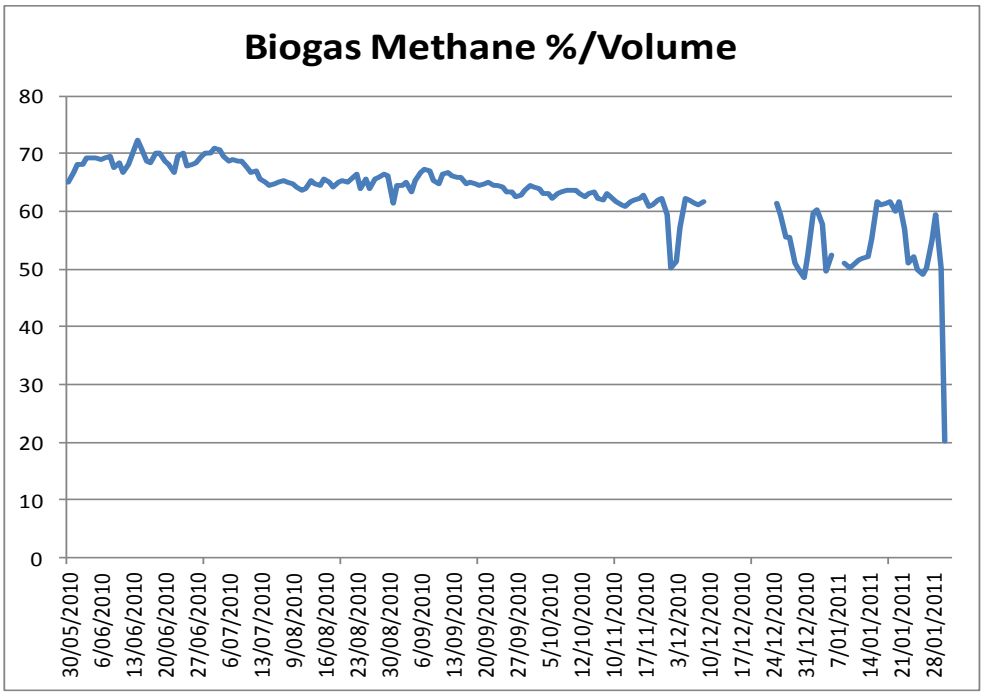

Figure 2

Data collected during January 2011 (Fig 3) shows the reduced flow of biogas to between 12 and 16m³ hour. The sudden drop off on 31st January indicates the precise moment of the fire.

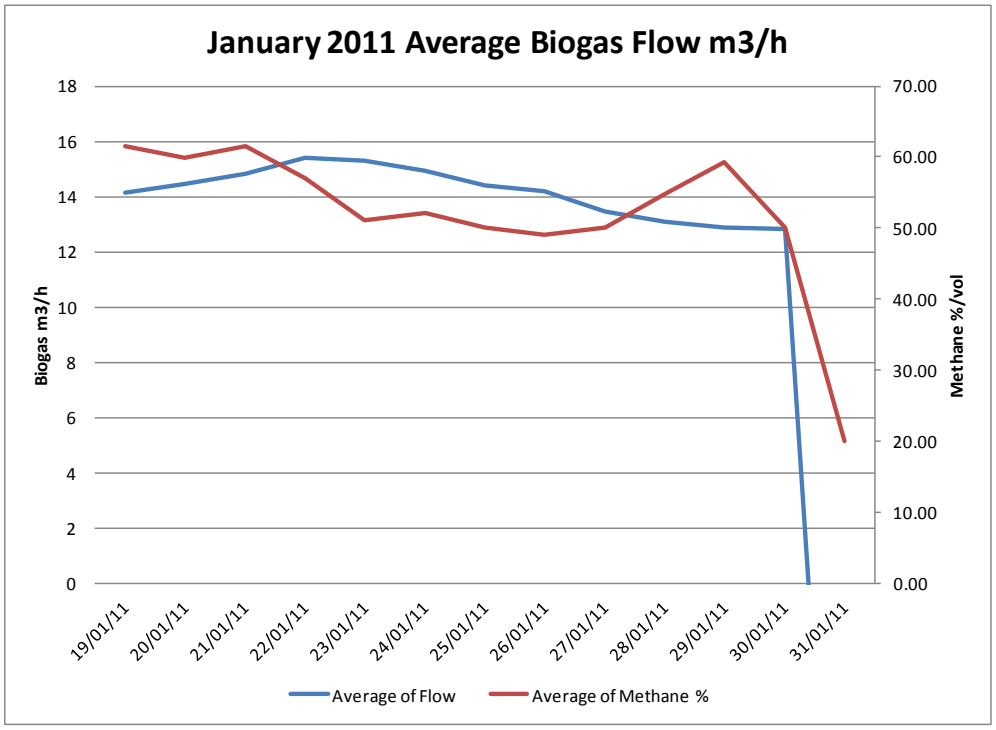

Figure 3

Biogas Accident Summary

The original cover was installed using a ballast method consisting of 100 mm poly pipes filled with concrete. One lateral connector was placed on the southern side of the lagoon with fingers laid across the cover. This design proved to be inadequate as the ballasts did not hold the cover in place sufficiently to provide enough positive pressure to push the gas out through the flares.

The flares operated on positive pressure from within the cover commonly refered to as a 'lazy' flame. This meant that the gas flowing to the flares was limited by the cover pressure which is only ever marginally above atmospheric pressure. This very limited pressure differential proved to be inadequate to allow gas to evacuate at a similar rate to production.

Around Septemeber/ October 2010, the cover inflated to the point where the ballasts slipped from their anchor straps, further reducing any downwards pressure on the cover.

The contractors returned to the site on January 31 2011 to reinstall the ballasts and anchor them in place. The contractors were hauling the ballasts back in place using ropes when the cover was ruptured at its peak and caught fire. The ignition source is uncertain, but is believed to have possibly come from an appliance being used in a pig shed, some 50m away.

As the fire spread, the cover was further ruptured giving rise to a very large plume of burning biogas. Fortunately, both the contractors themselves and a Rivalea manager saw the initial fire and ran from the area, narrowly avoiding a potentially deadly situation.

The plume of burning gas set fire to a pig shed roof (sandwich panel) and completely destroyed the cover. Damage to the flaring equipment was minor however the proximity of two large LPG tanks was of major concern to the fire brigade.

Ballast method

Open flare without wind shroud

September 2010 gas builds up under the cover. Ballasts still in place.

October 2010 – Pressure had built up in the cover to significantly alter the shape of the cover which caused the ballasts to slip out of the anchor straps. This then allowed the cover to inflate even further

16 November 2010 - having the cover fully inflated was dangerous as it allowed a large volume of gas to accumulate. Note the proximity of the LPG tanks.
The cover was at a similar level of inflation when it was ruptured and subsequently caught on fire.

Reconstruction

Some major lessons were learned from the fire and the design for the new cover was subsequently changed.

- New water filled ballast system with a rib cage design
- Installation of a 2.2kW specialist biogas blower both for flaring and venting
- Installation of a bank mounted automatic emergency vent
- Larger gas evacuation takeoff (200mm) to reduce pressure drop to less than 10 Pa at a flow rate of 200m³/h
- Rigorous commissioning regime that included inflating the cover to prove operation of the automatic vent

Reconstruction of the cover commenced in November 2011.

New cover being placed over the lagoon.

New ballast method included a rib-cage style system with central spine placed in the centre of the lagoon. The ballasts are filled with water which is topped up from time from a bank mounted filling hose. The new ballast has a design capacity of 14 tonnes.

Installation of blower capable of 500m³/h. The main control cabinet has now been moved to well beyond the hazardous area and can be seen in the background.

Existing flares fitted with wind shrouds and thermocouples.

Carbon Farming Initiative

The control system for the new installation has been designed in anticipation of generating carbon credits under the Carbon Farming Initiative (Department of Climate Change and Energy Efficiency, 2012). Additional equipment was limited to:

- Thermocouples installed in each flare to record a flame temperature greater than 500 Deg C. This was only achieved with the installation of wind shrouds to enable the thermocouples to be positioned in a steady flame stream.
- Programmable Logic Controller which performs data collection and transfer to the companies database on the internal network.
- Methane analyser was retained from the original installation however the CFI methodology allows a default rate of 70% so an analyser is not strictly needed.
- Biogas flow meter – Has been retained from original project however it has a limited range of 0-180 m^3/h which will limit the flow rate at which gas flows can be recorded even though the blower can evacuate more gas. This should not be a problem as the theoretical rate of gas production is under 100m^3/h.
- Gas flow valve – A pneumatically operated butterfly valve has been installed which now isolates the flares from the cover.

Post Fire Data Analysis

Task 4: Twelve Month Flare Operation

- Provide 12 months of methane flow and quality data from the covered effluent lagoon.

Due to the interruption of the project by the fire, a total of only 8 months of data has been collected. This data indicates the problems that were experienced with gas production in the latter weeks before the fire. The data however is a useful guide to diagnosing when problems arise.

Data collection was recommissioned in late April 2012 and has collected reliable data at 5minute intervals since 9 May 2012. An addendum to this report will be provided to APL in September 2012 to provide a full 12 months of data.

At the request of the piggery management, it was decided that flaring would initially only occur during times when staff were in attendance. This requirement has created a situation where gas is only flared six days per week for periods of 8 hours. This mode of operation records the amount of gas flared which may not accurately represent the amount of gas being produced by the lagoon on a day to day basis.

However the average daily gas flow of 1453 m^3/d over the full month is encouraging as it confirms the gas flows being recorded in the initial data set. The new control system will allow us to experiment with achieving an optimum flare rate to match the production rate and maintain a safe level of gas under the cover at all times. The addition of a pressure sensor added in May 2012 will assist with optimising the set point for gas flow rates which can be controlled by blower speed.

Date	Gas Flow	Methane %
9/05/2012	0	83
10/05/2012	1272	81
11/05/2012	2221	70
12/05/2012	1262	82
13/05/2012	0	83
14/05/2012	1317	82
15/05/2012	1799	75
16/05/2012	2026	70
17/05/2012	1235	72
18/05/2012	2377	67
19/05/2012	1191	77
20/05/2012	0	77
21/05/2012	2539	67
22/05/2012	1206	83
23/05/2012	1171	79
24/05/2012	752	81
25/05/2012	1600	88
26/05/2012	810	79
27/05/2012	0	86
28/05/2012	1746	90
29/05/2012	1194	84
30/05/2012	1406	82
31/05/2012	1397	82
1/06/2012	1398	83
2/06/2012	1418	75
3/06/2012	0	79
4/06/2012	643	
Grand Total	**31981**	**81**
Average per day*	**1453**	**80**

*Averaged by days when flare was burning

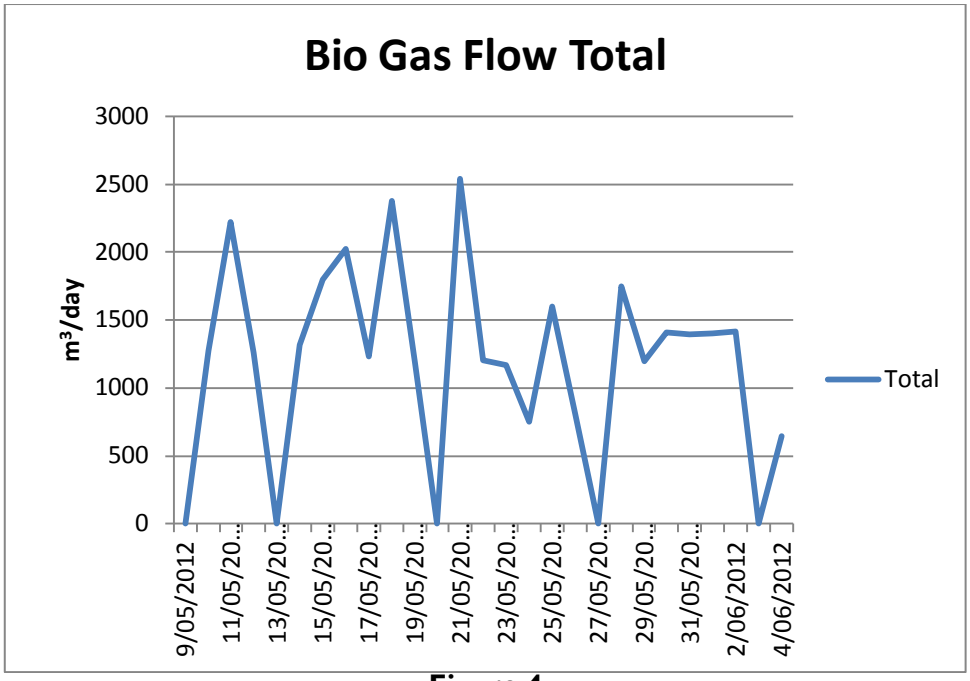

Figure 4

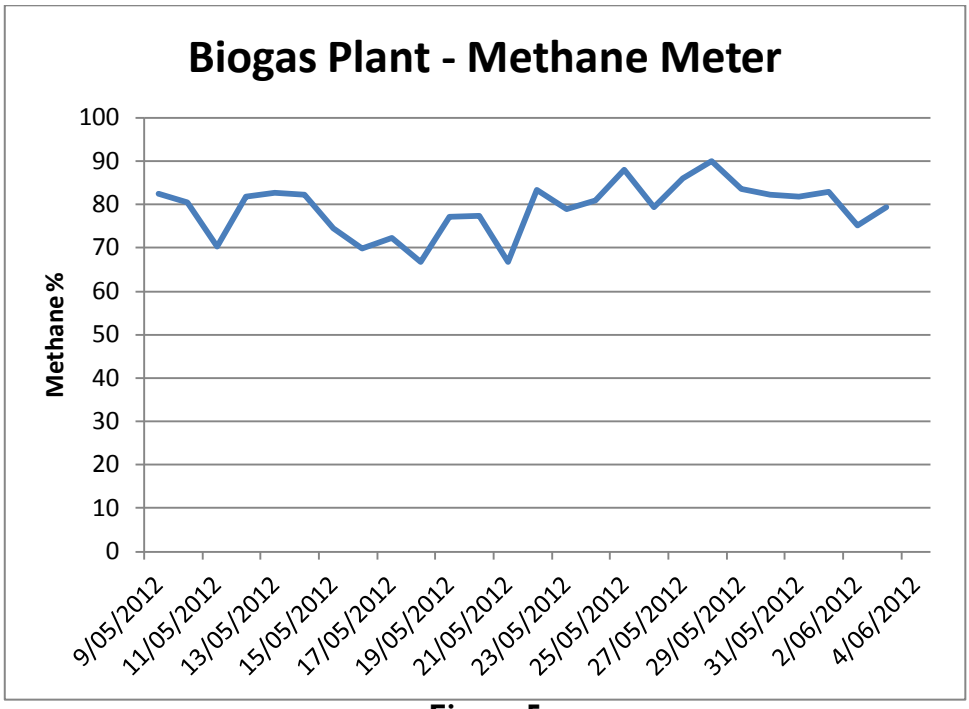

Figure 5

Achievement of Major Objectives of the Project

1. Reduction of Methane Emissions from an Anaerobic Lagoon by up to 90%

The introduction of the Carbon Farming Initiative during the construction phase of the new cover introduced the possibility of generating carbon credits. The design of the new control system was based partially on the published draft methodology. PigBal is an integral part of the methodology and will be used to establish the baseline emissions against which the collected data can be compared. Application of the methodology will demonstrate the reduction of methane emissions.

2. To Reduce Odour Emissions

Odour complaints to the EPA have continued but are greatly reduced. Complaints spiked when the effluent was reintroduced into the covered lagoon however this was due to the disturbance of the bypass lagoon which has now settled.

Complaints received in May 2012 have been isolated to particular weather conditions with ideal wind direction, speed, temperature and humidity. It is still unclear if the odours emanate from the effluent treatment system or piggery sheds.

An alternative method of measuring and logging odour has been implemented to determine what specific weather conditions give rise to odour emissions off property, and what, if any , actions can be taken in the piggery ahead of time to reduce or prevent odour emissions from impacting neighbours.

3. To Demonstrate that a Cover Can Be Retrofitted to an Existing Lagoon at Low Cost

This project has now installed two covers as well as removed one.

Removal of the burnt cover proved to be somewhat more difficult than first anticipated. We would expect that as more covered lagoons reach the end of their life, the cover contractors will develop better methods for removal and disposal of cover material.

Installation of the second cover was carried out by Waterlogic Pty Ltd who also designed and fitted both the new ballast system and the automatic vents.

The original cost of installing the biogas system was $140,000 however the cost to reinstate the system following the fire is estimated to be $175,000 which includes earthworks and mechanical/electrical services provided by Rivalea.

Estimated cost to remove and dispose of the old cover is $16,000 which should be considered in a full life-cycle analysis.

4. To Demonstrate that a Low Cost Retrofit Lagoon Cover Can Be Used to Mitigate Greenhouse Gas Emission

Greenhouse gas emissions from ponds are reduced by a factor of 21 when methane is burned and converted to carbon dioxide. Flaring provides a physical proof that methane is being converted. Data recorded since thermocouples have been installed indicate a destruction temperature of between 500-800 Deg C, well over the temperature required by the Carbon Farming methodology (Department of Climate Change and Energy Efficiency, 2012).

A second opportunity to mitigate greenhouse gas emissions exists when the energy from biogas can be usefully used to displace fossil fuel produced energy. Rivalea has commenced discussions with Quantum Power Limited with a view to generating electricity onsite using the biogas from the project as the fuel source.

Initial modeling suggests that a generator utilizing biogas could displace around 85% of the sites grid supplied electricity resulting in approximately 1350 T $CO_{2\ of}$ Scope 2emissions avoided (Department of Climate Change and Energy Efficiency, 2011)

5. To Provide 12 Months of Performance Data from a Covered Lagoon Digester to the Pork Industry

A total of eight months of data has been captured spanning both initial and new cover post the fire. The data confirms the consistent flow of biogas at a methane percentage which is high enough to pursue energy conversion options in the future.

This data also demonstrates how controls can be put in place on covered anaerobic lagoons to ensure that a potentially dangerous situation can be monitored and avoided if early preventative action takes place.

Rivalea (Australia) Pty Ltd undertakes to provide an addendum of data at the end of September 2012 to provide a full set of 12 months of data to complete the project.

Additional Data Added 21 August 2013

Date	Total Biogas Flared	Methane %
01/10/2012	1,601	75.34
02/10/2012	474	74.14
03/10/2012	806	73.90
04/10/2012	1,903	73.00
05/10/2012	956	68.83
06/10/2012	867	72.49
07/10/2012	0	72.81
08/10/2012	1,818	75.12
09/10/2012	1,470	74.47
10/10/2012	1,109	71.67
11/10/2012	1,010	71.20
12/10/2012	1,054	72.92
13/10/2012	0	71.45
14/10/2012	753	72.97
15/10/2012	1,914	74.51
16/10/2012	1,176	72.09
17/10/2012	1,018	72.36
18/10/2012	1,069	71.86
19/10/2012	1,065	71.41
20/10/2012	1,165	71.22
21/10/2012	1,220	71.64
22/10/2012	1,121	71.70
23/10/2012	1,051	71.78
24/10/2012	1,145	71.01
25/10/2012	1,262	69.94
26/10/2012	1,092	70.31
27/10/2012	0	69.56
28/10/2012	907	71.24
29/10/2012	1,547	71.87
30/10/2012	602	69.69
31/10/2012	1,351	70.54
01/11/2012	1,749	70.86
02/11/2012	1,054	70.98
03/11/2012	1,027	69.82
04/11/2012	1,075	69.81
05/11/2012	1,053	68.58
06/11/2012	1,135	68.87
07/11/2012	1,259	70.04
08/11/2012	1,227	71.34
09/11/2012	(51,613)	73.63
10/11/2012	53,965	72.84
11/11/2012	1,142	73.45
12/11/2012	1,251	73.60

13/11/2012	1,133	73.58
14/11/2012	1,178	73.09
15/11/2012	1,241	71.03
16/11/2012	1,178	69.23
17/11/2012	1,090	68.85
18/11/2012	1,083	67.95
19/11/2012	1,132	69.51
20/11/2012	1,374	73.16
21/11/2012	1,536	74.58
22/11/2012	1,475	76.02
23/11/2012	1,479	76.10
24/11/2012	1,502	75.22
25/11/2012	1,553	74.57
26/11/2012	1,625	74.82
27/11/2012	1,514	74.41
28/11/2012	1,510	74.92
29/11/2012	1,533	74.38
30/11/2012	1,800	75.16
01/12/2012	1,644	74.68
02/12/2012	1,541	76.01
03/12/2012	1,440	74.72
04/12/2012	1,304	74.05
05/12/2012	1,169	75.05
06/12/2012	988	76.13
07/12/2012	1,004	75.99
08/12/2012	981	73.36
09/12/2012	1,083	72.62
10/12/2012	913	70.43
11/12/2012	952	69.27
12/12/2012	953	68.22
13/12/2012	1,032	67.67
14/12/2012	986	66.04
15/12/2012	905	65.73
16/12/2012	925	65.80
17/12/2012	823	66.61
18/12/2012	881	65.99
19/12/2012	1,080	67.21
20/12/2012	1,381	72.77
21/12/2012	1,165	75.27
22/12/2012	773	74.64
23/12/2012	823	73.51
24/12/2012	653	70.98
25/12/2012	0	71.89
26/12/2012	0	71.20
27/12/2012	1,286	73.23
28/12/2012	1,210	75.48

29/12/2012	884	75.61
30/12/2012	1,353	74.26
31/12/2012	747	72.40
01/01/2013	781	73.18
02/01/2013	1,139	73.83
03/01/2013	1,493	75.59
04/01/2013	629	74.58
05/01/2013	0	72.44
06/01/2013	0	73.15
07/01/2013	930	73.59
08/01/2013	0	67.94
09/01/2013	0	68.77
10/01/2013	959	73.11
11/01/2013	0	71.44
12/01/2013	0	71.18
13/01/2013	0	72.50
14/01/2013	786	75.90
15/01/2013	1,169	77.13
16/01/2013	1,587	77.48
17/01/2013	1,279	76.30
18/01/2013	0	71.68
19/01/2013	0	72.94
20/01/2013	0	73.54
21/01/2013	1,280	75.70
22/01/2013	552	73.87
23/01/2013	697	75.12
24/01/2013	1,095	76.48
25/01/2013	1,265	75.86
26/01/2013	0	73.23
27/01/2013	0	73.94
28/01/2013	1,493	76.84
29/01/2013	1,122	75.97
30/01/2013	589	76.26
31/01/2013	1,194	76.97
01/02/2013	1,270	77.09
02/02/2013	0	76.07
03/02/2013	0	76.16
04/02/2013	1,507	80.79
05/02/2013	1,022	80.43
06/02/2013	974	79.93
07/02/2013	860	78.69
08/02/2013	1,030	80.14
09/02/2013	0	77.63
10/02/2013	0	78.23
11/02/2013	1,516	82.35
12/02/2013	1,141	81.42

13/02/2013	878	82.88
14/02/2013	840	82.75
15/02/2013	722	82.92
16/02/2013	0	83.03
17/02/2013	0	82.66
18/02/2013	1,436	85.72
19/02/2013	656	82.87
20/02/2013	1,009	84.10
21/02/2013	903	84.49
22/02/2013	920	85.01
23/02/2013	0	83.74
24/02/2013	0	80.37
25/02/2013	1,547	86.43
26/02/2013	1,065	84.16
27/02/2013	742	82.70
28/02/2013	0	81.85
01/03/2013	1,421	86.28
02/03/2013	0	85.18
03/03/2013	0	84.13
04/03/2013	1,420	88.33
05/03/2013	680	85.92
06/03/2013	730	84.94
07/03/2013	745	81.94
08/03/2013	677	79.20
09/03/2013	0	79.63
10/03/2013	0	81.60
11/03/2013	965	85.65
12/03/2013	1,193	87.59
13/03/2013	1,004	86.33
14/03/2013	798	87.28
15/03/2013	753	87.98
16/03/2013	0	76.67
17/03/2013	0	87.88
18/03/2013	739	90.64
19/03/2013	754	89.68
20/03/2013	579	88.32
21/03/2013	189	86.93
22/03/2013	639	88.72
23/03/2013	0	89.23
24/03/2013	0	88.55
25/03/2013	903	91.32
26/03/2013	0	88.84
27/03/2013	962	90.23
28/03/2013	730	89.48
29/03/2013	518	91.44
30/03/2013	0	89.44

31/03/2013	0	87.48
01/04/2013	1,042	88.47
02/04/2013	601	84.70
03/04/2013	31	81.26
04/04/2013	763	86.46
05/04/2013	485	86.32
06/04/2013	0	84.59
07/04/2013	0	84.52
08/04/2013	864	87.38
09/04/2013	714	87.04
10/04/2013	676	88.52
11/04/2013	633	87.76
12/04/2013	618	87.41
13/04/2013	657	85.51
14/04/2013	610	83.32
15/04/2013	598	81.78
16/04/2013	429	37.56
17/04/2013	0	0.00
18/04/2013	0	0.00
19/04/2013	0	47.30
20/04/2013	0	71.39
21/04/2013	0	57.93
22/04/2013	0	2.52
23/04/2013	0	11.41
24/04/2013	0	1.00
25/04/2013	0	1.00
26/04/2013	384	1.00
27/04/2013	2	1.00
28/04/2013	0	1.00
29/04/2013	664	1.00
30/04/2013	317	1.00
01/05/2013	393	0.86
02/05/2013	3	0.52
03/05/2013	298	12.16
04/05/2013	0	1.00
05/05/2013	0	1.00
06/05/2013	360	47.25
07/05/2013	430	13.56
08/05/2013	313	13.22
09/05/2013	0	4.29
10/05/2013	474	8.71
11/05/2013	408	1.00
12/05/2013	170	1.00
13/05/2013	563	44.81
14/05/2013	426	61.10
15/05/2013	66	29.32

16/05/2013	532	57.53
17/05/2013	378	58.45
18/05/2013	0	8.23
19/05/2013	0	2.00
20/05/2013	589	2.00
21/05/2013	290	1.32
22/05/2013	3	1.00
23/05/2013	0	1.00
24/05/2013	518	1.00
25/05/2013	2	1.00
26/05/2013	0	1.00
27/05/2013	509	1.00
28/05/2013	0	1.49
29/05/2013	470	12.52
30/05/2013	338	61.36
31/05/2013	0	9.23
01/06/2013	0	2.25
02/06/2013	0	1.48
03/06/2013	763	14.45
04/06/2013	2	1.00
05/06/2013	638	26.11
06/06/2013	0	9.41
07/06/2013	739	37.43
08/06/2013	78	20.55
09/06/2013	0	1.00
10/06/2013	775	31.69
11/06/2013	376	42.68
12/06/2013	0	8.30
13/06/2013	0	2.78
14/06/2013	1,019	31.60
15/06/2013	0	3.54
16/06/2013	0	1.00
17/06/2013	934	19.02
18/06/2013	2	12.57
19/06/2013	0	1.00
20/06/2013	755	25.11
21/06/2013	0	5.50
22/06/2013	0	1.00
23/06/2013	0	1.00
24/06/2013	902	36.99
25/06/2013	373	46.27
26/06/2013	0	13.64
27/06/2013	0	3.33
28/06/2013	764	29.92
29/06/2013	86	20.47
30/06/2013	0	1.00

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