TESTING AND MONITORING PLAN
40 CFR 146.90

GULF COAST SEQUESTRATION
PROJECT MINERVA

1.0 Introduction

This Testing and Monitoring Plan describes how Gulf Coast Sequestration ("GCS") will monitor the Project Minerva site pursuant to 40 CFR 146.90. In addition to demonstrating that the well is operating as planned, the carbon dioxide plume and pressure front are moving as predicted, and that there is no endangerment to underground sources of drinking water ("USDW"), the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO_2 within the storage zone to support Area of Review ("AoR") reevaluations and a non-endangerment demonstration.

Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan 40 CFR 146.94(a).

1.1 Facility Information

Facility name: Project Minerva
Wells 1-4

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1.2 Overall Strategy and Approach for Testing and Monitoring

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1.2.1 Project risk assessment

Monitoring is systematically designed to reduce project risk. This section outlines the site-specific risks and describes how the monitoring plan will systematically reduce them. Three prospective risk categories are identified:

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1.2.2 Design of the monitoring network to achieve risk management

The monitoring approaches selected to manage the risks described in the previous section are described for each of the categories listed above.

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1.2.3 Monitoring network

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1.2.6 Quality assurance procedures

A Quality Assurance and Surveillance Plan ("QASP") for all testing and monitoring activities, required pursuant to 146.90(k), is provided in the Appendix to this Testing and Monitoring Plan.

1.2.7 Reporting procedures

GCS will report the results of all testing and monitoring activities to the EPA in compliance with the requirements under 40 CFR 146.91.

1.3 Carbon Dioxide Stream Analysis [40 CFR 146.90(a)]

GCS will analyze the CO_2 stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a).

1.3.1 Sampling location, equipment and accuracy

CO_2 stream sampling will be conducted for all four injection wells using a gas chromatography machine will measure CO_2 composition at the storage facility transfer point.

1.3.2 Sampling frequency

CO_2 stream sampling will be conducted every three months (quarterly) or when known changes to the injected stream occur (i.e., source changes and/or additions/deletions to the existing stream).

Density measurements at the mass flow meter greater than normal variability and not correlated to thermal variations also will trigger sampling. The isotopic composition of carbon in CO_2 ($\delta C^{12}/C^{13}$ ratio and C^{14}) will be measured once and repeated only if new sources are added.

1.3.3 Analytical parameters

GCS will contract a vendor to analyze the CO_2 for the constituents identified in Table 1.3.3-1 using the methods listed. If the constituents are not found in initial analysis or are screened out at the source prior to CO_2 pipeline transport this will be documented and with the prior approval of the UIC Program Director, they will be removed from the list of analytical parameters.

1.3.4 Sampling methods

The sampling system will step down pressure from pipeline pressure to atmospheric pressure sample container without loss of minor impurities. The sampler will be purged with pipeline CO_2 to remove contaminants prior to sample collection. All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample container will be sealed and shipped to a Louisiana authorized laboratory(s).

1.3.5 Laboratory to be used/chain of custody and analysis procedures

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. The sample chain-of-custody procedures described in Section 4.2.3 of the QASP will be employed.)

1.4 Continuous Recording of Operational Parameters [40 CFR 146.88(e)(1), 146.89(b) and 146.90(b)]

GCS will install and use continuous recording devices to monitor as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b) the CO_2 mass delivered to the project at the transfer point, the volume and temperature of CO_2 allocated to each well, the pressure at well head, the pressure on the injection tubing, the pressure at well head on the annulus between the tubing and the long string casing; the annulus fluid volume added.

1.4.1 Monitoring location, equipment, accuracy and frequency

GCS will perform the activities identified in Table 1.4.1-1 to monitor operational parameters and verify internal mechanical integrity of injection wells. Monitoring will take place at the locations and frequencies shown in Table 1.4.1-1.

Following conventional practices at injection sites with multiple wells, Project Minerva will use a mass flow meter to measure CO_2 mass delivered to the project at the transfer point from the pipeline to the project (same location as CO_2 stream analysis so that any non-CO_2 impurities can

be subtracted from the storage accounting). Calibration will be conducted following the manufactures instructions and reported.

Additional flow meters will be installed on flow lines prior to each well to record CO_2 volume and temperature which will serve to guide the allocation of the CO_2 on a per well basis. Calibration will be conducted following the manufactures instructions and reported.

The following equipment/meter types will be used to facilitate the required monitoring requirements:

Injection pressure

- Proposed equipment: pressure transmitter
- Expected accuracy: Rosemount brand (or similar) – example accuracy is ± 0.04% reference accuracy resulting in ± 0.15% total operating performance; Stability (5-yr): ± 0.125%

Temperature

- Proposed equipment: temperature transmitter
- Expected accuracy: Rosemount brand (or similar) – example accuracy is ± 0.02% of span D/A Accuracy, RTD Stability: ± 0.25% or 0.25 °C, whichever is greater for years

CO_2 Rate and Volume

- Proposed equipment: Mass flow computer, senior orifice meter with mass flow computer or Coriolis meter (TBD)
- Expected accuracy: Orifice meter - Differential Absolute Pressure: ± 0.05% of span (for spans between 10% and 90% of Upper Range Limit (URL); Digital Output (spans < 10% URL): ± (0.005) x (URL/Span)% of Span; Long Term Drift Stability: ± 0.05% of URL per year over 5 years; Temperature: ± 0.15°C (±0.27 °F) (not including RTD uncertainties). Coriolis meter – mass flow accuracy: 0.1% of rate ± (zero offset/mass flow rate) x 100%; repeatability 0.075% within the range of 10:1 of full-scale (FS) and 0.5% within the range of 100:1 of FS; rangeability up to 100:1

Annulus pressure

- Proposed equipment: ABB absolute pressure instrumentation.
- Expected accuracy: Base accuracy: ± 0.1 %

Annulus fluid volume

The annular fluid volume is a fixed value rather than dynamic (that would require a meter) and will be calculated by using the following formula:

Annular capacity in bbl/ft = $(Dh^2 - Dp^2) \div 1029.4$

Where;
Dh in inch
Dp in inch

The calculated volume is based on the inside diameter of wellbore casing and outside diameter of tubing string above the packers set in the wellbore.

1.4.2 Monitoring details

The mass flow meter will be protected against damage by lightning.

Each well will be completed with equipment needed to 1) account for per-well injection mass and pressure as inputs to fluid flow modeling to validate AoR predictions and 2) assure well integrity is maintained.

Wellhead pressure and temperature gauges will be installed to detect changes and record changes in tubing pressure filled with CO_2 and the casing-tubing anulus (filled with corrosion-inhibited fluid). Replenishment of corrosion-inhibited fluid will occur as needed, and the amounts added will be recorded. A more-rapid-than-normal change in casing-tubing anulus pressure will trigger shut-in of inject and inspection of well components until failure is identified.

Downhole quartz pressure gages on wireline readout will provide needed input to models and serve as opportunities for additional calibration of fluid flow models during injection fall-off tests and as injection is started at each injection well. Downhole pressure monitoring protects the project against over-injection as the near well environment is cooled and CO_2 becomes denser. The gauge location will be on tubing above the packer where the gauge is protected by corrosion inhibited fluid with a pass though into the tubing. Pressure gauges will be calibrated according to manufactures instructions and corrected for drift by comparison to tubing deployed gauges during MIT.

Wireline logging to assess the injection profile will be conducted at a minimum six months and two years after the start of injection at each well to assess which zones are being used by CO_2 and input this into models. A commercial vendor will be selected to conduct this logging using any of the standard techniques. If the injection profile is not optimum, this log provides input to correct the strategy.

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1.5 Corrosion Monitoring

To meet the requirements of 40 CFR 146.90(c), GCS will monitor well materials during the operation period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to

ensure that the well components meet the minimum standards for material strength and performance.

GCS will monitor corrosion using coupons and collect samples according to the description below in all proposed monitoring wells put forth in this report.

1.5.1 Monitoring location and frequency

Analyzing coupons of the well construction materials used in the well casing and tubing (and any other well parts in contact with CO_2) and inspecting the materials in the coupons for loss of mass, thickness, cracking, pitting, and other signs of corrosion. Loop and coupon details to be specified as part of pipeline and well design. These tests will be performed by qualified vendor on a quarterly calendar basis starting at the end of the first quarter month (March, June, September, December) following authorization and start-up of injection.

1.5.2 Sample description

GCS anticipates that corrosion coupon (weight loss) technique will be used for monitoring purposes as is the best known and simplest of all corrosion monitoring techniques (alternative is to use flow line loops). The corrosion monitoring system will be located downstream of all process compression/dehydration/pumping equipment (i.e., at the beginning of the pipeline to the wellhead). This tray of coupons will operate any time injection is occurring. No other equipment will act on the CO_2 past the location of the tray; therefore, this location will provide representative exposure of the samples to the CO_2 composition, temperature, and pressures that will be seen at the wellhead and injection tubing. The holders and location of the system will be included in the pipeline design and will allow for continuation of injection during sample removal. The coupon method involves exposing a specimen sample material (the coupon) to a process environment for a given duration, then removing the specimen for analysis. Coupons will include materials of construction for all elements in contact with the CO_2 stream (Table 1.5.2-1). Corrosion analysis will consist of:

1. Sample photography
2. Cleaning
3. Precision weight loss analysis
4. Corrosion rate evaluation
5. Localized corrosion (pitting) analysis

Methods for initial coupon preparation and analysis/evaluation of exposed coupons will follow ASTM G1 - 03(2017) and/or NACE Standard RP0775-2005 Item No. 21017 standards.

1.5.3 Monitoring details

Per 40 CFR 146.90, GCS will run a casing inspection log (internal and external) to determine the presence or absence of corrosion in the protection (longstring) casing when the tubing is pulled from the well. The log(s) will be compared to those run during construction of the well (40 CFR

146.87). Additional inspection logging may be performed should the coupons show excessive corrosion in excess of design-life criteria.

Alternative testing other than those listed above may be conducted, with the written approval of the Administrator. To obtain approval for alternative testing, GCS will submit a written request to the Administrator setting forth the proposed test and all technical data supporting its use.

1.6 Above Confining Zone Monitoring

GCS will monitor two water-bearing zones in the AoR to meet the requirements of 40 CFR 146.90(d): the lower-most USDW of the Chicot Formation (fresh water) and the part of the Miocene above the Anahuac Confining Zone (saline water). Leakage detection strategy is different in the two zones, so they are discussed separately.

1.6.1 USDW monitoring in the lower part of the Chicot freshwater aquifer.

1.6.2 Monitoring location and frequency

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

1.6.3 Sampling methods

The sampling system will be used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with theme. Water samples will be collected from groundwater wells according to EPA method SESDPROC-301-R4 after purging three well volumes with a pump. Temperature, pH, specific conductivity, and dissolved oxygen and temperature will be measured in the field. Samples for isotopic analysis of DIC will be collected in 100-ml amber glass bottles with minimized headspace, and one drop of biocide (benzalkonium chloride) to eliminate biologic alteration of the sample. Samples will be immediately stored on ice and mailed overnight to a contracted laboratory for analysis of analytes listed in Table 1.6.2-2. All samples will be filtered in the field with a 0.45µm filter. Conditions during groundwater sampling will be recorded in the field.

All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample container will be sealed and sent to an authorized laboratory.

1.6.4 Laboratory to be used/chain of custody and analysis procedures

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas, major, minor and trace element compositions.. The sample chain-of-custody procedures described in Section 4.2.3 of the QASP will be employed.

1.6.5 AZMI monitoring in the Miocene above the Anahuac confining system

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1.6.6 Monitoring location and frequency

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1.6.7 Sampling methods (one-time sample from deep formations)

The sampling system used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with these gasses will be supplied by a vendor using Kuster sampler or equivalent tool. Deep brine sampling protocols are needed and all gasses not just hydrocarbons will be assessed. Methods are 1) Purge the casing volume to bring fresh fluids that have not reacted with casing and tubing to the sample point, 2) Deploy commercial downhole sampler on slickline to collect a fluid sample at pressure and then close to retain gas phases as sample is transported to the surface, 3) Conserve gas volumes as samples are stepped to atmospheric pressure for shipping and analysis, 4) Filter and conserve samples following protocols for brine sampling. All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample container will be sealed and sent to an authorized laboratory.

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1.6.8 Laboratory to be used/chain of custody and analysis procedures

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas, major, minor and trace element compositions.. The sample chain-of-custody procedures described in Section 4.2.3 of the QASP will be employed.)

1.7 External Mechanical Integrity Testing ("MIT")

GCS will conduct at least one of the tests presented in Table 1.7-1 periodically during the injection phase to verify external mechanical integrity as required at 146.89(c) and 146.90.

1.7.1 Testing location and frequency

GCS will perform an annual external mechanical integrity log on each injection well. Preferred testing will be performed using a temperature survey. The principal requirement for running temperature logs is that the well be shut-in long enough so that temperature effects related to well construction can dissipate, leaving a relatively simple temperature profile. Experience has shown that 36 hours is usually sufficient for the shut-in time period. Temperature survey data will be developed from the optical fiber attached to each injection well protection (longstring) casing.

Should the optical fiber not be functioning, the survey will be performed via a wireline truck and the temperature survey will be run over the entire interval of cemented casing. Note that to be effective, temperature logging tools must have good thermal coupling to the borehole environment, which means that they are not generally useful in gas or air-filled boreholes. Depending on phase of the carbon dioxide in the well, this may require that the wellbore be displaced with water or bine and allowed to thermally stabilize prior to logging. When possible, the sonde will be

calibrated to known temperature, such as in a bucket of ice water and in a bucket of water with a thermometer. The injection well will be logged from the surface downward, lowering the tool at a rate of no more than 30 feet per minute, which represents a practical balance between the tool response time and normal field time constraints. Note that slower logging speeds provide increasing detail. The temperature log should include both an absolute temperature curve and a differential temperature curve. A correlation log(s) should be recorded in track 1 (such as casing collar locator or gamma ray), and the two temperature curves recorded in tracks 2 and 3. The temperature log should be scaled at or about 20° F or 10° C degrees per track and the differential curve scaled in any manner appropriate to the logging equipment design, but it must be sensitive enough to readily indicate thermal anomalies.

Testing will be scheduled to be performed on an approximate annual basis, within +/- 45 days of the prior years' test. GCS will notify the Director ahead of testing should a testing event fall outside of the +/- 45-day window. Note that should a wireline truck be needed to run the surveys, testing for each well may be consolidated to a common timetable.

Alternate logging will consist of either a tracer survey, such as either a radioactive tracer or oxygen-activation log, or noise log. GCS will notify the Director ahead of testing should an alternate testing method be employed in one or more of the injection wells.

1.7.2 Testing details

Using temperature survey data from the optical fiber attached to each injection well protection (longstring) casing in each injection well is the simplest and preferred testing methodology for the demonstration of external integrity. Data from the optical fiber will be collected starting at cessation of injection and then accrued at increasing time intervals out to approximately 36 hours of shut in. Should the optical fiber not be functioning, the temperature survey will be performed via a wireline truck.

Subsequent temperature surveys will be compared to the baseline and prior surveys in each injection well. Deviations from a predictable geothermal gradient (initial survey), indicate the effects of injection. Within the Frio Formation, deviations will occur ion those sands receptive to flow. Deviations above the Anahuac Shale are anomalies. These may take the form of a nearly constant temperature between strata separated over a significant interval. In the case of the optical fiber temperature data, or if more than one log is run from a wireline truck, these anomalies are likely to "grow" as the other parts of the temperature profile returns toward the natural geothermal gradient. In addition, those areas with active flow will reach a stable temperature more quickly than other areas (zones of historical flow).

If there are unresolved temperature anomalies that cannot be explained, a failure of mechanical integrity of the injection well may be indicated. In such a case, additional logging may be necessary to show whether a loss of mechanical integrity is occurring in that injection well. Depending on the nature of the suspected movement, radioactive tracer, noise, oxygen activation,

or other logs approved by the Director may be required to further define the nature of the fluid movement. Identification of flow behind the casing is always made from long-term shut-in logs. The resolution of long-term shut-in logs for identifying the presence of flow is greater than that of logs made during injection. The temperature gradient from top to bottom within a well which has been injecting for some time is very shallow. The temperature at the Injection Zone may be only a few degrees different from that at the surface. The presence of a flow behind the casing will result in a fractional change in this gradient which will be proportional to the ratio of the flow rates within and outside the tubing. Therefore, only a rather substantial flow can be identified using logs made during injection.

1.8 Pressure Fall-Off Testing

GCS will perform pressure fall-off tests during the injection phase as described below to meet the requirements of 40 CFR 146.90(f). Special considerations will be made for pressure fall-off testing, as injection at one well will influence the pressure fall-off curve at other wells. For the offset wells (i.e., those not being tested), injection will cease prior to the test for a period of time exceeding the planned shut-in period, and injection rates will be held constant and continuously recorded during the test.

1.8.1 Testing location and frequency

GCS will perform a baseline pressure falloff test using brine or water mixed with a clay stabilizer in each injection well. This will allow for baseline characterization of the transmissibility of the Upper Frio at each injection well. The initial pressure falloff testing will be repeated using carbon dioxide within the first 60 days of injection operations. This will allow for comparison to the baseline test with the change in the injection fluid from brine water to carbon dioxide.

A subsequent pressure falloff test will be performed within +/-45 days of the 2-1/2-year anniversary of the start of carbon dioxide injection and within +/-45 days of the 5-year anniversary of the startup of injection. Thereafter, a pressure falloff test will be performed in each injection well within +/-45 days of each subsequent 5-year anniversary of the previous pressure test throughout the duration of the injection project. A final pressure falloff test will be run at the cessation of injection into each injection well.

1.8.2 Testing details

Testing procedures will follow the methodology detailed in EPA Region 6 UIC Pressure Falloff Testing Guideline-Third Revision (August 8, 2002). Bottomhole pressure measurements near the perforations are preferred due to phase changes within the column of carbon dioxide in the tubing. A surface pressure gauge may also serve as a monitoring tool for tracking the test progress.

The downhole pressure gauge can be either installed as part of the completion or can be deployed via a wireline truck. If a wireline truck deployed gauge is used, the wireline should be corrosion resistant (such as MP-35 line), and the deployed gauges should consist of a surface read-out gauge

with a memory backup. Gauge specifications should be as follows or similar to those shown in Table 1.8.2-1.

General testing procedure is as follows (presumes that a wireline deployed unit is used for the testing, note that dedicated downhole monitoring gauge may be used if installed on the injection well).

1. Mobilize wireline unit to the injection well and rig up on wellhead.
2. Rig up a wireline lubricator containing a calibrated downhole surface-readout pressure gauge ("SRO") with memory gauge installed in the tool string as a backup, to the adapter above the crown valve. Each gauge should have an operating range of 0-10,000 psi. Reference the gauge to kelly bushing ("KB") reference elevation and the elevation above ground level.
3. Open crown valve, record surface injection pressure, and run-in hole with SRO to just above the shallowest perforations in the completion while maintaining injection at a constant rate. Steady rates of injection should be maintained for at least 24 hours ahead of the planned shut-in of the injection well. Any offset injection well should be either shut-in or maintaining a constant rate of injection for the entire duration of the testing. This will minimize any cross-well interference effects.
4. With the SRO positioned just above the perforations, monitor the bottom-hole injection pressure response for ±1 hour to allow the gauge to stabilize (temperature and pressure stabilization). Ensure that the injection rate and pressure are stable.
5. Cease injection as rapidly as possible (controlled quick shut-in); close the control valve and the manual flowline valve at well site (start with the valve closest to the wellhead so that wellbore storage effect in early time is minimized). Conduct the pressure fall-off test for approximately 24 hours, or until bottomhole pressures have stabilized.
6. Lock out all valves on the injection annulus pressure system so that annulus pressure cannot be changed during the falloff period. Ensure that valves on flow line to the injection well are closed and locked to prevent flow to the well during the falloff period.
7. After 24 hours, download data and make preliminary field analysis of the falloff test data with computer-aided transient test software to estimate if or when radial flow conditions might be reached. If sufficient data acquisition is confirmed, end falloff test. If additional data is required, extend falloff test until radial flow conditions are confirmed. After confirmation of sufficient data acquisition, end falloff test.
8. Pull SRO tool up out of the well at 1,000 ft increments and allow the gauge to stabilize (five minutes each stop). Record stabilized temperature and pressure. Repeat the process to collect stabilized pressure data (five-minute stops) at 1,000 ft intervals and in the lubricator.

1.9 Carbon Dioxide Plume and Pressure Front Tracking

GCS will employ direct and indirect methods to track the extent of the carbon dioxide plume and the magnitude of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90(g).

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1.10 Environmental monitoring at the surface

To meet the requirements of 40 CFR 146.90(h), GCS will employ direct sampling and process-based analytical methods such that any brine or CO_2 leakage signal in soil or surface water can be quickly and effectively detected and isolated from background. The approach is similar to that proposed for groundwater but adapted to these sampling locations.

Project Minerva area is expected to be dynamic in terms of CO_2 production and uptake from active environments including wetland bottom sediments, intermittently saturation soils, plant and animal activities, and is used for grazing and other activities which are likely to change over time. Salinity variations are also present in the area as a result of past oilfield activities and from natural discharge of fluids from depth and around salt domes. Concentration-based detection are unlikely to be able to detect leakage from the high background variability. GCS proposes an anomaly response program to be deployed on an as-needed basis if an incident or anomaly with possible surface impact occurs.

1.11 Environmental surface monitoring location and frequency

Approximately 10 soil monitoring locations (soil gas wells) and 10 surface water monitoring stations will be sufficient to provide representative samples of the geochemical signatures of ecosystems within the AoR. For two years soil gas wells will be sampled seasonally (four times) and analyzed for gas CO_2, O_2, N_2, CH_4, C1-C5 hydrocarbons, $\delta^{13}C$ and ^{14}C of CO_2 and CH_4 and δD of CH_4. A similar sampling schedule will be applied to surface water assessment.

Soils will be collected during the installation of soil gas monitoring stations and may also be acquired at additional sites using hand-auger as informed by the conductivity survey. Soils will be tested for salinity according to United States Department of Agriculture methods to identify and characterize background types and occurrences of salinity and devise methods for attributing the source of salinity in the surface environment, whether natural or from industrial sources.

At the end of two years, protocols for detection of leakage signal will be developed for soil gas, sediments, and surface water, following the same methods but potentially different chemical components as used for groundwater attribution. A process-based method using ratios of CO_2, O_2, N_2, CH_4, can be used across all these environments to normalize diurnal and seasonal variations in soil CO_2 that results from variations in soil respirations rates, possible because these ratios remain stable with reference to the respiration line. A composition that plots to the right of the respiration line requires further assessment using isotopes $\delta^{13}C$ and ^{14}C of CO_2 and CH_4 and δD of CH_4.

2.0 Sampling/Analytical Procedures and QA/QC

This section provides details on sampling and analytical procedures and associated QA/QC requirements necessary to ensure valid data are obtained from the primary measurements to be conducted during the test. Details on the methods to be used are listed in Table 2.0-1.

Gas, water and soil samples will be collected into the appropriate sample containers, properly preserved and shipped to the contract laboratory for compositional analyses with reference to methodologies outlined in Table 1.6.2-2, Table 1.6.6-2 and Table 2.0-1.

For all samples collected, general information for each sampling station location will be recorded, including project name, borehole designation, borehole total depth, date and time of completion, borehole GPS location information, and field personnel information.

2.1.1 Soil Gas Sampling Station Construction

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4).]

3.0 Sampling/Analytical Procedures and QA/QC

Sediment sample information will be recorded in the field, including the top and bottom depths, the depth from which sediments are sampled, and the drilling system used. Sediment lithology will be described and noted in the field and will be documented with photographs. Sediment splits, approximately 0.5 to 1 kg of sample per 10 cm of core (or another suitable interval based on sediment lithology) will be removed and stored in 500 ml HDPE containers transported to the contracted laboratory as warranted. Soils will be analyzed by a contracted laboratory using soil solution extracts at higher-than-normal water contents. Anions, pH, electrical conductance, (e.g. salinity) +/- other analytes of importance for attribution as informed by the reservoir and groundwater characterization will be analyzed and a plan for attribution of any potential contamination from industrial activities, past or future will be devised.

3.1.1 Surface water sampling

Surface water is abundant, with freshwater and saltwater coastal marshes with rivers, lakes, bayous, tidal channels, and canals. Surface water will be sampled by either grab samples directly into the collection bottle or through peristaltic pump. Samples will be filtered and preserved according to protocol for each analyte as described in Table 1.6.2-2 and Table 2.1.1-1. The operating procedure for field sampling quality control (SESDPROC-011) will be followed as well as preservation requirements for surface water samples as outlined in USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM).

Gas and water samples will be collected into the appropriate sample containers, properly preserved and shipped to the contract laboratory for compositional analyses with reference to methodologies outlined in Table 3.1.1-1.

This section provides details on sampling and analytical procedures and associated QA/QC requirements necessary to ensure valid data are obtained from the primary measurements to be conducted during the test.

3.2 Quality Assurance and Surveillance Plan

Quality assurance procedures for these methods are presented in 4.1.5 of the QASP. The QASP contains items specific for the collection and analysis of environmental data. (USEPA, 2002). Thus the collection of such data occurs during the operational phase of Class VI permitted activity.

The QASP is required pursuant to 40 CFR 146.90(k). However the regulations do not indicate if such items are a Pre-Construction Phase item or a Pre-Authorization to inject requirement. The EPA Guidance for Testing and Monitoring (see EPA Guidance p. 66-67) has a brief discussion of QASP and directs project developers to EPA Guidance for Quality Assurance Plans, EPA QA/G-5 (December 2002). EPA QA/G-5 states that QASP's should be implemented "before the project is started (p 11). The finalization of the QASP therefore is an item for Pre-Authorization to inject. As outlined in Appendix A, the QASP is substantially complete for Section A. Section B and C have an outlined methodology to be completed and require approval of various items that remain contingent on the Permit to Construct, namely approval of Sections 1.2.3, 1.6, 1.8 and 1.9 herein. Thus the QASP remains an item addressed substantially in this Testing and Monitoring Plan subject to revision and update prior to receipt of Authorization to Inject.

3.3 Environmental surface monitoring Quality Management

To satisfy the project objectives, the quality and transparency of data collection, data analysis, and reporting will be managed at each stage.

3.4 Data Review and Validation

Data will be reviewed by the project operator or designee on an ongoing basis as the data are collected in the field and as results are received from the laboratory. Data review will consist of (for example):

- Verifying that data collection and calibrations/QC checks are complete and fully documented
- Examining raw data values and trends for consistency and reasonableness
- Making comparisons between related measured parameters and calculated values for agreement within reasonable expectations
- Flagging incomplete, invalid or suspect data and documenting the reason for the flag
- Initiating investigative or corrective actions as needed.

All valid data will be included in the data analysis and reflected in the reported results. Suspect data may or may not be considered or may receive special treatment as will be specifically indicated. The impact on data quality of any problems or issues that arise will be fully assessed, documented and reported. Any limitations on the use of the resulting data will be fully assessed and reported.

3.5 Sample Handling and Custody

3.5.1 Chain-of-Custody ("COC")

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis. The COC [QASP Section 4.2.3] is used to document sample handling during transfer from the field to the laboratory. The sample number, location, date, changes in possession and other pertinent data will be recorded in indelible ink on the form. The sample collector will sign

the COC and transport it with the sample to the laboratory. At the laboratory, samples are inventoried against the accompanying COC. Any discrepancies will be noted at that time and the COC will be signed for acceptance of custody.

3.5.2 Sample Handling and Labeling

Samples will be labeled on the container with an indelible, waterproof marker. Label information will include site identification, date, sampler's initials, and time of sampling. The COC form will accompany all sets of sample containers.

Following collection, samples will be preserved and transported to the appropriate analytical laboratory for analysis under the conditions designated by the method handling criteria outlined in methods shown in Table 2.1.1-1 until analysis.

3.6 Audits, Quality Assessment and Response Action

The technical systems audit is intended to ensure that the sampling, data collection and analysis, QA/QC measures, and documentation are executed in accordance with this plan and that the quality impact of any deviations from the plan is fully assessed and documented. To this end, the internal reviewer will prepare an audit checklist including all key elements of this plan and, to the extent possible, systematically verify in the field that each key element is conducted according to plan.

The audit of data quality will consist of verifying that reported results are fully supported by the data collected by tracing each result back to its sources in the raw data and verifying that all required QA/QC is complete and documented for each data source, and that calculations are correct, and results and uncertainties are correctly reported.

3.7 Data Management and Records

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files.

Documentation will be sufficient that a third party can reproduce the results from the raw data. This requires that all necessary information will be documented, and that the documents are organized and maintained such that the information may be practically retrieved and made use of.

Documentation will consist of instrument and other digital files, hard copy field log sheets, calibration certificates, laboratory reports, etc. All of these documents will ultimately be stored in electronic form; however, hard copy log sheets will be retained on file. An electronic data package will be compiled containing project documentation sufficient to allow a third party to reproduce the results and organized in such a manner that this may be done without undue effort.

3.8 Management of Change

Changes or deviations from this plan may be necessitated by field conditions, unexpected events, observations, or opportunities to improve the results as determined by the project operator. In such events, the reason for the change, and the new measures implemented will be documented in a note to the project log (if the change is minor) or deviations memorandum. This will include an

assessment of the impact of the change on data quality. Verification of this will be part of the internal field and data audits.

Comprehensive deviations memorandum will be prepared including an overall assessment of all changes on data quality. Any new or revised procedures will be documented. Significant deviations and their impact on data quality will also be addressed in the final report.

4.0 APPENDICES

4.1 Class VI Injection Well: Quality Assurance and Surveillance Plan ("QASP")

4.1.1 Project Management

4.1.2 A.1. Project/Task Organization

4.1.2.1 A.1.a/b. Key Individuals and Responsibilities

Project Minerva is led by Gulf Coast Sequestration ("GCS") and includes participation from several subcontractors. The Testing and Monitoring activities responsibilities will be shared between GCS and their designated subcontractors and conducted in the following subcategories:

1. CO_2 stream analysis surface sampling
2. Continuous recording of operational parameters
3. Corrosion monitoring
4. Above Confining Zone monitoring
5. External Mechanical Integrity Testing ("MIT")
6. Pressure fall-off testing
7. CO_2 plume and pressure from tracking
8. Environmental monitoring at the surface

4.1.2.2 A.1.c. Independence from Project QA Manager and Data Gathering

The majority of the physical samples collected, and data gathered as part of the Testing & Monitoring Plan are analyzed, processed, or witnessed by third parties independent and outside of the project management structure.

4.1.2.3 A.1.d. QA Project Plan Responsibility

GCS will be responsible for maintaining and distributing official, approved QA Project Plan. GCS will periodically review this QASP and consult with US EPA if/when changes to the plan are warranted.

4.1.2.4 A.1.e. Organizational Chart for Key Project Personnel

Figure 4.2.1.4-1 shows the organization structure of the project. GCS will provide to the UIC Program Director a contact list of individuals fulfilling these roles.

4.1.3 A.2. Problem Definition/Background

4.1.3.1 A.2.a. Reasoning

The Testing & Monitoring Plan is responsive to the requirements of the Class VI specifications and employs best practices developed in similar CO_2 storage projects.

4.1.3.2 A.2.b. Reasons for Initiating the Project

The Testing & Monitoring Plan goals are to comply with the Class VI protocols, to document via targeted data collection that the predictions made during characterization and modeling are correct and that CO_2 and brine in the Injection Zone will be isolated from USDW, surface and atmosphere.

4.1.3.3 A.2.c. Regulatory Information, Applicable Criteria, Action Limits

The Class VI rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project in order to ensure that the injection well maintains its mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that USDWs are not endangered. These monitoring activities include mechanical integrity tests, injection well testing during operation, monitoring of ground water quality, tracking of the CO_2 plume and associated pressure. This document details both the measurements that will be taken as well as the steps to ensure that the quality of all the data can be used with confidence in making decisions during the life of the project.

4.1.4 A.3. Project/Task Description

4.1.4.1 A.3.a/b. Summary of Work to be Performed

Table 4.1.4.1-1 provides a summary of the testing and monitoring. Table 4.1.4.1-2 provides an instrumentation summary.

4.1.4.2 A.3.c. Geographic Locations

Figures 1.2.3-1, 1.2.3-2 and 1.2.3-3 illustrate the locations of all Testing and Monitoring Plan elements.

4.1.4.3 A.3.d. Resource and Time Constraints

No additional resource or time constraints have been identified for the Testing and Monitoring Plan beyond project funding levels and the proposed timeline.

4.1.5 A.4.Quality Objectives and Criteria

The objective of the Quality Assurance Plan is to validate the necessary steps and attention to detail to ensure that the overall integrity of the Testing and Monitoring Plan is implemented, measured and verified. The QASP is the mechanism by which the UIC Program Director, and by extension the public, has confidence that the rigor of the Testing and Monitoring Plan is being implemented.

4.1.5.1 A.4.a. Performance/Measurement Criteria

Section and Tables 4.1.5.1-1, 4.1.5.1-2, 4.1.5.1-3, 4.1.5.1-4, 4.1.5.1-5 to be completed as vendor selection and onboarding is advanced and relevant scope of works are adopted and implemented.

4.1.5.2 A.4.b. Precision

Precision will be determined because of negotiation with selected vendors and contractors.

4.1.5.3 A.4.c. Bias

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their standard operating procedures and analytical methodologies. For direct pressure or logging measurements, there is no bias.

4.1.5.4 A.4.d. Representativeness

For groundwater sampling, data representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The sampling network has been designed to provide data representative of site conditions. For analytical results of individual groundwater samples, representativeness will be estimated by ion and mass balances. Ion balances with ±10% error or less will be considered valid. Mass balance assessment will be used in cases where the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference is greater than 10%, the sample may be considered non-representative.

4.1.5.5 A.4.e. Completeness

For groundwater sampling, data completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. It is anticipated that data completeness of 90% for groundwater sampling will be acceptable to meet monitoring goals. For direct pressure and temperature measurements, it is expected that data will be recorded no less than 90% of the time.

4.1.5.6 A.4.f. Comparability

Data comparability expresses the confidence with which one data set can be compared to another. The data sets to be generated by this project will be very comparable to future data sets because of the use of standard methods and the level of QA/QC effort.

Direct pressure, temperature, and logging measurements will be directly comparable to previously obtained data.

4.1.5.7 A.4.g. Method Sensitivity

To be discussed with the UIC Program Director post-draft approval of the Testing and Monitoring Plan. Table 4.1.5.7-1 to 4.1.5.7-11 to be completed.

4.1.6 A.5. Special Training/Certifications

4.1.6.1 A.5.a. Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, with documentation provided by the vendor. The subsequent data will be processed and analyzed according to industry standards. Environmental sampling will be conducted by qualified technicians who meet Louisiana requirements.

4.1.6.2 A.5.b/c. Training Provider and Responsibility

Training for personnel will be provided by the operator or by the subcontractor responsible for the data collection activity.

4.1.7 A.6. Documentation and Records

4.1.7.1 A.6.a. Report Format and Package Information

Reporting at the required frequency will contain all required project data, including testing and monitoring information as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the UIC Program Director.

4.1.7.2 A.6.b. Other Project Documents, Records, and Electronic Files

Other documents, records, and electronic files such as well logs, test results, or other data will be provided as required by the UIC Program Director.

4.1.7.3 A.6.c/d. Data Storage and Duration

GCS-designated contractor will maintain the required project data as provided elsewhere in the permit.

4.1.7.4 A.6.e. QASP Distribution Responsibility

GCS will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

4.2 <u>B. Data Generation and Acquisition</u>

4.2.1 B.1. Sampling Process Design

4.2.1.1 B.1.a. Design Strategy

4.2.1.1.1 CO_2 Stream Monitoring Strategy

To be updated when dedicated streams of CO_2 have been identified and contracted for Project Minerva.

4.2.1.1.2 Corrosion Monitoring Strategy

To be updated when dedicated streams of CO_2 have been identified and contracted for Project Minerva.

4.2.1.1.3 Shallow Groundwater Monitoring Strategy

To be updated when dedicated streams of CO_2 have been identified and contracted for Project Minerva.

4.2.1.1.4 Deep Pressure Monitoring Strategy

To be updated when dedicated streams of CO_2 have been identified and contracted for Project Minerva.

4.2.1.2 B.1.b. Type and Number of Samples/Test Runs

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.1.3 B.1.c. Site/Sampling Locations

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.1.4 B.1.d. Sampling Site Contingency

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.1.5 B.1.e. Activity Schedule

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.1.6 B.1.f. Critical/Informational Data

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.1.7 B.1.g. Sources of Variability

To be updated when UIC Program Director has approved draft permit for Project Minerva.

4.2.2 B.2. Sampling Methods

4.2.2.1 B.2.a/b. Sampling SOPs

This element will be negotiated with selected geochemical labs. Table 4.2.2.1-1 to be completed.

4.2.2.2 B.2.c. In-situ Monitoring

This element will be negotiated with selected geochemical labs

4.2.2.3 B.2.d. Continuous Monitoring

This element will be negotiated with selected geochemical labs

4.2.2.4 B.2.e. Sample Homogenization, Composition, Filtration

This element will be negotiated with selected geochemical labs

4.2.2.5 B.2.f. Sample Containers and Volumes

This element will be negotiated with selected geochemical labs

4.2.2.6 B.2.g. Sample Preservation

This element will be negotiated with selected geochemical labs

4.2.2.7 B.2.h. Cleaning/Decontamination of Sampling Equipment

This element will be negotiated with selected geochemical labs

4.2.2.8 B.2.i. Support Facilities

This element will be negotiated with selected geochemical labs

4.2.2.9 B.2.j. Corrective Action, Personnel, and Documentation

This is described in section D below

4.2.3 B.3. Sample Handling and Custody

4.2.3.1 B.3.a. Maximum Hold Time/Time Before Retrieval

This element will be negotiated with selected geochemical labs

4.2.3.2 B.3.b. Sample Transportation

This element will be negotiated with selected geochemical labs

4.2.3.3 B.3.c. Sampling Documentation

This element will be negotiated with selected geochemical labs

4.2.3.4 B.3.d. Sample Identification

This element will be negotiated with selected geochemical labs. Tables 4.2.3.4-1 and 4.2.3.4-2 to be completed.

4.2.3.5 B.3.e. Sample Chain-of-Custody

This element will be supplied by the selected geochemical labs

4.2.4 B.4. Analytical Methods

4.2.4.1 B.4.a. Analytical SOPs

This element will be negotiated with selected geochemical labs

4.2.4.2 B.4.b. Equipment/Instrumentation Needed

This element will be negotiated with selected geochemical labs

4.2.4.3 B.4.c. Method Performance Criteria

This element will be negotiated with selected geochemical labs

4.2.4.4 B.4.d. Analytical Failure

This element will be negotiated with selected geochemical labs

4.2.4.5 B.4.e. Sample Disposal

This element will be negotiated with selected geochemical labs

4.2.4.6 B.4.f. Laboratory Turnaround

This element will be negotiated with selected geochemical labs

4.2.4.7 B.4.g. Method Validation for Nonstandard Methods

This element will be negotiated with selected geochemical labs

4.2.5 B.5. Quality Control

4.2.5.1 B.5.a. QC activities

4.2.5.1.1 Blanks

This element will be negotiated with selected geochemical labs

4.2.5.1.2 Duplicates

This element will be negotiated with selected geochemical labs

4.2.5.2 B.5.b. Exceeding Control Limits

This element will be negotiated with selected geochemical labs

4.2.5.3 B.5.c. Calculating Applicable QC Statistics

4.2.5.3.1 Charge Balance

This element will be negotiated with selected geochemical labs

4.2.5.3.2 Mass Balance

This element will be negotiated with selected geochemical labs

4.2.5.3.3 Outliers

GCS or designated vendor is responsible for assessment and documentation of outliers

4.2.6 B.6. Instrument/Equipment Testing, Inspection, and Maintenance

Element is deferred until design is advanced and vendors are selected

4.2.7 B.7. Instrument/Equipment Calibration and Frequency

4.2.7.1 B.7.a. Calibration and Frequency of Calibration

Element is deferred until design is advanced and vendors are selected

4.2.7.2 B.7.b. Calibration Methodology

Element is deferred until design is advanced and vendors are selected

4.2.7.3 B.7.c. Calibration Resolution and Documentation

Element is deferred until design is advanced and vendors are selected

4.2.8 B.8. Inspection/Acceptance for Supplies and Consumables

4.2.9 B.8.a/b. Supplies, Consumables, and Responsibilities

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.10 B.9. Non-direct Measurements

4.2.10.1 B.9.a. Data Sources

Element is deferred until design is advanced and vendors are selected

4.2.10.2 B.9.b. Relevance to Project

Element is deferred until design is advanced and vendors are selected

4.2.10.3 B.9.c. Acceptance Criteria

Element is deferred until design is advanced and vendors are selected

4.2.10.4 B.9.d. Resources/Facilities Needed

Element is deferred until design is advanced and vendors are selected

4.2.10.5 B.9.e. Validity Limits and Operating Conditions

Element is deferred until design is advanced and vendors are selected

4.2.11 B.10. Data Management

4.2.11.1 B.10.a. Data Management Scheme

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.11.2 B.10.b. Recordkeeping and Tracking Practices

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.11.3 B.10.c. Data Handling Equipment/Procedures

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.11.4 B.10.d. Responsibility

GCS or designated vendor is responsible for data management

4.2.11.5 B.10.e. Data Archival and Retrieval

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.11.6 B.10.f. Hardware and Software Configurations

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.2.11.7 B.10.g. Checklists and Forms

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.3 C. Assessment and Oversight

4.3.1 C.1. Assessments and Response Actions

4.3.1.1 C.1.a. Activities to be Conducted

Assessments of each of the QASP elements:

I) CO_2 stream analysis surface sampling
II) Continuous recording of operational parameters
III) Corrosion monitoring
IV) Above Confining Zone monitoring
IV) External Mechanical Integrity Testing ("MIT")
V) Pressure fall-off testing
VI) CO_2 plume and pressure from tracking
VII) Environmental monitoring at the surface

4.3.1.2 C.1.b. Responsibility for Conducting Assessments

GCS or its designated subcontractor will assess data

4.3.1.3 C.1.c. Assessment Reporting

GCS will coordinate reporting of assessments

4.3.1.4 C.1.d. Corrective Action

GCS will coordinate corrective actions as warranted

4.3.2 C.2. Reports to Management

4.3.2.1 C.2.a/b. QA status Reports

This design is deferred until the Testing and Monitoring Plan draft has been approved by the UIC Director.

4.4 Data Validation and Usability

4.4.1 D.1. Data Review, Verification, and Validation

4.4.1.1 D.1.a. Criteria for Accepting, Rejecting, or Qualifying Data

Data will be evaluated to determine of the specified QC requirements have been met before data use.

4.4.2 D.2. Verification and Validation Methods

4.4.2.1 D.2.a. Data Verification and Validation Processes

Appropriate statistical software will be used to determine data consistency

4.4.2.2 D.2.b. Data Verification and Validation Responsibility

GCS or its designated subcontractor will verify and validate all data.

4.4.2.3 D.2.c. Issue Resolution Process and Responsibility

GCS or its designee will overview the data handling, management, and assessment process. Staff involved in these processes will consult with GCS to determine actions required to resolve issues.

4.4.2.4 D.2.d. Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. These will be detailed as site-specific design advances.

4.4.3 D.3. Reconciliation with User Requirements

4.4.3.1 D.3.a. Evaluation of Data Uncertainty

Statistical software will be used to determine data consistency using methods consistent with UIC Program Director guidance.

4.4.3.2 D.3.b. Data Limitations Reporting

GCS will be responsible for ensuring that data developed by vendors is presented with the appropriate data-use limitations.

4.5 References

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4).]