UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

STATEMENT OF BASIS
FOR ISSUANCE OF CLASS VI UNDERGROUND INJECTION CONTROL (UIC) PERMITS

Permit Numbers: IL-137-6A-0001, IL-137-6A-0002, IL-137-6A-0003 and IL-137-6A-0004

Facility Name: FutureGen 2.0 Morgan County CO_2 Storage Site

The FutureGen Alliance (Morgan County, Illinois) applied for four U.S. Environmental Protection Agency (EPA) permits for wells to be used for geologic sequestration of carbon dioxide as Class VI wells. These injection wells would be part of a larger Carbon Capture and Storage "CCS" project associated with the Meredosia Power Plant which will produce and capture the carbon dioxide (CO_2) to be injected –with a goal of reducing carbon emissions to the atmosphere to help mitigate climate change. The project is proposed to: inject 22 million metric tons of CO_2 into the Mt. Simon Sandstone for 20 years; and, monitor the CO_2 for an additional 50 years during the post-injection site care period.

EPA reviewed all information submitted by FutureGen to inform the draft permit decisions. EPA considered information and issues including:

- Geologic site characterization, injection and confining zone characterization, and project siting;
- Computational modeling of the project's Area of Review (AoR);
- The proposed well construction and operational conditions;
- The approach FutureGen proposed to monitor the wells and track the plume and pressure front to ensure protection of underground sources of drinking water (USDW) for the life of the project – including both the injection and post-injection site care periods;
- FutureGen's financial responsibility demonstration;
- The strategy to address and mitigate risks associated with induced seismicity;
- Emergency and remedial response strategy development;
- The CO_2 stream source, characteristics and purity;
- Environmental justice;
- Endangered species; and
- Ensuring USDW protection.

EPA's review of the permit applications indicates that the proposed injection project meets the requirements for Class VI injection wells and will not pose a risk of endangerment to USDWs. The EPA, therefore, is issuing draft permit decisions for four wells. Under the authority of Title 40 of the Code of Federal Regulations (40 CFR) Parts 144 and 146, EPA Class VI permits must specify conditions for the construction, operation, monitoring, reporting, plugging, post-injection site care and site closure of Class VI injection wells so as to prevent the movement of fluids into any USDW. General provisions for EPA UIC permit requirements are found at 40 CFR Parts 124, 144, 146 and 147. In accordance with 40 CFR 124.7, general information and highlighted permit conditions specific to these wells are discussed in the following sections. Additional, substantive discussion of many of these topics is also documented in separate documents of the Administrative Record for these permit decisions.

Area of Review and Corrective Action: In accordance with 40 CFR 144.55, 146.6 and 146.84, the Area of Review, or AoR, is the region surrounding the geologic sequestration project where any improperly sealed, completed or abandoned wells that penetrate the injection and/or confining zones could provide a conduit for fluid migration. The AoR for these wells has a radius of approximately 24 miles and was delineated pursuant to 40 CFR 146.84(c)(1) using a computational model that predicts the movement of the carbon dioxide plume and pressure front based on available information about planned injection operations and the subsurface rock formations. Figure 1 is a map of the project AoR.

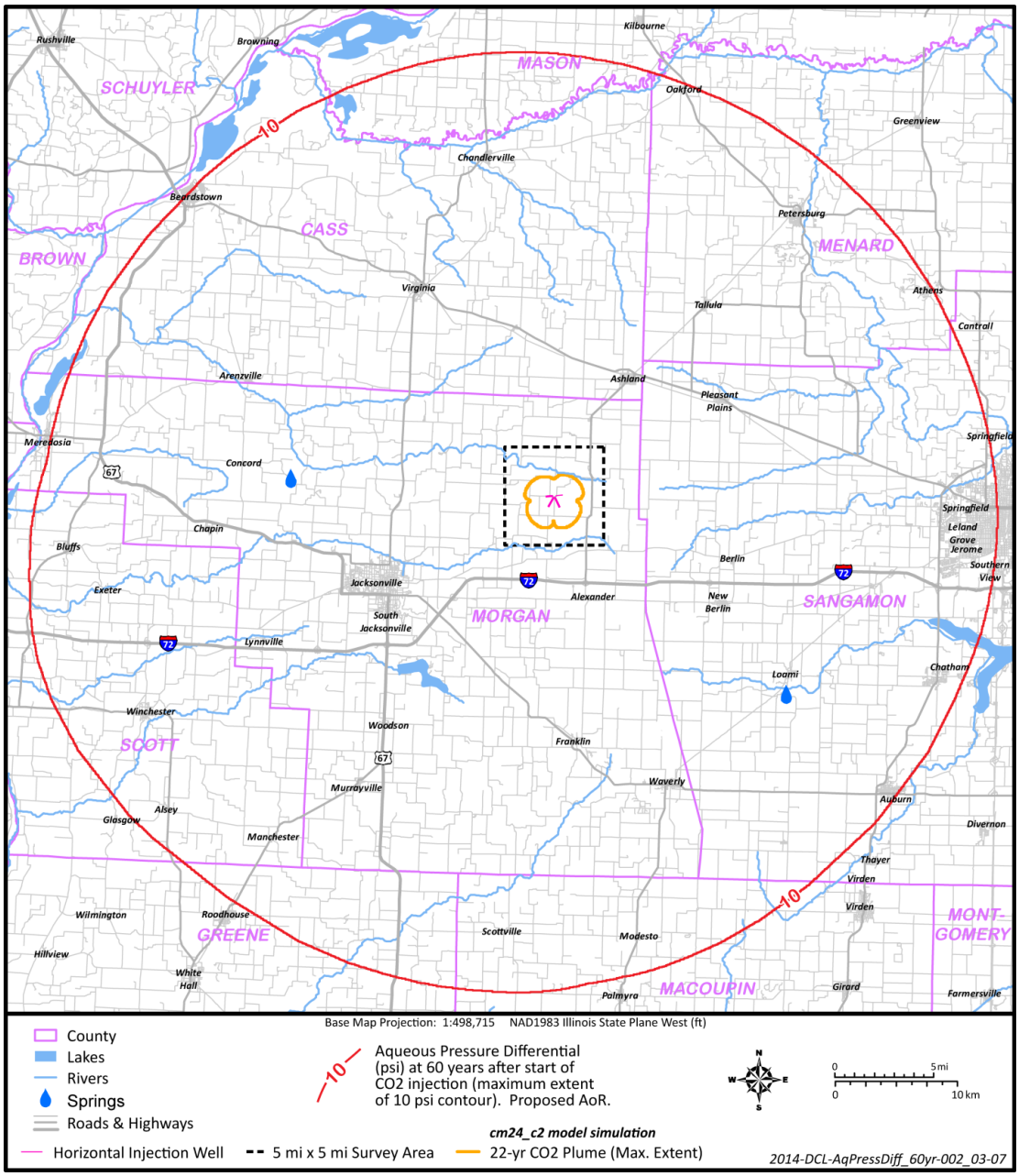

Figure 1. The FutureGen project proposed Area of Review including: the modeled CO_2 plume (in yellow) and the predicted area of elevated pressure (the red circle).

EPA performed an extensive evaluation of the AoR proposed by the permittee by independently modeling the AoR using the Subsurface Transport Over Multiple Phases (STOMP) multi-phase transport model, based on the site-specific geologic and operational data in the permit application and determined that the AoR delineated by the permittee is sufficiently extensive and meets the requirements of 40 CFR 146.84(c)(1). EPA also evaluated the modeling approach used by the permittee and determined that it meets the requirements for computational models to delineate Class VI AoRs. Information about EPA's independent assessment is available in a report in the Administrative Record for these permit decisions.

In accordance with 40 CFR 144.55 and 146.84, the permittee must perform corrective action to address any deficiencies identified in wells in the AoR, as described in the Area of Review and Corrective Action Plan of the permit. Based on an evaluation of well records, the FutureGen Alliance determined that only one well penetrates the confining zone –a stratigraphic test well constructed by FutureGen. It was

properly constructed and thus no wells require corrective action within the FutureGen AoR.

As required at 40 CFR 146.84(e), FutureGen will reevaluate the AoR using computational modeling at least every five years over the lifetime of the project to verify, based on monitoring and operating data, that the carbon dioxide plume and pressure front are moving as predicted. FutureGen will also review monitoring, operational and other data annually to determine whether additional reevaluations of the AoR are needed. This AoR reevaluation, and any additional corrective action that is needed, will be performed pursuant to the Area of Review and Corrective Action Plan, which is an enforceable condition of the Class VI permits. If this reevaluation indicates that there are changes from predictions, the permittee must revise all of the project-specific plans and the permit will be modified per 40 CFR 144.39.

Underground Sources of Drinking Water (USDWs): USDWs are defined by UIC regulations as aquifers or portions thereof which contain less than 10,000 milligrams per liter of total dissolved solids and are being used, or could be used, as a source of drinking water. The base of the lowermost USDW near the wells, the St. Peter Sandstone formation, is at a depth of 1,942 feet below the ground surface. The shallow, Quaternary glacial sediments that serve as the source of local drinking water are approximately 150 feet below the ground surface.

Injection and Confining Zone: Injection for geologic sequestration is limited by the permits to the Mt. Simon Sandstone and the lower member of the Eau Claire Formation (the Elmhurst Sandstone) in the interval between 3,785 feet and 4,432 feet below the ground surface. This injection zone is separated from the lowermost USDW by 1,843 feet of rock, including an impermeable confining zone, the upper members of the Eau Claire Formation (The Lombard and Proviso Members), which will act as barrier to fluid movement. Figure 2 includes a stratigraphic column at the site, including the depth of the injection and confining zones.

EPA has reviewed extensive information submitted by the permittee, including maps, well logs, cores, and the results of seismic surveys. Based on this information, EPA has determined that the regional and local geologic features at the site will allow the Mt. Simon Sandstone to receive the amount of carbon dioxide proposed to be injected without a buildup of pressure that would create faults or fractures. EPA also determined that the site is free of any known faults or fractures that could affect containment and that the Eau Claire Formation will provide suitable containment to ensure that the carbon dioxide remains in place and USDWs will not be endangered, as required under 40 CFR 146.83. Additionally, EPA evaluated information on seismic history in the area and potential seismic risk to conclude that the project poses a low risk of inducing felt seismic events. Information on this evaluation is available in a separate document in the Administrative Record for these permit decisions.

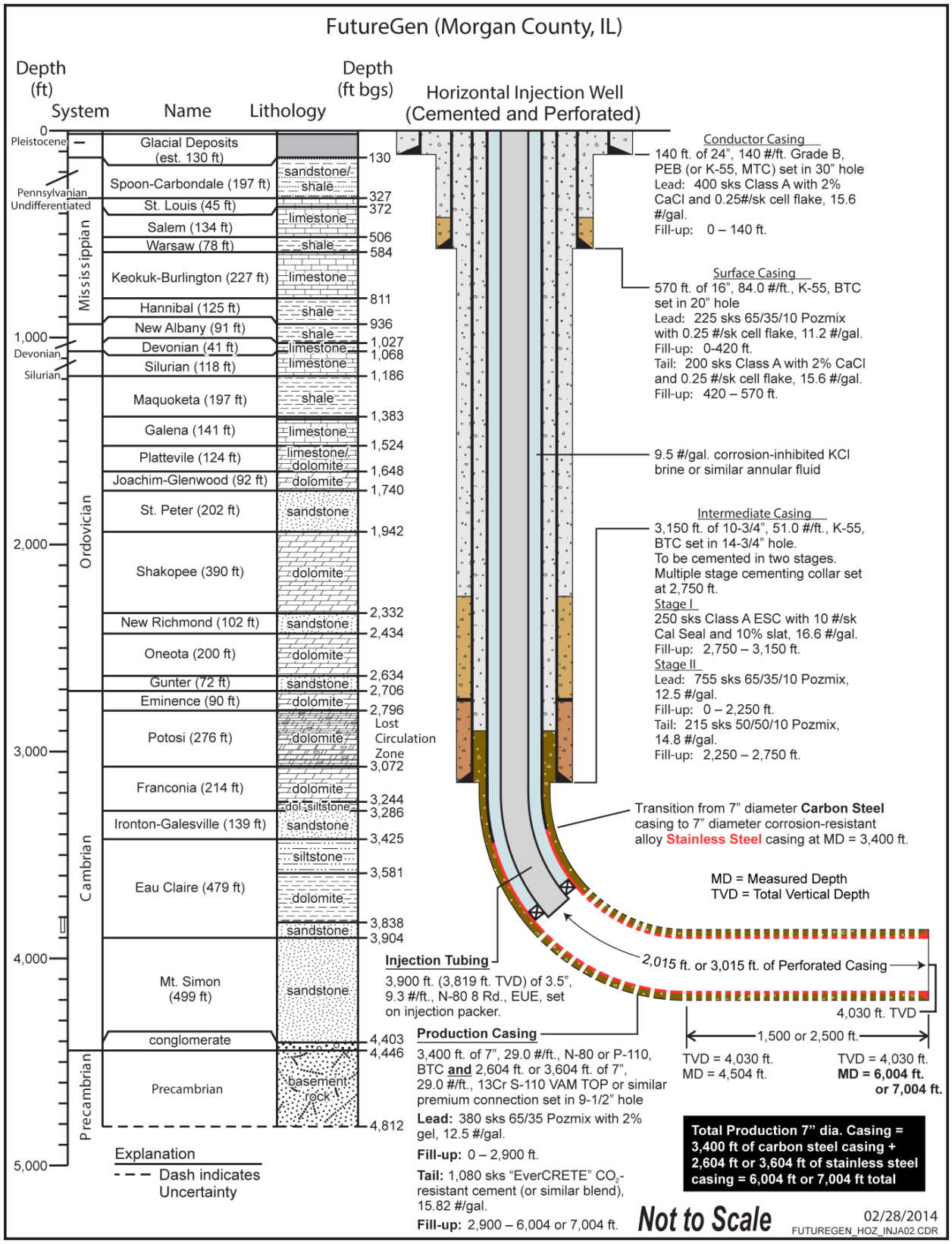

Figure 2. A stratigraphic column of the geology at the project site (on the left) including the Mt Simon Sandstone (the injection zone) and the Eau Claire Sandstone (the confining zone) and example well schematics.

Construction Requirements: The FutureGen project will consist of four horizontal wells that will be directionally drilled from a single well pad. Proposed construction of the wells meets the regulatory

criteria of 40 CFR 146.86. All Class VI wells must be constructed with materials and cements that can withstand exposure to CO_2 and CO_2/water mixtures without excessive corrosion over the life of the project (See Figure 2). Class VI wells must also be cased and cemented to prevent the movement of fluids into or between USDWs. The wells will be equipped with automatic surface shut-off devices that will shut off the wells if any permitted operating parameters (such as injection pressure) diverge from limitations set in the permits. EPA reviewed the proposed well schematics submitted with the permit applications to verify that the cements and other materials proposed for the wells will be compatible with the carbon dioxide stream and planned operations (e.g., injection pressures). Following well construction, pursuant to 40 CFR 146.82(c), EPA will review any final "as built" well schematics to confirm that the wells were constructed to ensure USDW protection, meet the goals of the Class VI Rule at 40 CFR 146.86(a), and are equipped with the required shut-down devices before injection is authorized.

Injection Fluid: The permits limit the fluid that may be injected to CO_2 from the Meredosia Power Plant. Captured emissions will be passed through a purification and compression unit, and then transported through an underground pipeline to the wells. The fluid will contain trace impurities but will be at least 97 percent CO_2. FutureGen anticipates injecting a total of 22 million metric tons of CO_2 over 20 years.

Maximum Injection Pressure: The maximum injection pressure will be limited to 2,237 pounds per square inch gauge (psig) measured at 3,850 feet to ensure that the pressure during injection does not initiate fractures in the injection or confining zones, pursuant to 40 CFR 146.88(a). This, in turn, ensures that the injection pressure will not cause the movement of injection or formation fluids into a USDW as prohibited by 40 CFR 146.86(a). This pressure is 90 percent of the fracture pressure of the Mt. Simon Sandstone, which was determined based on data obtained from the FutureGen Project 2.0 stratigraphic well. EPA confirmed, based on geomechanical information about the injection and confining zones (e.g., fracture pressure, porosity, and permeability), that the injection pressure is appropriate and will not initiate fractures in the injection or confining zones.

Monitoring and Reporting Requirements: In accordance with 40 CFR 146.90, FutureGen will implement an approved Testing and Monitoring Plan for the project. The multi-faceted Testing and Monitoring Plan, which is an enforceable condition of the Class VI permits, includes the following testing that FutureGen will undertake to ensure USDW protection:

- Analyzing the carbon dioxide quarterly: to provide information about its chemical and physical characteristics.
- Testing of the injection well: to demonstrate the integrity of the well before injection commences and throughout injection operations. FutureGen must conduct and pass a two-part mechanical integrity test (MIT), in accordance with 40 CFR 146.8 and 146.89, before receiving authorization to inject. After injection commences, the permittee will continuously observe and record injection pressure, flow rate and volume and the pressure on the annulus to detect leaks in the casing, tubing or packer. In addition, FutureGen must demonstrate external mechanical integrity annually using a temperature or noise log or another method approved by the Director to detect fluid movement behind the casing. They will also test the well materials for signs of corrosion on a quarterly basis to provide early warning of corrosion due to contact with carbon dioxide in the presence of water that could compromise the wells.
- Monitoring the environment near the wells: to verify that the project and the injected carbon dioxide plume and pressure front are behaving as predicted (See the section entitled "Area of Review and Corrective Action" for details on the delineation of this area and Figure 1). FutureGen will:
    - Perform monitoring above the confining zone using shallow wells and monitor ground water quality in deeper wells to detect geochemical changes that may be a result of changes

in the subsurface (such as leaching or mobilization of heavy metals and organic compounds or fluid displacement) that could impact USDWs.
    - Conduct annual pressure fall-off testing to verify that the injection zone is responding to injection as predicted.
    - Monitor the carbon dioxide plume and pressure front using direct methods (e.g., fluid sampling and pressure/temperature monitoring) and indirect methods (e.g., pulsed neutron capture/reservoir saturation logs and Differential Interferometric Synthetic Aperture Radar) to verify that the carbon dioxide plume and pressure front are moving as predicted or provide early warning if they are not.
- Monitoring for natural or induced seismic events: to verify that the project is operating as predicted and the geologic system and injection wells are not compromised by any felt or unfelt microseismic events, whether natural or induced.

In accordance with 40 CFR 144.54 and 146.91, FutureGen will submit the results of this monitoring to the permitting authority semiannually or within 30 days of the completion of an MIT or other required testing.

EPA evaluated the permittee's proposed Testing and Monitoring Plan to ensure that all testing procedures are appropriate to the planned operations, the wells' construction, and the geologic environment and that this testing and monitoring meets the requirements of the Class VI Rule at 40 CFR 146.90. The proposed well testing is appropriate to the planned well construction and will provide early warning of any problems that may occur. EPA also determined, based on information regarding the anticipated movement of the carbon dioxide plume and pressure front that the locations and methods for monitoring ground water quality and the position of the plume and pressure front will provide the information needed to provide early warning of ground water quality changes or carbon dioxide leakage. EPA considered modeling data, hydrogeologic information on the properties of the injection and confining zone, and the need to limit the number of penetrations of the confining zone in determining the appropriate direct and indirect ground water and carbon dioxide monitoring regime.

Emergency and Remedial Response: In accordance with 40 CFR 146.94, FutureGen developed a site-specific Emergency and Remedial Response Plan that identifies the resources that may be at risk due to the injection activities, including USDWs. The Plan, an enforceable part of the permit, also describes the responses that would be taken to address adverse events, and the staff and equipment available to support this and other such activities. The Emergency and Remedial Response provisions of the permit will facilitate expedient responses and prevent or mitigate harm to the environment, including USDWs. EPA evaluated the Emergency and Remedial Response Plan to verify that sufficient, specific procedures are in place should an adverse event (including a well failure, leakage of carbon dioxide, or a seismic event) that impacts any identified resource in the AoR arise, so that the permittee can expeditiously take effective actions to prevent or mitigate harm to USDWs.

Financial Responsibility: In accordance with 40 CFR 146.85, FutureGen has demonstrated and will maintain adequate financial resources to perform all needed corrective action on wells in the AoR, to plug the injection wells, to perform all required post-injection site care and close the site, and to conduct any emergency and remedial responses needed to address adverse events at the site. This financial assurance confirms that resources will be available to perform all USDW-protective activities without using public/taxpayer money. The FutureGen Alliance estimated the costs necessary to cover the activities described above and provided a signed Trust Agreement to demonstrate that sufficient resources will be available. FutureGen will update the cost estimates on an annual basis and, if necessary, adjust the financial responsibility demonstration to address any changes, e.g., based on inflation or changes to the project that affect these costs.

EPA determined that the Trust Agreement amount is adequate by comparing cost estimates provided by the FutureGen Alliance for the covered activities to estimates EPA independently generated using its Cost Estimation Tool, which estimates financial responsibility costs based on site-specific information (e.g., about well depth, the presence of USDWs in the AoR, and the volume of carbon dioxide to be injected). EPA also evaluated the financial responsibility instruments using checklists developed by the UIC Program that evaluate the strength of available instruments. Additionally, EPA concluded that the pay-in-period suggested for funding the instrument is appropriate and protective. Information on EPA's cost estimation analysis is documented in a report that is available in the Administrative Record for these permit decisions.

Plugging and Abandonment: In accordance with 40 CFR 146.92, the permits include Well Plugging Plans for environmentally protective closure of the injection wells to ensure that the wells will be plugged in a manner that will not allow movement of injected or native fluids into USDWs. The wells will be plugged using approved materials that are compatible with carbon dioxide/water mixtures to ensure that they will not serve as a conduit for fluid movement. EPA evaluated the permittee's proposed Injection Well Plugging Plans to verify that the wells will be plugged with sufficient numbers and types of plugs and cement, based on the proposed depth and design of the wells and geologic information, to ensure that after they are plugged, the wells will not serve as a conduit for fluid movement. EPA will review the Well Plugging Plans after the permittee submits the final "as built" well schematics following construction of the wells to confirm that the Well Plugging Plans are appropriate. The Injection Well Plugging Plans are enforceable conditions of the Class VI permits.

Post-Injection Site Care (PISC) and Site Closure: In accordance with 40 CFR 146.93, the permittee must implement an approved Post-Injection Site Care and Site Closure Plan, which is an enforceable condition of the Class VI permit. Following the cessation of injection, FutureGen must continue to monitor ground water quality and track the movement of the carbon dioxide plume and pressure front in a manner similar to that described under "Monitoring and Reporting Requirements" above. This monitoring will help confirm predictions about the behavior of the carbon dioxide plume and pressure front (i.e., that pressures will subside after injection ceases), provide early warning of any USDW endangerment, and eventually inform a non-endangerment demonstration (i.e., that the site no longer poses a risk of endangerment to USDWs and no further monitoring or site care are needed). EPA evaluated the proposed post-injection monitoring along with its review of the injection phase ground water and carbon dioxide plume and pressure front monitoring, as described under "Monitoring and Reporting Requirements," above.

The permittee will continue this post-injection monitoring for at least 50 years and until they can demonstrate that the site does not pose a risk of endangerment to USDWs and that site closure may be authorized. Post-injection monitoring must continue until the permittee can successfully demonstrate that the site does not pose a risk to USDWs, based on site-specific information that is descried in the Post-Injection Site Care and Site Closure Plans. This non-endangerment demonstration will be based on a comparison of monitoring data to model predictions and an evaluation of the carbon dioxide plume, mobilized fluids, reservoir pressure, and potential conduits for fluid movement.

Following authorization of site closure, the permittee will plug all monitoring wells with carbon dioxide-compatible materials to ensure that they cannot serve as conduits for fluid movement and will restore the site to its original condition (by removing all equipment and planting vegetation).

Issuance and Effective Date of Permit: In accordance with 40 CFR 124.15, the permit will become effective immediately upon final issuance if no public comments were received during the public comment period that requested a change in the draft permits. However, in the event that public comments are received that request a change in the draft permits, then the final permits will become effective 45 days after the date of issuance unless the permits are appealed. In accordance with 40 CFR 144.36(a), the permits will be in effect for the life of the project, unless they are otherwise modified, revoked and reissued, or terminated as provided at 40 CFR 144.39, 144.40 and 144.41. The permits will expire in one year if FutureGen fails to commence construction, unless a written request for an extension of this one year period has been approved by the Director. Authorization to inject under these permits will be granted following well construction and compliance with additional requirements as outlined in the permit and regulations at 40 CFR 146.82, 146.86, 146.87 and 146.89. If significant changes occur to the permit between this draft decision and the authorization to inject, there will be an additional opportunity for public comment pursuant to requirements at 40 CFR 144.39.

Opportunity for Public Input: Questions, comments and requests for additional information may be submitted in writing to Jeffrey McDonald at mcdonald.jeffrey@epa.gov via the internet. The public comment period on this permitting action will close on May 15, 2014, 45 days after the date of the public notice. During the comment period, EPA will also conduct a public hearing, on May 7, 2014 from 7–9 pm at MacMurray College, 447 E. College Ave., Jacksonville, IL to facilitate submittal of verbal comments on these permits.

The administrative record index for these permits is available at www.epa.gov/region5/water/uic/futuregen/. The full administrative record, including all data and information submitted by FutureGen in support of its permit applications, is available for public review at EPA's Chicago regional office. The office is open 8:30 a.m.– 4:30 p.m., weekdays.

To preserve your right to appeal any final permit decision that may be made in this matter under 40 CFR Part 124, you must either participate in the public hearing or send in written comments on the draft permit decisions. The first appeal must be made to the Environmental Appeals Board; only after all agency review procedures have been exhausted may you file an action in the appropriate Circuit Court of Appeals for review.