Post-Injection Site Care (PISC) and Site Closure Plan

About this Document

This document compiles text from the FutureGen permit application for Morgan County Class VI UIC Wells 1, 2, 3, and 4 into the PISC and site closure plan template provided in the *Class VI Project Plan Development Guidance*. The intent is to identify whether sufficient information was provided in the permit application to complete the project plans; **this is not considered a complete or approvable project plan**.

Identified deficiencies and questions are presented in highlighted text.

To facilitate reference to applicant submittals, text is color-coded and sections of the original documents are noted (some text has been edited slightly):

- Red text is from the FutureGen permit application.
- Blue text is from the additional information provided in November 2013.
- Green text is from the additional information provided in December 2013.
- Purple text is from additional information provided in January 2014 (including the Testing and Monitoring spreadsheet)

Text written by EPA is black.

- Text written by the Alliance is orange.

Table and figure numbers reflect the labels in FutureGen's submissions.

~~Post-Injection Site Care (PISC) and Site Closure Plan~~

Facility Information

Facility name: FutureGen 2.0 Project: Morgan County Class VI UIC Wells 1, 2, 3, and 4

Facility contacts (names, titles, phone numbers, email addresses):

Kenneth Humphreys, Chief Executive Officer, FutureGen Industrial Alliance, Inc., Morgan County Office, 73 Central Park Plaza East, Jacksonville, IL 62650, 217-243-8215

Location (town/county/etc.): Morgan County, IL; 26−16N−9W; 39.800266ºN and 90.07469ºW"

Pre- and Post-Injection Pressure Differential

The information regarding pre- and post-injection pressure differentials, as required by 40 CFR 146.93(a)(2)(i) is presented below.

The maximum injection pressure differential is 479 psi at the injection well when injection stops. The magnitude and area of elevated pressure gradually decreases over time after injection stops; as further detailed below in Table 1 and Figure 1.

Changes in pressure relative to initial conditions were calculated from simulation results. Pre-injection pressures were defined as the initial pressure measured at the monitoring locations before injection begins. Simulations were conducted for 20 years of carbon dioxide (CO_2) injection at a rate of 1.1 MMT/yr distributed into the injection wells, followed by 80 years of post-injection. Table 1 lists predicted aqueous pressure differentials over time at the ~~top of the injection zone~~ monitoring locations of the monitoring wells. For the injection well, the depth corresponds to the monitoring locations of the single-level in-reservoir (SLR) monitoring wells~~and for one depth interval immediately above the primary confining zone (MW3, the ACZ early-detection monitoring well)~~. The model suggests a maximum injection pressure differential of ~~446~~ 479 psi at the injection well at the time injection is stopped. Simulation results show the magnitude and area of elevated pressure gradually decreasing over time after injection stops.

The FutureGen Industrial Alliance, Inc. (Alliance) will conduct model calibration, on an annual basis for the first 5 years following the initiation of injection operations. Following the fifth year of injection, the model calibration will occur at a minimum of every 5 years. Some conditions would warrant reevaluation prior to the next scheduled reevaluation. These conditions are described in the Area of Review and Corrective Action Plan.

~~Model calibration may also occur when actual operational data differ significantly from initial estimated operational values that were used for model inputs, or when monitoring data and model results differ significantly as per specified in the regulation.~~

Figure 1 shows the pressure differential versus time for monitoring well locations in the Area of Review (AoR) and at the geometric centroid of the four horizontal injection wells. Simulated pressures ~~at the top of the injection zone~~ at the injection "point" increase during the 20-year injection period from ~~1,693~~1,779 psi to a maximum of ~~2,139~~2,258 psi. The highest pressures are in the immediate vicinity of each injection well. As shown, pressures at the injection and monitoring well locations decline over time after injection is stopped.

Table 1. Pressure differential to baseline conditions at well locations near the base of the Ironton Formation for ~~Well 3~~ Above Confining Zone Well 1 (ACZ1) and ACZ2 and at the ~~top of~~ middle of the Mount Simon 11 layer in the injection zone for the rest of the wells during and after injection (Table 7.1 from FutureGen's permit application).

	Pressure Differential (psi)				
Year	SLR1	SLR2	ACZ1	ACZ2	Injection Well
Distance from Injection Well (ft)	3740	6555	1010	3740	0
Elevation (ft)	-3371	-3414	-2763	-2751	-3390
0 (Start injection)	0	0	0	0	0
1	223	125	0	0	350
2	277	165	0	0	394
3	311	192	0	0	417
4	333	211	0	0	431
5	348	225	0	0	441
10	393	274	0	0	466
15	413	313	1	1	475
20 (Stop injection at year end)	425	338	2	2	479
21	255	235	2	2	259
22 (Approximate maximum extent of CO_2 Plume)	199	186	2	2	200
23	167	157	2	2	167
24	145	137	3	3	145
25	129	121	3	3	128
30	85	81	4	4	84
35	64	61	4	4	63
40	51	49	5	5	50
45	42	40	5	5	41
50	36	34	5	5	35
60	27	26	5	5	26
70	22	21	5	5	21
80	18	17	5	5	17
90	15	14	5	5	14
100	13	12	4	4	12

SLR1	Single Level Reservoir #1
SLR2	Single Level Reservoir #2
ACZ1	Above Confining Zone #1
ACZ2	Above Confining Zone #2
Injection Well	Geometric centroid of four horizontal laterals

~~Level Level~~

Year	Pressure Differential (psi)				
	MW 1	MW 2	MW 3	MW 4	Injection Well
Distance from Injection Well (ft)	7,749	3,149	1,221	6,574	0
0 (Start injection)	0	0	0	0	0
1	116	166	0	119	289
2	155	209	0	160	339
3	181	236	0	187	365
4	200	255	0	206	381
5	215	271	0	221	393
10	263	319	0	270	424
15	292	343	1	300	438
20 Stop injection at year end)	313	358	2	320	446
21	228	242	2	234	258
22 (Approximate maximum extent of CO_2 Plume)	183	191	2	188	200
23	155	161	2	160	168
24	136	141	3	140	145
25	121	125	3	125	129
30	81	84	4	84	85
35	62	64	4	64	64
40	50	51	5	51	51
45	41	42	5	43	42
50	35	36	5	36	36
60	27	27	5	28	27
70	21	22	5	22	21
80	18	18	5	18	17
90	15	15	5	15	14
100	13	13	4	13	12

	Well Identifier on Figure 7.1
MW 1	Stratigraphic Well (converted to Single-Level Monitoring Well)
MW 2	Injection Zone Multi-Level Monitoring Well
MW 3	ACZ Early-Detection Monitoring Well
MW 4	Injection Zone Single-Level Monitoring Well
Injection Well	Geometric centroid of four horizontal laterals

Commented [JRM1]: Table should be updated to reference well names as defined in the T&M plan. A comment in the T&M plan was to create a table that lists all the monitoring wells (RAT#1, RAT#2, SLR#1, SLR#2, ACZ#1, ACZ#2) and their locations. This can then be referred to from this plan.

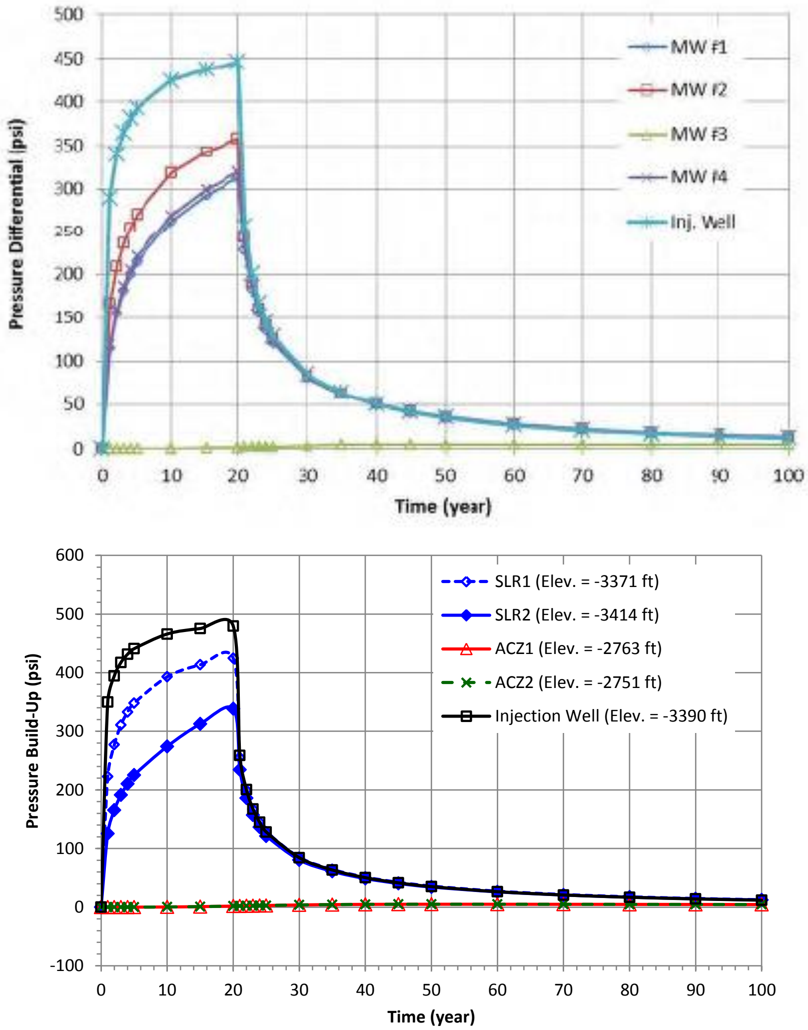
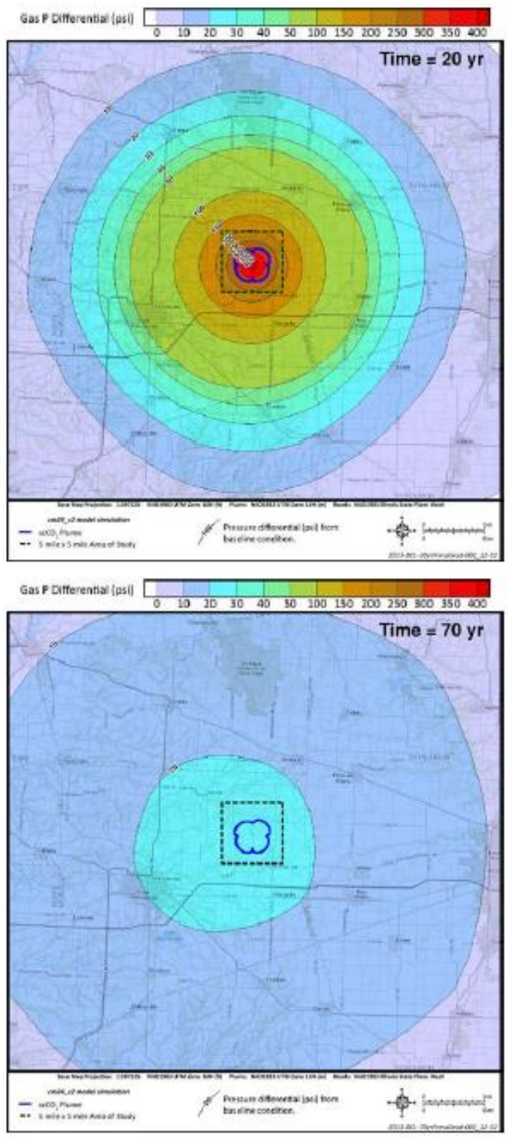
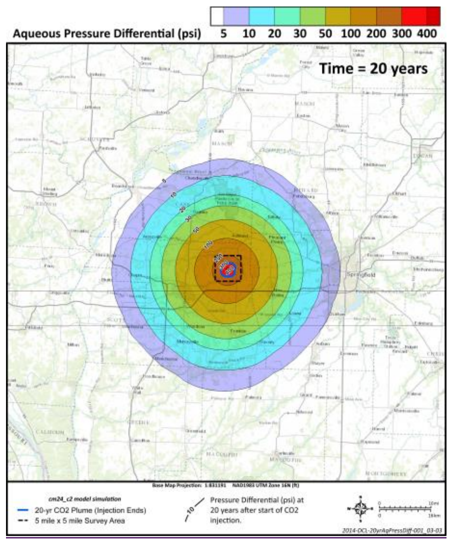
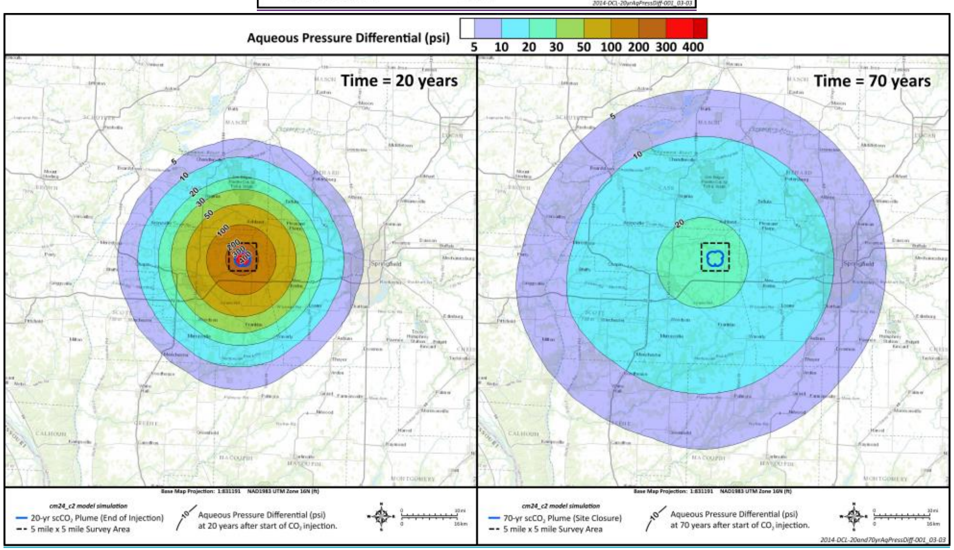


Figure 1. Simulated aqueous pressure differential versus time at monitoring well locations near the base of the Ironton Formation for ACZ1 and ACZ2 and at the middle of the Mount Simon 11 layer in the injection zone for the rest of the wells (replaces Figure 7.1 from FutureGen's permit application).


Gas P Differential (psi)
0 10 20 30 40 50 100 150 200 250 300 350 400
Time = 20 yr
Pressure differential (psi) from baseline condition.
Gas P Differential (psi)
0 10 20 30 40 50 100 150 200 250 300 350 400
Time = 70 yr
Pressure differential (psi) from baseline condition.



Aqueous Pressure Differential (psi)
5 10 20 30 50 100 200 300 400
Time = 20 years
cm24_c2 model simulation
20-yr CO2 Plume (Injection Ends)
5 mile x 5 mile Survey Area
Pressure Differential (psi) at 20 years after start of CO2 injection.



Aqueous Pressure Differential (psi)
5 10 20 30 50 100 200 300 400
Time = 20 years
Time = 70 years
cm24_c2 model simulation
20-yr scCO2 Plume (End of Injection)
5 mile x 5 mile Survey Area
Aqueous Pressure Differential (psi) at 20 years after start of CO2 injection.
cm24_c2 model simulation
70-yr scCO2 Plume (Site Closure)
5 mile x 5 mile Survey Area
Aqueous Pressure Differential (psi) at 70 years after start of CO2 injection.

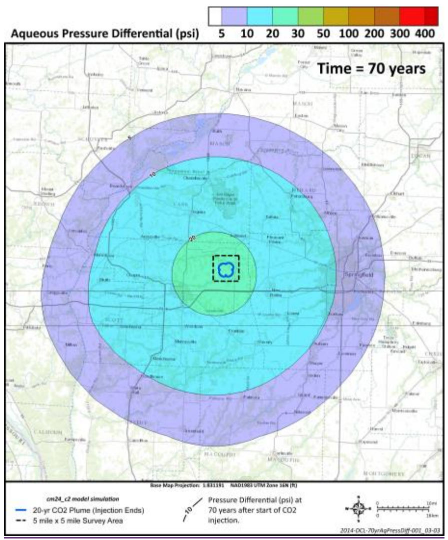


Figure 2. Aqueous Pressure differentials from baseline condition at the top of the injection zone and CO_2 plume extents at 20 years (end of injection) and 70 years (site closure) after start of injection

Predicted Position of the CO_2 Plume and Associated Pressure Front Upon Cessation of Injection and at Site Closure

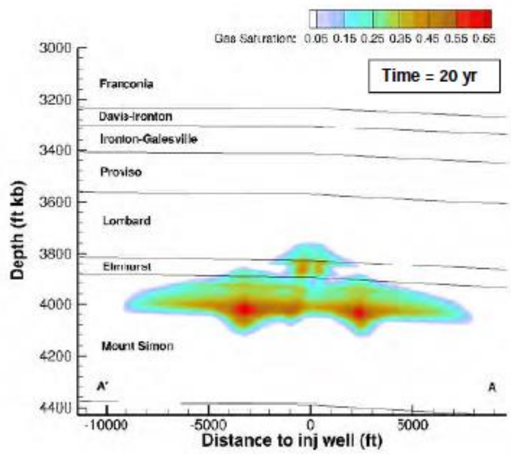
The information regarding the predicted position of the carbon dioxide plume and associated pressure front at site closure, as required by 40 CFR 146.93(a)(2)(ii) is presented below.

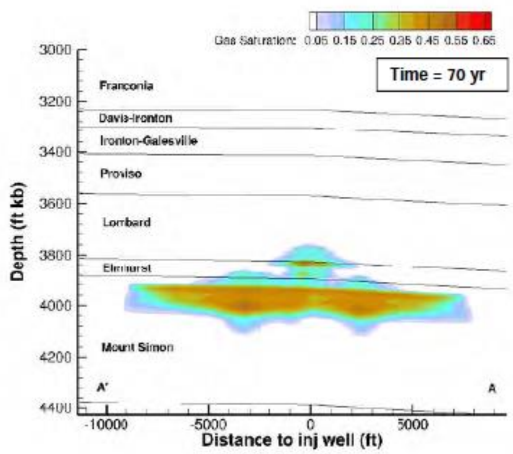
The areal extent of the CO_2 plume increases during injection and for 2 years post-injection. As the areal extent decreases (at year 22), the plume migrates predominately upward. The computational modeling results indicate that the sequestered CO_2 will migrate above the Mount Simon Sandstone, into the Elmhurst as well as the lower part of the Lombard .

Commented [AG2]: Will need to update to incorporate the change to the IZ.

Figure 3 and Figure 4 show the upward migration of the CO_2 plume near the injection well at 20 and 70 years. These two-dimensional images demonstrate various levels of gas saturation or upward migration into the injection zone (Mount Simon Formation, Elmhurst Sandstone, and lower part of the Lombard)~~and into the primary confining zone~~. The computational model results indicate indeed that the Model Layer "Lombard 5" is the top unit containing a fraction of injected CO_2 during the 100-year simulation. The top of the injection zone is set at -3,153 ft (above MSL) at the FutureGen 2.0 stratigraphic well, corresponding to the top of the Lombard 5 layer of the numerical model.

The CO_2 plume forms a cloverleaf pattern as a result of the four lateral-injection-well designs. The plume grows both laterally and vertically as injection continues. Most of the CO_2 resides in the Mount Simon Sandstone. A small amount of CO_2 enters into the Elmhurst and the lower part of the Lombard Formation. When injection ceases at 20 years, the lateral growth becomes negligible but the plume continues to move slowly primarily upward. Once CO_2 reaches the low-permeability zone in the upper Mount Simon it begins to move laterally.


Gas Saturation: 0.05 0.15 0.25 0.35 0.45 0.55 0.65
Time = 20 yr
Franconia
Davis-Ironton
Ironton-Galesville
Proviso
Lombard
Elmhurst
Mount Simon
A'
A
Depth (ft kb)
Distance to inj well (ft)


Gas Saturation: 0.05 0.15 0.25 0.35 0.45 0.55 0.65
Time = 70 yr
Franconia
Davis-Ironton
Ironton-Galesville
Proviso
Lombard
Elmhurst
Mount Simon
A'
A
Depth (ft kb)
Distance to inj well (ft)

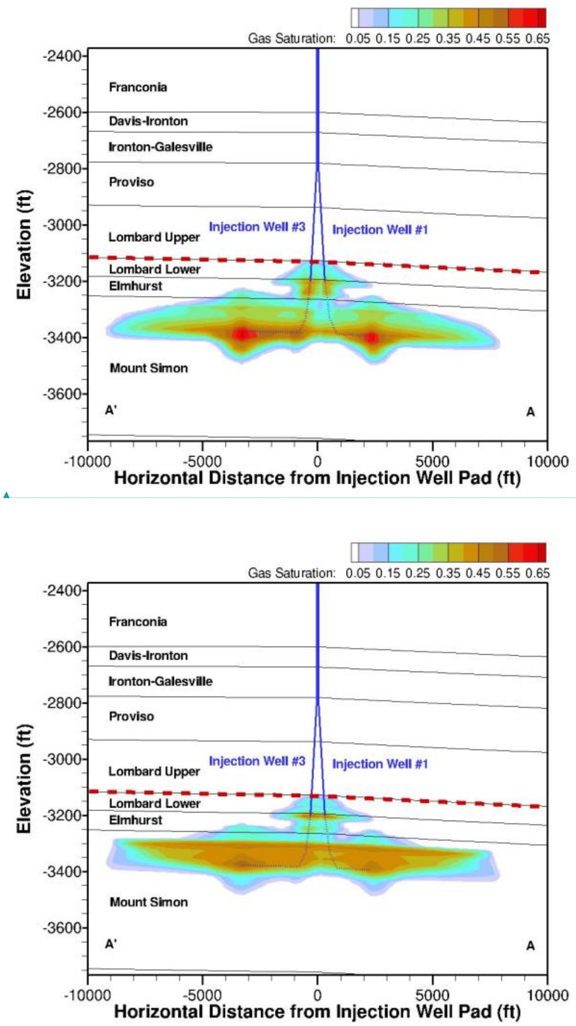


Figure 3. Cutaway view of CO_2-rich phase saturation along A-A' (Injection Wells 1 and 3) at 20 and 70 years. The red dashed line indicates the top of the injection zone (from Figure 3.22 in FutureGen's permit application).

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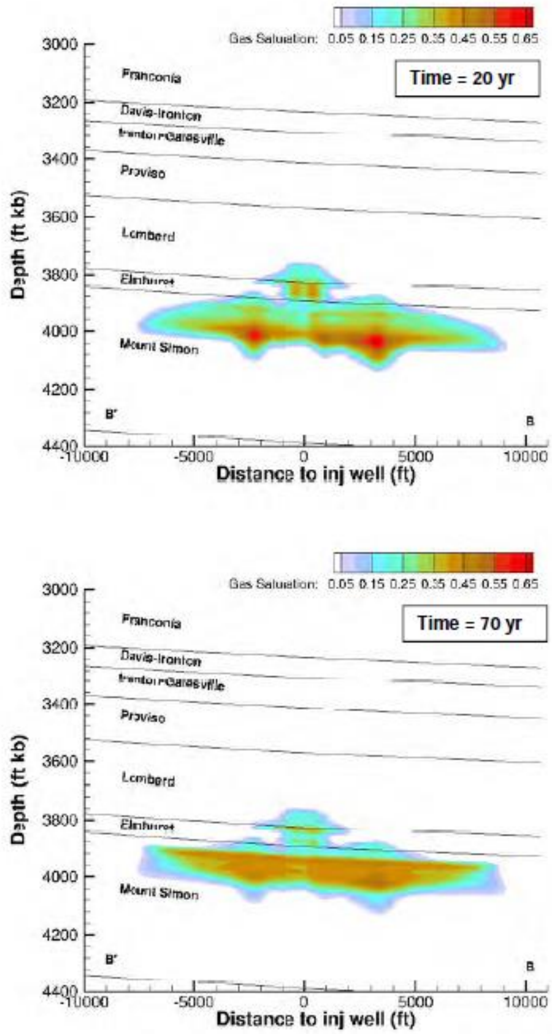
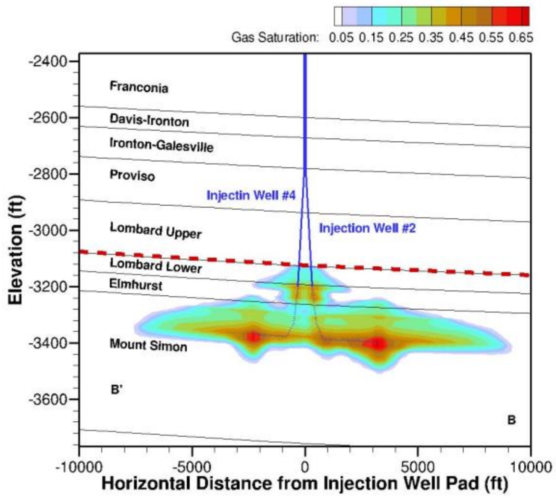

Gas Saturation: 0.05 0.15 0.25 0.35 0.45 0.55 0.65
Time = 20 yr
Franconia
Davis-Ironton
Proviso
Lombard
Elmhurst
Mount Simon
Depth (ft kb)
3000
3200
3400
3600
3800
4000
4200
4400
B'
B
-10000
-5000
0
5000
10000
Distance to inj well (ft)
Gas Saturation: 0.05 0.15 0.25 0.35 0.45 0.55 0.65
Time = 70 yr
Franconia
Davis-Ironton
Proviso
Lombard
Elmhurst
Mount Simon
Depth (ft kb)
Distance to inj well (ft)



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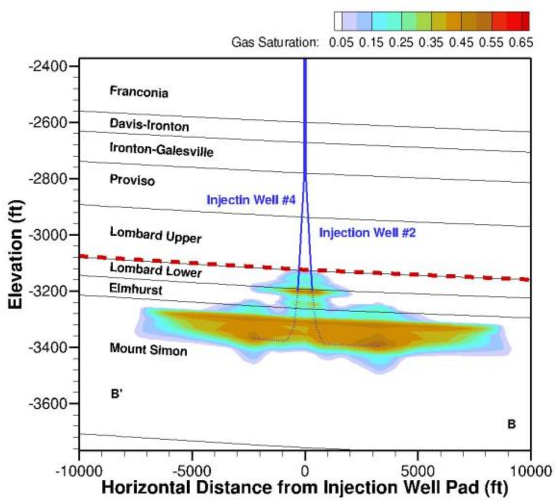


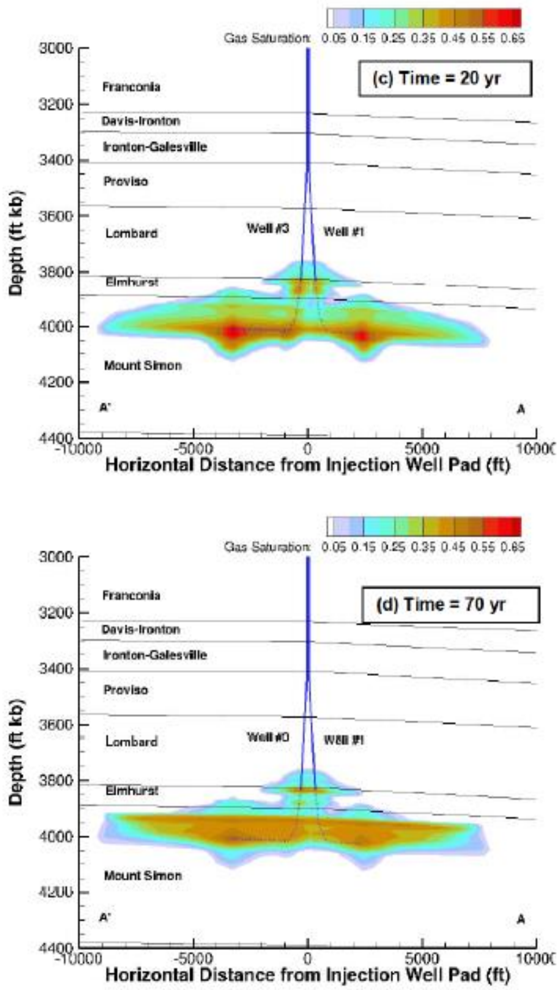
Figure 4. Cutaway view of CO_2-rich phase saturation along B-B' (Injection Wells 2 and 4) at 20 and 70 years. The red dashed line indicates the top of the injection zone (from Figure 3.23 in FutureGen's permit application).

Reservoir conditions are such that the CO_2 remains in the supercritical state throughout the domain and for the entire simulation period. The three-dimensional distribution of the CO_2-rich (or separate-) phase saturation is presented for selected times (i.e., 20 and 70 years). Additionally, ~~and~~ to better illustrate the CO_2 migration through time and space, a cross-sectional view of the CO_2 plume is presented as slices through the center of the injection wells and along the well traces. Figure 3 and Figure 4 show the CO_2-rich (or separate) phase saturation for selected times for slices A-A' and B-B', respectively.

~~The cloverleaf pattern of the CO_2 plume that forms as a result of the four lateral-injection-well design.~~ The central portion of the plume is a result of CO_2 injection into the Elmhurst in the vertical section of each well. Figures presenting the cross-sectional views show the location of the open interval relative to the plume and stratigraphic units. It can be seen in Figure 3 and Figure 4~~Figure 6 and Figure 7~~ that after 20 years of continuous CO_2 injection, the plume has spread both laterally and vertically, with some CO_2 migrating into the lower part of the Lombard. At 20 years, the plume grows larger with time primarily in the lateral direction, but also vertically. Two years after the cessation of CO_2 injection (at 22 years), the plume reaches its maximum lateral extent. However, the CO_2 within the plume continues to redistribute by migrating slowly upward due to buoyancy effects, ~~with~~ and some of the CO_2 dissolv~~ing~~es at the CO_2-brine interface at the edge of the plume. The vertical layering represented in the model is one of the controlling factors in the plume shape at later times. In general, the CO_2 tends to accumulate below a layer with a relatively higher gas entry pressure (and often lower permeability) than that of the layer directly below it. This area of relatively higher CO_2 saturation can be seen as the green "ledge" feature in the plume, and as the flat-topped orange zone. Because the plume migrates primarily upward after injection ceases, the green feature becomes narrower with time. The vertical cross sections showing the plume at 70 years illustrate how the CO_2 distribution within the plume becomes more uniform with time. Because of the dissolution process, the CO_2 separate-phase plume area (in the horizontal plane) at 100 years is 2.2% smaller than the maximum area at 22 years.

The maximum pressure differential corresponds to the end of the injection period (year 20). After that time, the pressure slowly dissipates resulting in the maximum pressure differential being below 30 psi at 70 years, and below 20 psi at 100 years. The pressure differential distribution has been presented instead of a defined pressure front because the calculated pressure head in the Mt Simon is greater than the calculated pressure head in the lower most USDW, the St Peter Sandstone, under initial conditions prior to injection, Formatted: Font color: Green

~~**Figure 5. Determination of the Top of the Injection Zone, based on Geophysical Logs and Modeling Results**~~.



~~Figure 6. Cutaway view of CO_2-rich phase saturation along A-A' (Wells 1 and 3) at 20 and 70 years (from Figure 3.22 in FutureGen's December 2013 submission).~~

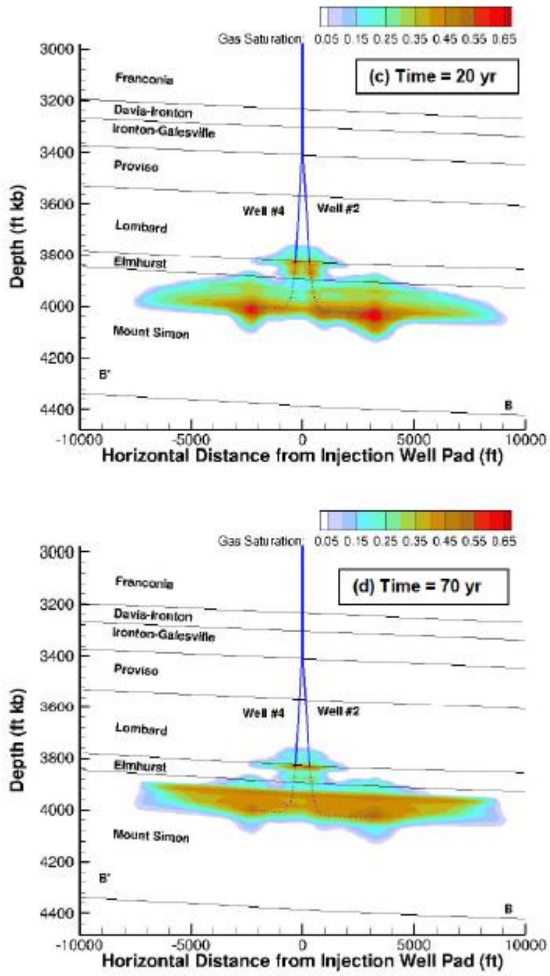
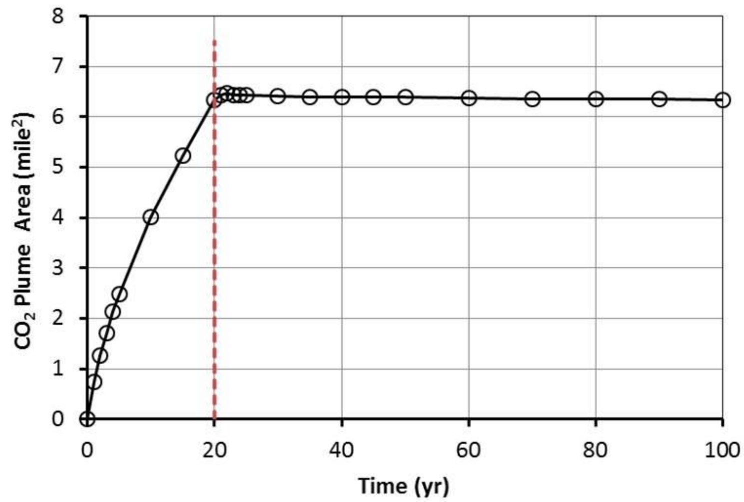


Figure 7. Cutaway view of CO_2-rich phase saturation along B-B' (Wells 2 and 4) at 20 and 70 years (from Figure 3.23 in FutureGen's December 2013 submission).

CO_2 migration during the post-injection site care (PISC) period was modeled to predict CO_2 plume redistribution after injection ceases. The model predicts that the areal extent of the CO_2 plume (defined as 99.0 percent of the separate-phase CO_2 mass) increases during injection and for 2 years post-injection and then begins to decrease as buoyancy forces dominate and plume migration is predominately upward. **Error! Reference source not found.** Figure 5. Simulated plume area over time (the vertical dashed line denotes the time CO_2 injection ceases) (Figureshows the cumulative area of the CO_2 mass plume with time. The maximum plume extent, 6.46 mi^2, occurs at 22 years after the start of injection (2 years after the cessation of injection).



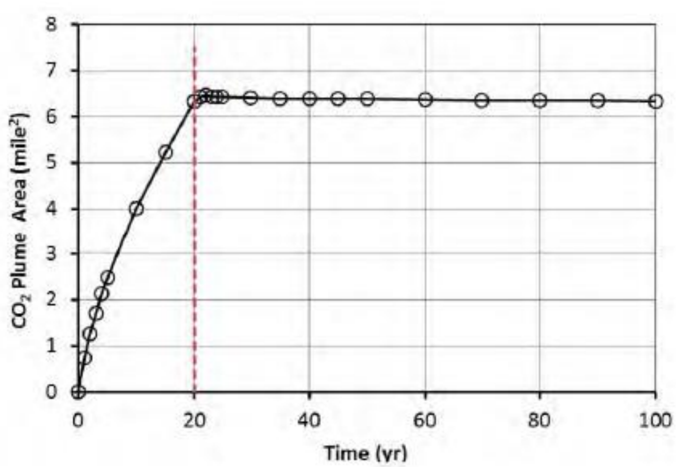
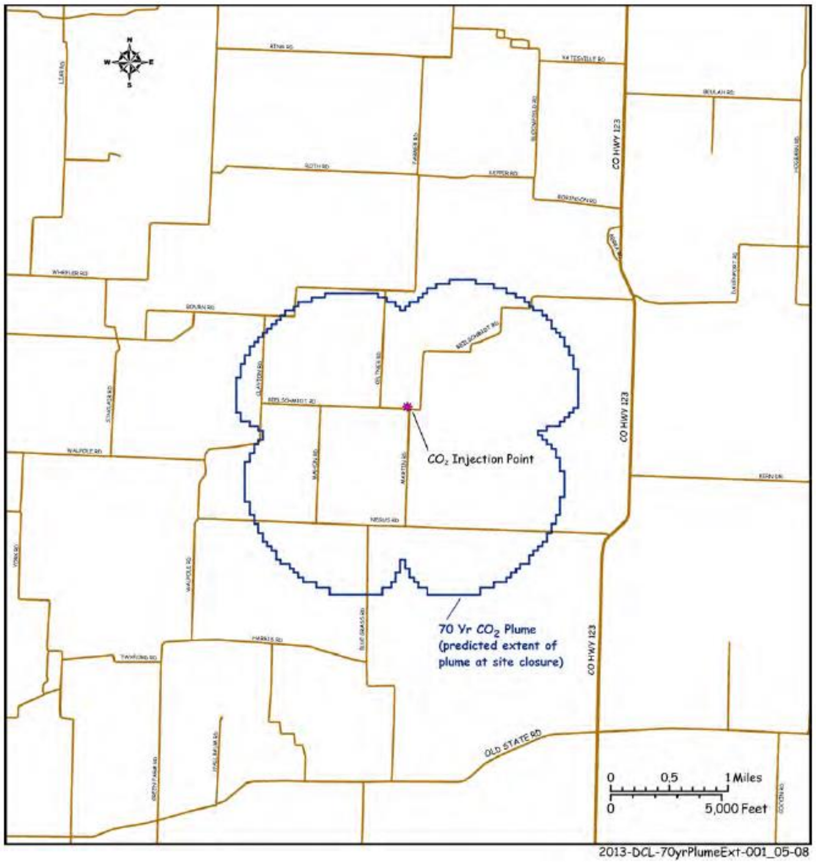


Figure 5. Simulated plume area over time (the vertical dashed line denotes the time CO_2 injection ceases) (Figure 7.2 in FutureGen's permit application).

The predicted extent of the CO_2 plume at the time of site closure, 50 years after the cessation of CO_2 injection, was determined from the computational model results.

Figure 6 shows the predicted areal extent of the CO_2 plume (defined as 99.0 percent of the separate-phase CO_2 mass) at the time of site closure. The simulation predictions show that 99.0 percent of the separate-phase CO_2 mass would be contained within an area of 6.35 mi^2 at the time of site closure. This plume is only 1.7% smaller than the maximum plume area, which occurs at 22 years after the start of injection (Figure 5. Simulated plume area over time (the vertical dashed line denotes the time CO_2 injection ceases) (Figure**Error! Reference source not found.**).


CO HWY 123
CO_2 Injection Point
70 Yr CO_2 Plume
(predicted extent of
plume at site closure)
OLD STATE RD
0 0.5 1 Miles
0 5,000 Feet
2013-DCL-70yrPlumeExt-001_05-08

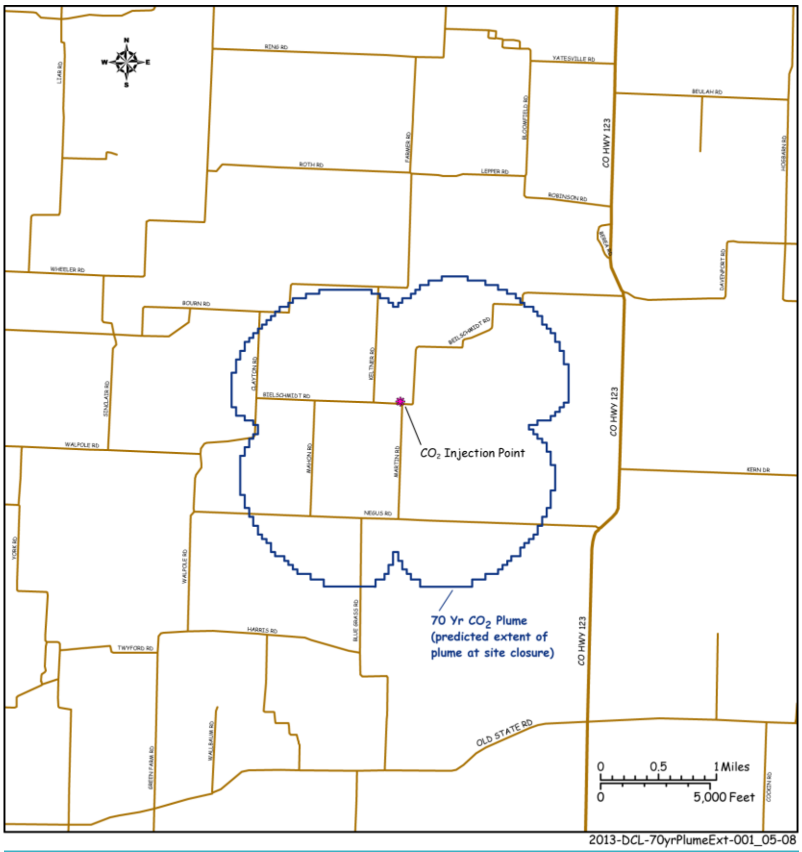


Figure 6. Simulated areal extent of the CO_2 plume at the time of site closure (70 years after CO_2 injection was initiated) (Figure 7.3 in FutureGen's permit application).

Post-Injection Monitoring Plan

FutureGen will perform post-injection monitoring, as required by 40 CFR 146.93(b), as described below.

Pressure monitoring of the injection zone will occur in four monitoring wells. The Testing and Monitoring ~~section of this permit~~Plan lists planned and considered monitoring. In addition, FutureGen will conduct groundwater sampling in the shallow, semi-consolidated glacial sediments that make up the surficial aquifer.

Commented [TE3]: Incorporate table or reference T&M Plan in the draft permit.

Three~~wo~~ fully cased reservoir access tubes (RATs) will be installed within the boundaries of the simulated 5-year CO_2 plume. The RATs will extend to the base of the reservoir and into the Precambrian bedrock. The RATs will be non-perforated, cemented casings used to monitor CO_2 arrival and quantify saturation levels via downhole pulsed-neutron capture (PNC) geophysical logging across the reservoir and confining zone.

A discussion and location map showing the updated and revised monitoring well network are provided below.

Location of Monitoring Wells

Monitoring well locations are described in the Testing and Monitoring Plan. Their coordinates are provided in Attachment A. The objective of the monitoring program is to select and implement a suite of monitoring technologies that are both technically robust and provide an effective means of 1) evaluating CO_2 mass balance and 2) detecting any unforeseen containment loss.

As part of the project's design optimization, the monitoring well network has been configured (Figure 7) to effectively monitor and account for the injected CO_2. The design includes a total of eight~~seven~~ monitoring wells as follows:

- Two Above Confining Zone (ACZ) wells – These wells will be used to monitor immediately above the Eau Claire caprock in the Ironton Sandstone. Monitored parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.

Commented [TE4]: Specify or reference table.

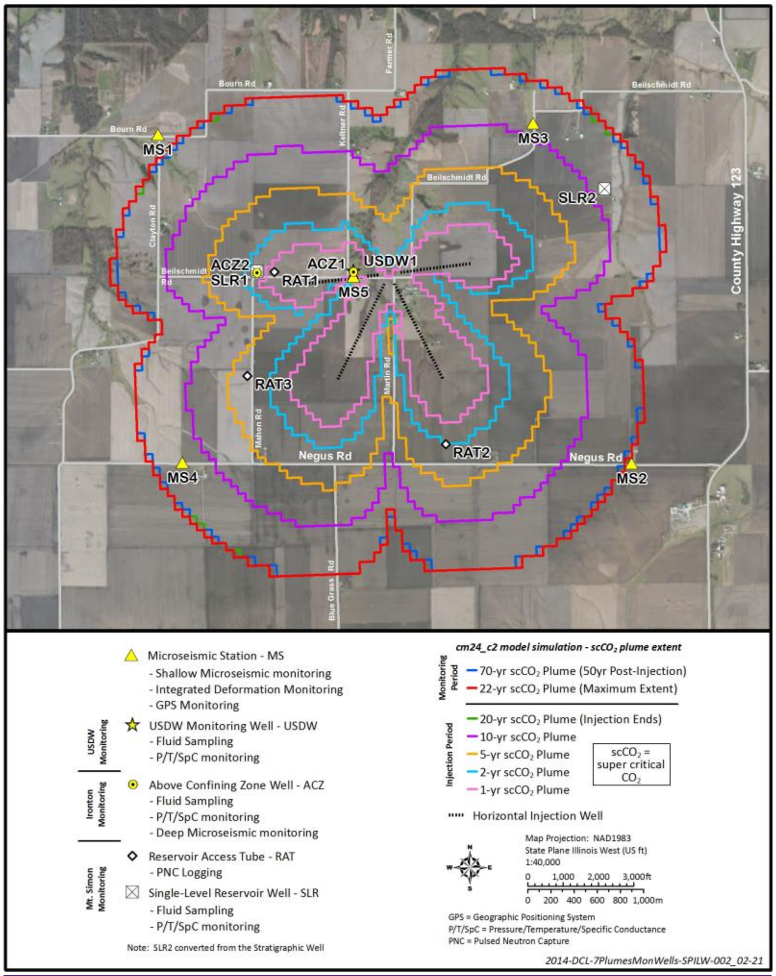
- Two ~~single-level in-reservoir (~~SLR~~)~~ wells (one of which is a reconfiguration of the previously drilled stratigraphic well~~). ~~) – These wells will be used to monitor within the injection zone beyond the east and west ends of the horizontal CO_2-injection laterals. Monitored parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.

Commented [TE5]: Specify or reference table.

- ~~Two~~ Three ~~reservoir access tube (~~RAT~~)~~ wells – These are fully cased wells, which allow access for monitoring instrumentation in the reservoir via ~~pulsed-neutron~~PNC logging equipment. ~~The wells will not be perforated so as~~ To avoid two-phase flow near the borehole, which can distort the CO_2 saturation measurements, the wells will not be perforated. Monitoring parameters: quantification of CO_2 saturation across the reservoir and caprock.

- One underground sources of drinking water (USDW) well − This well will be used to monitor the lowermost USDW (St. Peter Sandstone). Monitored parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.

Commented [TE6]: Specify or reference table.


Bourn Rd
Bourn Rd
Farmer Rd
Kettner Rd
Beilschmidt Rd
Beilschmidt Rd
Beilschmidt Rd
Clayton Rd
County Highway 123
MS1
MS2
MS3
MS4
MS5
SLR1
SLR2
ACZ1
ACZ2
USDW1
RAT1
RAT2
RAT3
Martin Rd
Mahon Rd
Negus Rd
Negus Rd
Blue Grass Rd
Microseismic Station - MS
- Shallow Microseismic monitoring
- Integrated Deformation Monitoring
- GPS Monitoring
USDW Monitoring
USDW Monitoring Well - USDW
- Fluid Sampling
- P/T/SpC monitoring
Ironton Monitoring
Above Confining Zone Well - ACZ
- Fluid Sampling
- P/T/SpC monitoring
- Deep Microseismic monitoring
Mt. Simon Monitoring
Reservoir Access Tube - RAT
- PNC Logging
Single-Level Reservoir Well - SLR
- Fluid Sampling
- P/T/SpC monitoring
Note: SLR2 converted from the Stratigraphic Well
cm24_c2 model simulation - $scCO_2$ plume extent
Monitoring Period
70-yr $scCO_2$ Plume (50yr Post-Injection)
22-yr $scCO_2$ Plume (Maximum Extent)
Injection Period
20-yr $scCO_2$ Plume (Injection Ends)
10-yr $scCO_2$ Plume
5-yr $scCO_2$ Plume
2-yr $scCO_2$ Plume
1-yr $scCO_2$ Plume
$scCO_2$ = super critical CO_2
Horizontal Injection Well
N
S
E
W
Map Projection: NAD1983
State Plane Illinois West (US ft)
1:40,000
0 1,000 2,000 3,000ft
0 200 400 600 800 1,000m
GPS = Geographic Positioning System
P/T/SpC = Pressure/Temperature/Specific Conductance
PNC = Pulsed Neutron Capture
2014-DCL-7PlumesMonWells-SPILW-002_02-21

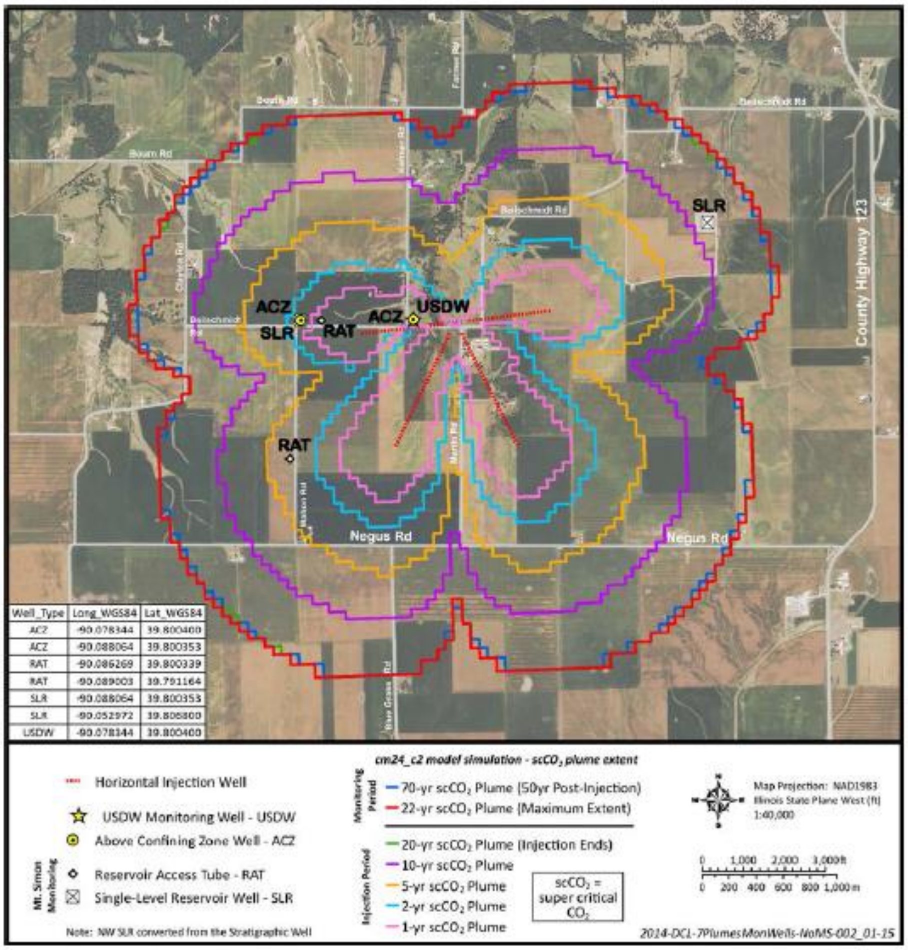
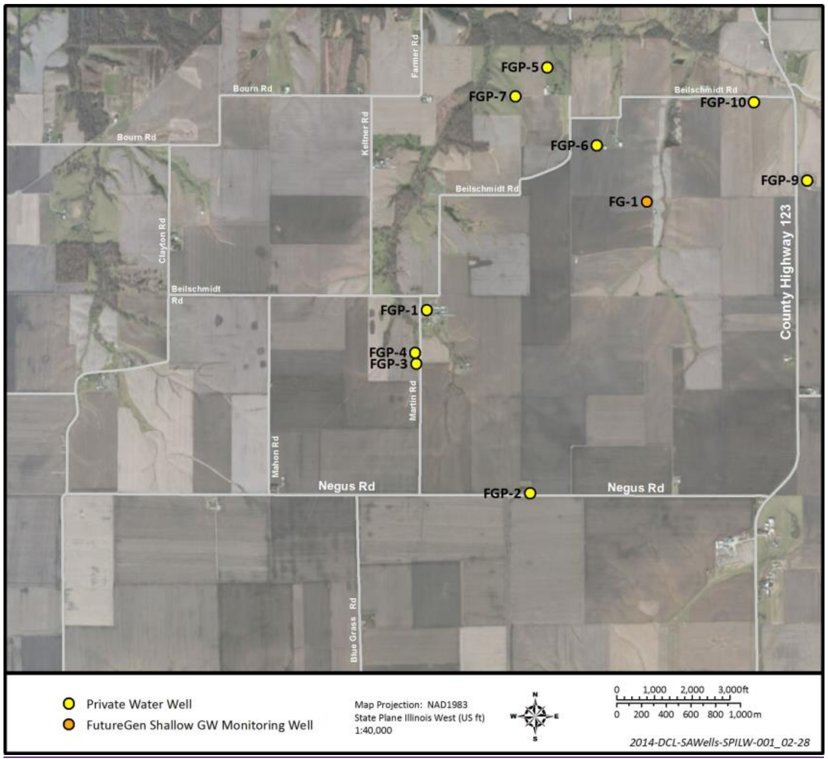


Figure 7. Updated and revised plan for monitoring wells (submitted January 2014).

FutureGen will also conduct sampling in the shallow, semi-consolidated glacial sediments that make up the surficial aquifer, using approximately 10 local landowner wells and one well drilled for the project~~(Figure 8)~~. The coordinates of these wells are provided in Attachment B.


FGP-5
FGP-7
FGP-10
FGP-6
FGP-9
FG-1
FGP-1
FGP-4
FGP-3
FGP-2
Bourn Rd
Farmer Rd
Kettner Rd
Beilschmidt Rd
Clayton Rd
Beilschmidt Rd
Martin Rd
Mahon Rd
Negus Rd
Blue Grass Rd
County Highway 123
Private Water Well
FutureGen Shallow GW Monitoring Well
Map Projection: NAD1983
State Plane Illinois West (US ft)
1:40,000
0 1,000 2,000 3,000ft
0 200 400 600 800 1,000m
2014-DCL-SAWells-SPILW-001_02-28

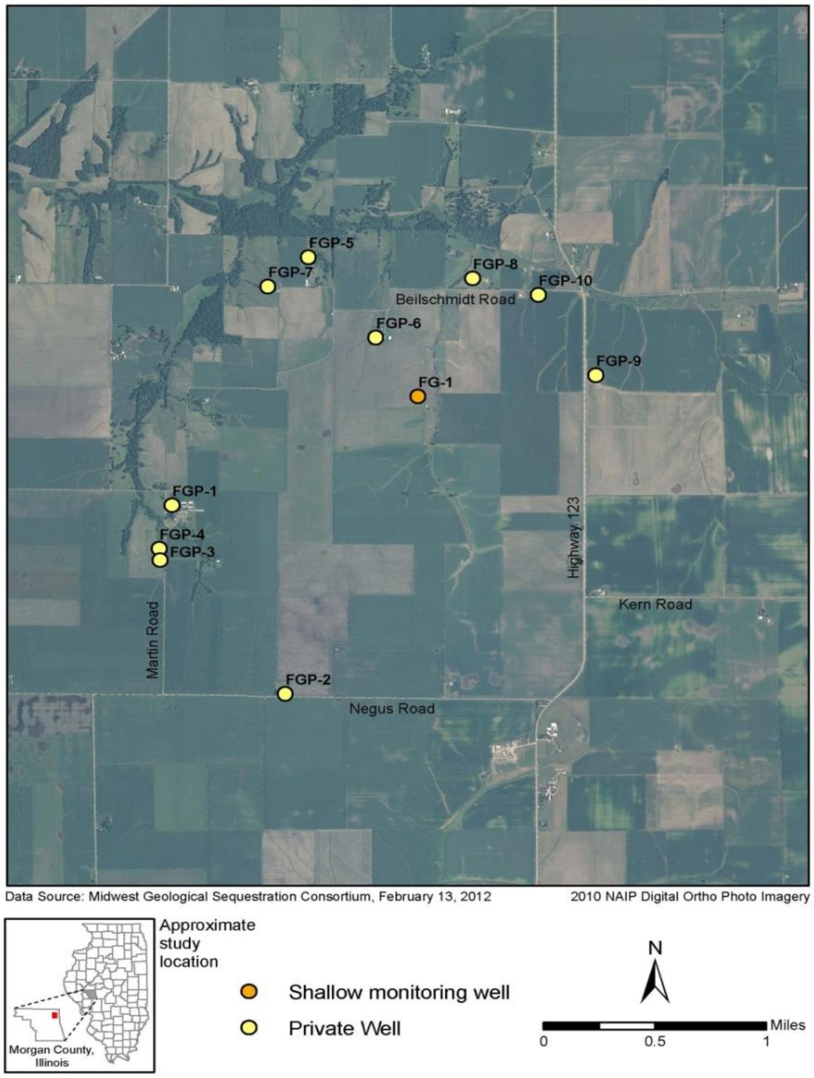


Figure 8. Surficial aquifer monitoring locations. Well FG-1 is a dedicated well drilled for the purposes of the FutureGen project, while wells FGP-1 through FGP-10 wells are local landowner wells.

Commented [TE7]: Add corresponding table with GPS coordinates for proposed groundwater monitoring wells (consistent with T&M Plan)

FutreuGen : provided in attachment

Summary of Planned Post-Injection Monitoring Activities

A suite of indirect geophysical monitoring methods were evaluated to assess their efficacy and effectiveness for monitoring the areal extent, evolution, and fate and transport of the injected CO_2 plume under site-specific conditions. Technologies that were retained for implementation in the monitoring program include PNC logging, passive seismic monitoring, integrated surface deformation monitoring, and time-lapse gravity surveys. These methodologies will be applied during both injection and post-injection phases of the project. ~~The following table~~Table 2 summarizes the testing and monitoring activities planned for the post-injection phase.

Table 2. Summary of post-injection monitoring activities.

Monitoring Category	Monitoring Method/Location	Frequency (Post-Injection Phase)
Groundwater Quality and Geochemistry Monitoring	Fluid sampling in surficial aquifers: 10 local landowner wells and 1 project-drilled well	~~Every 5 years~~None Planned
	Fluid sampling in St. Peter: one lowermost USDW well	Geochemistry Every 5 years Continuous temperature and pressure monitoring
	Fluid sampling in Ironton: two ACZ wells	Geochemistry Every 5 years Continuous temperature and pressure monitoring
Injection Zone Monitoring	Fluid sampling in Mount Simon: two single-level monitoring wells	Every 5 years
	Pulsed-neutron capture (PNC) logging at 3 RAT wells	Every 5 years
	Pressure monitoring in Mount Simon: two single-level monitoring wells	Continuous
Indirect Geophysical Monitoring Techniques	Integrated deformation monitoring: five surface monitoring stations	Continuous
	Passive ~~Passive seismic monitoring (microseismicity): five surface monitoring stations and downhole~~ deep microseismic arrays in two ACZ wells and five seismometers in shallow cased bore holes.	Continuous

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Groundwater Quality Monitoring

FutureGen will conduct groundwater sampling every 5 years according to the procedures described below, from Section 7.2.1 of the permit application.

Explicitly specify which **specific parameters** that will be analyzed. FutureGen is also lacking specific details in its sampling methods, analytical techniques, laboratory information, and quality assurance and surveillance measures. [Request from FutureGen.]

Commented [TE8]: Groundwater sampling parameters.

Commented [TE9]: Request QASP.

Specific information concerning the sampling methods, analytical techniques, laboratories and quality assurance for sampling for the post-injection monitoring program are presented in the FutureGen Quality Assurance and Surveillance Plan (QASP). See QASP Table A.2 for Monitoring Tasks, Methods, and Schedule. The information is summarized below.

Sampling will take place at the frequencies specified in Table 3 (for the surficial aquifers), Table 4 (for the St. Peter), and Table 5 (for the Ironton). Because near-surface environmental impacts are not expected, surficial aquifer (<100 ft bgs) monitoring will only be conducted for a sufficient duration to establish baseline conditions (minimum of three sampling events). Surficial aquifer monitoring is not planned during the injection phase; however, the need for additional surficial aquifer monitoring will be continually evaluated throughout the operational phases of the project, and may be reinstituted if conditions warrant or if requested by the EPA UIC Program Director.

Target parameters for the ACZ wells include pressure, temperature, and hydrogeochemical indicators of CO_2 (Table 6) and brine composition. A comprehensive suite of geochemical and isotopic analyses will be performed on collected fluid samples and analytical results will be used to characterize baseline geochemistry and provide a metric for comparison during operational phases. Selection of this initial analyte list was based on relevance for detecting the presence of fugitive brine and CO_2. Results for this comprehensive set of analytes will be evaluated and a determination will be made regarding which analytes to carry forward through the operational phases of the project. This selection process will consider the uniqueness and signature strength of each potential analyte and whether their characteristics provide for a high-value leak-detection capability. Once baseline conditions have been established, observed differences in the geochemical and isotopic signature between the reservoir and overlying monitoring intervals, along with predictions of leakage-related pressure response, will be used to specify triggers values that would prompt further action, including a detailed evaluation of the observed response and possible modification of the monitoring approach and/or storage site operations. This evaluation will be supported by numerical modeling of theoretical leakage scenarios that will be used to evaluate leak-detection capability and interpret any observed pressure and/or geochemical/isotopic change in the ACZ wells.

Commented [TE10]: Specify or reference table 5.

Target parameters for the USDW and surficial aquifer wells include pressure, temperature, and hydrogeochemical indicators of CO_2 (Table 6) and brine composition. A comprehensive suite of geochemical and isotopic analyses will be performed on collected fluid samples during the

Commented [TE11]: Specify or include table for reference…or reference table 3.

baseline monitoring period. Tables 7 and 8 in the FutureGen 2.0 Testing and Monitoring Plan respectively list of the initial parameters to be sampled and analyzed, respectively. The selection of this initial analyte list was based on relevance for detecting the presence of fugitive brine and CO_2. Results for this comprehensive set of analytes will then be evaluated and a determination will be made regarding which analytes to carry forward through the operational phases of the project. This selection process will consider the uniqueness and signature strength of each potential analyte and whether their characteristics provide for a high–value leak-detection capability. Trigger values for the lowermost USDW monitoring well and the surficial aquifer monitoring wells have not been defined. If a leakage response is observed in the ACZ early-detection monitoring wells (Ironton) then the decision not to institute USDW aquifer triggers will be reevaluated based on the magnitude of the observed leakage response and predictive simulations of CO_2 transport between the Ironton and the St. Peter aquifers.

Note: FutureGen has **not yet submitted a final list of the planned parameters**; see the text above. In particular, aqueous and/or separate-phase CO_2 is not listed as a target parameter under consideration in these tables, and this should be discussed further. Depending on the final suite of parameters chosen, it may be appropriate to monitor for CO_2 indirectly, e.g., by monitoring dissolved inorganic carbon concentrations in combination with pH as recommended by researchers such as Wilkin and Digiulio (2010). However, this determination will need to be made after the final list of parameters is received. (Reference: Wilkin, R.T. and D.C. Digiulio. 2010. Geochemical Impacts to Groundwater from Geologic Carbon Sequestration: Controls on pH and Inorganic Carbon Concentrations from Reaction Path and Kinetic Modeling. Environ. Sci. Technol. 44(12): 4821-4827.)

Also, while the "ACZ - PISC" tab of the January 2014 spreadsheet indicates that FutureGen is planning to take samples from the surficial aquifers every five years, **the "ACZ - Inj" tab indicates that FutureGen does not plan to take any samples from the surficial aquifers after the baseline period**. This should be clarified.

Commented [TE12]: Request spreadsheet be completed or simply include frequency in PISC.

Table 33. Sampling schedule for surficial aquifer monitoring wells.

Monitoring well name/location/map reference: Surficial aquifer monitoring wells **Well depth/formation(s) sampled:** Shallow glacial sediments (approx. 17 ft – 49 ft)	
Parameter/Analyte	**Frequency (Post-Injection Phase)**
Dissolved or separate-phase CO_2	Every 5 years None Planned
Pressure	None Planned Every 5 years
Temperature	None Planned Every 5 years
Other parameters, including total dissolved solids, pH, specific conductivity, major cations and anions, trace metals, dissolved inorganic carbon, total organic carbon, carbon and water isotopes, and radon	None Planned Every 5 years

Table 44. Sampling schedule for the USDW monitoring well.

Monitoring well name/location/map reference: One USDW monitoring well (see Figure 7) **Well depth/formation(s) sampled:** St. Peter Sandstone (2,000 ft)	
Parameter/Analyte	**Frequency (Post-Injection Phase)**
Dissolved or separate-phase CO_2	Every 5 years
Pressure	Continuous
Temperature	Continuous
Other parameters, including total dissolved solids, pH, specific conductivity, major cations and anions, trace metals, dissolved inorganic carbon, total organic carbon, carbon and water isotopes, and radon	Every 5 years

Table 55. Sampling schedule for ACZ monitoring wells.

Monitoring well name/location/map reference: Two ACZ monitoring wells (see **Error! Reference source not found.**7) **Well depth/formation(s) sampled:** Ironton Sandstone (3,470 ft)	
Parameter/Analyte	**Frequency (Post-Injection Phase)**
Dissolved or separate-phase CO_2	Every 5 years
Pressure	Continuous
Temperature	Continuous
Other parameters, including total dissolved solids, pH, specific conductivity, major cations and anions, trace metals, dissolved inorganic carbon, total organic carbon, carbon and water isotopes, and radon	Every 5 years

Sampling methods:

~~SA s~~ampling ~~plan~~ procedures are~~is referenced~~ discussed below, ~~but not provided~~ and specific details are provided in the FutureGen QASP Table A.2.

Specific field sampling protocols are in the project-specific sampling plan to be developed prior to initiation of field test operations, once the test design has been finalized. The work will comply with applicable U.S. Environmental Protection Agency (EPA) regulatory procedures and relevant ~~American Society for Testing and Material~~ASTM International, ~~IS~~ and other procedural standards applicable for groundwater sampling and analysis. All sampling and analytical measurements will be performed in accordance with project quality assurance (QA) requirements, samples will be tracked using appropriately formatted chain-of-custody forms, and analytical results will be managed in accordance with a project-specific data management plan. Investigation-derived waste will be handled in accordance with site requirements.

During all groundwater sampling, field parameters (pH, specific conductance, and temperature) will be monitored for stability and used as an indicator of adequate well purging (i.e., parameter stabilization provides indication that a representative sample has been obtained). Calibration of field probes will follow the manufacturer's instructions using standard calibration solutions. A comprehensive list of target analytes under consideration and groundwater sample collection requirements is provided in Table 6. The relative benefit of each analytical measurement will be evaluated throughout the design and initial injection testing phase of the project to identify the analytes best suited to meeting project monitoring objectives under site-specific conditions. If some analytical measurements are shown to be of limited use and/or cost prohibitive, they will be removed from the analyte list. All analyses will be performed in accordance with the analytical requirements listed in Table 7. Additional analytes may be included for the shallow USDW based on landowner requests (e.g., coliform bacteria). If implemented, monitoring for tracers will follow standard aqueous sampling protocols.

Sampling and analytical techniques for target parameters are given in Table 6 and Table 7, respectively.

Table 6. Aqueous sampling requirements for target parameters (adapted from Table 7 of FutureGen's Testing and Monitoring Plan ~~permit application~~).

Parameter	Volume/Container	Preservation	Holding Time
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Trace Metals: Sb, As, Cd, Cr, Cu, Pb, Se, Tl	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Cyanide (CN-)	250-mL plastic vial	NaOH to pH > 12, 0.6g ascorbic acid Cool 4°C,	14 days
Mercury	250-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	28 days
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, NO_3^-	125-mL plastic vial	Filtered (0.45 µm), Cool 4°C	45 days
Total and Bicarbonate Alkalinity (as $CaCO_3^{2-}$)	100-mL HDPE	Filtered (0.45 µm), Cool 4°C	14 days
Gravimetric Total Dissolved Solids (TDS)	250-mL plastic vial	Filtered (0.45 µm), no preservation, Cool 4°C	7 days
Water Density	100-mL plastic vial	No preservation, Cool 4°C	
Total Inorganic Carbon (TIC)	250-mL plastic vial	H_2SO_4 to pH <2, Cool 4°C	28 days
Dissolved Inorganic Carbon (DIC)	250-mL plastic vial	Filtered (0.45 µm), H_2SO_4 to pH <2, Cool 4°C	28 days
Total Organic Carbon (TOC)	250-mL amber glass	Unfiltered, H_2SO_4 to pH <2, Cool 4°C	28 days
Dissolved Organic Carbon (DOC)	125-mL plastic vial	Filtered (0.45 µm), H_2SO_4 to pH <2, Cool 4°C	28 days

Volatile Organic Analysis (VOA)	Bottle set 1: 3-40-mL sterile clear glass vials Bottle set 2: 3-40-mL sterile amber glass vials	Zero headspace, Cool <6 °C, Clear glass vials will be UV-irradiated for additional sterilization	7 days
Methane	Bottle set 1: 3-40-mL sterile clear glass vials Bottle set 2: 3-40-mL sterile amber glass vials	Zero headspace, Cool <6 °C, Clear glass vials (bottle set 1) will be UV-irradiated for additional sterilization	7 days
Stable Carbon Isotopes $^{13/12}C$ ($\delta^{13}C$) of DIC in Water	60--mL plastic or glass	Filtered (0.45-µm), Cool 4°C	14 days
Radiocarbon ^{14}C of DIC in Water	60-mL plastic or glass	Filtered (0.45-µm), Cool 4°C	14 days
Hydrogen and Oxygen Isotopes $^{2/1}H$ (δD) and $^{18/16}O$ ($\delta^{18}O$) of Water	60-mL plastic or glass	Filtered (0.45-µm), Cool 4°C	45 days
Carbon and Hydrogen Isotopes (^{14}C, $^{13/12}C$, $^{2/1}H$) of Dissolved Methane in Water	1-L dissolved gas bottle or flask	Benzalkonium chloride capsule, Cool 4°C	90 days
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H_{10}, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_6+)	1-L dissolved gas bottle or flask	Benzalkonium chloride capsule, Cool 4°C	90 days
Radon (^{222}Rn)	1.25-L PETE	Pre-concentrate into 20-mL scintillation cocktail. Maintain groundwater temperature prior to pre-concentration	1 day
pH	Field parameter	None	<1 h
Specific Conductance	Field parameter	None	<1 h
HDPE = high-density polyethylene; PETE = polyethylene terephthalate			
HDPE = high-density polyethylene; PETE = polyethylene terephthalate			

Parameter	Volume/Container	Preservation	Holding Time
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Trace Metals: Sb, As, Ba, Cd, Cr, Cu, Pb, Hg, Se, Tl	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, NO_3^-,	20-mL plastic vial	Cool 4°C	45 days
Gravimetric Total Dissolved Solids (TDS), compare to TDS by calculation from major ions	250-mL plastic vial	Filtered (0.45 µm), no preservation Cool 4°C	-
Water Density	100 mL plastic vial	Filtered (0.45 µm), no preservation Cool 4°C	60 days
Alkalinity	100 mL HDPE	Filtered (0.45 µm) Cool 4°C	5 days
Dissolved Inorganic Carbon (DIC)	20-mL plastic vial	Cool 4°C	45 days
Total Organic Carbon (TOC)	40 mL glass	unfiltered	14 days
Carbon Isotopes (^{14}C, $^{13/12}C$)	5-L HDPE	pH >6	14 days
Water Isotopes ($^{2/1}H$, $^{18/16}O$)	20-mL glass vial	Cool 4°C	45 days
Radon (^{222}Rn)	1.25-L PETE	Pre-concentrate into 20-mL scintillation cocktail. Maintain groundwater temperature prior to pre-concentration	1 day
Naphthalene Sulfonate or Fluorinated Benzoic Acid Tracers (aqueous phase)	500 mL HDPE	Filtered (0.45 µm), no preservation	60 days
Perfluorocarbon Tracer (PFT) ($scCO_2$ or gas phase)	500 mL glass	unfiltered, Cool 4°C	60 days
pH	Field parameter	None	<1 h
Specific Conductance	Field parameter	None	<1 h
Temperature	Field parameter	None	<1 h

HDPE = high-density polyethylene; PETE = polyethylene terephthalate

Table 7. Analytical requirements (adapted from Table A.7- of FutureGen's permit applicationTesting and Monitoring PlanQASP).

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	ICP-AES, EPA Method 6010B or similar	1 to 80 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Trace Metals: Sb, As, Cd, Cr, Cu, Pb, Se, Tl	ICP-MS, EPA Method 6020 or similar	0.1 to 2 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Cyanide (CN-)	SW846 9012A/B	5 µg/L	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Mercury	CVAA SW846 7470A	0.2 µg/L	±20%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, NO_3^-	Ion Chromatography, EPA Method 300.0A or similar	33 to 133 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Total and Bicarbonate Alkalinity (as $CaCO_3^{2-}$)	Titration, Standard Methods 2320B	1 mg/L	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Gravimetric Total Dissolved Solids (TDS	Gravimetric Method Standard Methods 2540C	10 mg/L	±10%	Balance calibration, duplicate samples
Water Density	ASTM D5057	0.01 g/mL	±10%	Balance calibration, duplicate samples
Total Inorganic Carbon (TIC)	SW846 9060A or equivalent Carbon analyzer, phosphoric acid digestion of TIC	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Dissolved Inorganic Carbon (DIC)	SW846 9060A or equivalent Carbon analyzer, phosphoric acid digestion of DIC	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Total Organic Carbon (TOC)	SW846 9060A or equivalent Total organic carbon is converted to carbon dioxide by chemical oxidation of the organic carbon in the sample. The carbon dioxide is measured using a non-dispersive infrared detector.	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Dissolved Organic Carbon (DOC)	SW846 9060A or equivalent Total organic carbon is converted to carbon dioxide by chemical oxidation of the organic carbon in the sample. The carbon dioxide is measured using a non-dispersive infrared detector.	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Volatile Organic Analysis (VOA)	SW846 8260B or equivalent Purge and Trap GC/MS	0.3 to 15 µg/L	±20%	Blanks, LCS, spike, spike duplicates per batch of 20
Methane	RSK 175 Mod Headspace GC/FID	10 µg/L	±20%	Blanks, LCS, spike, spike duplicates per batch of 20

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Stable Carbon Isotopes $^{13/12}C$ ($1^{13}C$) of DIC in Water	Gas Bench for $^{13/12}C$	50 ppm of DIC	±0.2p	Duplicates and working standards at 10%
Radiocarbon ^{14}C of DIC in Water	AMS for ^{14}C	Range: 0 i 200 pMC	±0.5 pMC	Duplicates and working standards at 10%
Hydrogen and Oxygen Isotopes $^{2/1}H$ (δ) and $^{18/16}O$ ($1^{18}O$) of Water	CRDS H_2O Laser	Range: -500‰ to 200‰ vs. VSMOW	$^{2/1}H$: ±2.0‰ $^{18/16}O$: ±0.3‰	Duplicates and working standards at 10%
Carbon and Hydrogen Isotopes (^{14}C, $^{13/12}C$, $^{2/1}H$) of Dissolved Methane in Water	Offline Prep & Dual Inlet IRMS for ^{13}C; AMS for ^{14}C	^{14}C Range: 0 & DupMC	^{14}C: ±0.5pMC ^{13}C: ±0.2‰ $^{2/1}H$: ±4.0‰	Duplicates and working standards at 10%
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H_{10}, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_6+)	Modified ASTM 1945D	1 to 100 ppm (analyte dependent)	Varies by compon-ent	Duplicates and working standards at 10%
Radon (^{222}Rn)	Liquid scintillation after pre-concentration	5 mBq/L	±10%	Triplicate analyses
pH	pH electrode	2 to 12 pH units	±0.2 pH unit For indication only	User calibrate, follow manufacturer recommendations
Specific Conductance	Electrode	0 to 100 mS/cm	±1% of reading For indication only	User calibrate, follow manufacturer recommendations

ICP-AES = inductively coupled plasma atomic emission spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; LCS = laboratory control sample; GC/MS = gas chromatography–mass spectrometry; GC/FID = gas chromatography with flame ionization detector; AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; IRMS = isotope ratio mass spectrometry; LC-MS = liquid chromatography-mass spectrometry; ECD = electron capture detector

~~Parameter~~	~~Analysis Method~~	~~Detection Limit or Range~~	~~Typical Precision/ Accuracy~~	~~QC Requirements~~
~~Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,~~	~~ICP-OES, PNNL-AGG-ICP-AES (similar to EPA Method 6010B)~~	~~0.1 to 1 mg/L (analyte dependent)~~	~~±10%~~	~~Daily calibration; blanks and duplicates and matrix spikes at 10% level per batch of 20~~

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Trace Metals: Sb, As, Ba, Cd, Cr, Cu, Pb, Hg, Se, Tl	ICP-MS, PNNL-AGG-415 (similar to EPA Method 6020)	1 µg/L for trace elements	±10%	Daily calibration; blanks and duplicates and matrix spikes at 10% level per batch of 20
Anions: Cl^-, Br^-, F^-, $SO4^{2-}$, NO_3^-, CO_3^{2-}	Ion Chromatography, AGG-IC-001 (based on EPA Method 300.0A)	-	±15%	Daily calibration; blanks and duplicates at 10% level per batch of 20
TDS	Gravimetric Method Standard Methods 2540C	12 mg/L	± 5%	Balance calibration, triplicate samples
Water Density	Standard Methods 227	0.0001 g/mL	±0.0%	Triplicate measurements
Alkalinity	Titration, standard methods 102	4 mg/L	±3 mg/L	Triplicate titrations
Dissolved Inorganic Carbon (DIC)	Carbon analyzer, phosphoric acid digestion of DIC	0.002%	±10%	Triplicate analyses, daily calibration
Total Organic Carbon (TOC)	Carbon analyzer; total carbon by 900°C pyrolysis minus DIC = TOC	0.002%	±10%	Triplicate analyses, daily calibration
Carbon Isotopes ($^{14/12}C$, $^{13/12}C$)	Accelerator MS	10^{-15}	±4‰ for ^{14}C; ±0.2‰ for ^{13}C	Triplicate analyses
Water Isotopes ($^2H/^1H$, $^{18/16}O$)	Water equilibration coupled with IRMS ; Alternatively, consider WS-CRDS	10^{-9}	IRMS: ±1.0‰ for ^2H; ±0.15‰ for ^{18}O; WS-CRDS: ±0.10‰ for ^2H; ±0.025‰ for ^{18}O	Triplicate analyses
Radon (^{222}Rn)	Liquid scintillation after pre-concentration	5 mBq/L	±10%	Triplicate analyses
Naphthalene Sulfonate **or** Benzoic Acid Tracer (aqueous phase)	Liquid chromatography-mass spectrometry (LC-MS) **or** gas chromatography with electron capture detector (ECD)	5 parts per trillion (5 x 10^{12}) **or** 10 parts per quadrillion (10 x 10^{15})	Varies with conc.,±30% at detection limit	Duplicates 10% of samples, significant number of blanks for cross-contamination
Perfluorocarbon Tracer (PFT) (scCO_2 or gas phase)	Gas chromatography with electron capture detector (ECD)	10 parts per quadrillion (10 x 10^{15})	Varies with conc., ±30% at detection limit	Duplicates 10% of samples, significant number of blanks for cross-contamination
pH	pH electrode	2 to 12 pH units	±0.2 pH unit For indication only	User calibrate, follow manufacturer recommendations

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Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Specific conductance	Electrode	0 to 100 mS/cm	±1% of reading For indication only	User calibrate, follow manufacturer recommendations
Temperature	Thermocouple	5 to 50°C	±0.2°C For indication only	Factory calibration
ICP = inductively coupled plasma; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; OES = optical emission spectrometry; WS-CRDS = wavelength scanned cavity ring-down spectroscopy.				

Laboratory to be used/chain-of-custody procedures:

Samples will be tracked using appropriately formatted chain-of-custody forms. The sample handling and chain of custody of water, flormation fluids, and pipeline fluid as well as environmental gas or air samples will conform to EPA guidance as discussed in Section B.1.3 of the FutureGen 2.0 QASP.

Detail in its description of laboratory and chain-of-custody procedures is limited. FutureGen should provide a more detailed Testing and Monitoring Plan containing this information. a[Request from FutureGen.]

FutureGen Response: See FutureGen QASP Sections B.1.3, B.1.5 thru B.1.7.

Quality assurance and surveillance measures:

The Quality Assurance and Surveillance QASP is incorporated as an attachment to the Testing and Monitoring Plan.

Data quality assuranceQA and surveillance protocols adopted by the project are designed to facilitate compliance with the requirements specified in 40 CFR 146.90(k). Quality Assurance (QA) requirements for direct measurements within the injection zone, above the confining zone, and within the shallow USDW aquifer that are critical to the Monitoring, Verification, and Accounting (MVA) program (e.g., pressure and aqueous concentration measurements). QA requirements for selected geophysical methods, which provide indirect measurements of CO_2 nature and extent will be performed based on best industry practices and the QA protocols recommended by the geophysical services contractors selected to perform the work.

FutureGen lacks detail in its description of quality assurance and surveillance protocols. [Request from FutureGen.]

Section B of the FutureGen QASP provides details of QA and surveillance protocols.

Plan for guaranteeing access to all monitoring locations:

The locations of the ACZ and USDW wells ha~~s~~ve been finalized, pending final signing of landowner agreements. For these wells, the land will either be purchased or leased for the life of the project, so access will be secured.

Access to the surficial aquifer wells will not be required over the lifetime of the project. Access to wells for baseline sampling has been on a voluntary basis by the well owner. Ten local landowners originally agreed to have their surficial aquifer wells sampled; one opted out during a recent sampling event.

Carbon Dioxide Plume and Pressure-Front Tracking

Direct Pressure Monitoring

FutureGen will conduct direct pressure-front monitoring to meet the requirements of 40 CFR 146.93(b). Continuous monitoring of injection zone pressure and temperature (P/T) will be performed with sensors installed in wells that are completed in the injection zone. P/T monitoring in the monitoring wells will be performed using a real-time monitoring system with surface readout capabilities so that pressure gauges do not have to be removed from the well to retrieve data. Power for all monitoring wells will be provided by a stand-alone solar array with battery backup so that a dedicated power supply to these more distal locations is not required.

The following measures will be taken to ensure that the pressure gauges are providing accurate information on an ongoing basis:

- High-quality (high-accuracy, high-resolution) gauges with low drift characteristics will be used.

- Gauge components (gauge, cable head, cable) will be manufactured of materials designed to provide a long life expectancy for the anticipated downhole conditions.

- Upon acquisition, a calibration certificate will be obtained for every pressure gauge. The calibration certificate will provide the manufacturer's specifications for range, accuracy (% full scale), resolution (% full scale), ~~and~~ drift (< psi per year), and calibration results for each parameter. The calibration certificate will also provide the date that the gauge was calibrated and the methods and standards used.

- Gauges will be installed above any packers so they can be removed if necessary for recalibration by removing the tubing string. Redundant gauges may be run on the same cable to provide confirmation of downhole pressure and temperature. Pressure gauges will be calibrated on an annual basis with current annual calibration certificates provided with test results to the EPA. In lieu of removing the injection tubing, the calibration of downhole pressure gauges will demonstrate accuracy by using a second pressure gauge, with current certified calibration, that will be lowered into the well to the same depth as the permanent downhole gauge. Calibration curves, based on annual calibration checks (using the second calibrated pressure gauge) developed for the downhole gauge, can be used for the purpose of the fall-off test. If used, these calibration curves (showing all historic pressure deviations) will accompany the fall-off test data submitted to the EPA.

- Upon installation, all gauges will be tested to verify they are functioning (reading/transmitting) correctly.
- Gauges will be pulled and recalibrated whenever a workover occurs that involves removal of tubing. A new calibration certificate will be obtained whenever a gauge is recalibrated.

Once the reservoir model has been updated with detailed site-specific information from the injection site, predictive simulations of pressure response will be generated for each ~~single-level reservoir monitoring~~SLR well. These predicted responses will be compared ~~to~~ with monitoring results throughout the operational phase of the project and significant deviation in observed response would result in further action, including a detailed evaluation of the observed response, calibration/refinement of the numerical model, and possible modification to the monitoring approach and/or storage site operations.

Direct pressure monitoring in the injection zone will take place as indicated in Table 8.

Table 8. Monitoring schedule for direct pressure-front tracking.

Well Location/Map Reference	Depth(s)/Formation(s)	Frequency (Post-Injection Phase)
Two single-level monitoring wells (SLR Wells 1 and 2, see Figure 7)	Mount Simon/4,150 ft.	Continuous

Quality assurance and surveillance measures:

Data ~~quality assurance~~QA and surveillance protocols adopted by the project will be designed to facilitate compliance with the requirements specified in 40 CFR 146.90(k). ~~Quality Assurance (~~QA~~)~~ requirements for direct measurements within the injection zone, above the confining zone, and within the shallow USDW aquifer that are critical to the MVA program (e.g., pressure and aqueous concentration measurements) are covered in Sections 5.2.2 and 5.2.3 above. QA requirements for selected geophysical methods, which provide indirect measurements of CO_2 nature and extent and are being tested for their applicability under site conditions, are not addressed in this plan. These measurements will be performed based on best industry practices and the QA protocols recommended by the geophysical services contractors selected to perform the work.

FutureGen is also lacking specific details in its quality assurance and surveillance measures. FutureGen should provide more detailed quality assurance and surveillance measures. [Request from FutureGen.]

FutureGen Response: See FutureGen QASP Section B.7.

Plan for guaranteeing access to all monitoring locations:

The location of these wells has been finalized, pending final signing of landowner agreements. The land will either be purchased or leased for the life of the project, so access will be secured.

Direct Geochemical Plume Monitoring

FutureGen will conduct direct CO_2 plume monitoring to meet the requirements of 40 CFR 146.93(b). Target parameters include pressure, temperature, and hydrogeochemical indicators of CO_2 and brine composition. A comprehensive suite of geochemical and isotopic analyses will be performed on collected fluid samples and analytical results will be used to characterize baseline geochemistry and provide a metric for comparison during operational phases. Selection of this initial analyte list was based on relevance for detecting the presence of CO_2 within the reservoir and fugitive brine and CO_2 above the primary confining zone. The results for this comprehensive set of analytes will be evaluated and a determination will be made regarding which analytes to carry forward through the operational phases of the project. This selection process will consider the uniqueness and signature strength of each potential analyte and whether their characteristics provide for a high-value leak-detection capability. Once baseline hydrogeochemical/isotopic conditions have been established and the reservoir model has been refined, predictive simulations of pressure and CO_2 arrival response will be generated for each SLR monitoring well. These predicted responses will be compared with monitoring results throughout the operational phase of the project and significant deviation in observed response would result in further action, including a detailed evaluation of the observed response, calibration/refinement of the numerical model, and possible modification to the monitoring approach and/or storage site operations.

Commented [TE13]: Specify or reference table.

In addition to direct plume sampling and characterization, indirect montoring of the CO_2 plume will be conducted by continuing the periodic PNC logging across the injection zone and primary confining zone. PNC logging is a proven method for quantifying CO_2 saturation around a borehole. The PNC logging will be conducted using the three RAT wells. The RAT wells will be logged every 5 years during the post-injection period. Information collected will be compared with prior logs to determine trends.

Direct fluid sampling in the injection zone will take place as ~~shown~~ indicated in Table 9.

Table 9. Monitoring schedule for direct geochemical plume monitoring.

Monitoring well name/location/map reference: Two SLR monitoring wells (see Figure 7) **Well depth/formation(s) sampled:** Mount Simon Sandstone (4,150 ft)	
Parameter/Analyte	**Frequency (Post-Injection Phase)**
Dissolved or separate-phase CO_2	Every 5 years
Pressure	Continuous
Temperature	Continuous
Other parameters, including major cations and anions, selected metals, general water-quality parameters (pH, alkalinity, total dissolved solids, specific gravity), and any tracers added to the CO_2 stream	Every 5 years

Sampling methods:

The FutureGen QASP and Testing and Monitoring Plan provide supplemental details about the sampling and analysis protocols for the direct fluid sampling that are outlined below.

A sampling plan is referenced below, but not provided.

Periodically, fluid samples will be collected from the monitoring wells completed in the injection zone. Fluid samples will be collected using an appropriate method to preserve the fluid sample at injection zone temperature and pressure conditions. Examples of appropriate methods include using a bomb-type sampler (e.g., Kuster sampler) after pumped or swabbed purging of the sampling interval, using a Westbay sampler, or using a pressurized U-tube sampler (Freifeld et al. 2005). These types of pressurized sampling methods are needed to collect the two-phase fluids (i.e., aqueous and $scCO_2$ solutions) for measurement of the percent of water and CO_2 present at the monitoring location. Fluid samples will be analyzed for parameters that are indicators of CO_2 dissolution, including major cations and anions, selected metals, general water-quality parameters (pH, alkalinity, TDS, specific gravity), and any tracers added to the CO_2 stream. Changes in major ion and trace element geochemistry are expected in the injection zone, but the arrival of proposed fluorocarbon or sulfonate tracers (co-injected with the CO_2) should provide an improved early-detection capability, because these compounds can be detected at 3 to 5 orders of magnitude lower relative concentration. Analysis of carbon and oxygen isotopes in injection zone fluids and the injection stream ($^{13/12}C$, $^{18/16}O$) provides another potential supplemental measure of CO_2 migration. Where stable isotopes are included as an analyte, data quality and detectability will be reviewed throughout the active injection phase, and upon the UIC Program Director's approval, will be discontinued if these analyses provide limited benefit.

Sampling and analytical techniques for target parameters are ~~given~~ listed in Table 10 and Table 11, respectively.

Table 10. Aqueous sampling requirements for target parameters (adapted from Table 5.4 of FutureGen's permit application).

Parameter	Volume/Container	Preservation	Holding Time
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Trace Metals: Sb, As, Cd, Cr, Cu, Pb, Se, Tl	20-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	60 days
Cyanide (CN-)	250-mL plastic vial	NaOH to pH > 12, 0.6g ascorbic acid Cool 4°C,	14 days
Mercury	250-mL plastic vial	Filtered (0.45 µm), HNO_3 to pH <2	28 days
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, NO_3^-	125-mL plastic vial	Filtered (0.45 µm), Cool 4°C	45 days
Total and Bicarbonate Alkalinity (as $CaCO_3^{2-}$)	100-mL HDPE	Filtered (0.45 µm), Cool 4°C	14 days
Gravimetric Total Dissolved Solids (TDS)	250-mL plastic vial	Filtered (0.45 µm), no preservation, Cool 4°C	7 days
Water Density	100-mL plastic vial	No preservation, Cool 4°C	
Total Inorganic Carbon (TIC)	250-mL plastic vial	H_2SO_4 to pH <2, Cool 4°C	28 days
Dissolved Inorganic Carbon (DIC)	250-mL plastic vial	Filtered (0.45 µm), H_2SO_4 to pH <2, Cool 4°C	28 days
Total Organic Carbon (TOC)	250-mL amber glass	Unfiltered, H_2SO_4 to pH <2, Cool 4°C	28 days
Dissolved Organic Carbon (DOC)	125-mL plastic vial	Filtered (0.45 µm), H_2SO_4 to pH <2, Cool 4°C	28 days
Volatile Organic Analysis (VOA)	Bottle set 1: 3-40-mL sterile clear glass vials Bottle set 2: 3-40-mL sterile amber glass vials	Zero headspace, Cool <6 °C, Clear glass vials will be UV-irradiated for additional sterilization	7 days
Methane	Bottle set 1: 3-40-mL sterile clear glass vials Bottle set 2: 3-40-mL sterile amber glass vials	Zero headspace, Cool <6 °C, Clear glass vials (bottle set 1) will be UV-irradiated for additional sterilization	7 days
Stable Carbon Isotopes $^{13/12}C$ ($\delta^{13}C$) of DIC in Water	60-mL plastic or glass	Filtered (0.45-µm), Cool 4°C	14 days

Radiocarbon ^{14}C of DIC in Water	60-mL plastic or glass	Filtered (0.45-µm), Cool 4°C	14 days
Hydrogen and Oxygen Isotopes $^{2/1}H$ (δD) and $^{18/16}O$ ($\delta^{18}O$) of Water	60-mL plastic or glass	Filtered (0.45-µm), Cool 4°C	45 days
Carbon and Hydrogen Isotopes (^{14}C, $^{13/12}C$, $^{2/1}H$) of Dissolved Methane in Water	1-L dissolved gas bottle or flask	Benzalkonium chloride capsule, Cool 4°C	90 days
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H_{10}, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_6+)	1-L dissolved gas bottle or flask	Benzalkonium chloride capsule, Cool 4°C	90 days
Radon (^{222}Rn)	1.25-L PETE	Pre-concentrate into 20-mL scintillation cocktail. Maintain groundwater temperature prior to pre-concentration	1 day
pH	Field parameter	None	<1 h
Specific Conductance	Field parameter	None	<1 h
HDPE = high-density polyethylene; PETE = polyethylene terephthalate			

Table 11. Analytical requirements (adapted from Table 5.5 of FutureGen's permit application).

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	ICP-AES, EPA Method 6010B or similar	1 to 80 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Trace Metals: Sb, As, Cd, Cr, Cu, Pb, Se, Tl	ICP-MS, EPA Method 6020 or similar	0.1 to 2 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Cyanide (CN-)	SW846 9012A/B	5 µg/L	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Mercury	CVAA SW846 7470A	0.2 µg/L	±20%	Daily calibration; blanks, LCS, and duplicates and matrix spikes at 10% level per batch of 20
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, NO_3^-	Ion Chromatography, EPA Method 300.0A or similar	33 to 133 µg/L (analyte dependent)	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Total and Bicarbonate Alkalinity (as $CaCO_3^{2-}$)	Titration, Standard Methods 2320B	1 mg/L	±10%	Daily calibration; blanks, LCS, and duplicates at 10% level per batch of 20
Gravimetric Total Dissolved Solids (TDS	Gravimetric Method Standard Methods 2540C	10 mg/L	±10%	Balance calibration, duplicate samples
Water Density	ASTM D5057	0.01 g/mL	±10%	Balance calibration, duplicate samples
Total Inorganic Carbon (TIC)	SW846 9060A or equivalent Carbon analyzer, phosphoric acid digestion of TIC	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Dissolved Inorganic Carbon (DIC)	SW846 9060A or equivalent Carbon analyzer, phosphoric acid digestion of DIC	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Total Organic Carbon (TOC)	SW846 9060A or equivalent Total organic carbon is converted to carbon dioxide by chemical oxidation of the organic carbon in the sample. The carbon dioxide is measured using a non-dispersive infrared detector.	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Dissolved Organic Carbon (DOC)	SW846 9060A or equivalent Total organic carbon is converted to carbon dioxide by chemical oxidation of the organic carbon in the sample. The carbon dioxide is measured using a non-dispersive infrared detector.	0.2 mg/L	±20%	Quadruplicate analyses, daily calibration
Volatile Organic Analysis (VOA)	SW846 8260B or equivalent Purge and Trap GC/MS	0.3 to 15 µg/L	±20%	Blanks, LCS, spike, spike duplicates per batch of 20
Methane	RSK 175 Mod Headspace GC/FID	10 µg/L	±20%	Blanks, LCS, spike, spike duplicates per batch of 20

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Stable Carbon Isotopes $^{13/12}C$ ($1^{13}C$) of DIC in Water	Gas Bench for $^{13/12}C$	50 ppm of DIC	±0.2p	Duplicates and working standards at 10%
Radiocarbon ^{14}C of DIC in Water	AMS for ^{14}C	Range: 0 i 200 pMC	±0.5 pMC	Duplicates and working standards at 10%
Hydrogen and Oxygen Isotopes $^{2/1}H$ (δ) and $^{18/16}O$ ($1^{18}O$) of Water	CRDS H_2O Laser	Range: -500‰ to 200‰ vs. VSMOW	$^{2/1}H$: ±2.0‰ $^{18/16}O$: ±0.3‰	Duplicates and working standards at 10%
Carbon and Hydrogen Isotopes (^{14}C, $^{13/12}C$, $^{2/1}H$) of Dissolved Methane in Water	Offline Prep & Dual Inlet IRMS for ^{13}C; AMS for ^{14}C	^{14}C Range: 0 & DupMC	^{14}C: ±0.5pMC ^{13}C: ±0.2‰ $^{2/1}H$: ±4.0‰	Duplicates and working standards at 10%
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H_{10}, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_6+)	Modified ASTM 1945D	1 to 100 ppm (analyte dependent)	Varies by compon-ent	Duplicates and working standards at 10%
Radon (^{222}Rn)	Liquid scintillation after pre-concentration	5 mBq/L	±10%	Triplicate analyses
pH	pH electrode	2 to 12 pH units	±0.2 pH unit For indication only	User calibrate, follow manufacturer recommendations
Specific Conductance	Electrode	0 to 100 mS/cm	±1% of reading For indication only	User calibrate, follow manufacturer recommendations

ICP-AES = inductively coupled plasma atomic emission spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; LCS = laboratory control sample; GC/MS = gas chromatography–mass spectrometry; GC/FID = gas chromatography with flame ionization detector; AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; IRMS = isotope ratio mass spectrometry; LC-MS = liquid chromatography-mass spectrometry; ECD = electron capture detector

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Major Cations: Al, Ba, Ca, Fe, K, Mg, Mn, Na, Si,	ICP-OES, PNNL-AGG-ICP-AES (similar to EPA Method 6010B)	0.1 to 1 mg/L (analyte dependent)	±10%	Daily calibration; blanks and duplicates and matrix spikes at 10% level per batch of 20

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Trace Metals: Sb, As, Ba, Cd, Cr, Cu, Pb, Hg, Se, Tl	ICP-MS, PNNL-AGG-415 (similar to EPA Method 6020)	1 µg/L for trace elements	±10%	Daily calibration; blanks and duplicates and matrix spikes at 10% level per batch of 20
Anions: Cl^-, Br^-, F^-, $SO4^{2-}$, NO_3^-, CO_3^{2-}	Ion Chromatography, AGG-IC-001 (based on EPA Method 300.0A)	-	±15%	Daily calibration; blanks and duplicates at 10% level per batch of 20
TDS	Gravimetric Method Standard Methods 2540C	12 mg/L	± 5%	Balance calibration, triplicate samples
Water Density	Standard Methods 227	0.0001 g/mL	±0.0%	Triplicate measurements
Alkalinity	Titration, standard methods 102	4 mg/L	±3 mg/L	Triplicate titrations
Dissolved Inorganic Carbon (DIC)	Carbon analyzer, phosphoric acid digestion of DIC	0.002%	±10%	Triplicate analyses, daily calibration
Total Organic Carbon (TOC)	Carbon analyzer; total carbon by 900°C pyrolysis minus DIC = TOC	0.002%	±10%	Triplicate analyses, daily calibration
Carbon Isotopes ($^{14/12}C$, $^{13/12}C$)	Accelerator MS	10^{-15}	±4‰ for ^{14}C; ±0.2‰ for ^{13}C	Triplicate analyses
Water Isotopes ($^{2}H/^{1}H$, $^{18/16}O$)	Water equilibration coupled with IRMS ; Alternatively, consider WS-CRDS	10^{-9}	IRMS: ±1.0‰ for ^{2}H; ±0.15‰ for ^{18}O; WS-CRDS: ±0.10‰ for ^{2}H; ±0.025‰ for ^{18}O	Triplicate analyses
Radon (^{222}Rn)	Liquid scintillation after pre-concentration	5 mBq/L	±10%	Triplicate analyses
Naphthalene Sulfonate **or** Benzoic Acid Tracer (aqueous phase)	Liquid chromatography-mass spectrometry (LC-MS) **or** gas chromatography with electron capture detector (ECD)	5 parts per trillion (5×10^{12}) **or** 10 parts per quadrillion (10×10^{15})	Varies with conc.,±30% at detection limit	Duplicates 10% of samples, significant number of blanks for cross-contamination
Perfluorocarbon Tracer (PFT) (scCO2 or gas phase)	Gas chromatography with electron capture detector (ECD)	10 parts per quadrillion (10×10^{15})	Varies with conc., ±30% at detection limit	Duplicates 10% of samples, significant number of blanks for cross-contamination
pH	pH electrode	2 to 12 pH units	±0.2 pH unit For indication only	User calibrate, follow manufacturer recommendations

Parameter	Analysis Method	Detection Limit or Range	Typical Precision/ Accuracy	QC Requirements
Specific conductance	Electrode	0 to 100 mS/cm	±1% of reading For indication only	User calibrate, follow manufacturer recommendations
Temperature	Thermocouple	5 to 50°C	±0.2°C For indication only	Factory calibration
ICP = inductively coupled plasma; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; OES = optical emission spectrometry; WS-CRDS = wavelength scanned cavity ring-down spectroscopy.				

ICP = inductively coupled plasma; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; OES = optical emission spectrometry; WS-CRDS = wavelength scanned cavity ring-down spectroscopy

Laboratory to be used/chain-of-custody procedures:

FutureGen Response: See FutureGen QASP Sections B.4.3 thru B.4.7.

[Not specified.]

Quality assurance and surveillance measures:

Quality QA and surveillance protocols to be followed during the post-injection period are specified in the FutureGen QASP.

Data quality assuranceQA and surveillance protocols adopted by the project **will be designed** to facilitate compliance with the requirements specified in 40 CFR 146.90(k). Quality Assurance (QA) requirements for direct measurements within the injection zone, above the confining zone, and within the shallow USDW aquifer that are critical to the MVA program (e.g., pressure and aqueous concentration measurements) are covered in Sections 5.2.2 and 5.2.3 above. QA requirements for selected geophysical methods, which provide indirect measurements of CO_2 nature and extent will be performed based on best industry practices and the QA protocols recommended by the geophysical services contractors selected to perform the work.

Plan for guaranteeing access to all monitoring locations:

The location of these wells has been finalized, pending final signing of landowner agreements. The land will either be purchased or leased for the life of the project, so access will be secured.

Indirect Carbon Dioxide Plume and Pressure--Front Tracking

FutureGen will track the carbon dioxideCO_2 plume and pressure front to meet the requirements of 40 CFR 146.93(b).

The frequency of indirect plume and pressure-front monitoring activities during the post-injection phase, based on the information submitted in January 2014, is given in Table 12.

Table 12. Monitoring schedule for indirect plume and pressure-front monitoring.

Monitoring Technique	Location	Frequency (Post-Injection Phase)
Integrated deformation monitoring	5 locations (see ~~below~~)	Continuous
Passive seismic monitoring (microseismicity)	Surface measurements (see Figure 7 ~~below~~) plus downhole sensor arrays at ACZ Wells 1 and 2	Continuous

The coordinates of the monitoring wells/stations are provided in Attachment C.

Integrated deformation monitoring

Integrated deformation monitoring integrates ground data from permanent Global Positioning System (GPS) stations, tiltmeters, supplemented with annual Differential GPS (DGPS) surveys, and larger-scale Differential Interferometric Synthetic Aperture Radar (DInSAR) surveys to detect and map temporal ground-surface deformation. These data reflect the dynamic geomechanical behavior of the subsurface in response to CO_2 injection. These measurements will provide useful information about the evolution and symmetry of the pressure front. These results will be compared with model predictions throughout the operational phase of the project and significant deviation in observed response would result in further action, including a detailed evaluation of the observed response, calibration/refinement of the numerical model, and possible modification to the monitoring approach and/or storage site operations.

Integrated deformation monitoring will take place at the locations shown in **Error! Reference source not found.**.

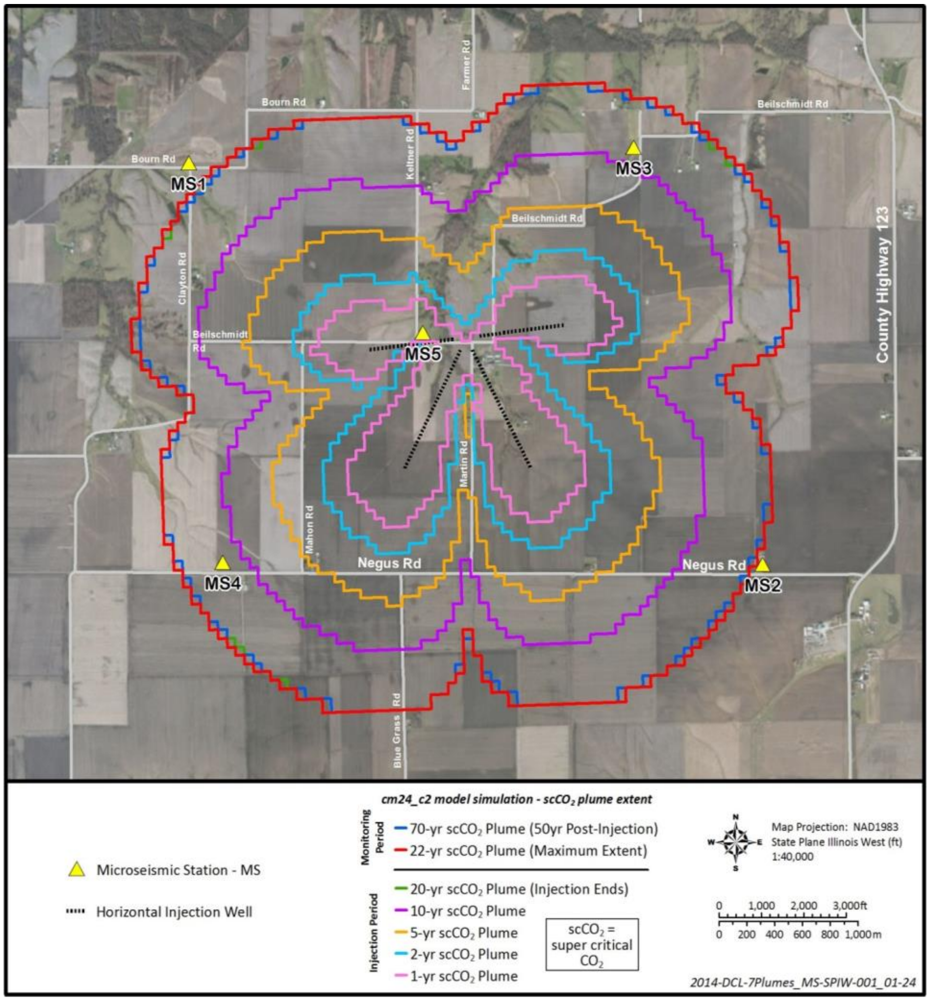

Figure 1012. Collocated Microseismic and Integrated Surface Deformation Monitoring Stations.

Passive seismic monitoring (microseismicity)

Note: Some of this information may need to be included in the Emergency and Remedial Response Plan instead of or in addition to the Testing and Monitoring Plan.

The objective of the microseismic monitoring network (Figure 7; downhole arrays will also be installed at the two ACZ wells) is to accurately determine the locations, magnitudes, and focal mechanisms of injection-induced seismic events with the primary goals of: 1) addressing public and stakeholder concerns related to induced seismicity, 2) estimating the spatial extent of the pressure front from the distribution of seismic events, and 3) identifying features that may indicate areas of caprock failure and possible containment loss. Once a seismic event has been identified, a decision must be made regarding the level of impact a given event could have on storage site operations and what the response will be. This decision and response framework will consist of an automated event location and magnitude determination, followed by an alert for a technical review in order to reduce the likelihood of false positives. Identification of events with sufficient magnitude or that are located in a sensitive area (caprock) will be used as input for decisions that guide the adaptive strategy. Seismic events that affect the operations of CO_2 injection can be divided into two groups/tiers:- 1) events that create felt seismicity at the surface and may lead to public concern or structural damage, and 2) events not included in group one, but that might indicate failure or impending failure of the caprock. The operational protocol for responding to events in group one (Tier I) will follow a "traffic light" approach (modified after Zoback 2012; National Research Council 2012) that uses three operational states:

1. Green: Continue normal operations unless injection-related seismicity is observed with magnitudes greater than M = 2.

2. Yellow: Injection-related seismic events are observed with magnitude 2 < M< 4. The injection rate will be slowed and the relationship between rate and seismicity will be studied to guide mitigation procedures, including reduced operational flow rates.

3. Red: Magnitude 4 or greater seismic events. Injection operations will stop and an evaluation will be performed to determine the source and cause of the ground motion.

Tier II operational responses to an event or collection of events that indicate possible failure of the primary confining zone may include initiation of supplemental adaptive monitoring activities, injection rate reduction in one or more injection laterals, or pressure reduction using brine extraction wells.

Proposed Schedule for Submitting Post-Injection Monitoring Results

FutureGen will submit monitoring reports annually.

During the PISCpost-injection site care period, monitoring reports will be prepared and submitted to the EPA Region 5 UIC office annually. PISCost-injection site care monitoring reports will be submitted within 90 days of completion of field work associated with the monitoring event. The reports will summarize methods and results of the groundwater-quality monitoring, CO_2 storage zone pressure tracking, and indirect geophysical monitoring for CO_2 plume tracking. Monitoring reports will include appropriate sampling records, laboratory analysis, and field data.

From *Draft UIC Program Guidance on Class VI Well Plugging, Post-Injection Site Care, and Site Closure:*

The EPA requests that the following information be submitted with all reports:

- a list of all monitoring events that have taken place during the reporting period and all monitoring dates
- identification of any data gaps
- identification of any changes to the monitoring program during the reporting period (e.g., drilling of new monitoring wells, closure of monitoring wells)
- presentation, synthesis, and interpretation of the entire historical data set of monitoring results, with respect to any change in risk of endangerment to USDWs
- any necessary changes to the project PISC and Site Closure Plan to continue protection of USDWs
- for groundwater geochemistry monitoring using wells: the most recent and up-to-date historical database of all groundwater monitoring results and Quality Assurance/Quality Control (QA/QC) monitoring results
- interpretation of any changing trends and evaluation of fluid leakage and migration, including uncertainty analysis (if appropriate). This may include graphs of relevant trends and interpretive diagrams (e.g., Piper and Stiff diagrams)
- a map showing all monitoring wells and indicating wells that are believed to be in the location of the separate-phase carbon dioxide plume
- an evaluation of data quality for each sampling event
- copies of all laboratory analytical reports
- records of calibration of all field instrumentation
- a description of all sampling equipment and sampling methods used
- sample chain-of-custody records
- the name and contact information for the EPA-certified laboratory conducting the analysis
- documentation of the monitoring well construction specifications (or reference to previously submitted documentation), sampling procedure, laboratory analytical procedure, and QA/QC standards
- for groundwater pressure monitoring: measured depth to fluid, or pressure transducer readings in all wells, fluid density, and fluid temperature
- if using pressure transducers, records of the most recent calibration or verification of the measurement instruments

- records of the surveying of wellhead and measurement point elevations (or reference to previously submitted documentation)
- measured pressure in all wells
- time-series graphs and pressure or head maps used in interpretation of pressure data
- for geophysical surveys: a description and technical justification of all survey techniques and methodologies used (or reference to previously submitted documentation)
- a map showing the location of all survey equipment positions during the test
- maps showing the interpreted location of separate-phase CO_2 in the injection zone and its location in any additional zones in which it was detected using geophysical surveys.

The PISC~~post-injection site care~~ monitoring plan will be reviewed prior to cessation of injection operations. Monitoring and operational results will be reviewed for adequacy in relation to objectives of the PISC~~post-injection site care~~ monitoring. The monitoring locations, methods, and schedule will be analyzed in relation to the size of the CO_2 storage zone, pressure front, and protection of USDWs. If the PISC~~post- injection site care~~ plan changes, a modified plan will be submitted to the EPA Region 5 UIC Branch Office for approval within 30 days of implementing the changes in the field.

The PISC plan will be reviewed every 5 years during the PISC period. Results of the plan review will be included in the PISC monitoring reports. Monitoring and operational results will be reviewed for adequacy in relation to the objectives of PISC monitoring. The monitoring locations, methods, and schedule will be analyzed in relation to the size of the CO_2 storage zone, pressure front, and protection of USDWs. In case of change to the PISC plan, a modified plan will be submitted to the EPA Region 5 UIC Branch Office for approval within 30 days of making of the changes.

Table 13. Post-injection phase reporting schedule.

Planned Testing/Monitoring	Reporting Schedule
Groundwater Quality Monitoring Data	Annual
Carbon Dioxide Plume and Pressure-Front Tracking Data	Annual
Direct Pressure Monitoring Data	Annual
Indirect Carbon Dioxide Plume and Pressure-Front Tracking Data	Annual

Alternative Post-Injection Site Care Time Frame

FutureGen is not requesting an alternative PISC time frame.

Non-Endangerment Demonstration Criteria

During the PISC, the owner or operator may submit a demonstration of non-endangerment of USDWs to reduce the initial permitted PISC monitoring time frame. EPA suggestions for non-endangerment demonstrations begin on page 41 of the guidance and include the following:

- 3.3.1 Summary of Existing Monitoring Data
- 3.3.2 Comparison of Monitoring Data and Model Predictions and Model Documentation
- 3.3.3 Evaluation of Carbon Dioxide Plume
- 3.3.4 Evaluation of Mobilized Fluids
- 3.3.5 Evaluation of Reservoir Pressure
- 3.3.6 Evaluation of Potential Conduits for Fluid Movement.

Site Closure Plan

FutureGen will conduct site closure activities to meet the requirements of 40 CFR 146.93(e).

Site closure will occur at the end of the PISC~~post-injection site care~~ period. Site- closure activities will include decommissioning surface equipment, plugging monitoring wells, restoring the site, and preparing and submitting site closure reports. The EPA Region 5 UIC Branch Office will be notified at least 120 days before site closure. In addition, state and local agencies including the Illinois State Geological Survey and Illinois Department of Natural Resources, as well as City of Jacksonville and Morgan County agencies will be notified prior to the scheduled site closure.

At this time, there are no federally recognized Native American Tribes located within the AoR or the State of Illinois (http://www.ncsl.org/research/state-tribal-institute/list-of-federal-and-state-recognized-tribes.aspx). If a federally recognized Native American Tribe exists in the AoR or the State of Illinois at the time of site closure, it will be notified of site closure at that time.

A revised site closure plan will be submitted to the EPA Region 5 UIC Branch Office and state and local (and tribal) governmental agencies, if any changes have been made to the original site -closure plan. After site closure is authorized, site closure field activities will be completed.

Site Closure Reporting

A site closure report will be submitted to the EPA Region 5 UIC Branch Office and the previously notified state and local regulatory agencies within 90 days of site closure. The site -closure report will include the following information:

- documentation of appropriate well plugging, including a survey plat of the injection well location
- documentation of the well-plugging report to Illinois and local agencies that have authority over drilling activities at the facility site
- records reflecting the nature, composition, and volume of the CO_2 injected in UIC wells~~.~~

In association with site closure, a record of notation on the facility property deed will be added to provide any potential purchaser of the property with the following information:

- notification that the subsurface is used for CO_2 storage
- the name of the Illinois and local agencies and the EPA Region 5 Branch Office to which the survey plat was submitted
- the volume of fluid injected, the injection zone, and the period over which injection occurred.

PISC~~ost-injection site care~~ and site closure records will be retained for 10 years after site closure. At the conclusion of the 10-year period, these records will be delivered to the EPA Region 5 UIC Branch Office for further storage.

Planned Remedial/Site Restoration Activities

At the end of the PISC~~post-injection site care~~ phase, FutureGen will ensure the site is reclaimed and returned to predevelopment~~-development~~ condition to meet the requirements of 40 CFR 146.93(e).

Surface equipment decommissioning will occur in two phases: the first phase will occur after the active injection phase, and the second phase will occur at the end of PISC~~post-injection site care~~ phase. The surface facilities at the storage site will include the Site Control Building and the WAPMMS (Well Annular Pressure Maintenance and Monitoring System) Building.

At the end of the active injection period, plume monitoring will continue, but there will be no further need for the pumping and control equipment. The Site Control Building will be demolished. All features will be removed except the WAPMMS Building, a 12-ft-wide access road with five parking spaces, a concrete sidewalk from the parking lot to the building, underground electrical and telephone services, and a chain-link fence surrounding the building. The common wall between the WAPMMS Building and the Site Control Building will be converted to an exterior wall. The injection wells will be plugged and capped below grade (see Chapter 6.0). The gravel pad will be removed. The WAPMMS Building at the storage site will be repurposed to act as the collection node for data from the plume monitoring equipment. The building will contain equipment to receive real-time data from the monitoring wells and other monitoring stations and send the data via an internet connection to be analyzed offsite during the 50-year post-injection monitoring period.

All surface facilities will be removed at the end of the PISCpost-injection site care phase. These facilities will include the WAPMMS Building, the access road with parking spaces, all sidewalks, underground electrical and telephone services, and fencing at the injection well sites. The site will be reclaimed to and returned to predevelopment development condition.

Plugging the Monitoring Wells

FutureGen will plug the monitoring wells to meet the requirements of 40 CFR 146.93(e). There are two types of well completion designs being considered: one with a perforated-cased horizontal lateral, the other with an open, uncased horizontal lateral.The FutureGen monitoring well design includes five deep monitoring wells and three deep RAT wells, as listed in Table 14. Monitoring well construction and plugging schematics showing the depth to tubing stub, exposed formation intervals, casing diameters, casing depths, depths to USDWs, and the placement of all plugs are presented for each well type in Attachment D.

Table 14. . Planned monitoring wells within the FutureGen site network.

	Single-Level In-Reservoir (SLR)	Above Confining Zone (ACZ)	USDW	Reservoir Access Tube (RAT)
# of Wells	2	2	1	3
Total Depth (ft)	4,150	3,470	2,000	4,465
Monitored Zone	Mount Simon SS	Ironton SS	St. Peter SS	Mount Simon SS
Monitoring Instrumentation	Fiber-optic P/T (tubing conveyed)[b]; P/T/SpC probe in monitored interval[(a)]	Fiber-optic (microseismic) cable cemented in annulus; P/T/SpC probe in monitored interval[(a)]	P/T/SpC probe in monitored interval[(a)]	Pulsed-neutron logging equipment

(a) The P/T/SpC (pressure, temperature, specific conductance) probe is an electronic downhole multiparameter probe incorporating sensors for measuring fluid P/T/SpC within the monitored interval. This probe may also be configured with sensors to measure pH and Eh. The probe is installed inside tubing string, which is perforated (slotted) over the monitoring interval. Sensor signals are multiplexed to a surface data logger through a single conductor wireline cable.
(b) Fiber-optic cable attached to the outside of the tubing string, in the annular space between the tubing and casing.
SS = sandstone.

Since FutureGen did not propose performing regular MIT tests of the monitoring wells, we should verify whether they will perform one on the monitoring wells before plugging.

Upon site conclusion of the post-operations monitoring period (~50 years), all monitoring wells will be plugged and capped below grade in accordance with the approved monitoring well Plugging and Abandonment Plans (see Attachment E). All deep monitoring wells at the site will be plugged to prevent any upward migration of the CO_2 or formation fluids to USDWs. Each of the deep monitoring wells will be plugged and abandoned using best practices to prevent ~~and~~ communication of fluids between the injection zone and the USDWs. The deep monitoring wells in the injection interval have a direct connection between the injection formation and ground surface. The well-plugging program will be designed to prevent communication between the injection zone and the USDWs.

Before the wells are plugged, the internal and external integrity of the wells will be confirmed by conducting cement-bond, temperature, and noise logs on each of the wells. In addition, a pressure fall-off test will be performed above the perforated intervals (where present) to confirm well integrity. The results of the logging and testing will be reviewed and approved by appropriate regulatory agencies prior to plugging the wells.

The wells with perforations (the SLR monitoring wells, the ACZ monitoring wells, and lowermost USDW monitoring well) will be plugged using a CO_2-resistant cement retainer method to cement the perforated intervals and a balanced plug method to cement the well above the perforated zones and the cement retainer. The RAT ~~seismic~~ monitoring wells will not have perforations; therefore, only the balanced plug method will be used to plug these wells. Once the interior of the casing has been properly plugged with cement, the casing will be cut off below ground and capped. Regulations at the time of the plugging and abandonment will dictate the specifications regarding the depth at which the casing is cut and the method used to cap the well. The cap will ~~have~~ be inscribed with the well identification number and the date of plug and abandonment ~~inscribed on it~~.

Soil will be backfilled around the well to bring the area around the well back to pre-well-installation grade. Any remaining surface faciliites associated with the monitoring well will be reclaimed and the area will be returned to predevelopment condition. All gravel pads, access roads, and surface facilities will be removed, and the land will be reclaimed for agricultural or other beneficial pre-construction uses.

~~Each injection well casing will be plugged with cement and 6 percent water gel spacers to ensure that the well does not provide a conduit from the injection zone to the USDW zone or ground surface. As mentioned above, two types of well completion designs are being considered: one with a perforated-cased horizontal lateral, the other with an open, uncased horizontal lateral. The procedures for plugging and abandoning both types of horizontal CO_2 injection wells are very similar, whether they are a cased and perforated completion or an open-hole completion. However, cement volumes will differ depending upon the total depth and horizontal length of the well. Table 6.1 summarizes the plugging plans for each type of well completion and describes intervals that will be plugged and the materials and methods that will be used to plug the intervals.~~

~~For both well completion designs, the portion of the well corresponding to the injection zone will be plugged using CO_2-resistant cement with a retainer method. Class A well cements are formulated in accordance with API Specification 10A (API 2010) standards and are similar to~~

~~ASTM Type I Portland cements (ASTM C465, ASTM 2010). CO_2-resistant cement is formulated with the addition of pozzalan or other materials that reduce production of calcium hydroxide and calcium silicate hydrate, that weaken cements in the presence of CO_2. The cement retainer will be set at a depth of 3,900 ft, at the contact between the Eau Claire Formation and the Mount Simon Sandstone, and will be constructed of corrosion resistant materials. Depending upon the horizontal length and well construction, approximately 450 to 1,475 sacks of CO_2-resistant cement will be used to plug the injection interval (this includes a 10 percent excess volume to be squeezed through the perforations into the Mount Simon Sandstone).~~

~~The pressure used to squeeze the cement will be determined from the bottom-hole pressure data measured before beginning the plugging and abandonment process. However, the injection pressure of the cement will not exceed the fracture pressure of the Mount Simon Sandstone. If it appears that the injection pressure will exceed the fracture pressure and the total amount of cement has not been pumped into the injection zone, cement pumping will cease and the tubing will be removed from the cement retainer to allow the pressure to return to static conditions. After allowing the pressure to reduce, the tubing will be re-strung through the cement retainer and cement pumping will be attempted again. A rapid increase in pressure on the tubing would indicate that the perforations have been sealed with cement, and no additional cement will be added to the zone or plug.~~

~~After the remainder of the casing has been filled with cement, the casing sections will be cut off approximately 5 ft bgs, and a steel cap will be welded to the top of the deep casing string. The cap will have the well identification number, the UIC Class VI permit number, and the date of plug and abandonment inscribed on it. Soil will be backfilled around the well to bring the area around the well back to pre-well-installation grade. This area will then be planted with natural vegetation.~~

The methods and materials described in this plan are based upon current understanding of the geology at the site and current well designs. If necessary, the plans will be updated to reflect the latest well designs. These new designs, materials, and methods will be described in the Notice of Intent to Plug submitted at least 60 days prior to the plugging of the well.

After the completion of the plugging activities, a plugging report will be submitted to the UIC Program Director describing the methods used and test performed on the well during plugging. This report will be submitted to the UIC Program Director within 60 days of completing the plugging activities.

~~Plugging the Verification Well~~

Commented [t14]: The verification/stratigraphic well will be completed as a single level reservoir well. The plugging of this well type is discussed in the section above. Should this be "Plugging the Injection Wells"?

~~Information on Plugs:~~

-	~~Plug #1~~	~~Plug #2~~	~~Plug #3~~	~~Plug #4~~	~~Plug #5~~	~~Plug #6~~	~~Plug #7~~
~~Diameter of Boring in Which Plug Will be Placed~~	-	-	-	-	-	-	-

Depth to Bottom of Tubing or Drill Pipe	-	-	-	-	-	-	-
Sacks of Cement to be Used (each plug)	-	-	-	-	-	-	-
Slurry Volume to be Pumped	-	-	-	-	-	-	-
Slurry Weight	-	-	-	-	-	-	-
Top of Plug	-	-	-	-	-	-	-
Bottom of Plug	-	-	-	-	-	-	-
Type of Cement or Other Material	-	-	-	-	-	-	-
Method of Emplacement (e.g., balance method, retainer method, or two-plug method)	-	-	-	-	-	-	-

Attachments:
Injection well construction plan/schematics showing depth to tubing stub, exposed formation intervals, casing diameters, depths, etc.

Information on formations, depths to USDWs, etc.

Schematic/drawings of the placement of all plugs.

Tests or Measures to Determine Bottom-Hole Pressure

Bottom-hole pressure measurements will be used to determine the pressure required to squeeze the cement from the well casing into the injection reservoir. In addition, these data will be used to determine the need for well control equipment. The weight of brine required to prevent the well from flowing will be calculated using this information. The pressure measurements will also be used to determine the formulation of cement to be used to plug the well (i.e., cement-setting retardants may need to be added to the cement to prevent premature setting and curing of the cement).

Bottom-hole pressure measurements will be performed and recorded throughout the duration of the project. Pressure gauges will be placed in the injection tubing or within the deep casing string within the injection zone, and these pressure-measurement devices will allow for continuous, real-time, surface readout of the pressure data. The bottom-hole reservoir pressure will be obtained using the final measurements from the pressure gauges in the injection zone after the injection of CO_2. After the bottom-hole pressure is determined, a buffered fluid (brine) will be used to flush and fill each well to maintain pressure control of the well. The bottom-hole pressure will be used to determine the proper weight of brine that should be used to stabilize each well.

Injection Well Testing to Ensure Mechanical Integrity

The mechanical integrity of each well must be demonstrated after CO_2 injection and prior to the plugging of the well to ensure conduits between the injection zone and the USDWs or ground surface have not developed. External mechanical integrity will be evaluated by performing temperature logging on the injection well..

The temperature log will be run over the entire depth of each injection well. Data from the logging run will be evaluated for anomalies in the temperature curve, which would be indicative of fluid migration outside of the injection zone. These data will also be compared to data from the logs performed prior to injection of CO_2 into the well. Deviations between the temperature logs performed before and after the injection of CO_2 may indicate issues related to the integrity of the well casing or cement.

Plugging Plan

Each injection well casing will be plugged with cement and 6 percent water gel spacers to ensure that the well does not provide a conduit from the injection zone to the USDW zone or ground surface. Two types of well completion designs are being considered: one with a perforated-cased horizontal lateral, the other with an open, uncased horizontal lateral. The procedures for plugging and abandoning both types of horizontal CO_2 injection wells are very similar, whether they are a cased and perforated completion or an open-hole completion. However, cement volumes will differ depending upon the total depth and horizontal length of the well.

For both well completion designs, the portion of the well corresponding to the injection zone will be plugged using CO_2-resistant cement with a retainer method. Class A well cements are formulated in accordance with API Specification 10A (API 2010) standards and are similar to ASTM Type I Portland cements (ASTM C465, ASTM 2010). CO_2-resistant cement is formulated with the addition of pozzalan or other materials that reduce production of calcium hydroxide and calcium silicate hydrate, that weaken cements in the presence of CO_2. The cement retainer will be set at a depth of 3,900 ft, at the contact between the Eau Claire Formation and the Mount Simon Sandstone, and will be constructed of corrosion resistant materials. Depending upon the horizontal length and well construction, approximately 450 to 1,475 sacks of CO_2-resistant cement will be used to plug the injection interval (this includes a 10 percent excess volume to be squeezed through the perforations into the Mount Simon Sandstone).

The pressure used to squeeze the cement will be determined from the bottom-hole pressure data measured before beginning the plugging and abandonment process. However, the injection pressure of the cement will not exceed the fracture pressure of the Mount Simon Sandstone. If it appears that the injection pressure will exceed the fracture pressure and the total amount of cement has not been pumped into the injection zone, cement pumping will cease and the tubing will be removed from the cement retainer to allow the pressure to return to static conditions. After allowing the pressure to reduce, the tubing will be re-strung through the cement retainer and cement pumping will be attempted again. A rapid increase in pressure on the tubing would indicate that the perforations have been sealed with cement, and no additional cement will be added to the zone or plug.

After the remainder of the casing has been filled with cement, the casing sections will be cut off approximately 5 ft bgs, and a steel cap will be welded to the top of the deep casing string. The cap will have the well identification number, the UIC Class VI permit number, and the date of plug and abandonment inscribed on it. Soil will be backfilled around the well to bring the area around the well back to pre-well-installation grade. This area will then be planted with natural vegetation.

The methods and materials described in this plan are based upon current understanding of the geology at the site and current well designs. If necessary, the plans will be updated to reflect the latest well designs. These new designs, materials, and methods will be described in the Notice of Intent to Plug submitted at least 60 days prior to the plugging of the well.

After the completion of the plugging activities, a plugging report will be submitted to the UIC Program Director describing the methods used and test performed on the well during plugging. This report will be submitted to the UIC Program Director within 60 days of completing the plugging activities.

Plugging the Geophysical Wells:

See P&A Plans.

Tests or Measures to Determine Bottom-Hole Pressure

Commented [TE15]: Cite location or include P&A Plans…and plug to surface.

Bottom-hole pressure measurements will be used to determine the pressure required to squeeze the cement from the well casing into the injection reservoir. In addition, these data will be used to determine the need for well control equipment. The weight of brine required to prevent the well from flowing will be calculated using this information. The pressure measurements will also be used to determine the formulation of cement to be used to plug the well (i.e., cement-setting retardants may need to be added to the cement to prevent premature setting and curing of the cement).

Bottom-hole pressure measurements will be performed and recorded throughout the duration of the project. Pressure gauges will be placed in the injection tubing or within the deep casing string within the injection zone, and these pressure-measurement devices will allow for continuous, real-time, surface readout of the pressure data. The bottom-hole reservoir pressure will be obtained using the final measurements from the pressure gauges in the injection zone after the injection of CO_2. After the bottom-hole pressure is determined, a buffered fluid (brine) will be used to flush and fill each well to maintain pressure control of the well. The bottom-hole pressure will be used to determine the proper weight of brine that should be used to stabilize each well.

Injection Well Testing to Ensure Mechanical Integrity

The mechanical integrity of each well must be demonstrated after CO_2 injection and prior to the plugging of the well to ensure conduits between the injection zone and the USDWs or ground surface have not developed. External mechanical integrity will be evaluated by performing temperature logging on the injection well, as described in Section 5.3.2.

The temperature log will be run over the entire depth of each injection well. Data from the logging run will be evaluated for anomalies in the temperature curve, which would be indicative of fluid migration outside of the injection zone. These data will also be compared to data from the logs performed prior to injection of CO_2 into the well. Deviations between the temperature logs performed before and after the injection of CO_2 may indicate issues related to the integrity of the well casing or cement.

Plugging Plan

The FutureGen microseismic seismic and deformation monitoring designs include five geophysical monitoring stations. Two types of well completions will be constructed at each of the five geophysical monitoring stations: both well types will be completed as sealed access tubes designed to support downhole installation of either microseismic or tiltmeter instrumention in a subsurface moisture free environment. Well construction and plugging schematics showing the exposed formation intervals, casing diameters, casing depths, depths to USDWs, and the placement of all plugs are presented for each well type in Error! Reference source not found..

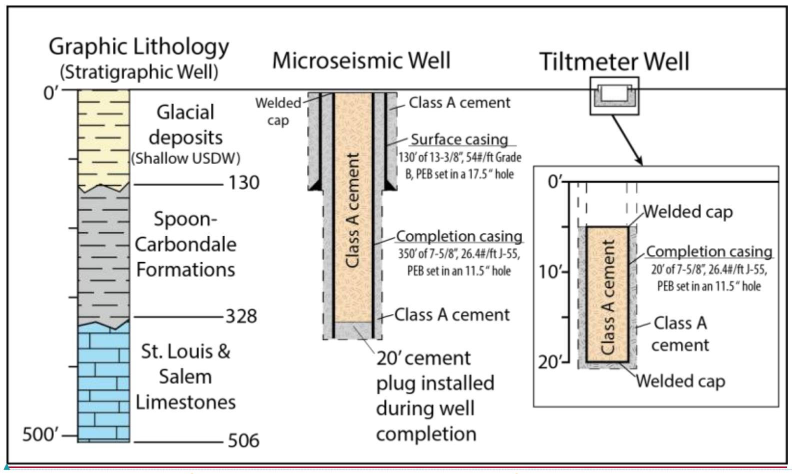

Figure 8. . **Diagram of Microseismic and Tiltmeter Wells After Plugging and Abandonment**

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Upon conclusion of the post-operations monitoring period, all geophysical wells will be plugged and capped below grade in accordance with the approved monitoring well Plugging and Abandonment Plans (see Attachment E). All downhole instrumentation will be removed and each ~~injection~~ microseismic well casing and tiltmeter well casing will be plugged with cement ~~and 6 percent water gel spacers~~ to ensure that the well does not provide a conduit ~~from~~ to the ~~injection zone~~ shallow ~~to the~~ USDW zone or ground surface. ~~As discussed in Chapter 4.0, two types of well completion designs are being considered: one with a perforated-cased horizontal lateral, the other with an open, uncased horizontal lateral .~~ The procedures for plugging and abandoning both types of ~~horizontal CO_2 injection~~ wells are very similar~~, whether they are a cased and perforated completion or an open-hole completion~~. However, cement volumes will differ depending upon the total depth ~~and horizontal length~~ of the well.

For both well-completion designs, ~~, the portion of the well corresponding to the injection zone will be plugged using CO_2-resistant cement with a retainer method.~~ c~~C~~lass A ~~well~~ cement will be ~~s are formulated in accordance with API Specification 10A (API 2010) standards and are similar to ASTM Type I Portland cements (ASTM C465, ASTM 2010). CO_2-resistant cement is formulated with the addition of pozzalan or other materials that reduce production of calcium hydroxide and calcium silicate hydrate, that weaken cements in the presence of CO_2. The cement retainer will be set at a depth of 3,900 ft, at the contact between the Eau Claire Formation and the Mount Simon Sandstone, and will be constructed of corrosion resistant materials. Depending upon the horizontal length and well construction, approximately 450 to 1,475 sacks of CO_2-resistant cement will be~~ used to plug the ~~injection interval (this includes a 10 percent excess volume to be squeezed through the perforations into the Mount Simon Sandstone).~~ well casing.

The geophysical wells will not have perforations; therefore, the balanced plug method will be used to plug these wells. Once the interior of the casing has been properly plugged with cement, the casing will be cut off below ground and capped. Regulations at the time of the plugging and abandonment will dictate the specifications regarding the depth at which the casing is cut and the method used to cap the well. ~~The pressure used to squeeze the cement will be determined from the bottom-hole pressure data measured before beginning the plugging and abandonment process. However, the injection pressure of the cement will not exceed the fracture pressure of the Mount Simon Sandstone. If it appears that the injection pressure will exceed the fracture pressure and the total amount of cement has not been pumped into the injection zone, cement pumping will cease and the tubing will be removed from the cement retainer to allow the pressure to return to static conditions. After allowing the pressure to reduce, the tubing will be re-strung through the cement retainer and cement pumping will be attempted again. A rapid increase in pressure on the tubing would indicate that the perforations have been sealed with cement, and no additional cement will be added to the zone or plug.~~

~~After the remainder of the casing has been filled with cement, the casing sections will be cut off approximately 5 ft bgs, and a steel cap will be welded to the top of the deep casing string.~~ The cap will ~~have~~ be inscribed with the well identification number~~, the UIC Class VI permit number,~~ and the date of plug and abandonment ~~inscribed on it~~.

Soil will be backfilled around the well to bring the area around the well back to pre-well-installation grade. ~~This area will then be planted with natural vegetation.~~ Any remaining surface faciliites associated with the geophysical monitoring station will be reclaimed and the area will be returned to predevelopment condition. All gravel pads, cement surface pads, instrumentation vaults, GPS monuments, access roads, and surface facilities will be removed, and the land will be reclaimed for agricultural or other beneficial pre-construction uses.

The methods and materials described in this plan are based upon current understanding of the geology at the site and current well designs. If necessary, the plans will be updated to reflect the latest well designs. These new designs, materials, and methods will be described in the Notice of Intent to Plug submitted at least 60 days prior to the plugging of the well.

After the completion of the plugging activities, a plugging report will be submitted to the UIC Program Director describing the methods used and test performed on the well during plugging. This report will be submitted to the UIC Program Director within 60 days of completing the plugging activities.

Attachment A

Locations of the Deep Monitoring Wells

Well ID	Well Type	Latitude (WGS84)	Longitude (WGS84)
ACZ1	Above Confining Zone #1	39.80034315	-90.07829648
ACZ2	Above Confining Zone #2	39.80029543	-90.08801028
USDW1	Underground Source of Drinking Water	39.80048042	-90.0782963
SLR1	Single-Level in-Reservoir 1	39.8004327	-90.08801013
SLR2	Single-Level in-Reservoir 2	39.80680878	-90.05298062
RAT1	Reservoir Access Tube #1	39.80035565	-90.08627478
RAT2	Reservoir Access Tube #2	39.78696855	-90.06902677
RAT3	Reservoir Access Tube #3	39.79229199	-90.08901656

Attachment B

Location of Surficial Aquifer Monitoring Wells

Well ID	Well Type	Latitude	Longitude
FG-1	FutureGen Shallow Monitoring Well	39.80675	-90.05283
FGP-1	Private Well	39.79888	-90.0736
FGP-2	Private Well	39.78554	-90.0639
FGP-3	Private Well	39.79497	-90.0746
FGP-4	Private Well	39.79579	-90.0747
FGP-5	Private Well	39.81655	-90.0622
FGP-6	Private Well	39.81086	-90.057560
FGP-7	Private Well	39.81444	-90.065241
FGP-9	Private Well	39.80829	-90.0377
FGP-10	Private Well	39.81398	-90.0427

Attachment C

Locations of Microseismic Monitoring Stations and Integrated Deformation Stations

Well ID/Station ID	Well/Station Type	Latitude (WGS84)	Longitude (WGS84)
MS1	• Microseismic monitoring Station 1(shallow borehole) • Integrated deformation monitoring station	39.8110768	-90.09797015
MS2	• Microseismic monitoring Station 2 (shallow borehole) • Integrated deformation monitoring station	39.78547402	-90.05028403
MS3	• Microseismic monitoring Station 3 (shallow borehole) • Integrated deformation monitoring station	39.81193502	-90.06016279
MS4	• Microseismic monitoring Station 4 (shallow borehole) • Integrated deformation monitoring station	39.78558513	-90.09557015
MS5	• Microseismic monitoring Station 5 (shallow borehole) • Integrated deformation monitoring station	39.80000524	-90.07830287
ACZ1	• Deep microseismic station (deep borehole)	39.80034315	-90.07829648
ACZ2	• Deep microseismic station (deep borehole)	39.80029543	-90.08801028

Attachment D

1

Planned Construction Design and Plugging and Abandonment Plan Diagrams for Deep Monitoring Wells and Reservoir Access Tube Wells

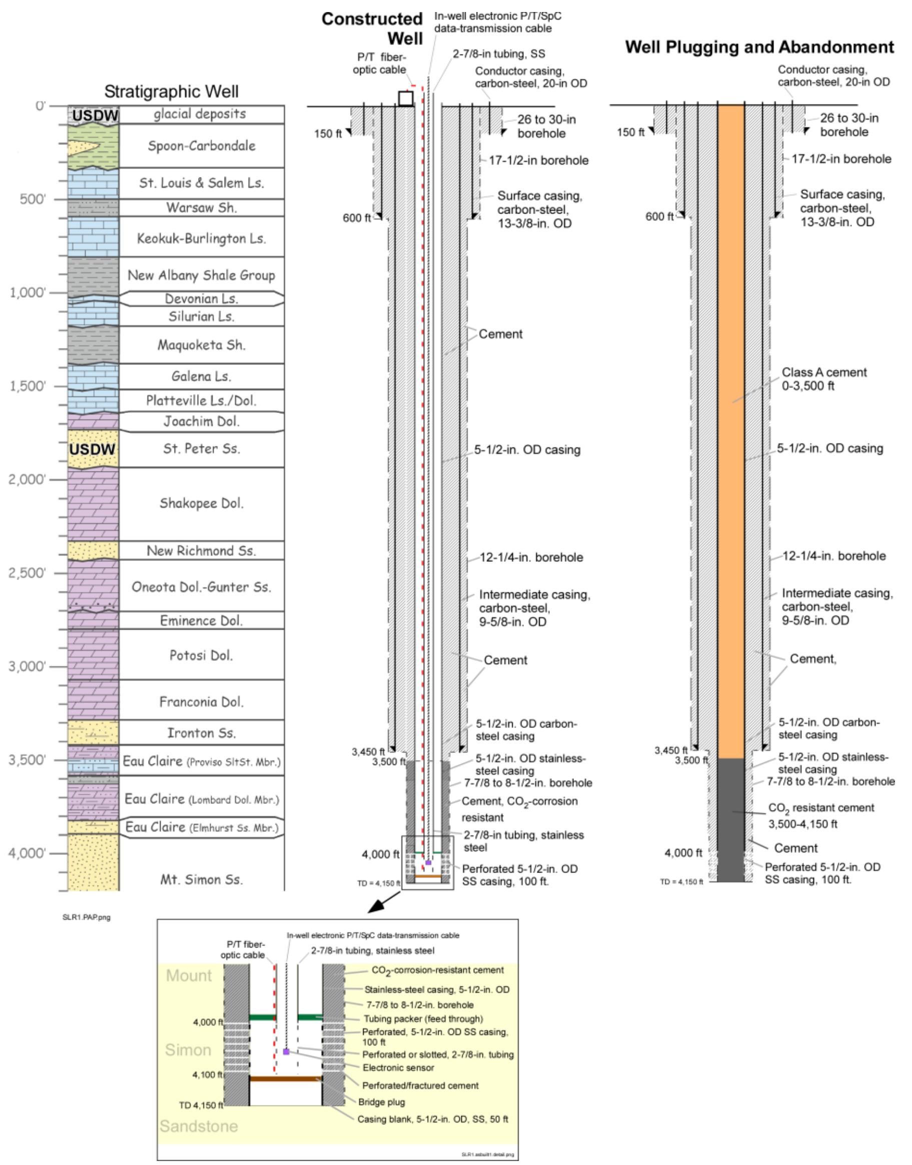


Figure A-1. Construction design and plugging and abandonment plan for new 5.5-in.-diameter single-level in-reservoir monitoring well.

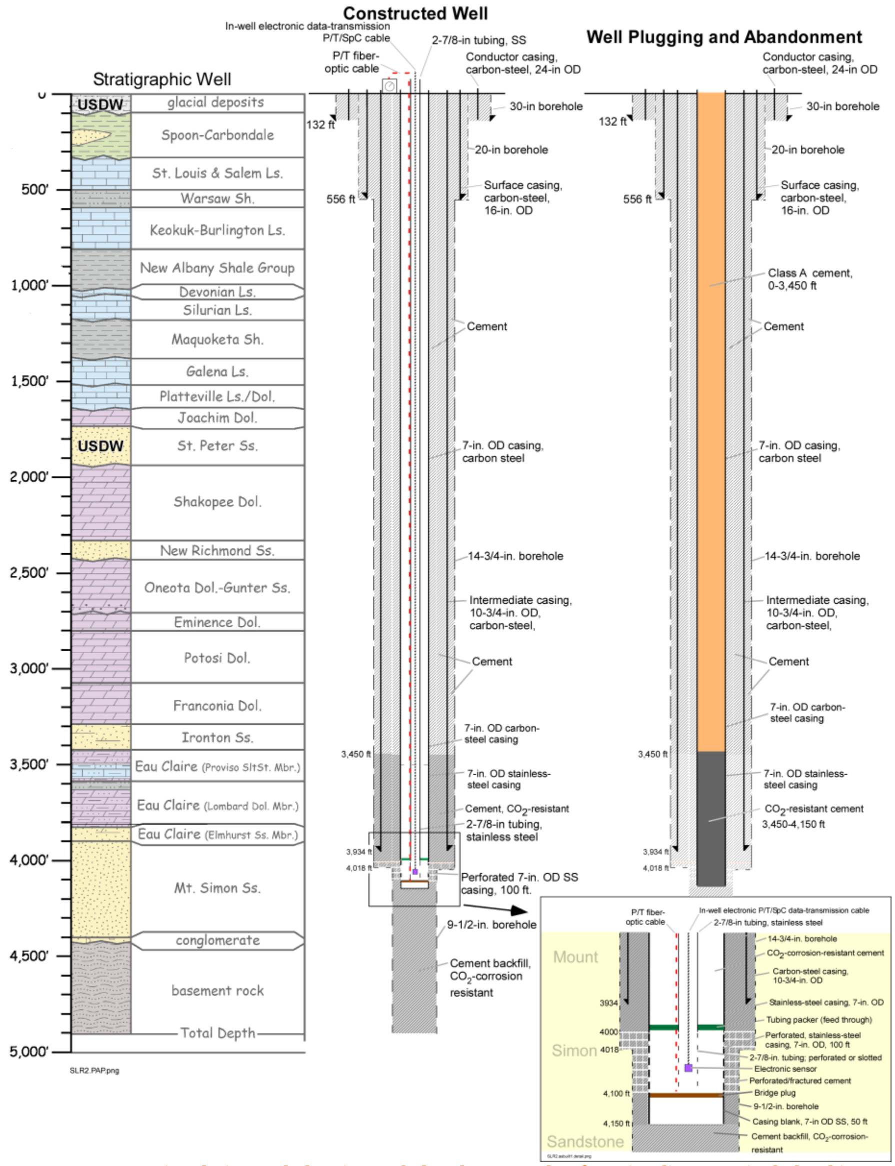


Figure A-2. Construction design and plugging and abandonment plan for 7-in.-diameter single-level in-reservoir monitoring well to be reconfigured from the stratigraphic well.

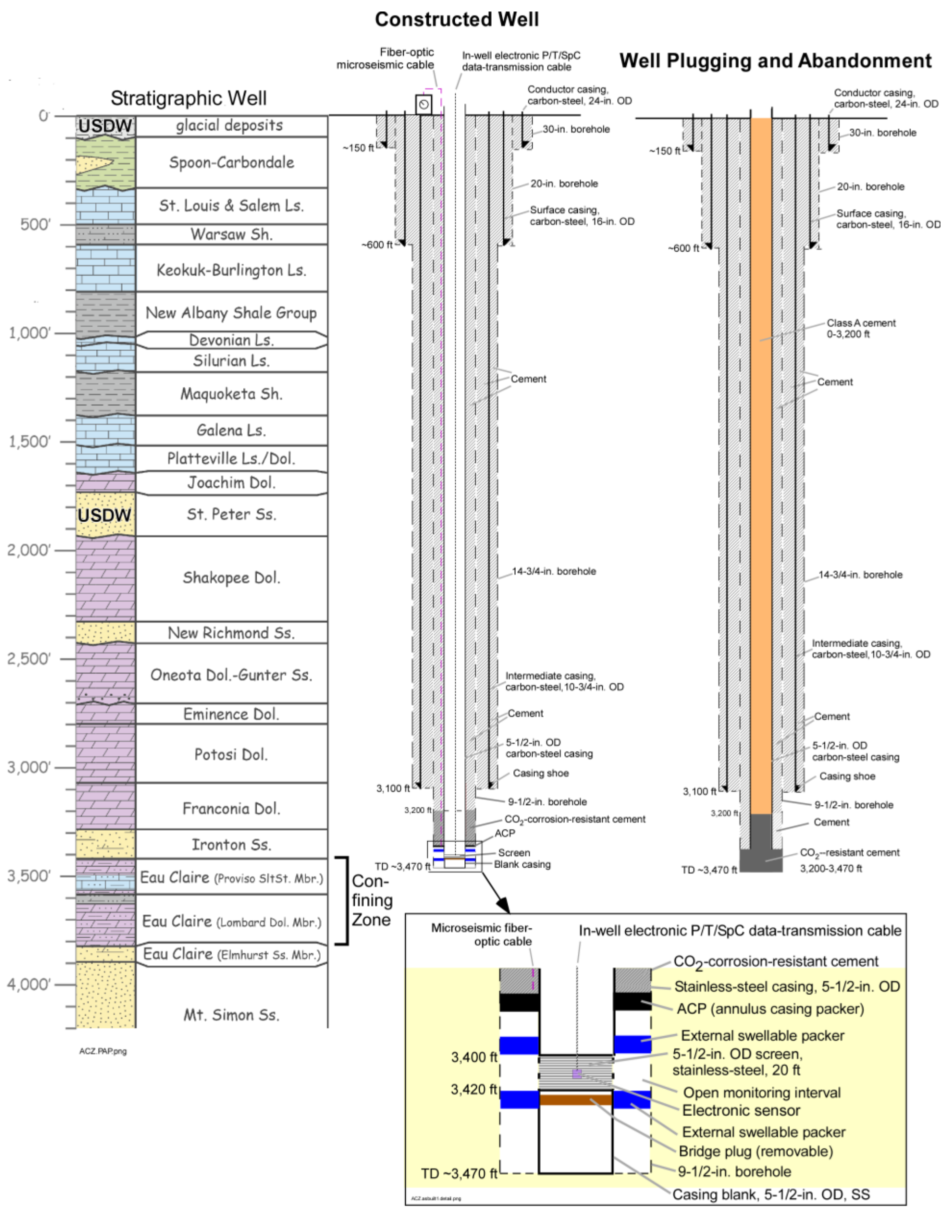


Figure A-3. Construction design and plugging and abandonment plan for the Above Confining Zone monitoring wells.

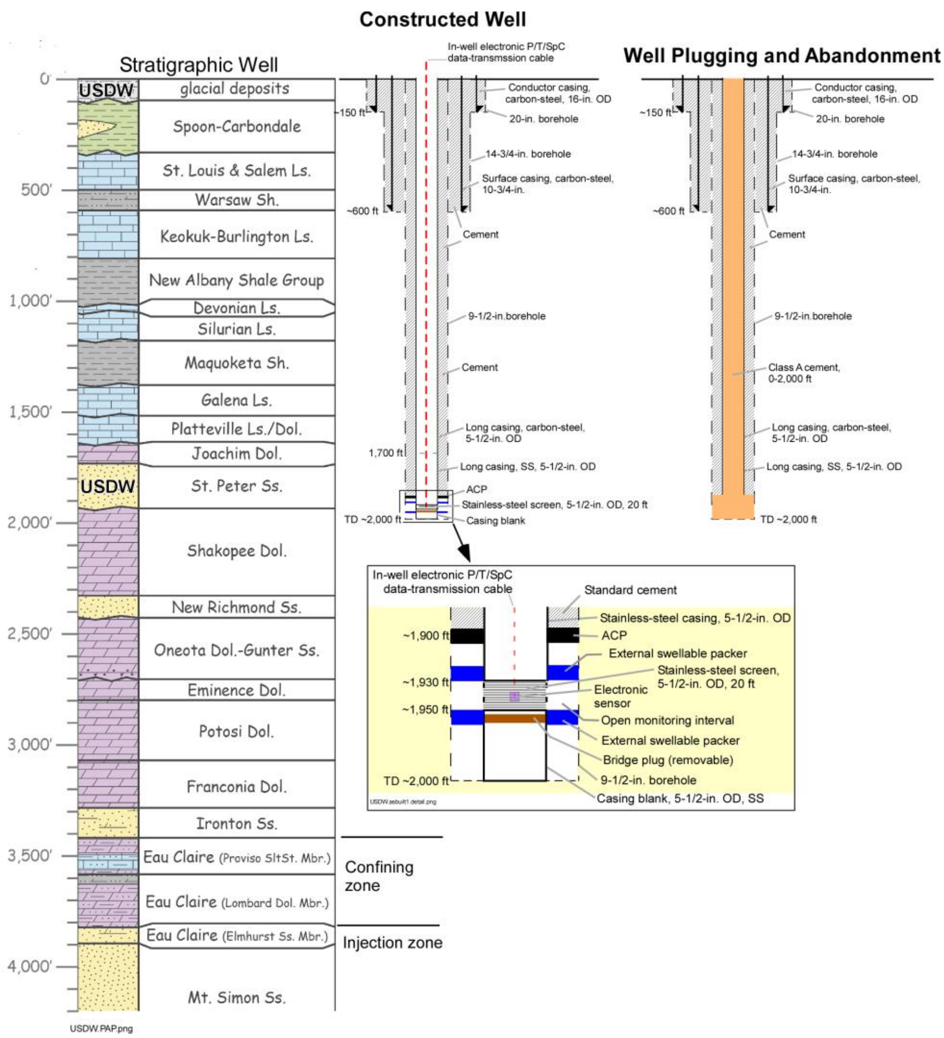


Figure A-4. Construction design and plugging and abandonment plan for the USDW monitoring well.

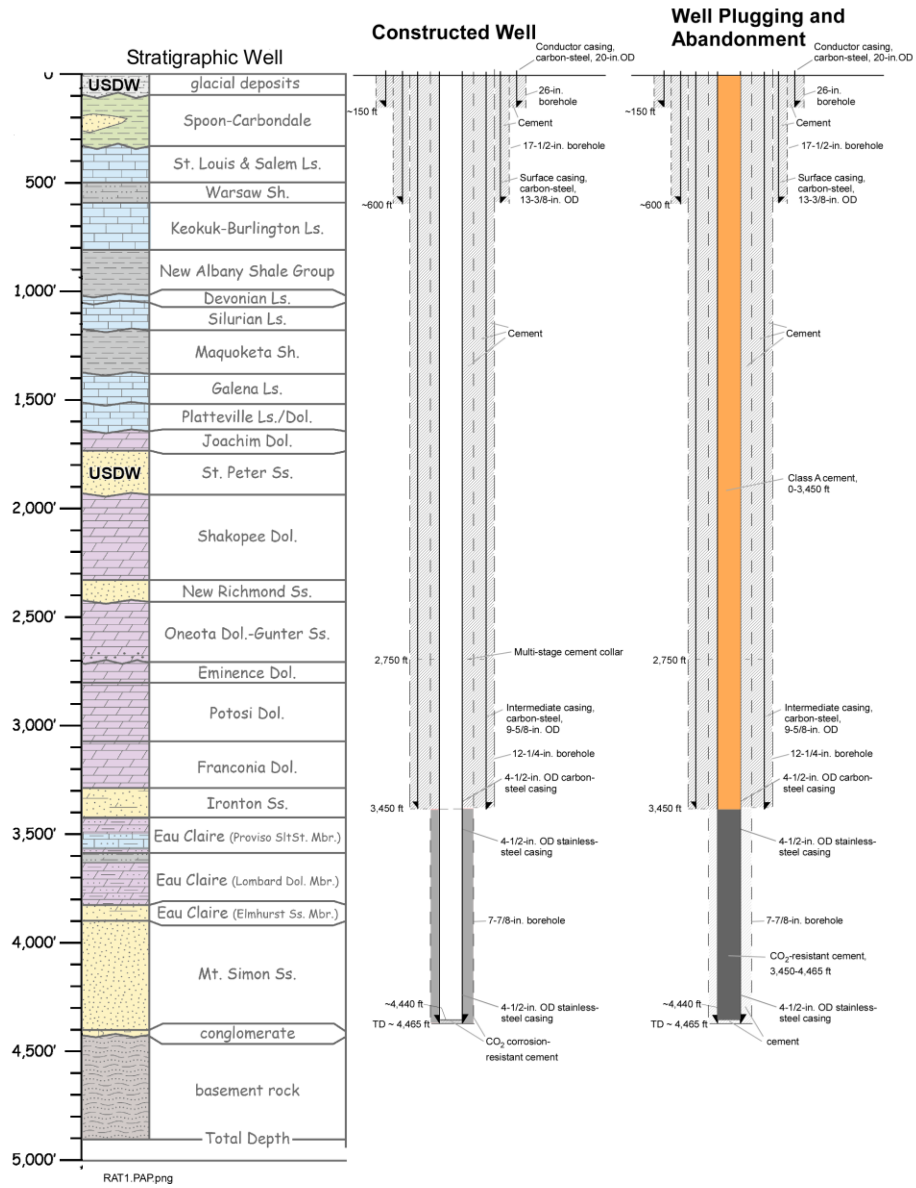


Figure A-5. Construction design and plugging and abandonment plan for the reservoir access tube wells.

Attachment E

Plugging and Abandonment Plans for Deep Monitoring Wells, Reservoir Access Tube Wells, and Geophysical Wells

Plugging and abandonment plans for the following monitoring wells are provided in this attachment:

Monitoring wells

- ACZ1
- ACZ2
- RAT1
- RAT2
- RAT3
- SLR1-5.5"
- SLR2-7"
- USDW1

Geophysical Wells

- MS1
- MS2
- MS3
- MS4
- MS5
- TM1
- TM2
- TM3
- TM4
- TM5

OMB No. 2040-0042 Approval Expires 11/30/2014

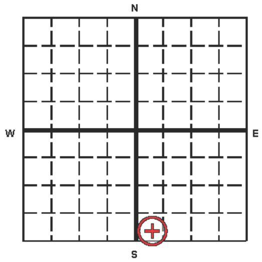
EPA

United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well ACZ1, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

sw 1/4 of sw 1/4 of sw 1/4 of se 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
24"	140	0-150	150	30"
16"	84	0-600	600	20"
10-3/4	51	0-3,100	3,100	14.75"
5-1/2"	17	0-3,470	3,470	9.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	9.5"	5.5"	5.5"				
Depth to Bottom of Tubing or Drill Pipe (ft	3,470'	3,350	3,200				
Sacks of Cement To Be Used (each plug)	61	17	354				
Slurry Volume To Be Pumped (cu. ft.)	68	20	418				
Calculated Top of Plug (ft.)	3,350	3,200	418				
Measured Top of Plug (if tagged ft.)	3,350	3,200	0				
Slurry Wt. (Lb./Gal.)	15.82	15.82	15.6				
Type Cement or Other Material (Class III)	EverCret	EverCret	Class A				

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To
3,470'	3,350' (perforated)		
3,400'	3,420' (screened)		

Estimated Cost to Plug Wells

$429,480

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

EPA Form 7520-14 (Rev. 12-11)

OMB No. 2040-0042 Approval Expires 11/30/2014

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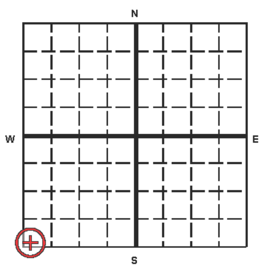
United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well ACZ2, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

SW 1/4 of SW 1/4 of SW 1/4 of SW 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
24"	140	0-150	150	30"
16"	84	0-600	600	20"
10-3/4	51	0-3,100	3,100	14.75"
5-1/2"	17	0-3,470	3,470	9.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	9.5"	5.5"	5.5"				
Depth to Bottom of Tubing or Drill Pipe (ft	3,470'	3,350	3,200				
Sacks of Cement To Be Used (each plug)	61	22	447				
Slurry Volume To Be Pumped (cu. ft.)	68	25	528				
Calculated Top of Plug (ft.)	3,350	3,200	0				
Measured Top of Plug (if tagged ft.)	3,350	3,200	0				
Slurry Wt. (Lb./Gal.)	15.82	15.82	15.6				
Type Cement or Other Material (Class III)	EverCret	EverCret	Class A				

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To
3,470'	3,350' (perforated)		
3,400'	3,420' (screened)		

Estimated Cost to Plug Wells

$429,480

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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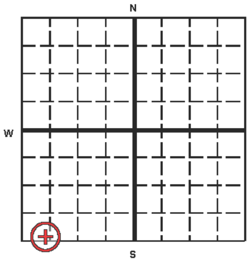
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
RAT1 Well, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

se 1/4 of sw 1/4 of sw 1/4 of sw 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface
Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

Lease Name

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
20"	94	0-150	150	26"
13-3/8	61	0-600	600	17.5"
9-5/8"	36	0-3,450	3,450	12.25"
4-1/2"	10.5	0-4,465	4,465	7.875"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	4.5"	4.5"					
Depth to Bottom of Tubing or Drill Pipe (ft	4,440'	3,450'					
Sacks of Cement To Be Used (each plug)	79	262					
Slurry Volume To Be Pumped (cu. ft.)	89	309					
Calculated Top of Plug (ft.)	3,450'	0'					
Measured Top of Plug (if tagged ft.)	3,450'	0'					
Slurry Wt. (Lb./Gal.)	15.82	15.6					
Type Cement or Other Material (Class III)	EverCret	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$308,830

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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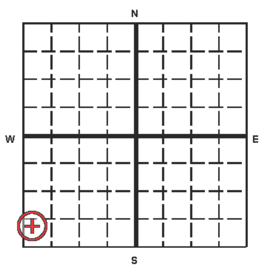
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
RAT2 Well, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description: nw 1/4 of sw 1/4 of sw 1/4 of sw 1/4 of Section 36 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location __ ft. frm (N/S) __ Line of quarter section
and __ ft. from (E/W) __ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name __ Well Number __

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
20"	94	0-150	150	26"
13-3/8	61	0-600	600	17.5"
9-5/8"	36	0-3,450	3,450	12.25"
4-1/2"	10.5	0-4,465	4,465	7.875"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	4.5"	4.5"					
Depth to Bottom of Tubing or Drill Pipe (ft	4,440'	3,450'					
Sacks of Cement To Be Used (each plug)	79	262					
Slurry Volume To Be Pumped (cu. ft.)	89	309					
Calculated Top of Plug (ft.)	3,450'	0'					
Measured Top of Plug (if tagged ft.)	3,450'	0'					
Slurry Wt. (Lb./Gal.)	15.82	15.6					
Type Cement or Other Material (Class III)	EverCret	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells
$308,830

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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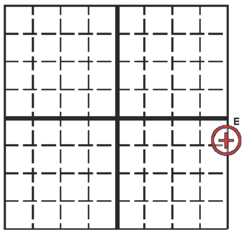
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
RAT3 Well, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

se 1/4 of ne 1/4 of ne 1/4 of se 1/4 of Section 34 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface
Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
20"	94	0-150	150	26"
13-3/8	61	0-600	600	17.5"
9-5/8"	36	0-3,450	3,450	12.25"
4-1/2"	10.5	0-4,465	4,465	7.875"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	4.5"	4.5"					
Depth to Bottom of Tubing or Drill Pipe (ft	4,440'	3,450'					
Sacks of Cement To Be Used (each plug)	79	262					
Slurry Volume To Be Pumped (cu. ft.)	89	309					
Calculated Top of Plug (ft.)	3,450	0					
Measured Top of Plug (if tagged ft.)	3,450	0					
Slurry Wt. (Lb./Gal.)	15.82	15.6					
Type Cement or Other Material (Class III)	EverCret	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$308,830

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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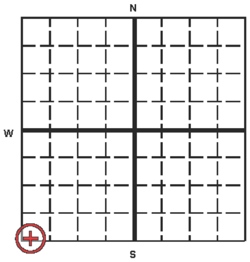
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well SLR1, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres

N



W E

S

State	County	Permit Number
Illinois	Morgan	

Surface Location Description

SW 1/4 of SW 1/4 of SW 1/4 of SW 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface
Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION	WELL ACTIVITY
☑ Individual Permit	☐ CLASS I
☐ Area Permit	☐ CLASS II
☐ Rule	☐ Brine Disposal
Number of Wells 1	☐ Enhanced Recovery
	☐ Hydrocarbon Storage
	☐ CLASS III
Lease Name	Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
20"	94	0-150	150	26"
13-3/8	61	0-600	600	17.5"
9-5/8"	36	0-3,450	3,450	12.25"
5-1/2"	17	0-4,150	4,150	8"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

☑ The Balance Method
☐ The Dump Bailer Method
☐ The Two-Plug Method
☐ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	5-1/2"	5-1/2"					
Depth to Bottom of Tubing or Drill Pipe (ft	4,150'	3,500'					
Sacks of Cement To Be Used (each plug)	78	388					
Slurry Volume To Be Pumped (cu. ft.)	87	458					
Calculated Top of Plug (ft.)	3,500'	0'					
Measured Top of Plug (if tagged ft.)	3,500'	0'					
Slurry Wt. (Lb./Gal.)	15.82	15.6					
Type Cement or Other Material (Class III)	EverCret	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To
4000'	4100' (perforated and fractured)		

Estimated Cost to Plug Wells

$536,600

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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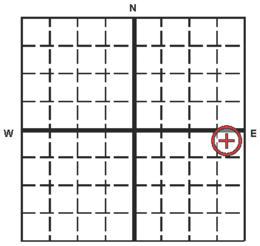
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility: Well SLR2, FutureGen 2.0, Morgan County, IL

Name and Address of Owner/Operator: FutureGen Alliance, 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description: nw 1/4 of ne 1/4 of ne 1/4 of se 1/4 of Section 25 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- ☑ Individual Permit
- ☐ Area Permit
- ☐ Rule

Number of Wells 1

WELL ACTIVITY

- ☐ CLASS I
- ☐ CLASS II
  - ☐ Brine Disposal
  - ☐ Enhanced Recovery
  - ☐ Hydrocarbon Storage
- ☐ CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
24"	140	0-132	132	30"
16"	84	0-556	556	20"
10-3/4	51	0-3,934	3,934	14.75"
7"	29	4,150	4,150	9.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☑ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☐ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7"	7"					
Depth to Bottom of Tubing or Drill Pipe (ft	4,150'	3,500'					
Sacks of Cement To Be Used (each plug)	124	619					
Slurry Volume To Be Pumped (cu. ft.)	139	730					
Calculated Top of Plug (ft.)	3,500'	0'					
Measured Top of Plug (if tagged ft.)	3,500'	0'					
Slurry Wt. (Lb./Gal.)	15.82	15.6					
Type Cement or Other Material (Class III)	EverCret	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To
4000'	4100' (perforated and fractured)		

Estimated Cost to Plug Wells: $571,600

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title (Please type or print)	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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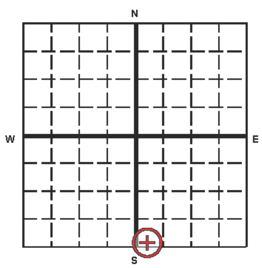
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well USDW1, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description
sw 1/4 of sw 1/4 of sw 1/4 of se 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
16"	55	0-150	150	20"
10-3/4	40.5	0-600	600	14.75"
5-1/2"	17	0-2,000	2,000	9.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	9.5"	5.5"					
Depth to Bottom of Tubing or Drill Pipe (ft	2,000'	1,880'					
Sacks of Cement To Be Used (each plug)	56	209					
Slurry Volume To Be Pumped (cu. ft.)	63	246					
Calculated Top of Plug (ft.)	1,880'	0					
Measured Top of Plug (if tagged ft.)	1,880'	0					
Slurry Wt. (Lb./Gal.)	15.6	15.6					
Type Cement or Other Material (Class III)	Class A	Class A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To
2,000'	1,880' (perforated)		
1,930'	1,950' (screened)		

Estimated Cost to Plug Wells
$319,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

EPA Form 7520-14 (Rev. 12-11)

OMB No. 2040-0042 Approval Expires 11/30/2014

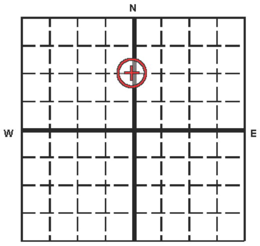
EPA

United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS1, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

se 1/4 of se 1/4 of ne 1/4 of nw 1/4 of Section 27 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION	WELL ACTIVITY
☑ Individual Permit	☐ CLASS I
☐ Area Permit	☐ CLASS II
☐ Rule	☐ Brine Disposal
	☐ Enhanced Recovery
Number of Wells 1	☐ Hydrocarbon Storage
	☐ CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
13-3/8	54	0-130	130	17.5"
7-5/8	26.4	0-350	350	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☑ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☐ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	330						
Sacks of Cement To Be Used (each plug)	74						
Slurry Volume To Be Pumped (cu. ft.)	87						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$25,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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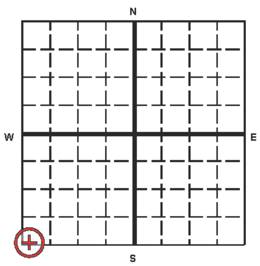
United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS2, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

SW 1/4 of SW 1/4 of SW 1/4 of SW 1/4 of Section 31 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

Lease Name

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
13-3/8	54	0-130	130	17.5"
7-5/8	26.4	0-350	350	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
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Depth to Bottom of Tubing or Drill Pipe (ft	330						
Sacks of Cement To Be Used (each plug)	74						
Slurry Volume To Be Pumped (cu. ft.)	87						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$25,000

Certification

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Name and Official Title (Please type or print)	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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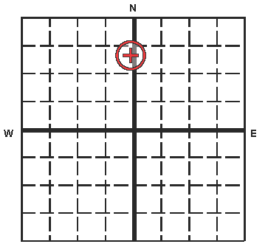
EPA

United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS3, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

ne 1/4 of se 1/4 of ne 1/4 of nw 1/4 of Section 25 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
13-3/8	54	0-130	130	17.5"
7-5/8	26.4	0-350	350	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
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Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$25,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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EPA

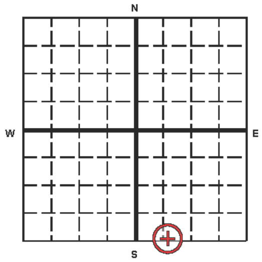
United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility: Well MS4, FutureGen 2.0, Morgan County, IL

Name and Address of Owner/Operator: FutureGen Alliance, 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State: Illinois **County:** Morgan **Permit Number:**

Surface Location Description

sw 1/4 of se 1/4 of sw 1/4 of se 1/4 of Section 34 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- ☑ Individual Permit
- ☐ Area Permit
- ☐ Rule

Number of Wells 1

WELL ACTIVITY

- ☐ CLASS I
- ☐ CLASS II
  - ☐ Brine Disposal
  - ☐ Enhanced Recovery
  - ☐ Hydrocarbon Storage
- ☐ CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
13-3/8	54	0-130	130	17.5"
7-5/8	26.4	0-350	350	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☑ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☐ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	330						
Sacks of Cement To Be Used (each plug)	74						
Slurry Volume To Be Pumped (cu. ft.)	87						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells: $25,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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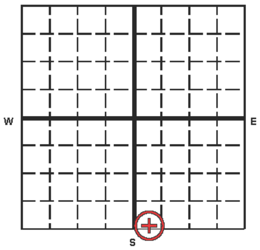
EPA

United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS5, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

sw 1/4 of sw 1/4 of sw 1/4 of se 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
13-3/8	54	0-130	130	17.5"
7-5/8	26.4	0-350	350	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	330						
Sacks of Cement To Be Used (each plug)	74						
Slurry Volume To Be Pumped (cu. ft.)	87						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$25,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

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Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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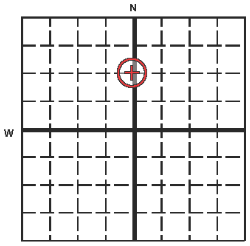
United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility: Well TM1, FutureGen 2.0, Morgan County, IL

Name and Address of Owner/Operator: FutureGen Alliance
73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State: Illinois **County:** Morgan **Permit Number:**

Surface Location Description: se 1/4 of se 1/4 of ne 1/4 of nw 1/4 of Section 27 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface
Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Lease Name ___ Well Number ___

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
7-5/8	26.4	0-20	20	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [ ] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [x] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	20						
Sacks of Cement To Be Used (each plug)	4						
Slurry Volume To Be Pumped (cu. ft.)	5						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells: $2,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

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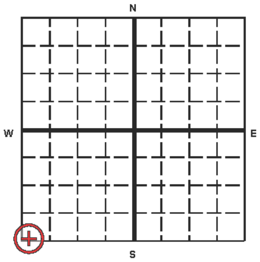
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well TM2, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description: SW 1/4 of SW 1/4 of SW 1/4 of SW 1/4 of Section 31 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

Lease Name

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
7-5/8	26.4	0-20	20	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [ ] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [x] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	20						
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Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells
$2,000

Certification

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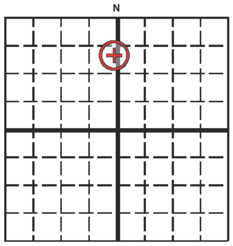
PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well TM3, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

ne 1/4 of se 1/4 of ne 1/4 of nw 1/4 of Section 25 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION	WELL ACTIVITY
☑ Individual Permit	☐ CLASS I
☐ Area Permit	☐ CLASS II
☐ Rule	☐ Brine Disposal
Number of Wells 1	☐ Enhanced Recovery
	☐ Hydrocarbon Storage
	☐ CLASS III
Lease Name	Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
7-5/8	26.4	0-20	20	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☐ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☑ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	20						
Sacks of Cement To Be Used (each plug)	4						
Slurry Volume To Be Pumped (cu. ft.)	5						
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Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$2,000

Certification

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Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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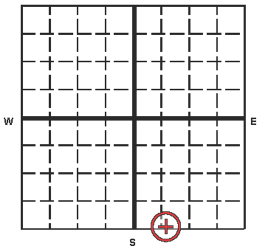
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS4, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

sw 1/4 of se 1/4 of sw 1/4 of se 1/4 of Section 34 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

Lease Name

WELL ACTIVITY

- [ ] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
7-5/8	26.4	0-20	20	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [ ] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [x] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inche	7-5/8"						
Depth to Bottom of Tubing or Drill Pipe (ft	20						
Sacks of Cement To Be Used (each plug)	4						
Slurry Volume To Be Pumped (cu. ft.)	5						
Calculated Top of Plug (ft.)	0						
Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$2,000

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

EPA Form 7520-14 (Rev. 12-11)

OMB No. 2040-0042 Approval Expires 11/30/2014

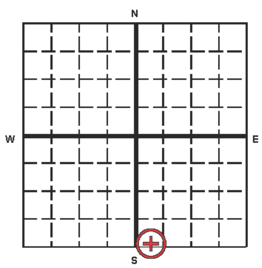
United States Environmental Protection Agency
Washington, DC 20460

EPA

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Well MS5, FutureGen 2.0, Morgan County, IL	FutureGen Alliance 73 Central Park Plaza East, Jacksonville, IL 62650

Locate Well and Outline Unit on Section Plat - 640 Acres



State	County	Permit Number
Illinois	Morgan	

Surface Location Description

sw 1/4 of sw 1/4 of sw 1/4 of se 1/4 of Section 26 Township 16n Range 9w

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. frm (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of quarter section.

TYPE OF AUTHORIZATION	WELL ACTIVITY
☑ Individual Permit	☐ CLASS I
☐ Area Permit	☐ CLASS II
☐ Rule	☐ Brine Disposal
Number of Wells 1	☐ Enhanced Recovery
	☐ Hydrocarbon Storage
	☐ CLASS III
Lease Name	Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
7-5/8	26.4	0-20	20	11.5"

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☐ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☑ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
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Measured Top of Plug (if tagged ft.)	0						
Slurry Wt. (Lb./Gal.)	15.6						
Type Cement or Other Material (Class III)	Class A						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

$2,000

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Kenneth K. Humphreys, Chief Executive Officer	Kenneth K. Humphreys	03/03/2014

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