Kingaroy Concerned Citizens Group

Response to:

Department of Environment
And
Resource Management

Concerning:

Cougar Energy

Environmental Evaluations
Dated : 16 August 2010
1 October 2010
15 October 2010

Summary of Findings

- There are no records in Cougars report of:
    - Dewatering of chamber before the burn process
    - Gas scrubbed from the process
    - Gas vented during the 5 day burn
    - Amount of coal burnt
    - Well temperatures
    - Amount of by-products now stored in the wastewater dam
    - No mention of temperature profiles recorded or estimated in P4

  It is clear that these records would be needed to make an accurate assessment of the pollution event.

- Calibration of recording equipment on site was poor with some parameters not recorded.
- The crucial hydro-geological report water submitted by Golders is extremely generalist in nature and lacks specific information needed to assess the risk to local water supplies.
- In the UCG process vast quantities of toxic chemicals are from the onset, mixed with upward travelling two-phase fluids which have the ability to permeate through the aquitard (an aquitard only retards and does not stop fluid movement).
- With UCG the 'perfect gas' components of N2,CO2,CO etc in the two-phase fluid can vent to the atmosphere at the ground surface leaving behind the bulk of the toxic chemicals in the liquid phase. This toxic liquid would now be ideally placed to flow downwards from ground level to contaminate important groundwater**.**
- The use of high pressure air which did escape in large quantities into the coal seam or surrounding strata. Why was high pressure air used for such a long period of time risking the spread of contaminants?
- No conclusive evidence as to the cause of the fracture in well P4
- No adequate explanation for the blockage of wells by cement.
- An admission that wells could block in the future which indicates ample chance for further water contamination. This proves there is little hope for the safety of water resources with this experiment.
- No duplicate samples of water taken at site bores or nearby bores
- No sampling for BTEX chemicals at surrounding landholder wells before ignition or after ignition of plant to obtain base line data.
- The contamination observed 3 weeks after the breakdown in wells T5037 and T5038 could have originated from the burning cavity and not necessarily from the fractured production well P4. Perhaps both sources were involved?

- Thermal ratcheting of the production well pipes is likely to be a continuing problem leading to further breakdowns, blockage and release of pollutants.
- Blockage of wells in the future is freely admitted as a distinct possibility, further
- Toxins from the project were likely to have emanated in an area 360° from around the pipe yet
- The travel of gases radiating in all directions from P4 through the soil, and the gases escaping untreated through damaged plant and equipment above ground has not to our knowledge been fully investigated.

Recommendations

- Environmental problems with UCG are insurmountable and we recommend that Queensland should relinquish its interest in UCG in favour of above ground coal gasification technology.
- The Kingaroy site be permanently closed and the company allowed to continue its experiment at it's other site if it is found to be suitable i.e. not on strategic cropping land, not a threat to potable water supplies, no threat to local businesses.
- The process to date is estimated to have produced 10kgs of benzene. In burning the allowable 20,000 tonnes in this experiment there would be 60 tonnes of benzene produced and released to the environment. Given the record of this company it is an unacceptable risk for them to continue under any circumstance.
- This company has clearly demonstrated it does not have the necessary expertise to cope with likely problems with the very complex process of UCG on an unsuitable site
- Submitted reports show beyond any doubt that this is an experimental project with much undeveloped technology. We consider that such experiments have no place situated dangerously close to a populated area and its water supplies.
- It is strongly recommended that the Queensland Government is entitled to reject any claim for financial compensation. KCCG believes that termination of this project is also in the best interests of Cougar shareholders because it is likely that a 400 MW(E) power station as planned near Kingaroy faces the distinct likelihood of compulsory closure on environmental grounds.
- The State Government has chosen to ban the use of benzene and toluene as fraccing chemicals due to their toxic threat to ground water it is clear that the UCG process has no place at Kingaroy.
- Cougar Energy bases the "safety" of its project on the separation of toxic gases and the groundwater by an aquitard above the coal seam. This is now proven to be not the case and as the name suggests an aquitard only slows movement of water and pollutants.

Part 1: EE: 16-8-10

RESPONSE FROM KCCG TO REPORT ENTITLED

'ENVIRONMENTAL EVALUATION, COUGAR ENERGY PILOT BURN AT KINGAROY,'

SUBMITTED TO DERM ON 16TH August 2010

INTRODUCTION

It is hard to cover all the severe deficiencies in this report submitted as a response to the regulatory authority responsible for this project. For example, there is a failure to include necessary supplementary information which would enable DERM, or its consultants, to assess the problem independently. For example, where are:-

- The logged-records of the flared (or otherwise extracted) syngas, including its flow rate and composition from March 16th onwards? Was the gas scrubbed and, if so, where are the details?

- The logged-record of injected air pressure and flow rate tabulated against the combustion chamber water pressure from March 16th onwards?

- The logged-record of the estimated audit of coal consumption?

Because the project is an experimental feasibility study, these data would be expected to be of interest to Cougar Energy. In view of the mishap under examination they are also of interest to DERM. and/or KCCG.

In addition to the above information needed:

- Was a logged time-record made of the gas emanation rate and its composition from well T5037 when the water and gas were seen bubbling to the surface?
- What are the technical details of dewatering the cavity prior to ignition?
- How much water was extracted and over what period of time, compared with the estimated initial size of the chamber? (This would enable a rough estimate of the water seepage rate into the new unused cavity to be made).

These data would then enable us to have some idea as to how the seepage rate would vary with the air pressure in the chamber. These data would enable us to have some idea of the pressure control characteristics needed for correct combustion. These data could perhaps give an estimate of flow rate of air that was needed to maintain the cavity pressure and enable us to try to find an audit of material transfer? Thereby at least an attempt could be made to estimate the leakage of lost gas from the cavity. All these data would be expected to help us to have an insight into the mass transfer mechanisms within the geological strata.

CRITIQUE OF COUGAR's REPORT

The Report is lengthy and full of speculative explanations which usually have little, if any, scientific basis.

Some specific questions/criticisms are as follows:-

- The report expresses criticism of DERM's Limit of Reporting (LOR) requirements. On page (4) it is stated:-

"The trigger levels for reporting to DERM are exceedences of the Australian Guidelines for Drinking Water (AGDW) being 1ppb for benzene and 800 ppb for toluene which Cougar Energy believes are levels relevant to defining potential contamination" Furthermore the ADWG guidelines clearly state *"there are no safe levels of benzene in drinking water"*

This is an obfuscation of the purpose of monitoring wells which have their limitations in that they cannot be expected to detect the worst areas of contamination. Do Cougar Energy believe that they are entitled to get as close as they dare to the LOR of a limited number of test wells? It will be suggested below (Appendix 1) in KCCG's 'chimney effect' explanation of the observations in Cougar's report that there is good reason to suspect much larger contamination closer to P4. Moreover this contamination would have worsened progressively and spread upwards if the burn had continued. Statistically-speaking a large number of vents would be expected of syngas leaking from the ground, not just from the monitoring wells. There is no reason to suppose that leaking gas would move preferentially towards any particular monitoring well. If it was possible, (which it is not) to cover the whole site with water it would be expected that gas bubbles would be seen emerging at several places.
With regard to the above suggestion that Cougar seems to feel that they have the right to contaminate within the LOR's prescribed, this seems to be a reprehensible attitude within the UCG industry generally An examination of past 'in house' UCG conferences (see Appendix II) indicates a most conspicuous lack of UCG Industry attention to and interest in pollution problems.
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* On page (5) DERM requires a hydro-geological investigation. In response Cougar simply quote the original report from Golders which unfortunately is not available to KCCG.

From the part of Golder's report quoted (section 4.6.7) it is apparent that this is a 'water only' study such as one might expect for a relatively straightforward analysis of an above-ground surface polluting industry. In UCG the potentially polluting fluid is <u>generated</u> underground and is also a two-phase fluid namely a mixture of contaminating water together with gases such as CO2 and nitrogen carrying VOC's (volatile organic chemicals)

The CO2/nitrogen mixture can be considered, nevertheless to behave as an inert 'perfect gas' carrier. Any tradesman-plumber knows that it is relatively easy to seal a water leak because of water's surface tension whereas a potential gas leak requires a much tighter, completely solid, soldered-joint fitting. It follows that with UCG the potential two-phase fluid penetration of the aquitard and other geological strata is a much more complex, <u>likely</u> and worrying issue.

For this reason we have to question the adequacy of Golder's report for the Kingaroy Project. Section 4.6.7 of Golder's report appears to be a 'desk study' and it is conspicuous that it is also couched in such imprecise terms as *'is expected'*;*'unlikely'*;*'is thought to lie'*;*'and possibly'*; ' *may have'*; *'may contribute'*; *'might be influenced'* etc

Whereas KCCG does not have access to the full Golders Report, it has received a public relations document (GOLDERS ASSOCIATES, 2010) from Golders dated 1st February 2010. Pages 3-8 of this document are given over to extolling the excellence of the Golders organisation, mentioning 7000 employees in 160 offices and 6000 clients involved with 12000 projects. Yet nowhere in this public relations document is there any mention that Golders have been involved previously with a UCG project.

In view of all this, the question has to be asked- is the Golders Report sufficient?

On page (6) '*the mechanism for potential movement of contaminants'* is a very complex issue. KCCG believes that an adequate explanation must involve the 'chimney effect' which is described more fully in Appendix I.

Cougar attempt to explain the strange observation that T5037 only detected benzene and T5038 only detected toluene. Their explanation based on different volatilities may have some credence. However this also seems to suggest that there may be two or more different pathways of contaminating fluid moving towards the two wells even if they are so close together. At these temperatures and at atmospheric pressure benzene has a water solubility of 1700mg/l and a vapour pressure of 76mmHg. The corresponding values for toluene are 540 mg/l and 22mmHg. As stated correctly in Cougar's report, the various phenolic compounds (and also PAHs) have lower values.

If different venting pathways are involved there is no differentiated and absolute information relating to soil adsorbing effects which might help us to explain these strange observations. (HARRINGTON ET AL,1999; LEWIS AND EVANS, 2006, MA YAN ET AL,2010).

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*On page 7 (third paragraph) Cougar entertains the possibility of accidental contamination of the bores. Such a hypothesis disregards the observation of gas emanating from T5037. Cougar support their suggestion with an unscientific test to enhance their argument.

* Also on page 7 it is predicted that 'groundwater travel time from P4 to T5037 would be likely to exceed 2 years". The reality is that contamination took less than a month to travel this distance, not 2 years. This is typical of what can happen when reliance is placed on theoretical models (such as often carried out by hydrogeology consultants) which presume uniform permeability without consideration of the influence of water transfer though fissures.

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* On page 10, Apart from the chimney effect which suggests that worse contamination is further underground closer to P4, there are likely (in a statistical sense) to be other undetected exit points for the gas and its contaminants.

- On page 12, Cougar offer an explanation for the fracture and collapse of the inner casing which seems to make no sense at all to KCCG. Consulting geothermal experts is unlikely to be profitable because of the much lower temperatures involved with geothermal energy. **It is astonishing in Cougar's Report that no mention at all is made of the temperature of the production gas in the 7 inch pipe. It is beyond reasonable belief that this lack of detail in their report is accidental. Are Cougar concealing the real cause of this mishap?** Fig (6) suggests that the API steel casing has softened due to overheating (CHEN ET AL, 2006). Presumably it was possible to make an above ground inspection of the upper part of the pipe above the break. Was it evaluated by a metallurgist? Moreover KCCG has been unable to find any technical literature from the UCG Industry related to production gas well casings. Is this just another deception in this very secretive industry? **Is the integrity of production well casings yet another very serious problem area associated with UCG?** API well bore steels are selected for high pressure tensile performance at low temperatures.

By way of explanation, above ground coal gasifiers such as those used by Shell, BP and Texaco operate at very high temperatures of about 1500^{o}C, well beyond the working range of all steels, Consequently these gasifiers are protected internally by expensive refractory linings.

Obviously the syngas coming up the pipe at Kingaroy is at a much lower temperature, but what is this temperature?

KCCG cannot comment further until this issue is clarified. In view of this serious deficiency in the present report KCCG has decided to request the revised Cougar Report as soon as it becomes available.

CONCLUSION

The most surprising feature of Cougar's report is the speed with which contaminants can move through the soil. This emphasises the importance of using the two-phase fluid dynamics mechanisms approach outlined briefly in Appendix I in this review.

Fortunately the quantity of contaminants dispersed at Kingaroy is likely to be small from such a short-duration burn.

KCCG concludes that the environmental problems with UCG are insurmountable and recommends that Queensland should relinquish its interest in UCG in favour of <u>above ground</u> coal gasification technology. Although the latter is more expensive it has a proven record in other parts of the world (CHANDASEKHAR, 2006).

APPENDIX 1:

THE INFLUENCE OF TWO-PHASE FLOW WITH REGARD TO UCG.

The following scenario is described for the full-scale planned Kingaroy power station ultimately intended to consume 70 million tonnes of coal. It is assumed that CRIP (directional drilling) would be used at this stage. The coal seam roof, illustrated in Fig. (1), can be expected to be undulating. If this is not its natural shape it will inevitably develop this way by spallation (rock falls). These cavities in the roof would collect relatively slow moving gas. A slow vortex gas circulation is shown in Fig (1) to illustrate the situation.

Away from the combustion front (A), the gas would be cooler with condensation of some combustion products and their solution into water seeping into the chamber. This mixture would tend initially to diffuse upwards slowly into the strata of the roof cavity because it is less dense than the adjacent surrounding water in the cavity. As it rises the 'perfect' gases (nitrogen, CO, CO2, H2 etc. in the mixture will probably tend to expand, reducing the density of the two-phase fluid thus increasing the upward propulsive pressure force. The cooling effect due to vertical movement away from the cavity would tend to offset this.

However the net effect is an inevitable upward movement of the gas phase which will entrain some water with it. This is the mechanism of the industrial air lift pump but in the UCG situation the pumping of the adjacent liquid upwards is much more efficient because of the small size of the gas bubbles and consequent strong viscous coupling Consequently this upward movement of fluid would be slow at first, particularly where the strata has a low permeability.

However, in low permeability strata, the gas and liquid phases would have a relatively strong viscous coupling (they move together). When they find a fissure, the gas phase will .move faster than the liquid but a gas pocket will develop when the fluid meets a dome of low permeability strata. This would continue until the increasing volume of gas finds a fissure whereupon the upward motion accelerates. As the twisting column of two-phase fluid gets longer in the vertical sense it will cause suction, further encouraging ingress of the fluid at the combustion cavity wall. The higher the column of leaking gas the greater the upward propulsive pressure force. However, acting against this is the increasing friction in the longer path of flow

In principle it is possible, theoretically, to calculate this because, due mainly to the interests in the petroleum industry and also chemical engineering generally, two-phase flow in porous media is one of the best covered fields we have in applied mathematics (COREY, KUEPER & FRIND,1991: WHITAKER,1986, RAMANATHVAN,2010). However, the reality with geology is that it is hard to know sufficiently accurate input data in order to derive meaningful results in these very lengthy and non-linear computer calculations. This is especially true in applying it to UCG where geological discontinuities are mainly unknown.

Much the same criticisms can be directed at computer modelling of UCG combustion, although these computer models seem to be more useful and realistic than computer modelling of groundwater flows with UCG.

However, despite these problems with theoretical studies, fortunately we also have some useful and very relevant observed data to throw light on the 'chimney effect' of upward material transfer from UCG burning cavities. It is particularly helpful to examine critically a video documentary called "Gasland" by Josh Fox. 'Gasland' shows actual contamination events resulting from hydraulic fracturing of oil shales to enhance release of entrapped methane gas. This process of mining natural gas is now widespread in the United States. All the examples in the documentary show methane contaminating the underground water supplies, often to such an extent that the water stream could be ignited as it issued from the household tap (faucet).

However so far as KCCG knows, there is no known health risk in drinking methane-contaminated water. In just a few examples in this video other much more dangerous forms of contamination were included with the methane such as BTEX or other chemicals. It seems to KCCG that these examples of chemical contamination were the result of 'bad luck' because the rising water/ methane 2-phase fluid must have picked up these chemicals from unknown underground deposits. The chemicals used in hydraulic fracturing are innocuous and cannot be held responsible. Accelerated release of methane using hydraulic fracturing is from very deep oil shales about 2 km below ground. If such copious upward movement is evident from 2 km, then we can expect at least a similar strong effect from UCG especially at the Kingaroy site which is only 200m deep.

The difference is that with UCG vast quantities of toxic chemicals are. from the onset, mixed with this upward- travelling two-phase fluid .

'Gaslands' also shows the 'multiple paths' of escaping gas in waterlogged land. In the case of UCG the 'perfect gas' components of N2,CO2,CO etc in the two-phase fluid would simply vent to the atmosphere at the ground surface leaving behind the bulk of the toxic chemicals in the liquid phase. **This toxic liquid would now be ideally placed to flow downwards from ground level to contaminate important groundwaters.**

We have no option but to conclude that although UCG is attractive financially as a cheap process, is nothing more than an unattainable dream.

Fortunately we have the reasonably safe alternative of *above ground* coal gasification. This process is more expensive but close to 100 full scale plants are now operating safely throughout the world (CHANDRASEKHAR, 2006)

APPENDIX II

a) 5th UCGP International Conference and Workshop on Underground Coal Gasification, London, 23-24 March 2010

b) 2nd International Conference on UCG, ABM-AMRO Bank, Bishopsgate, London, 7th Feb, 2007

c) see also list of similar conferences at http://www.ergoexergy.com/papers.htm

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Fig (1)

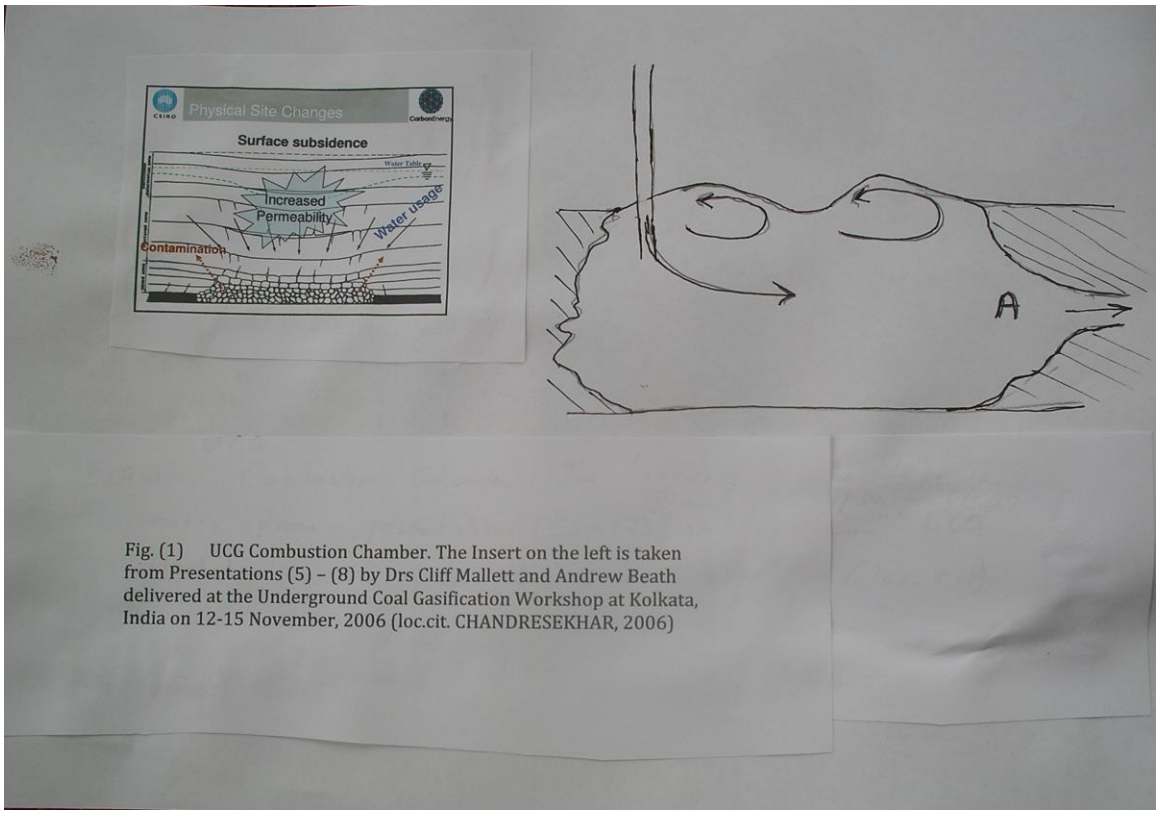

Fig. (1) UCG Combustion Chamber. The Insert on the left is taken from Presentations (5) – (8) by Drs Cliff Mallett and Andrew Beath delivered at the Underground Coal Gasification Workshop at Kolkata, India on 12-15 November, 2006 (loc.cit. CHANDRESEKHAR, 2006)

Part 2: EE 01-10-10

EVALUATION BY KCCG OF REPORT BY COUGAR ENERGY TO DERM DATED 1 OCTOBER 2010
ENTITLED

'RESPONSE TO REQUIREMENT 19 OF ENVIRONMENTAL EVALUATION DATED 16 SEPTEMBER 2010'

Date of compilation 24/10/2010

1ST DRAFT This document is still in the process of compilation as at 21st November 2010 and has not yet been reviewed and authorised by KCCG. Only a limited number of members of KCCG have had access to this document. For this reason it is STRICTLY CONFIDENTIAL and made available only to DERM officers and their delegates (who have been officially appointed), with a view to expediting speedier assessment.

For example it would seem to be appropriate for DERM to discuss this document with the Government's Expert Panel if it so chooses. It seems reasonable for DERM to have every right to seek answers because its correspondence with both Cougar and KCCG seems to pose more questions than the correspondence provides answers. There are many well-informed scientists throughout the world who can help to provide these answers such as some in CSIRO and universities throughout the world. KCCG considers that the way DERM can seek these answers is to isolate questions from their context in this document in a discreet way thus avoiding violating the rights of Cougar. UNDER NO CIRCUMSTANCES SHOULD THIS DOCUMENT BE RELEASED TO THE MEDIA.

SPECIFIC COMMENTS

General overview of this report.

Although this report gives more detail than the original rejected report it can still be criticised severely as being defensive to the point of being evasive. This brings into question the government policy of allowing potentially dangerous industries to regulate themselves. KCCG, as a public interest body, considers that the present report under our evaluation does not meet minimum standards of acceptability. In KCCG's evaluation given below, only the more important issues and deficiencies are considered in the following details.

Details

*P (3), para 2 DERM requests "*Also identify and provide detail of the operating conditions of the combustion chamber……"*

There is no direct instrumentation for this. Indeed it is difficult to see how the pressure and temperature lower down the well and in the combustion chamber can be measured directly. It seems that Cougar may have attempted to calculate these details but this is not included in their report. Such a theoretical evaluation would be expected to be subject to significant errors and uncertainty.

In KCCG's earlier (incomplete) draft (last dated as at 24/10/2010), it was considered essential, in order to be able to investigate the mishap, that we have adequate details of the temperature profile down the gas production pipe. We regret that this necessary detail has not been made available in the present report under evaluation. This is a continuing hindrance to our assessment.

*P (3) Section 2 Instrumentation.
Cougar states "*The underground gasifier operating conditions were monitored indirectly and continuously"* Translating this explanation as we understand it, it appears that there was no instrumentation except for that installed at ground level. It is possible to estimate the temperature and pressure fall along the production pipe mathematically but the lack of a confirming measurement further down the pipe nearer to the cavity makes such a calculation uncertain and unreliable.

*On p (4) para (1), Cougar claims to have 'a device that allows a survey of the temperature gradients over the length of the inside of the well. What is this 'device'? Is this just a calculation algorithm as suggested above?

*The Gas Chromatograph data given in the report only present data for the 'permanent' gases H2;CO;CO2;CH4 and N2 whereas many of these widely-varying designs of GC instruments which are commercially-available can also measure VOCs and other chemicals. Are these data also available?

This point is raised because neither Cougar nor KCCG have managed to find an adequate and reasonably convincing explanation of the reasons for the breached production well P4 and the true source of contamination. Consequently, to be realistic, we have to entertain the possibility of similar problems in the future. According to Cougar's future plans, outlined in their reports, this may require repairs to damaged wells. This raises potential air pollution problems which are considered elsewhere in our assessment. Hence the interest and need for measurements and reporting of other chemical species in the pre-flared syngas.

*P4, Sequence of Observed Effects
The Reverse Combustion Linking method (and also the frequent changes in operating conditions) raises the possibility that production well breaching may have been caused by 'thermal ratcheting' which is discussed in Appendix I. This thermal ratcheting explanation and other theories submitted by Cougar can all only be described as speculative thus leaving well breaching as an unsolved problem area which can be expected to recur.

*P5, para 7
The hot pipes would need to be cooled before dismantling. Dismantling the pipes and removing the blockage would vent raw unscrubbed producer gas to the atmosphere. What precautions were taken to assess and control this form of atmospheric contamination?

*P5, para 9.
The remedial action to inject compressed air into P4 seems to KCCG to be an extraordinary, inexplicable and dangerously-risky form of remedy. The explanation for this action is given in Cougar's first report of 16th August (page 12) where it is stated that it was "thought to keep all possible residual gasifier gases trapped down inside the cavity and restricted from entering the P4 casing i.e. an air block".

Scientifically this assertion seems to makes no sense at all and the stated reason for using this approach is contrary to the known nature of the physical behaviour of gas mixtures. The relatively cold compressed air would tend to move down the gas production pipe and mix with the upward moving hot syngas. In other words the remedy would be ineffective. Is this a demonstration of ignorance and lack of expertise on the part of Cougar or did they have other reasons for compressed air injection which have not been reported? Perhaps they were trying to maintain cavity combustion to prevent extinguishing the flame front by using this risky form of remedy? Cougar seem to have a case to answer on this point.

*P 5 Section 4.1
KCCG is concerned that this use of high pressure air to dry in-situ coal might also be used to reignite a quenched burn in a seam which has already been subject to gasification. This would exacerbate the release of pollutants. What is the procedure which would be used when reigniting coal in a partially used seam?

*P 6 Gas Pressures (and other details of the Forward Combustion Period)
It is a well-established principle in the UCG industry, after the contamination at Hoe Creek, that the cavity gas combustion pressure should always be held below the adjacent water pressure otherwise contaminants will be forced from the area of the combustion cavity. High gas pressure is a most effective way of accelerating the dispersal of contaminants.

While it is appreciated that starting ignition in an underground coal seam may be difficult, it is necessary to point out that a huge pressure differential of 2425 kPa was maintained for the first 24 hours. Thus, effectively almost all of the combustion products were forced from the combustion cavity. The data in figs A and B suggest that about 4000nm^3 of gas was involved. Most of this would be expected to have entered the rock strata around the chamber. In addition to this volume is the unspecified amount of air used to dry the coal. In the first place perhaps it can be argued that the supposedly oxygen-rich combustion conditions would have reduced toxic contaminants, although the fact that good quality syngas (see figs F-I) was being produced at the time would make this suggestion doubtful. However, what is also important is that pathways upwards in the strata above the cavity were already being developed for the upward flow of escaping gas. **Thus it is certainly possible that the contamination observed 3 weeks later in wells T5037 and T5038 could have originated from the burning cavity and not necessarily from the fractured production well P4. Perhaps both sources were involved?**
……

Footnote KCCG estimates that the total quantity of benzene produced in the 120 hour trial was probably not more than about 10 kg with a likely lower possible limit of 500 grams. In the rejected earlier report of Cougar on page 10 they estimate (also without explanation) that the amount of benzene emitted was only in the range 5 -10 grams.
……..

* The suggestion in Groundwater Pressure, P.6 that "there is little influence of the high pressure (air) being injected into P.1 on the surrounding coal seam" cannot be interpreted to mean that the injection of high pressure air was unimportant. VWPs measure the pressure of water or gas or gas/water mixtures equally effectively and are insensitive to the nature of the actuating fluid. The more likely interpretation of the data in Fig: E is to suggest that the gas from the burn cavity is finding its way through the adjacent strata easily.

* The section under gas composition P. 6 indicates that good quality product gas containing H2, CO, and CH4 was being generated so that toxic contaminants such as BTEX components would also be present.

Readers should note when interpreting data that the time-scales in figs A-E are 19 hours longer than the corresponding time scales in figs F-I.

*Pgs 6/7 and Figs A-D
It is presumed in Figs A and B that nm^3hr^{-1} means that the volume flow rates have been normalised for comparison purposes to NTP conditions of 0 deg C and 760mmHg.

…….
Footnote
: B.S. 1991:Part1:1954 (which may now be superseded) lists the abbreviation s.t.p. (standard temperature and pressure) in place of N.T.P.
…….

During the time interval 20-56 hrs the data in Figs A and B seem to indicate a considerably smaller gas production rate (~700 normalised cubic metres per hour) compared with the air injection rate figure of about 1500 cubic metres per hour. This suggests that a large proportion of the input air is being is being lost to the adjacent combustion chamber strata. The excess air is explained away by Cougar as forming a bubble in the coal seam but the excess air may just as easily have moved into the adjacent rock strata. KCCG suggests that there has been a very significant air flow rate out of the coal seam and this is of concern. It also lends some credibility to the alternative suspicion that the contamination measured in wells T5037 and T5038 may have come directly from the combustion chamber in the initial forward burn and not from the breached production pipe. Pyrolytically generated chemicals have already moved into the strata during the forward combustion phase and the additional air injected from 24-56 hours would be expected to accelerate the movement of these contaminants upwards as suggested above. Perhaps the contamination in wells T5037/8 came from both sources, namely the chamber combustion and the breached pipe?

The data from 60-90 hours (and up to the time of blockage) suggests less loss of product gas from the cavity. In Fig D, the period from 24-56 hrs shows an air injection pressure of 2000 kPa which, when compared with the much lower VWP water inlet pressure of 1070 kPa in fig E, suggests that

significant amounts of inlet air were indeed forced to leak directly from the coal seam. This is a big over-pressurising compared with our expectation and it would be expected to cause a large loss of gas. This is a matter of much concern. Comparison of the data in Figs A and B for the period 24-56 hours with the data for 60-115 hrs shows a different ratio of the two, inward and outward, gas flow rates.

This whole area of operations control seems to be shrouded in much uncertainty because there is no direct instrumentation down the well and we have to rely on interpreting ground surface instrumentation. It seems to KCCG that this is a fundamental weakness in the UCG process and it limits sound and reliable control. The likely consequences of these uncertainties would be much more worrisome in a full scale plant than they are in this relatively small trial of limited duration.

*Page 7
The explanation in section 4.2 under flowrate that the high rate of input air creates a bubble in the coal seam seems to be dubious, as explained above. This is because about 30,000 cubic metres of air at NTP would have gone into the coal seam bubble. This would make it a very large bubble. KCCG suspects that most of this additional air has leaked from the cavity completely and was not accommodated in the "coal-seam bubble'. The high air injection pressure is about 1000 kPa above the water pressure surrounding the cavity making our suspicion a plausible deduction. Once again we are limited by not having instruments or visual data to clarify what is happening in the underground chamber.

* The last sentence in the third 'flowrate' paragraph seems to be a questionable deduction. The higher production gas outlet temperature is likely to be caused by the higher flow rate of product gas. This would be expected to result from proportionately less heat loss, percentage-wise, as the gas travels up the production well.

*The statement under the subheading 'Pressures' that "the production pressure was maintained just below groundwater pressure" seems to be questionable. The data in Fig D seem unclear as to the size of the pressure drop across the burning coal face which would be expected to be less than 1000kPa. Because of the nature of 2-phase flow in porous media, an adequate influx of water into the chamber could still occur under these conditions. The spike in the groundwater pressure at 27 hrs in fig E also suggests some loss of air into the strata but it seems to be impossible to quantify this even approximately.

*On Page 8…..

In the last line under 'pressures' the statement about "decreasing water pressure resulting from excess air re-entering the cavity and taking part in gasification" is a speculative statement and seems unlikely. Water will be drawn in but excess air in the strata is more likely to migrate upwards. KCCG finds it hard to accept such explanations.

The poor fuel quality production from 40-80 hrs shown in Figs F & G is strange. Particularly with regard to the low hydrogen content, it seems that the water influx into the chamber may have been severely retarded by gas in the strata surrounding the combustion chamber.

Again KCCG suspects that air which has moved under pressure into the strata may be responsible. However again, because of the lack of instrumentation to show what is happening, our suggestion is only speculative.

However, the high CO2 content over this same interval tends to lend credence to our suspicions that water has been driven away from the cavity wall and was only returning slowly. It seems unlikely that the impending blockage was the cause. The data in Figs A&B seem to indicate that blockage occurred suddenly.

*The explanation for the strange phenomena mentioned in the 'Gas Composition' section on page 7 (3rd paragraph down- actually the second paragraph on page 8) were supposed to be discussed in section 8.2 but this section was not included in the document made available to KCCG

In summary, it is hard to analyse what happened in the 110 hrs of operation of this burn and both Cougar's and KCCG's interpretations are open to question. Without better instrumentation how can one control such a complex process adequately when it is 200 metres underground? The problem is that it seems to be impractical to provide this instrumentation 200 m underground in a very hot environment.

An Additional Consideration

In DERM's Notice dated 17th July 2010 to Cougar to "Conduct or Commission an Environmental Evaluation", the requirements (19, f &g) were also to address:-

Connectivity with other Aquifiers and Connectivity with Surface waters.

KCCG considers that these aspects have not been covered adequately in the present report under evaluation. However KCCG's own supplementary information concerning these points may be found useful. These are outlined in Appendix I of the 2nd draft of the following document:-

Suggested Contribution to Response from KCCG Entitled 'Environmental Evaluation, Cougar Energy Pilot Burn at Kingaroy, submitted to DERM on 16th August 2010

Appendix I in the above document is also relevant with respect to DERM's requirement 19c "The Mechanism of Potential Movement of Contaminants"

A draft copy of the above document is already in the possession of DERM but it may be missing fig (1) The most up to date copy of this document (compilation date 24/10/2010) includes fig. (1) and can be obtained from KCCG's Secretary, Mr John Dalton email jdalton59@gmail.com

*Pages 9-19 In view of the difficulty in completing this assessment in a reasonable time, it has been decided not to comment on this part of Cougar's report. We feel that this is justified because Cougar are planning to use uncased production wells in the future.

Perhaps this may present new problems and even thermal racheting may still be relevant, even if the effects differ with uncased wells. It is appropriate to point out that we feel that the well steel temperature was too high for the cement grouts available. Some commentary relevant to Chapter 6, the Casing Break, is included in Appendix I of this assessment.

CONCLUSIONS

KCCG believes that the pilot project should be terminated as soon as reasonably possible. The evidence from Cougar's reports indicates that this company does not have the necessary expertise to cope with likely problems with the very complex process of UCG. Indeed it is questionable if they even have the basic knowledge in 'physics' to guide their remedial action in a sensible way when correcting mishaps. These problems are exacerbated by the complete lack of vital instrumentation in the cavity and lower down in the production well, a feature which is a fundamental and a very relevant weakness in UCG technology.

Furthermore KCCG considers that it was ill-considered and/or recklessly irresponsible to propose the Kingaroy project in the first place. The submitted reports show beyond any doubt that this is an experimental project with much undeveloped technology. We consider that such experiments have no place situated dangerously close to a populated area and its water supplies. KCCG considers that to propose such a project is a breach of the reasonable expectation of trust on the part of Governments, Regulatory Authorities and Local Communities, namely that a commercial organisation should be expected to have the necessary experience and expertise to conduct a proposed industrial project safely.

For the above reasons and the evidence from their reports it is considered that this company does not meet minimum standards of expertise and that they are wholly responsible for their financial loss if the project is not allowed to proceed. It is suggested that the Queensland Government is entitled to reject any claim for financial compensation. KCCG believes that termination of this project is also in the best interests of Cougar shareholders because it is likely that a 400 MW(E) power station as planned near Kingaroy faces the distinct likelihood of compulsory closure on environmental grounds. For example, and to illustrate our point, if 70 million tonnes of coal are to be burnt underground and if 2kg of benzene are produced per tonne of coal burnt (as is the case in coke ovens where coal processing conditions bear a very approximate rough comparison of similarity) then 140,000 tonnes of benzene would be produced under our land near Kingaroy. Even if this production rate of benzene has been overestimated by a factor of 10, then 14,000 tonnes of widely-dispersed underground benzene would still be completely unacceptable. If the State Government has chosen to ban the use of benzene and toluene as fraccing chemicals due to their toxic threat to ground water it is clear that the UCG process has no place at Kingaroy.

Appendix I The Possibility that Thermal Ratcheting may Damage UCG Production Wells

We still have no information concerning the temperature profile down the production wells P1 and P4. Therefore for the sake of general discussion let's consider the freestanding elongation of a 200m steel pipe which is raised 300 C° uniformly above ambient temperature. The resulting elongation is quite large at about 70 cm. Because the thermal conductivity of steel is much larger than the thermal conductivity of the surrounding cement grout, the steel responds much more quickly to changes in production gas temperature. Also the temperature of the grout falls radially from the pipe centre anyway thus giving a vertical shear stress in the grout.

Normally the grout would be expected to experience an additional large shear force in the vertical direction to restrain much of the steels elongation when hotter gas comes up the production well. At a sufficiently high temperature, a thin-walled, small diameter pipe can buckle inwards and

break away from the grout in much the same way as is illustrated in the damaged casing under investigation in Cougar's reports. Much would seem to depend on the steel/cement interface bond. In some places it is naturally weak and in other places naturally stronger. Where the interface bond is sufficiently weak to allow the steel/grout interface bond to slip, the compressive stress along the steel pipe will be relieved locally.

When the pipe cools the process is not reversible so that different parts of the steel pipe may experience a different compression force compared with other parts of the pipe. There will be corresponding opposite shearing forces in the grout which may have also fractured in some places. With thermal cycling, a thermal ratcheting effect may give varying conditions in different parts of the pipe and over a period of time there may be some net axial movement between the steel pipe and the surrounding grout. The mechanics of the process are complicated and almost unpredictable. High temperatures will be expected to increase such effects lower down in the hotter part of the production well.

Thus it is probably impossible to quantify the effect accurately in a UCG well because of the uncertain statistics of the steel/grout interface shear strength and the complications of variable temperature and possibly even the reduction in yield strength of the steel if very high temperatures are experienced near the coal combustion cavity.

To the best of KCCG's knowledge no research has been done on any thermal ratcheting effect in geothermal or UCG pipes. Most of the research has related to nuclear power reactors where many different types of thermal ratcheting have been experienced. Codes of practice exist, there are good standard texts on the subject and significant research is still continuing (e.g. Zhang et. al. 2010). However these studies are not directly applicable to UCG. The only study known to KCCG involving steel and concrete is thermal ratcheting causing damage in silos but this involves radial movement and downward irreversible settling of the silo contents. This example is also not applicable to UCG pipes.

KCCG has not investigated the matter further because Cougar propose to use single string production wells in the future. These may be less prone to thermal ratcheting but we cannot be certain of this in some geological strata.

The possibility of thermal ratcheting in well P4 may have been significant. The repeated movement of the well-head suggests that thermal ratcheting followed by fracture may have taken place. This well was highly stressed due to changeover from production to reverse combustion linking and vice-versa. Fig C shows that in just 120 hours the well was subjected to 8 major temperature transients.

*Ref. Zhang, Z, Chen, C., Xu, F, and Weiwei, Y, "Anti-Ratcheting Design Software for Primary Auxiliary Pipeline in Nuclear Power Plant", Advanced Materials Research,**118-120**, pp 126-130, 2010*

Part 3:

EVALUATION BY KCCG OF REPORT BY COUGAR ENERGYTO DERM DATED 15 OCTOBER 2010
ENTITLED

'RESPONSE TO REQUIREMENT 20 OF ENVIRONMENTAL EVALUATION DATED 16 SEPTEMBER 2010'

1ST DRAFT (dated 19 November 2010) This document is still in the process of compilation and has not yet been reviewed and authorised by KCCG. Only a limited number of members of KCCG have had access to this document

At this time it is not possible to present a meaningful assessment of Cougar's report until we have clarification of three important issues, tabulated as A- C below.

A On page 11, section 4.2,.1 line 3, it is stated that (a coiled tube rig) is good for carrying out live workovers in UCG operations.

What is a live workover? We believe that this should be explained in some detail for people who have no direct experience in UCG technology.

B On page 9, section 3.2.5, para 2, it is stated that:-

"By having multiple wells operating, blocked or damaged casing wells can be unblocked or repaired whilst maintaining the process underground. The functional wells can be used to lower gasifier pressure and more easily allow repair to the in-operational wells."

To the uninitiated, such a task seems to present extraordinary difficulties. The use of other wells to lower gasifier pressure seems to confirm our understanding that it is impractical to use a shut-off valve at the base of a well. Consequently we have to ask how is it possible to repair a well safely without emission of large quantities of un-scrubbed syngas to the environment. Even it the well is allowed to cool before repair, large quantities of hot syngas would be expected vent up the damaged pipe. The pipe is a very long chimney and would create a very strong updraft.

We seek explanatory technical details.

C On page 7, section 3.1.5, temperature measurement, para1, the importance of producer well temperatures is acknowledged but nowhere have we been given any information relating to Cougar's assessment of the temperature profile along the pipe. This has impeded any investigation as to which mechanism was responsible for the 7 inch casing failure namely:-

1) Cougar's suggestion that casing failure was caused by entrapped water in the grout

2) Cougar's suggestion that compressive stress in the 7 inch pipe may have caused it to buckle

3) KCCG's suggestion that the failure may have resulted from thermal ratcheting,

The temperatures experienced by the steel is critically important in analysis of the mode of failure

We await further information with interest

Part 4:

LETTER TO MINISTER KATE JONES AND DERM OUTLINING THE NEED TO EXTEND THE EVALUATION OF THE COUGAR ENERGY PILOT BURN TO EXAMINE

ALL ASPECTS OF GASEOUS CONTAMINATION

Honourable Kate Jones
Minster for Climate Change and Sustainability
GPO Box 2454,
Brisbane Qld 4001
ccs@ministerial.qld.gov.au

Dear Minister,

Kingaroy Concerned Citizens Group (KCCG) has recently met with two officers from DERM to discuss Cougar Energy's reports to DERM: Environmental Evaluation (16th August 2010, 1st October 2010 and 15th October 2010).

While acknowledging that KCCG shares DERM's concerns about the quality of explanations given in those reports, there is a serious omission from the reports that is at least partly attributable to DERM.

At DERM's request, the reports submitted by Cougar Energy so far focus on the root cause of ground water contamination. Since water was the tangible evidence of contamination, DERM's intent and Cougar Energy's subsequent reports prematurely discount air contamination as both a contributing and separate factor.

The purpose of this letter is to point out that contamination by gases from two separate sources should be exhaustively examined by DERM.

Source 1: Gas Migration through Soil and Water

(A) Cougar Energy's dubious explanation of the contaminating event suggests that contaminated gases escaped through an 'S" bend of broken bore casings and ruptured cement, and then migrated through the earth to monitoring wells some270m away.

Figure 5: P4 Casing and String Design of page 22 (EE 16th Aug) which Cougar Energy uses to support this explanation also eliminates this as a closed event because the passage of air shown by arrows does not at any stage pass through the gasification chamber and absorb contaminates.

This diagrammed explanation also does not take into account that the bore casing is damaged but not sealed at 62m, and therefore the injected air would be effective to bottom of the bore at 205m.

(B) This suggests an alternative theory proposed by KCCG that the compressed air absorbed contaminants under pressure in the gasification chamber and migrated through wet coal and coal seams, upwards through cracks and fissures to the monitoring wells T37 and T38. The presence, size and frequency of these cracks and fissures is confirmed in the report when it is documented that some 3300 litres of concrete was used to fill one such void found adjacent to bore P4 during drilling and cementing.

Both explanation (A) and (B) rely on gas as the medium of travel.

Figure 5: P4 Casing and String Design is of course just one vertical section that is used to make clear a possible pathway to just one confirmed point of contamination. Pressure applied to gases down P4 would radiate horizontally and equally through a 360 deg radius from the point of entry into the soil, depending on the placement of cracks and fissures.

It is therefore most probable that gases that transported contaminants to wells T37 and T38 also radiated from the gasification chamber and escaped into the atmosphere in a manner identical to their confirmed migration to wells T37 and T38.

The Environmental Evaluations confirm that irrespective of which path of migration was most active, gases containing benzene and toluene can and do travel through soil and water, and retain significant toxicity when they do so. This fact alone suggests that what we now know for certain in the vertical sector from P4 to T37 was also happening in the other 360 deg radiating outwards from the gasification chamber.

Also, in the same manner in which soil strata did not strip benzene and toluene from gas in its migration to wells T37 and T38, it would not have stripped it when it passed through the water in these monitoring wells. This suggests that contaminated gases also escaped though these wells in addition to any other number of random paths of least resistance for gases from below.

Source 2: Gas Migration Through Ruptured Equipment.

Contaminated gases are also most likely to have escaped untreated into the atmosphere when the bore casing rose out of the ground twice and ruptured head works at the top of the P4. This event is documented in EE 16th Aug.

Supporting the probability of this event is the fact that:

- Repairs were acknowledged (EE 16th Aug pp12)
- Gases were observed emanating out of the ground as steam (EE 16th Aug pp12)
- Syngas was still produced after damage noted (EE 16th Aug pp12)

- A well head pressure gauge was shattered (EE 16th Aug pp12)

- No evidence of use of the "scrubber" is mentioned or contaminated substance proportional to hours of use acknowledged.

- Two local farmers acknowledged anecdotally that they smelt gas during the period of gasification.

- Prevailing wind for Kingaroy Airport at the time were almost entirely from the SE to the NW. This is not just in the direction of farms which have since recorded traces of benzene and toluene in cattle, but is also the path toward the town of Kingaroy. (see appendix)

Conclusion:

While acknowledging that the Cougar Energy was instructed by DERM to report on the root cause of the contamination of ground water, it is the opinion of KCCG members that since gas is the medium of travel between gasification and the water in the wells, the full extent of that gas migration must be exhaustively considered.

This includes both the travel of gases radiating in all directions from P4 through the soil, and the gases escaping untreated through damaged plant and equipment above ground.

We trust that the points contained in this letter are passed on the three member expert panel for evaluation, and that these matters will receive your serious consideration.

Yours faithfully,

John Dalton
Secretary
Kingaroy Concerned Citizens Group.

Appendix

Source: http://www.bom.gov.au/climate/dwo/201003/html/IDCJDW4069.201003.shtml

Kingaroy, **Queensland**
March 2010 Daily Weather Observations

		Temps		Rain	Evap	Sun	Max wind gust			9 am						3 pm					
Date	Day	Min	Max				Dir	Spd	Time	Temp	RH	Cld	Dir	Spd	MSLP	Temp	RH	Cld	Dir	Spd	MSLP
		°C	°C	mm	mm	hours	km/h		local	°C	%	8th	km/h		hPa	°C	%	8th	km/h		hPa
1	Mo	20.7	25.6	1.0			ESE	31	20:57	22.9	87		E	9	1012.4	23.0	90		E	15	1008.1
2	Tu	19.0	22.4	53.2			SE	54	20:22	19.4	94		ESE	17	1007.2	19.0	94		ESE	31	1004.2
3	We	18.2	26.3	36.2			ESE	50	00:05	22.2	83		ESE	24	1009.3	23.8	77		ESE	24	1007.6
4	Th	18.8	24.4	1.2			ESE	41	10:58	21.3	81		ESE	20	1012.1	23.3	76		ESE	20	1009.7
5	Fr	19.4	25.5	0.6			E	30	09:32	22.8	87		ENE	15	1010.4	23.9	88		E	13	1007.6
6	Sa	19.7	25.8	67.2			E	35	12:35	22.6	94		ESE	15	1009.9	23.5	92		E	9	1008.4
7	Su	19.4	22.8	13.0			E	28	13:22	22.4	88		ESE	17	1013.2	21.9	91		E	9	1011.5
8	Mo	18.8	26.1	6.0			ENE	24	00:37	22.1	86		ENE	7	1015.7	25.3	75		NE	7	1013.6
9	Tu	16.7	29.1	0.6			S	24	14:40	22.9	81		NW	9	1017.3	28.6	58		S	17	1014.2
10	We	18.5	29.7	0.2			S	26	15:11	24.5	50		SW	11	1018.3	28.6	47		SSW	17	1016.0
11	Th	19.3	27.2	0			SE	41	21:08	22.1	79		SE	17	1021.8	26.3	59		SE	17	1020.1
12	Fr	17.6	25.5	0.2			SE	46	10:13	19.6	86		SE	20	1026.0	21.4	68		SE	22	1024.7
13	Sa	15.5	24.7	0.2			ESE	44	14:07	21.4	67		ESE	22	1026.0	24.3	54		ESE	26	1022.9
14	Su	16.3	25.0	0.4			E	39	15:27	19.3	80		ESE	22	1023.4	24.2	59		ESE	19	1020.0
15	Mo	15.4	24.3	0.8			E	35	15:18	19.8	81		ESE	15	1022.2	21.0	71		ESE	22	1018.7
IGNITION OF UCG TRIAL																					
16	**Tu**	**15.3**	**25.9**	**0**			**ESE**	**35**	**15:35**	**19.7**	**78**		**SE**	**17**	**1020.0**	**24.3**	**61**		**ESE**	**24**	**1016.9**
17	**We**	**15.0**	**25.2**	**0**			**ESE**	**44**	**13:13**	**21.2**	**73**		**SE**	**20**	**1021.4**	**25.0**	**61**		**ESE**	**20**	**1019.5**
18	**Th**	**16.7**	**25.0**	**0.2**			**E**	**43**	**09:08**	**21.2**	**64**		**ESE**	**28**	**1023.3**	**23.3**	**64**		**E**	**22**	**1020.6**
19	**Fr**	**13.4**	**26.4**	**0.2**			**ESE**	**43**	**10:38**	**22.9**	**62**		**E**	**19**	**1021.3**	**25.8**	**47**		**ESE**	**19**	**1018.5**
20	**Sa**	**15.8**	**25.1**	**0**			**E**	**44**	**09:41**	**21.6**	**67**		**SE**	**22**	**1019.4**	**24.2**	**65**		**ESE**	**22**	**1017.9**
21	**Su**	**18.9**	**25.1**	**0.2**			**ESE**	**31**	**10:14**	**21.2**	**86**		**ESE**	**13**	**1019.9**	**23.7**	**76**		**ENE**	**9**	**1017.3**
22	**Mo**	**18.9**	**23.7**	**0**			**S**	**13**	**07:51**	**21.2**	**91**		**E**	**4**	**1018.3**	**23.5**	**79**		**NNW**	**9**	**1016.3**
23	**Tu**	**16.5**	**28.3**	**0.6**			**E**	**26**	**16:41**	**21.6**	**82**		**ESE**	**7**	**1019.6**	**26.7**	**52**		**ESE**	**11**	**1015.7**
24	**We**	**16.9**	**28.1**	**0.6**			**SSE**	**31**	**12:30**	**21.3**	**83**		**ESE**	**11**	**1019.9**	**26.9**	**53**		**SE**	**17**	**1016.6**
25	**Th**	**13.9**	**27.4**	**0**			**E**	**35**	**12:38**	**20.6**	**76**		**ESE**	**19**	**1022.3**	**26.7**	**48**		**ESE**	**13**	**1018.5**
26	**Fr**	**12.7**	**27.9**	**0**			**E**	**26**	**14:55**	**19.3**	**88**		**ESE**	**13**	**1022.1**	**27.0**	**51**		**E**	**19**	**1017.7**
27	**Sa**	**11.6**	**27.3**	**0.2**			**E**	**26**	**09:05**	**20.6**	**76**		**E**	**19**	**1020.8**	**26.4**	**47**		**SSE**	**9**	**1016.8**
28	**Su**	**14.3**	**26.3**	**0.2**			**ESE**	**33**	**14:52**	**20.7**	**85**		**ESE**	**13**	**1019.6**	**22.3**	**76**		**ESE**	**20**	**1016.0**
29	**Mo**	**14.3**	**27.9**	**0**			**E**	**31**	**15:51**	**22.8**	**73**		**E**	**11**	**1019.9**	**27.7**	**51**		**NE**	**7**	**1016.3**
30	**Tu**	**13.9**	**28.0**	**0.2**			**E**	**24**	**17:41**	**21.0**	**83**		**ESE**	**11**	**1019.6**	**26.2**	**55**		**N**	**9**	**1015.0**
31	**We**	**16.6**	**27.4**	**0**			**WNW**	**24**	**18:56**	**21.1**	**81**		**NE**	**4**	**1017.9**	**26.9**	**51**		**NE**	**9**	**1013.2**
Statistics for March 2010																					
Mean		16.7	26.1							21.4	79			15	1018.4	24.7	65			16	1015.5
Lowest		11.6	22.4	0						19.3	50		#	4	1007.2	19.0	47		NE	7	1004.2
Highest		20.7	29.7	67.2			SE	54		24.5	94		ESE	28	1026.0	28.6	94		ESE	31	1024.7
Total				183.2																	

Kingaroy, **Queensland**
April 2010 Daily Weather Observations

		Temps		Rain	Evap	Sun	Max wind gust			9 am						3 pm					
Date	Day	Min	Max				Dir	Spd	Time	Temp	RH	Cld	Dir	Spd	MSLP	Temp	RH	Cld	Dir	Spd	MSLP
		°C	°C	mm	mm	hours	km/h		local	°C	%	8th	km/h		hPa	°C	%	8th	km/h		hPa
1	**Th**	**17.7**	**27.5**	**18.4**			**SSE**	**30**	**14:49**	**20.0**	**90**		**S**	**2**	**1016.9**	**25.3**	**59**		**SSE**	**15**	**1013.3**
2	**Fr**	**18.4**	**26.4**	**0**			**SE**	**31**	**11:58**	**21.4**	**77**		**ESE**	**13**	**1017.3**	**25.8**	**54**		**SE**	**11**	**1014.1**
3	**Sa**	**15.9**	**25.9**	**0**			**E**	**30**	**09:43**	**20.3**	**78**		**ESE**	**13**	**1018.7**	**25.5**	**57**		**ESE**	**13**	**1014.9**
4	**Su**	**14.6**	**25.3**	**0**			**ESE**	**31**	**09:54**	**20.0**	**71**		**SE**	**20**	**1018.5**	**24.4**	**55**		**SE**	**13**	**1015.1**
5	**Mo**	**11.9**	**25.5**	**0**			**SSE**	**28**	**15:10**	**19.5**	**70**		**ESE**	**11**	**1018.7**	**24.7**	**51**		**E**	**13**	**1015.3**
6	**Tu**	**12.9**	**25.8**	**0**			**E**	**24**	**10:12**	**18.5**	**81**		**ESE**	**11**	**1020.7**	**24.9**	**46**		**NE**	**11**	**1017.3**
7	**We**	**11.6**	**26.2**	**0**			**N**	**20**	**15:07**	**20.7**	**66**		**ENE**	**9**	**1021.4**	**25.2**	**48**		**N**	**6**	**1017.9**
8	**Th**	**17.7**	**29.2**	**0**			**NNW**	**30**	**11:15**	**21.6**	**78**		**NNW**	**19**	**1019.6**	**28.2**	**52**		**NW**	**17**	**1014.4**
9	**Fr**	**14.9**	**30.3**	**0**			**WNW**	**26**	**15:04**	**24.1**	**57**		**SE**	**6**	**1014.6**	**29.3**	**35**		**WNW**	**17**	**1009.9**
INJECTION OF AIR INTO UCG CAVITY CEASES																					
10	Sa	18.2	29.3	0			W	20	13:05	22.1	82		NNW	7	1013.6	27.9	51		WNW	9	1009.5
11	Su	18.0	30.6	0			SSW	31	14:07	24.5	78		NNW	9	1013.7	27.1	68		ENE	7	1009.9
12	Mo	20.1	25.0	2.8			S	31	21:51	22.3	88		W	2	1014.4	23.6	77		SSW	15	1011.8
13	Tu	14.0	19.1	2.6			S	35	15:24	15.2	79		S	2	1018.2	18.7	73		SE	17	1016.3
14	We	8.3	24.5	0.2			E	33	11:03	18.5	74		SE	13	1020.2	23.8	51		ESE	15	1017.8
15	Th	11.2	24.9	0.2			ESE	30	14:29	17.8	86		SSE	15	1020.7	23.8	40		SE	17	1017.9
16	Fr	10.3	22.9	0			ESE	39	15:22	17.4	83		ESE	17	1023.0	21.0	67		SE	19	1020.6
17	Sa	13.2	25.1	0			E	44	10:41	19.5	72		SE	17	1023.4	23.4	56		ESE	20	1020.7
18	Su	15.8	24.9	0			E	35	14:49	19.3	81		ESE	20	1023.7	22.8	60		ESE	22	1020.2
19	Mo	16.5	24.0	0			SE	41	11:37	18.5	87		ESE	17	1022.2	22.7	55		SE	24	1019.3
20	Tu	15.3	24.6	0			E	39	13:25	19.5	76		SE	19	1020.9	23.3	62		E	17	1017.2
21	We	16.6	23.3	0			SE	35	15:48	19.2	82		SE	19	1020.3	20.8	81		SE	13	1018.3
22	Th	16.7	24.9	0.4			E	31	12:30	18.9	88		SE	13	1021.9	24.2	60		SE	19	1019.1
23	Fr	16.3	25.8	0.2			E	26	10:13	19.7	76		SE	15	1021.8	24.7	53		E	15	1017.7
24	Sa	12.1	26.1	0.4			NE	20	10:25	19.5	90		ESE	15	1019.5	25.0	65		NNE	9	1015.6
25	Su	18.2	29.6	0			SSW	46	21:23	21.7	81		NW	15	1017.9	29.2	35		WNW	17	1013.4
26	Mo	11.6	23.5	0			ESE	31	10:56	17.7	54		SE	15	1021.5	22.4	36		E	9	1019.5
27	Tu	4.5	24.7	0			NNW	24	12:46	18.6	64		ESE	13	1022.5	23.4	43		NNE	9	1018.8
28	We	12.0	26.5	0			NNE	17	16:01	20.3	72		WNW	4	1022.6	25.2	45		NNW	6	1018.5
29	Th	13.3	27.6	0			W	20	12:12	18.7	89		WNW	2	1022.4	27.2	34		W	13	1018.4
30	Fr	6.2	26.4	0.2			SW	24	14:37	19.4	52		SSW	6	1022.9	26.0	27		SSW	7	1019.4
Statistics for April 2010																					
Mean		14.1	25.8							19.8	76			11	1019.8	24.7	53			13	1016.4
Lowest		4.5	19.1	0						15.2	52		#	2	1013.6	18.7	27		#	6	1009.5
Highest		20.1	30.6	18.4			SSW	46		24.5	90		#	20	1023.7	29.3	81		SE	24	1020.7
Total				25.4																	

V