Alberta Energy Regulator (AER)

Summary of Stakeholder Feedback and Reservoir Containment Team (RCT) Response on Technical Reports

Section	Stakeholder Feedback - Issue	Possible Solution or Recommendation	Rationale to Support Solution or Recommendation	RCT Response
RC-01, Section 1, Page 1.	"A caprock breach at shallow depths poses a potential safety risk because a likely consequence is a surface steam release…" CAPP notes there are other potential risks within the shallow thermal area besides a release to surface. As a result of the geological complexity within the region, projects can have substantially different risk profiles and should be considered accordingly. There are number of strategies that can be used to alter the risk profile of the project in addition to operating pressure and they should all be used in combination to ensure the safe and responsible development of the oil sands resource in the shallow area.	The AER should formally adopt a risk management based approach for evaluating and making decisions on project proposals within the shallow thermal area. The risk based regulatory approach should accept and encourage the use of a variety of technically supported approaches (e.g. timing of development, project scale, development buffers, operating pressure, injection fluid type and volumes, modeling, and monitoring) to reduce residual project risks and ensure safe and responsible operations. The AER should more formally recognize and support the use of appropriate demonstration projects to advance the understanding of caprock behavior, injection operation, transmission pathways, and associated project risks in a shallow geological environment.	By adopting a risk management based approach for the evaluation of projects in the shallow thermal area the AER will be able to ensure a more thorough evaluation is conducted and that all project- specific risks are appropriately mitigated. In cases where technical uncertainties are creating unacceptable risks for large-scale, commercial projects, smaller scale, field demonstrations could be used to advance technical understanding and reduce or eliminate risk. If only the MOP formula is used in isolation to determine operating pressure, there may be risks present that are not mitigated appropriately. Additionally, other hazards, such as pressure diffusion, the transfer of stress and pore pressure, and heave can affect some receptors. Including a project specific risk management based approach to build upon the existing regulatory framework will allow the AER to balance the risks presented with development to amount of data needed to support the project. In addition, some projects that may present challenges to move forward with a project at a large commercial scale could be proved safe by conducting field pilots at a smaller scale that would demonstrate how the reservoir and caprock would respond to operations in the area.	The RCT agrees that a risk based approach should be used for evaluating and making decisions on project proposals within the shallow thermal area. The RCT is open to appropriate scale field testing with clear objectives where the operations can be performed in a safe manner. Applications would be reviewed on a case by case basis.
RC-02, Page 1, Section 2, Shallow Thermal Area Discussion.	"the Quaternary strata and the Grand Rapids Formation do not contain caprocks"	Reword to include "to date, the Quaternary strata and the Grand Rapids Formation have not demonstrated their capability as caprock as defined below."	If technical data supporting currently unrecognized caprocks can be provided, it should be considered on a technical and risk weighted basis.	The RCT agrees with CAPP's proposed wording.
RC-02, Page 1, Section 3 b), Shallow Thermal Area Discussion.	Caprock is required to "…be composed of clay-rich bedrock of the Clearwater Formation with a gamma- ray value greater than 75 API units"	Reword to "be composed of clay-rich bedrock of the Clearwater Formation (with a gamma-ray value greater than 75 API units) or a demonstrated equivalent". Evaluation of caprock should be based on: • Caprock Seal Geometry • Caprock Seal Capacity • Caprock Seal Integrity	RC-02 specifically "the Quaternary strata and the Grand Rapids Formation do not contain caprocks". This conclusion is based on a lack of data that proves these strata can function effectively as a caprock. It is not based on actual data that demonstrates the strata cannot function as a caprock. Industry believes data exists and/or can be compiled that supports the use of non-Clearwater caprocks. Limiting the definition of caprock to only the Clearwater formation may unnecessarily cause a significant delay to the development of a large oil sands resource	If a geological strata other than the lower Clearwater shale is demonstrated to be an effective caprock over a project area, the RCT would be prepared to accept it.
RC-02, Page 1, Section 3.c, Shallow Thermal Area page 7, fig 1	The shallow thermal area is not consistent with criteria when compared with available industry data.	The AER should revise the shallow thermal area boundary as per the Appendix to this submission.	Additional well data and mapping used by industry can be reviewed with the AER	Based on additional well data (including the data provided by CAPP) and the use of different mapping software (ie. Petra), the RCT has revised the Shallow Thermal Area boundary map.

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RC-02, Page 8,Figure 2	Reference well log is not representative, has no publically available core for reference, and lacks regional and stratigraphic context.	The AER should formally adopt the proposed regional geological cross sections for the shallow area as per the Appendix to this submission.	Industry has provided representative wells that reflect the stratigraphic variation across the Shallow Thermal area and identified the core and caprock analysis available for these wells.	The RCT agrees that use of cross sections is more representative than a single type well. However, the RCT proposes to use some alternate wells to increase the degree of core coverage and public data availability.
RC-02, Page 5, Section 6.4, Shallow Thermal Area Discussion	Allow consideration of alternative geophysical methods.	Recommend AER amend wording to “3D seismic or an equivalent imaging technique that can adequately demonstrate the geometry and integrity of the caprock be completed for all projects in shallow thermal area.	Other applicable imaging techniques are available and others may become available that will meet the need for demonstrating geometry and integrity of caprock. It would be reasonable to allow the use of alternatives to 3D seismic when such imaging techniques can be shown to provide equivalent or adequate resolution of the geometry and integrity of the caprock.	The RCT would be prepared to consider an imaging technique that is demonstrated to be equivalent to 3D seismic.
RC-02, Page 5, Section 6.4.c, Shallow Thermal Area Discussion.	To provide “structure and isopach maps of the Prairie Evaporite Formation, Paleozoic Era, Wabiskaw Member, and Clearwater Formation; “ would require trespass in most cases	The AER and Alberta Energy should ensure sufficient legislative and regulatory flexibility exists for drilling operations so that applicants can adequately demonstrate the Pre Cretaceous stratigraphy without trespass.	This will allow the evaluation of deeper formations to get a more fulsome characterization and maintain consistency within the evaluation process. Operators should be able to drill into the Pre Cretaceous without concern or limitation from Alberta Energy	The RCT understands that an application process exists whereby operators can make requests to Alberta Energy to drill deeper than their leased formation.
RC-02, Note:	1) Context of key geological features, set back implications, evaluation techniques and associated risks need to be considered at time of application. 2) Requirement to identify vertical and horizontal pathways/containment. 3) Notification of stakeholder should be consistent with risk evaluation.	The regulatory process should require applicants to provide a comprehensive project risk assessment that includes the following: • A comprehensive, site specific geological assessment that is proportional to the risk and complexity of the geological environment within that project. • A flow pathway assessment that identifies those pathways requiring mitigation through project design o All mechanisms by which the cap rock and overburden can respond to injection operations must be considered (surface and subsurface release, surface heave, and subsurface transfer of pore pressure and geomechanical stress). o All potential receptors within the region of influence for that mechanism must be considered o All potential consequences relevant to that receptor must be considered. • Stakeholder notification activities must be aligned with the receptors identified in the flow pathway assessment.		The RCT agrees that applicants should provide a comprehensive risk assessment.

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RC-03, page 2	The MOP formula is : MOP(bottom hole) = (Safety factor of 0.8) × (Caprock fracture closure gradient) × Depth(shallowest base of caprock)	The regulatory process should allow the applicant to identify a specific area within which a particular Maximum Operating Pressure (MOP) will apply (MOP Area). • MOP Area will be flexible and could range from a well pattern (minimum) to an entire project area (maximum). • Applicants will be required to provide a technically supported operational strategy that is consistent with the requested MOP Area The MOP for a corresponding MOP Area would be determined using the formula: MOP (bottomhole) = 0.8 * Caprock Fracture Closure Gradient * Depth of Shallowest Base of Caprock • Where Caprock Fracture Closure Gradient is based on the most representative (not necessarily the lowest) gradient for the corresponding MOP area. • Where Depth of Shallowest Base of Caprock is based on the shallowest base of caprock depth within the corresponding MOP area and surface topography is considered.	CAPP is supportive of the use of this formula for determination of tensile failure provided that a risk based management evaluation is undertaken in addition to the formula that is fitting with the associated geological complexity and risk receptors present at each project and within the region of influence potentially affected by the project. Large projects could have considerable variation in the depth of the base of caprock and should be able to manage variations in MOP throughout the project with an appropriate, technically supported operating strategy. Inherently, there are uncertainties in the entire methodology of estimating the fracture closure pressure which can easily lead to erroneous measurements and interpretations. Only accepting the minimum value for FCG for a project could mean using a value that is a result of operation/ interpretation error. It is important to note that errors are not biased in a particular direction and could lead to MOPs that could be either too high or overly conservative. A thorough analysis of a broader range of available data should produce a more representative value on which to base project designs. Varying surface topography could have a large impact on the calculated depth and should be considered in the evaluation process; specifically lakes and borrow pits.	The AER currently approves MOPs down to a pattern level. The RCT continues to believe that it should use what it considers to be the lowest valid caprock fracture closure gradient obtained from representative diagnostic fracture tests. The RCT agrees that the MOP equation should use the shallowest base of caprock taking into consideration the surface topography.
RC 03, page 2	“The MOP formula uses a safety factor of 0.8 to account for potential errors and uncertainties in estimating the caprock fracture closure gradient.”	The AER should acknowledge that a more conservative Safety Factor (i.e. less than 0.8) is a potential risk mitigation tool (depending on the site specific risk evaluation of the caprock criteria, assessed failure modes, and risk receptors).	There may be circumstances where it is appropriate to use a lower factor of safety based on the results of the site specific risk based evaluation.	The RCT believes that the safety factor and the MOP equation are only meant to deal with the tensile failure of the caprock and not other risk considerations

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RC 03, page 3	The AER will use what it considers to be the lowest valid caprock fracture closure gradient obtained from representative diagnostic fracture injection tests." There is uncertainty associated with the determination of the fracture closure gradient - Collection and interpretation of the data used to determine the gradient - The aerial distribution of stress fields within the caprock over the project area.	Propose using • Where Caprock Fracture Closure Gradient is based on the most representative (not necessarily the lowest) gradient for the corresponding MOP area. Industry and the AER should immediately begin collaborating to develop a public database of raw and interpreted fracture closure gradient data to support identification of "representative" fracture closure gradients and assist in reducing the uncertainty associated with MOP formula inputs	"Representative" fracture closure gradient requires the operator to understand both the geological and geomechanical characteristic of the proposed project. This is not necessary the lowest value of the fracture closure gradient. More measurements may be required in more complex locations and an operator may require information from off- setting leases, whether or not the data exists. Operators should be able toprovide their argument for a representative fracture gradient, which may vary spatially, and be able to address data outliers. Creating a public database would be very useful to allow data collection and interpretation methods being readily available to the AER, industry and the public.	The RCT continues to believe that it should use what it considers to be the lowest valid caprock fracture closure gradient obtained from representative diagnostic fracture tests. The RCT believes the development of a database would be beneficial, subject to AER priorities.
RC 03, page 4	The AER's proposed MOP formula applies to all phases of SAGD operation, which may hinder or preclude some SAGD operational needs. Use of the MOP formula during start- up or early life will be difficult to manage in certain situations.	The regulatory process should acknowledge that it may be appropriate for the Regulator to permit, with conditions, the calculated MOP to be exceeded during certain operations (e.g. drilling, circulation, dilation start up).	During certain phases or operations, pressures higher than allowed by the proposed the MOP formula may be required for efficient start-up and production lifting operations, or to establish communication with the reservoir. The MOP formula will result in reduced steam injectivity in some situations (shallow areas where initial reservoir pressures and geological heterogeneities are high). Steaming wells in these conditions may decrease steam chamber conformance along the wellbore increasing the risk of steam coning. These conditions may affect the long term operability of the wells and impact ultimate recoveries.	The RCT believes that applications for limited (i.e. volume, time, and pressure) exceedances may be appropriate.
RC-03, page 3	AER notes the MOP should be calculated at the shallowest base of the caprock.	CAPP supports the calculation of MOP at the shallowest base of caprock in the applied for MOP area. CAPP wants to ensure surface topography is considered in the evaluation.	Varying surface topography could have a large impact on the calculated depth and should be considered in the evaluation process; specifically lakes and borrow pits	The RCT agrees with CAPP's recommendation that surface topography must be considered.
RC-04, Section 1, page 1 and Section 6, page 8	The AER proposes asking operators to assess the potential for shear failure using geomechanical modeling.	Geomechanical modelling should be required for all applications in the shallow thermal area. Geomechanical modelling should be updated during project operations at a frequency agreed upon by the applicant and the AER. Updated modelling should incorporate the results of the project's monitoring program.	Modelling is beneficial as it delivers an assessment of the following: • Thermal effects, • Lifting, • Permeability enhancement, • Combining shear and tensile failures, • Stress and pore pressure transfer within region of influence, and • Comparison of predictions to actual field measurement	The RCT agrees that geomechanical modelling should be required for all projects in the shallow thermal area to assess the potential for shear failure. The RCT agrees that modelling should be updated using project monitoring results and that the frequency of updates needs to be addressed as a part of the application process.

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RC-04, Section 4.1, page 3	"The majority of geomechanical modelling studies submitted to the AER to address caprock integrity issues have used either GEOSIM or ABAQUS."	The complexity of the modelling should be proportional to complexity of the proposed development and its associated risks.	The report describes the state of the art of [continuum] geomechanical modeling, although the discussion is limited to two software tools; other commercial (e.g., STARS+FLAC or STARS- Geomechanics Module) and proprietary models are used by members as well. The AER should accept the use of any suitable geomechanical modelling software or advanced simulation techniques and focus on judging the adequacy of the applicant's modelling efforts and results.	The RCT does not intend to prescribe the geomechanical modelling software that should be used.
RC-04, Section 4.1, page 3	To accurately determine an MOP for shallow SAGD schemes, a complete 2-way coupling method is important.	The complexity of the modelling should be proportional to complexity of the proposed development and its associated risks.	The level of rigor required for a risk assessment is determined by the severity of the potential harm to receptors (i.e., the severity of consequence), the complexity of the geological, geomechanical and hydrological setting of the project and the scenario being assessed. Complete 2-way coupled models might not be necessary.	The RCT does not intend to prescribe that 2-way coupled modelling should be used.
RC-04, Section 4.2, page 5	c) The bottom boundary is a roller boundary, but there must be some reasonable thickness of the underlying strata in order to make sure that the boundary proximity is not affecting the results. The thickness of the underburden should be 4–5 times the thickness of the SAGD zone".	The AER should not specify the underburden thickness used in modelling and should instead assess the adequacy of the applicant's modelling efforts on a case by case basis.	The requirement to model the underburden to 4-5 times the SAGD zone thickness is problematic as this potentially represents 50 to about 200 metres of underburden , which in some cases does not exist. Currently there is limited data in Pre Cretaceous horizons and acquisition requires approval from Alberta Energy since operators generally do not have rights below the McMurray Fm. The factor of 4-5 times comes from tunnel and foundation design, but in reality the issue is a function of different stiffness ratios between the reservoir and underburden. For stiffer underburden, the thickness of the underburden that needs to be included in the model is significantly less. Modelling a few metres may be enough for hard underburden such as Devonian but this needs more study.	The RCT does not intend to prescribe the underburden thickness that should be used for modelling.
RC-05, General Comments	Deformation measurements seem to be the preferred monitoring methods described in RC-05	Future regulatory requirements should not be based soley on the RC-05 report. Applicants should be required to include a suitable monitoring program that is based on project- specific risks and compliments the identified flow pathway assessment, caprock characteristics and the geomechanical modelling conducted in support of the application. Future monitoring results should be used to test assumptions and validate/improve modelling predictions.	While the information in RC-05 provides an overview of different monitoring methods, it does not recognize the benefits when a combination of monitoring methods are used that are designed in a fit for purpose application for a given project's assessed risk receptors.	The RCT agrees that future monitoring requirements should not be based solely on RC-05. The RCT agrees that suitable monitoring programs should be required and used to update modelling.

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RC-05, Near-Surface Tilt Measurements, page 53	RC-05 states that "… 150-200 sites per square kilometer will be needed." According to Pinnacle (Halliburton Data Sheet H08451) a tilt meter density of 1/3 the shallowest subsiding depth would be required to optimally resolve the deformation. For Shallow SAGD projects this would require approximately 400 sites per square kilometer. This degree of density could make the use of tilt meters impractical for large developments in shallow reservoirs.	Tilt meters may be practical for small scale developments (1-2 km2) or in localized areas of a larger development, but are not currently practical for full field deformation monitoring of shallow SAGD projects.	The higher cost and footprint required to implement this technology would likely make it impractical for use at a full field scale at a commercial project (generally larger then 4-5 km2)	The RCT acknowledges that tilt meters may be more practical for a small scale project.
RC-05, Ground Based Interferometric Synthetic Aperture Radar, page 59	Relatively short operational range makes Ground Based InSAR challenging to implement in large development areas in the Athabasca.	This approach may be an appropriate technology in areas with minimal vegetation however most of the shallow SAGD projects would require additional clearing to increase site lines and data quality.	Working range is estimated to be approximately 4 km in line of site (as per Alberta Geological Survey. 2013. Ground-Based InSAR on Turtle Mountain). For large developments continuous line of site would be difficult to achieve and would require additional footprint disturbance at a project.	The RCT acknowledges that ground based InSAR may be more appropriate in an area with less vegetation.
RC-05, Differential GPS Approaches, page 55	RC-05 states that differential GPS can "give the difference in elevation to precisions on the order of 10 millimeters (better if the sites are guaranteed to be stably anchored at shallow depths). The coarse precision of D-GPS would make deformation alarming challenging.	D-G PS is another technology that could be used to gather valuable vertical deformation data; however the relatively low precision of the technology may make D-GPS inappropriate for alarming applications.	Surface heave is generally a slow and gradual process (20-50 mm a year). If a subsurface deformation event was to occur, it may induce a surface deformation that is below the precision of the D-GPS and therefore could not be properly resolved/detected. The precision would also increase the likelihood of false alarms if this technology was used for that purpose.	The RCT agrees with CAPP on the use and limitations of D-GPS.
RC-05, Section 1.1 "Reasons for Monitoring", pages 1 and 2	Monitoring as described in RC-05 is generally described as not suitable for alarm use.	Monitoring is essential to validate engineering and geomechanical predictions. (Ref RC-05 page 15). This validation step is often missing in current monitoring and surveillance efforts. That validation can be useful to increase confidence in predictions and reduce operational risk. Future monitoring results should be used to test assumptions and validate/improve modelling predictions.	CAPP agrees with the RC-05 observation that monitoring is conducted for a variety of purposes beyond alarms for incipient loss of containment. Monitoring has multiple benefits and could potentially be used to take action to reduce the magnitude of the potential loss of containment event. Monitoring data when tailored to a site specific site can show trends and be used to determine if operations are responding as predicted in models conducted before operations commence.	The RCT agrees that monitoring results should be used to test assumptions and validate modelling predictions.
RC-05, Section 5 "Conclusions", page 68	Reliability of models used for heave inversion.	Heave inversion may be a fast and good estimation method, but it does rely on many assumptions that can affect accuracy (e.g., the rock deformations are only described in the elastic region and the rock is homogenous).	Further work would be required to extend heave inversion technology to extend its validity.	The RCT agrees that further work needs to be done to improve the accuracy of heave inversion technology.
RC-05, Section 2.3.1 "Are cap rock and overburden P & T Measurements useful for alarms?", pages 15-19	Ground water pressure and temperature monitor has been dismissed in RC-05 as ineffective in alarming an imminent loss in reservoir containment. The premise of RC-05 is that the monitoring is conducted in the silts and shales are contained in the Clearwater caprock as defined by the AER.	Industry has widely adopted ground water pressure and temperature monitor in sands both in and above the defined Clearwater cap rock. These monitored sands can exhibit excellent lateral continuity as well as wide range of permeability. These sands are beneficial in telegraphing a loss of fluid containment from beneath the Clearwater.	A broader recognition of Monitoring to have the capability to show deviations from normal operations and allow operator control over the system to manage operations as necessary needs to be incorporated.	The RCT acknowledges that monitoring could have the capability to show deviations from normal operations.

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RC-05, Section 2.3.2, page 19	RC-05 dismisses the use of "Chamber Injection Rates and Pressures" as ineffective in alarming an imminent loss in reservoir containment.	Some industry participants have adopted some form of monitoring "Chamber Injection Rates and Pressures" to detect loss of containment from the reservoir. It is recognized this technique becomes more difficult to use as steam chambers grow and coalesce with neighboring chambers and the system compressibility increases. This monitoring approach is believed to be a useful alarm technique to create alerts when there is the potential for a loss of fluid containment and the operator needs to manage the residual risk.	A broader recognition of Monitoring to have the capability to show deviations from normal operations and allow operator control over the system to manage operations as necessary needs to be incorporated.	The RCT acknowledges that monitoring could have the capability to show deviations from normal operations.
April 2, 2015 supplemental letter	Project monitoring and risk assessment.	CAPP suggests that verification of or any refinement of an operator's predisctive models and risk assessments be discussed with the AER durring the Directive 054 annual project performance review.	If the performance is not within the predicted range, operator intervention may be required to keep operations and risk within acceptable limits.	If an operator needs to undertake intervention in order to keep operations and risk within acceptable limits, the AER needs to be immediately notified. Notwithstanding, the Directive 054 process can be used as suggested by CAPP.