ATTACHMENT F: EMERGENCY AND REMEDIAL RESPONSE PLAN

This draft Emergency and Remedial Response Plan follows EPA's template (per the Project Plan Development Guidance), and is populated with information submitted by Berexco.

- Red text is extracted from Berexco's Emergency and Remedial Response Plan (submitted March 2015)
- Blue text is from the Wellington Seismic Action Plan and "Additional Monitoring Activities" document (submitted June 2015).
- Some response actions are derived from Berexco's Monitoring-Based Rapid Response Plan (submitted June 2015) to ensure consistency between that plan and the Emergency and Remedial Response Plan (this text is green).

Some rearranging of text and edits have been made.

This plan is provided to meet the requirements of 40 CFR 146.94. As steps to prevent unexpected carbon dioxide (CO_2) movement have already been undertaken in accordance with risk analysis, this plan is about actions to be taken, and to be prepared to take, if unexpected movement or any other emergency events occur.

Facility name: Wellington Field Small Scale Carbon Capture and Storage (CCS) Project
Injection well KGS 1-28

Facility contact: Dana Wreath, Vice President
2020 N. Bramblewood Street
Wichita, KS 67206
Tel: (316) 265-3311
Fax: (316) 265-8690

Well location: Sumner County, Kansas
Latitude 37.319485, Longitude -97.4334588

This emergency and remedial response plan (ERRP) describes actions that Berexco shall take to address movement of injection or formation fluids that may endanger an underground source of drinking water (USDW) during the construction, operation, and post-injection care time periods. [Note: because construction of KGS 1-28 is complete, this plan focuses on the operation and post-injection phases.] This plan addresses actions that will be taken in the event of endangerment of a USDW due to movement of injectate or fluid attributed to injection-related activities.

This plan is also part of the Wellington Operating Plan for Safe and Efficient Injection, which integrates activities related to operating conditions (see Attachment A), testing and monitoring (see Attachment C), and the Wellington Seismic Action Plan (described under "Seismic event," in Part 3 below), and this Emergency and Remedial Response Plan.

Berexco will also implement a Monitoring and Rapid Response Plan, which is is designed to provide early warning of CO_2 plume and pressure front deviations, which will trigger an analysis of the causes of the deviation, a potential revision of the expected plume movement, and place in action a set of enhanced monitoring activities to ensure safe injection. This Monitoring and Rapid Response Plan, which is reflected in various permit conditions, is Appendix 1 to this Emergency and Remedial Response Plan.

This plan ensures that, if Berexco obtains evidence that the injected CO_2 stream and/or associated pressure front endangers the USDW, Berexco will take the following actions:

1. Immediately shut down the injection well,
2. Identify and characterize the release,
3. Notify the permitting agency (UIC Program Director) of the event within 24 hours, and
4. Implement the ERRP presented below.

The Director may allow injection to resume before remediation if Berexco demonstrates that the injection operation will not endanger the USDW.

Where the phrase "initiate shutdown plan" is used, the following protocol will be employed: Berexco will immediately cease injection. However, in some circumstances, Berexco will, in consultation with the UIC Program Director, determine whether gradual cessation of injection (using the parameters set forth in Attachment A of the Class VI permit) is appropriate.

Part 1: Local Resources and Infrastructure

The facility is in a sparsely populated area where there are no major buildings, infrastructure, homes, or water wells. There are no potable water wells within the AoR. The injection well is located in a rural area with some non-irrigated crop cultivation. Additionally, there are no buildings or infrastructure near the site that would potentially be affected as a result of CO_2 emissions at the surface. Also, there are no municipal water supplies in the immediate area. The closest surface water feature is Slate Creek, which is approximately 3 miles south of the site.

The key resources/infrastructure in the area that may be impacted by escape of CO_2 from the confining zone include:

- USDW within the Upper Wellington Formation (ground surface to approximately 250 feet below ground)[1];
- Surface injection facility equipment: CO_2 storage tank, pump, and communication device; and
- The injection well (KGS 1-28) and monitoring well (KGS 2-28) and related equipment.

[1] The determination about the presence or absence of any USDW at the Wellington site will be made by the EPA Director after reviewing groundwater quality data to be collected by KGS/Berexco in September 2015.

Figure F-1 presents a map of the area.

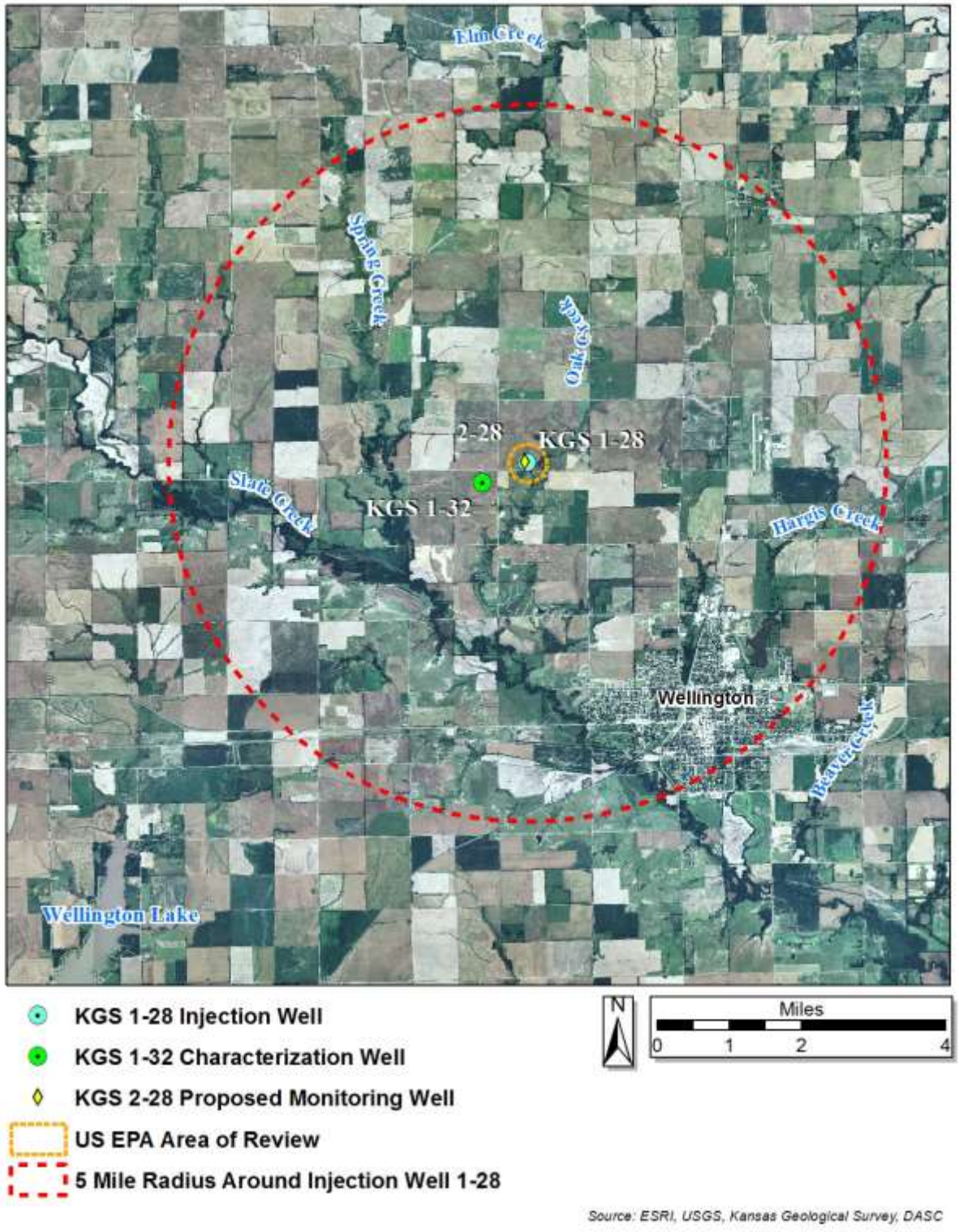

Figure F-1: Aerial map of Wellington storage site and vicinity, Sumner County, Kansas

Part 2: Potential Risk Scenarios

The following events related to the Wellington CCS Project could potentially result in the need for an emergency response:

- Well integrity failure, including annulus pressure failure;
- Equipment failure, including damage to the wellhead or a well blowout;
- Water quality changes/release to USDW;
- Release of CO_2 to the surface;
- Natural disaster; or
- Induced seismic event.

The classification of an emergency scenario is related to the degree of USDW endangerment posed by the scenario. Each scenario will constitute an emergency and trigger the ERRP, although response activities related to each scenario will depend on the nature of the failure and the severity of the event.

TABLE F-1. DEGREES OF RISK FOR EMERGENCY EVENTS

Emergency Condition	Definition
Major Emergency	Event poses immediate substantial risk to human health, resources, or infrastructure. Emergency actions involving local authorities (evacuation or isolation of areas) should be initiated.
Serious Emergency	Event poses potential serious (or significant) near term risk to human health, resources, or infrastructure if conditions worsen or no response actions taken.
Minor Emergency	Event poses no immediate risk to human health, resources, or infrastructure.

Part 3: Emergency Identification and Response Actions

Steps to identify, characterize, and respond to an event will depend on the specific issue identified, and the severity of the event. The potential risk scenarios identified in Part 2 are detailed below.

POTENTIAL ADVERSE EVENT: WELL INTEGRITY FAILURE.

A loss of integrity in the injection well and/or monitoring well may endanger USDWs. Integrity loss may have occurred if the following events occur:

- Automatic shutdown devices are activated.
  - Wellhead pressure exceeds the specified shutdown pressure specified in the permit;
  - Annulus pressure indicates a loss of external or internal well containment; or
- Mechanical integrity test results identify a loss of mechanical integrity.

Berexco must notify the UIC Program Director within 24 hours (40 CFR 146.91(c)(3)of <u>any triggering</u> of a shut-off system (i.e., down-hole or at the service).

Severity: Medium

Timing of event: Operational

Avoidance measures: Well maintenance; equip the well with an alarm and shutdown system that will be activated in the event of deviation of essential operating parameters.

Detection methods: The annular pressure will be monitored for internal mechanical integrity of the well. A sufficient anomalous pressure or fluid-level change in the annulus will require an investigation of the tubing/borehole.

Potential response actions:

Notify the UIC Program Director within 24 hours of the emergency event, per 40 CFR 146.91(c).

Determine the severity of the event, based on the information available, within 24 hours of notification.

For a Major or Serious Emergency (i.e., release):

- Initiate shutdown plan.
- Evaluate the cause of the violation, and mitigate if necessary (i.e., repair equipment).
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).

For a Minor Emergency:

- Conduct assessment to determine whether there has been a loss of mechanical integrity.
- If there has been a loss of mechanical integrity, initiate shutdown plan.

Confirm well integrity prior to restarting injection (upon approval of the UIC Program Director).

Response personnel: Berexco/KGS representative

Equipment: Drill rig, logging equipment, cement or casing as required.

POTENTIAL ADVERSE EVENT: EQUIPMENT FAILURE.

This scenario includes equipment failure, damage to the wellhead, or a well blowout.

Severity: Medium

Timing of event: Operational

Avoidance measures: Well maintenance and facility safety measures; equip the well with an alarm and shutdown system that will be activated in the event of deviation of essential operating parameters.

Detection methods: Monitoring; daily inspections of the well; personnel onsite during operations. Asudden loss of downhole and/or wellhead pressure at injection well (e.g., 25% drop in pressure over an average of 5 minutes) may indicate potential leakage from the well.

Potential response actions:

Notify the UIC Program Director within 24 hours of the emergency event, per 40 CFR 146.91(c).

Determine the severity of the event, based on the information available, within 24 hours of notification.

For a Major or Serious Emergency (i.e., release):

- Initiate shutdown plan.
- Review downhole, wellhead, and annulus pressure data.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
    - Isolate the nearby area, if needed; establish a safe distance and perimeter using a hand-held air-quality monitor.
    - Perform a well log to detect CO_2 movement outside of casing.

For a Minor Emergency:

- Conduct assessment to determine whether there has been a loss of mechanical integrity.
- If there has been a loss of mechanical integrity, initiate shutdown plan.

Evaluate the cause of the failure, and mitigate if necessary (i.e., repair equipment).

- In the event of a well blowout, "kill" the well by pumping fluid to stop the well from flowing.
- If there is damage to the wellhead, repair the damage and conduct a survey to ensure wellhead leakage has ceased.
- If a shut off is triggered by mechanical or electrical malfunctions, without endangering the USDW, repair faulty components.

Confirm well integrity prior to restarting injection (upon approval of the UIC Program Director).

Response personnel: Berexco/KGS representative

Equipment: Drill rig, logging equipment, cement or casing as required.

POTENTIAL ADVERSE EVENT: WATER QUALITY CHANGES/RELEASE TO USDW.

Includes detection of anthropogenic CO_2 in groundwater monitoring wells in statistically significant excess of background levels, or elevated concentrations of indicator parameter(s) in groundwater sample(s) or other evidence of fluid (brine) or CO_2 leakage into a USDW.

Severity: Medium to High, depending on location

Timing of event: Operational and post-injection

Avoidance measures: Well maintenance and injection in accordance with approved operational parameters

Detection methods: Water quality will be monitored in a network of observation wells in the shallow USDW and the Mississippian reservoir above the primary confining zone. Berexco will periodically collect and analyze water samples from these wells as described in the Testing and Monitoring Plan (Attachment C to this permit). Additionally, a sudden loss of downhole and/or wellhead pressure at the injection well (e.g., 25% drop in pressure over an average of 5 minutes) may indicate a breach of the caprock or formation of new fractures.

Potential response actions:

Notify the UIC Program Director within 24 hours of the emergency event, per 40 CFR 146.91(c).

Determine the severity of the event, based on the information available, within 24 hours of notification. Activities to be taken, in consultation with the UIC Program Director, may include the following:

- Conduct Hall Plot analysis;
- Sample and test water quality in the Mississippian and shallow monitoring wells;
- Conduct pressure fall-off test; or
- Obtain InSAR scene and analyze for caprock breach (if necessary and deemed feasible).

Initiate shutdown plan.

Arrange for an alternate potable water supply if the USDW was being utilized and has been caused to exceed drinking water standards.

If the presence of CO_2 or indicator parameters is confirmed, evaluate the cause and extent of the violation.

- If water quality changes or CO_2 migration are determined to be a consequence of well failure, attempt to identify the source location in the wellbore. This involves obtaining a suite of wireline logs to pinpoint the source location. Remediate using appropriate methods. On completion of the remedial work, acquire a new set of logs and perform a pressure test to validate well integrity prior to restarting injection (upon approval of the UIC Program Director).
- If water quality changes or CO_2 migration are determined to be due to confining zone failure or flow along structural features, develop a plan, in consultation with the UIC Program Director, to identify the extent of the problem and perform remedial measures. This may involve installing additional wells near the affected groundwater well(s) to delineate the extent of contamination, and conducting additional modeling to predict the fate of the CO_2 and/or brine. If CO_2 is found in the USDW, then the modeling will involve predicting the impacts to any surrounding wells and water resources. The shallow monitoring wells may also be used to vent gas that has reached the USDW.

Continue groundwater remediation and monitoring on a frequent basis (frequency to be determined by Berexco and the UIC Program Director) until unacceptable adverse USDW impact has been fully addressed.

If CO_2 is detected in the under-pressured Mississippian reservoir, the Mississippian monitoring wells may be used to release any CO_2 that has leaked into the reservoir. A 2-D seismic survey may also be conducted to identify the extent of plume migration.

Response personnel: Berexco/KGS representative

Equipment: Drill rig, geophysics monitoring equipment.

POTENTIAL ADVERSE EVENT: RELEASE OF CO_2 TO THE SURFACE.

Or, an escape of anthropogenic CO_2 into formations above the primary confining zone.

Severity: Medium

Timing of event: Operational and post-injection

Avoidance measures: Injection following approved operational parameters.

Detection methods: Passive seismic monitoring; a deviation in predited movement of the carbon CO_2 may indicate CO_2 leakage along preferential pathways. Additionally, a sudden loss of downhole and/or wellhead pressure at the injection well (e.g., 25% drop in pressure over average of past 5 minutes) may indicate a breach of the caprock or formation of new fractures.

Potential response actions:

Notify the UIC Program Director within 24 hours of the emergency event, per 40 CFR 146.91(c).

Determine the severity of the event, based on the information available, within 24 hours of notification. Activities to be taken, in consultation with the UIC Program Director, may include the following:

- Conduct Hall Plot analysis;
- Sample and test water quality in the Mississippian and shallow monitoring wells;
- Validate plume detection with U-Tube sampling if escape of CO_2 suspected near the Arbuckle montoring well KGS 2-32;
- Conduct pressure fall-off test; or
- Obtain InSAR scene and analyze for caprock breach (if necessary and deemed feasible).

Initiate shutdown plan.

Arrange for an alternate potable water supply if the USDW was being utilized and has been caused to exceed drinking water standards.

Evaluate the cause of the violation and mitigate, if necessary.

- If the release is along the wellbore and above the primary confining zone, perform a suite of wireline logs to identify the location of failure in the well. Make repairs. Confirm well integrity prior to restarting injection (upon approval of the UIC Program Director).

- If the leakage is farther away, or through the primary confining zone, develop a plan in consultation with the UIC Program Director to identify the extent of the problem and perform remedial measures. Implement approved remedial measures until adverse impacts are no longer present.

Response personnel: Berexco/KGS representative

Equipment:rig, logging equipment, cement or casing if required, portable water quality testing meters.

POTENTIAL ADVERSE EVENT: NATURAL DISASTER.

Well problems (integrity loss, leakage, or malfunction) may arise as a result of a natural disaster impacting the normal operation of the injection well. An earthquake may disturb surface and/or subsurface facilities; and weather-related disasters (e.g., tornado or lightning strike) may impact surface facilities.

Severity: Medium to high, depending on the nature of the event

Timing of event: Operational and post-injection

Avoidance measures: N/A

Detection methods: N/A

Potential response actions:

Notify the UIC Program Director within 24 hours of the emergency event, per 40 CFR 146.91(c).

Determine the severity of the event, based on the information available, within 24 hours of notification.

For a Major or Serious Emergency:

- Initiate shutdown plan.
- Shut in well (close flow valve).
- Vent CO_2 from surface facilities.
- Communicate with local authorities to initiate evacuation plans, if necessary.
- Monitor well pressure, temperature, and annulus pressure to verify well status and determine the cause and extent of any failure.
- Determine if any leaks to ground water or surface water occurred.
- If contamination or endangerment is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).

For a Minor Emergency:

- Conduct assessment to determine whether there has been a loss of mechanical integrity.
- If there has been a loss of mechanical integrity, initiate shutdown plan.
- Shut in well (close flow valve).

- Vent CO_2 from surface facilities.
- Monitor well pressure, temperature, and annulus pressure to verify integrity loss and determine the cause and extent of any failure.
- Identify and, if necessary, implement appropriate remedial actions (in consultation with the UIC Program Director).

Response personnel: Berexco/KGS representative

Equipment: drill rig, logging equipment, cement or casing if required, portable water quality testing meters.

POTENTIAL ADVERSE EVENT: INDUCED SEISMIC EVENT.

Induced seismicity could result from the injection of fluids into subsurface formations that lubricate and or change the stress state of pre-existing faults which causes fault plane movement and energy release.

Severity: Low to Medium depending upon the magnitude and location of the event

Timing of event: Operational and post-injection

Avoidance measures: Injection pressures and rates will be limited to reduce the potential for induced seismicity.

Detection methods: Berexco will conduct passive seismic monitoring at a 15-seismometer network (see Attachment C, the Testing and Monitoring Plan for specific information. Berexco will download data from the seismometer network once a week and analyze it for seismic activity. If the USGS National Earthquake Information Center (NEIC) detects an earthquake of magnitude greater than 2.5 with an epicenter within a mile of KGS 1-28, KGS personnel will be dispatched immediately to download seismometer data and confirm the magnitude and epicenter of the event.

Potential response actions:

Responses to seismic events will be according to the Wellington Seismic Action Plan (WSAP), which identifies remedial actions that are to be implemented if certain seismic threshold levels are exceeded. These thresholds are based on (a) the Kansas Seismic Action Plan (KSAP) SAS[2] and (b) the conventional seismic intensity magnitude (Richter Scale).

The response action to be implemented for various SAS and seismic intensity levels are presented in Table F-2. The response will only be initiated if the epicenter of the seismic event is within a mile of the injection well, because the model results indicates an induced pressure of less than 15 psi beyond this distance. If either the SAS (column 1) or the Richter (column 2) threshold is exceeded, Berexco will execute the corresponding response action specified in column 3. For example, if the SAS score is less than 17 and the seismic event is of magnitude less than 2.0, then operations are to continue with proper documentation of the event for semi-annual reporting to EPA. On the other end, if the SAS score is greater than 17 or if the seismic magnitude exceeds 2.5 and is felt, then operations will pause and a series of investigation and/or remedial measures implemented before commencing operations on approval of the UIC Program Director.

[2] The KSAP is triggered if a seismic event results in exceedance of a threshold SAS, which is calculated as:

$SAS = Magnitude + Score_{felt} + Score_{structure} + (2 \times Score_{number}) + Score_{local\ recursion} + Score_{recursion\ regional} + Score_{recursion\ time}$

The components of the formula address risk (captured by the "felt" and "structure" variables in the equation along with clustering and timing of seismic events (which may be indicative of induced seismicity as opposed to a natural occurrence and are captured by the variables for "number," "local recursion," "regional recursion," and "recursion time"). See http://kcc.ks.gov/induced_seismicity/draft_state_action_plan.pdf.

TABLE F-2. WSAP THRESHOLD LIMITS AND CORRESPONDING RESPONSE ACTION PLAN

The response action specified in column 3 will be executed if either the KSAP Threshold Condition (column 1) or the Seismic Event Magnitude Threshold Condition (column 2) is exceeded

KSAP Threshold Condition	Seismic Event Magnitude Threshold Condition[1]	Response Action Plan
<17	Seismic event greater than M2.0 and less than M2.5[2] and no felt report[3]	1. Continue site activities per permit conditions. 2. Document event for reporting to EPA in semi-annual reports.
< 17	Seismic event greater than M2.5[2] and no felt report[3]	1. Continue site activities per permit conditions. 2. Within 24 hours of the incident, notify UIC Program Director of the operating status of the facility. 3. Review seismic and operational data. 4. Report findings to the UIC Program Director and perform corrective action, if necessary.
≥ 17	Seismic event greater than M2.5[2] or local observation or felt report [3]	1. Initiate shutdown plan. 2. Within 24 hours of the incident, notify UIC Program Director of the operating status of the facility. 3. Monitor well pressure, temperature, and annulus pressure to verify well status and determine the cause and extent of any failure; identify and implement appropriate remedial actions (in consultation with the UIC Program Director). 4. Determine if leaks to ground water or surface water occurred. 5. If a leak is detected: a. Notify the UIC Program Director within 24 hours of the determination. b. Identify and implement appropriate remedial actions (in consultation with the UIC Program Director). 6. Review seismic and operational data. 7. Report finding to UIC Program Director and perform corrective actions.[4]

1 Seismic event within a mile of the injection well.
2 Determined by local Wellington or USGS seismic monitoring stations or reported by the USGS NEIC using the national seismic network.
3 Confirmed by local reports of felt ground motion or reported on the USGS "Did You Feel It?" reporting system.
4 Within 30 days of change in operating status.

Response personnel: Berexco/KGS representative

Equipment: drill rig, logging equipment, cement or casing if required, portable water quality testing meters.

Part 4: Response Personnel and Equipment

Site personnel, project personnel, and local authorities will be relied upon to implement this ERRP.

Site personnel to be notified (not listed in order of notification):

Personnel/Organization	Name	Phone Number	Email
Site Supervisor	Evan Mayhew	(316) 265-3311	emayhew@berexco.com
Berexco Project Manager	Dana Wreath	(316) 265-3511	dwreath@berexco.com
Project Engineer(s)	Dana Wreath	(316) 265-3511	dwreath@berexco.com
Plant Safety Manager(s)	Brett Blazer	(316) 265-3311	blazerb@berexco.com
Environmental Manager(s)	Evan Mayhew	(316) 265-3311	mayhewe@berexco.com

A site-specific emergency contact list will be developed and maintained during the life of the project. Berexco will provide the current site-specific emergency contact list to the UIC Program Director.

Local Authorities (including but not limited to):

Personnel/Organization	Name	Phone Number	Email
Sumner County Sheriff	Darren Chambers	(620) 326-8943	dchambers@co.sumner.ks.us
Sumner County Emergency Management	James Fair	(620) 326-7376	jfair@co.sumner.ks.us
State Police (Wellington Police Department Chief)	Tracy Heath	(620) 326-3331	tracyheath@cityofwellington.net
State Emergency Management Agency	Cody Charvat	(316) 660-5968	ccharvat@sedgwick.gov
Environmental Services Contractor	Allison Herring	(316) 337-6020	SCDOAdmin@kdheks.gov
UIC Program Director	Cynthia Khan	(785) 296-5554	ckhan@kdheks.gov
US EPA National Response Center (24 hr)	Scott Hayes	(913) 281-0991	hayes.scott@epa.gov
State Geological Survey	Rex Buchanan	(785) 864-2106	rex@kgs.ku.edu

Equipment needed in the event of an emergency and remedial response will vary, depending on the triggering emergency event. Response actions (cessation of injection, well shut-in, and evacuation) will generally not require specialized equipment to implement. Where specialized equipment (such as a drilling rig or logging equipment) is required, the designated Subcontractor Project Manager shall be responsible for its procurement.

Part 5: Emergency Communications Plan

Berexco will communicate to the public about any event that requires an emergency response to ensure that the public understands what happened and whether or not there are any environmental or safety implications. The amount of information, timing, and communications method(s) will be appropriate to the event, its severity, whether any impacts to drinking water or other environmental resources occurred, any impacts to the surrounding community, and their awareness of the event.

Berexco will describe what happened, any impacts to the environment or other local resources, how the event was investigated, what responses were taken, and the status of the response. For responses that occur over the long-term (e.g., ongoing cleanups), Berexco will provide periodic updates on the progress of the response action(s).

If a seismic event occurs, Berexco will provide information to the public regarding the magnitude of the event, whether any USDW contamination resulted from the event, and what actions will be taken.

Berexco will also communicate with entities who may need to be informed about or take action in response to the event, including local water systems, CO_2 source(s) and pipeline operators, land owners, and Regional Response Teams (as part of the National Response Team).

Part 6: Plan Review

Berexco will review and revise this ERRP:

a) Five years after commencement of injection, should the project extend for such a long duration;

b) Within one year of an area of review re-evaluation;

c) After any significant changes to the facility, such as the addition of injection or monitoring wells; or

d) Whenever required by the UIC Program Director.

If no changes to the ERRP are required after the review, then all documents in support of this determination will be provided to the UIC Program Director for approval. If amendments to the ERRP are deemed to be necessary, the revised ERRP will be submitted to the UIC Program Director for review and approval within six (6) months following an event that initiates the ERRP review procedure.

Part 7: Staff Training and Exercise Procedures

All personnel in charge of operations will receive training related to health and safety, operational procedures, and measures to be implemented in the event of an emergency. The training will be provided by Tiraz Birdie in conjunction with Lynn Watney and Dana Wreath. The initial training will emphasize both the injection and post-injection phases. Since the injection is to be completed within a year, the subsequent annual (refresher) course(s) will focus on the post-injection phase. In the event that a year has passed since the initial training, and if injection is on-going, then the annual training will also encompass procedures related to injection operations. The scope of training will encompass all aspects of the Wellington operations plan and the ERRP, with special focus on ways to prevent discharge of CO_2. Any new personnel on the operations team will receive training prior to discharging duties related to operations, monitoring, and equipment handling. Any lessons learnt from operating incidents will be shared with all team members, and if necessary, the EPA Director. All activities related to drilling, construction, operations, and equipment repair will be conducted by properly trained personnel. A record of the person's name, date of training, and the instructor's signature will be maintained.

Appendix 1: Monitoring-Based Rapid Response Plan

Activity	Monitoring Objective (Frequency of Evaluation)	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
CASSM - Early detection of plume at KGS2-28	Determine plume front/validate CO_2 -brine model (Weekly)	Plume expected to arrive at KGS 2-28 within 45-60 days of commencement of injection	Plume arrival at KGS 2-28 within 15 days of commencement of injection	Presence of preferential flow pathway(s)	• Validate plume detection with U-Tube sampling • Conduct Hall Plot analysis • Conduct Pressure Fall-Off Test • If necessary, recalibrate model • Revise projections of plume and pressure front • Recalculate AoR • Determine if any corrective action is required • Report finding to EPA Director.		
CASSM – Non-detection of plume at KGS2-28	Determine plume front/validate CO_2 -brine model (Weekly)	Plume expected to arrive at KGS 2-28 within 45-60 days of commencement of injection	Plume not detected within 120 days of commencement of injection	Non-radial migration of CO_2 through preferential pathway(s), escape of CO_2 into basement, breach of caprock, well integrity failure	• Conduct Hall Plot analysis • Conduct Pressure Fall-Off Test • Review annulus pressure data • Sample Mississippian and shallow well • Conduct MIT • If necessary, recalibrate model • Revise projections of plume and pressure front • Recalculate AoR • Determine if any corrective action required • Report finding to EPA Director.		Procedure to be repeated every 30 days if breakthrough at KGS 2-28 not achieved within 120 days of commencement of injection.

Activity	Monitoring Objective (Frequency of Evaluation)	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
Sudden loss of downhole and/or wellhead pressure at injection well	Monitor for leakage from well or caprock (Continuously)	Near steady pressures, increasing mildly with injection (except during start and stoppage of injection)	> 25% drop in pressure (over average of past 5 minutes)	Potential leakage from well, breach of caprock, or formation of new fracture(s)	• Pause injection • Review downhole, wellhead, and annulus pressure data. • Determine if loss of pressure due to CO_2 supply If positive, rectify problem, report findings to EPA Director and resume injection. • Conduct Hall Plot analysis. • Sample and test water quality in the Mississippian and shallow monitoring wells • Conduct MIT • Utilize all available monitoring data to calibrate model and predict plume extent • If necessary, implement Level 2 response • Report finding to EPA Director.	• Conduct Pressure Fall-Off Test (to determine if loss of pressure due to formation enhancement • Obtain InSAR scene and analyze for caprock breach (if deemed feasible)	
Unexpected increase of downhole or wellhead pressure gradients at injection well	Monitor for interception of barrier boundary, well plugging, reduced formation permeability (Continuously)	Near steady pressures, increasing slightly with time (except during start and stoppage of injection)	Unexpected increase in pressure gradient over time	Interception of barrier boundary, well plugging, reduced formation permeability due to chemical reactions, reduction of permeability due to lower	• Review downhole and wellhead temperature and pressure data. • Conduct Hall Plot analysis. • Determine if increase in pressure due to cooling effect of CO_2, formation plugging, or geochemical reactions. If positive, continue pumping but closely monitor pressures so as to not exceed operational limits.		

Activity	Monitoring Objective (Frequency of Evaluation)	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
				downhole temperature	• If pressure buildup due to interception of barrier boundary, then if necessary, revise conceptual model. • Recalibrate model and make fresh projections of plume and pressure front • Recalculate AoR • Determine if any Corrective Action required • Report finding to EPA Director.		
Felt Earthquake of magnitude 2.5 or greater with epicenter within 1 mile of injection well	Provide early warning of major earthquake (Continuously)	Earthquake magnitude < 2.0	Felt magnitude > 2.5	Presence of unknown fault(s)	Implement WSAP		
InSAR – surface deformation not detectable	Estimate subsurface pressure distribution in the injection zone based on land surface uplift estimated by InSAR interferograms (Monthly)	Detectable surface deformation (> 1 mm) in the close proximity to injection well	Unable to quantify any surface deformation within 120 days of commencement of pumpage	Experimental nature of InSAR technology	Make estimate of land surface deformation based on pressures measured at KGS 1-28 and KGS 2-28. If sub-mm deformation projected, then continue monitoring since deformation less than 1 mm are not easily identifiable. If > 1 mm deformation estimated, then rely on downhole pressure controls for safe injection.		Due to limited historical InSAR data which would account for seasonal influences/vegetation growth, and due to the experimental nature of the InSAR technology, the level of accuracy will be established during the course of the project.

Activity	Monitoring Objective (Frequency of Evaluation)	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
2D Seismic – Detection of plume above injection zone	Confirm plume location (One approximately midway during injection, and one post-injection)	Plume confined in (Arbuckle) injection zone	CO_2 suspected above injection zone	Potential breach of confining zone	Pause injection Implement Emergency and Remedial Response Plan		
3D seismic - Detection of plume above injection zone	Confirm plume location (One post-injection survey)	Plume confined in (Arbuckle)	CO_2 suspected above injection zone	Potential breach of confining zone	Pause injection Implement Emergency and Remedial Response Plan		
2D Seismic – non-detection of plume	Confirm plume location (One approximately midway during injection, and one post-injection)	Plume to remain confined in (Arbuckle) injection zone	Non-detect of CO_2 along seismic line	Plume escape along preferential pathway(s) in plane(s) out of the seismic line	If plume detected by other monitoring technologies: • Pause injection • Conduct Hall Plot analysis. • Utilize all available monitoring data to calibrate model and predict plume extent • Recalibrate model and make fresh projections of plume and pressure front • Recalculate AoR • Determine if any Corrective Action required • Report finding to EPA Director. If non-detect of plume by other monitoring technologies also: • Pause injection • Conduct water quality testing of Mississippian and shallow wells	Budget allowing, conduct additional seismic survey(s) if CO_2 plume cannot be detected by other monitoring technologies.	Absence of CO_2 could be due to (highly unlikely) escape of CO_2 in the basement

Activity	Monitoring Objective (Frequency of Evaluation)	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
					• Conduct MIT • Discuss path forward with EPA Director		