Class VI Injection Well: Quality Assurance and Surveillance Plan

Brown 4 Geologic Sequestration Project

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Title and Approval Sheet

This Quality Assurance and Surveillance Plan (QASP) is approved for use and implementation at Brown 4. The signatures below denote the approval of this document and intent to abide by the procedures outlined within it.

Signature Claimed as PBI	Date
Signature Claimed as PBI	Date

Distribution List

The following project participants will receive the completed Quality Assurance and Surveillance Plan (QASP) and all future updates for the duration of the project.

Name	Title	Address	Phone
[redacted]	[redacted]	Claimed as PBI [redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

A. Project Management

A.1. Project/Task Organization

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

The Brown 4 Geologic Sequestration Project (GSP), led by Lambda, includes participation from several designated service providers. Lambda will be responsible for any data and submissions made to the EPA.

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

Most of the physical samples acquired and data obtained through the monitoring, verification, and accounting program are analyzed, processed, or witnessed by independent third parties and outside of the project management structure. All samples collected by Lambda personnel will be documented accordingly.

A.1.d. QA Project Plan Responsibility

Lambda will be responsible for maintaining and distributing the official, approved Quality Assurance and Surveillance Plan (QASP). Lambda will conduct periodic reviews of this QASP and consult with the UIC Director if or when changes to the plan are warranted.

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

Figure 1 shows the tentative organizational chart for the Brown 4 GSP. Lambda will provide the UIC Director with a contact list of individuals fulfilling these roles.

Figure 1: Organizational chart

A.2. Problem Definition/Background

A.2.a. Reasoning

Lambda plans to adapt existing oil and gas infrastructure to enable storage of high purity CO_2 captured from multiple carbon-intensive operations, including ethanol plants, cement plants, natural gas processing plants, and future industrial sources with a desire to produce carbon-neutral products. These CO_2 sources will produce low carbon-intensity transportation fuel, cement, natural gas, and products to help the State of Michigan reach its aggressive decarbonization goals. The QASP will be utilized throughout the duration of the project, and will be used to guide all testing and monitoring requirements.

A.2.b. Reasons for Initiating the Project

The goal of the Brown 4 GSP is to permanently sequester large volumes of CO_2 into the Brown 4 Niagaran reef, thereby reducing atmospheric concentrations of CO_2. The field has available pore space, proven confinement, and all mineral and surface rights leased.

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

The Class VI Rule requires owners or operators of Class VI wells to perform several activities during the post-injection phase of the project. This is conducted to verify injection well integrity, monitor fluid migration, and the extent of the CO_2 plume and pressure front to ensure the non-endangerment of underground sources of drinking water (USDW). These monitoring activities will include mechanical integrity tests (MIT) of the injection and monitoring wells and monitoring of groundwater quality above the confining zone and in the USDW. This monitoring will verify no pressure loss in the injection zone, indicating no leakage has occurred. This document details both the measurements that will be taken as well as the steps to ensure the data quality can be used with confidence in making decisions during the life of the project.

A.3. Project/Task Description

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

Reference Table 1 and Table 2 below.

A.3.c. Geographic Locations

Figure 1 shows the geographic location of the Brown 4 GSP.

A.3.d. Resource and Time Constraints

Lambda has leased all minerals/pore space and surface access rights have been guaranteed for the duration of the Brown 4 GSP.

A.4.Quality Objectives and Criteria

A.4.a. Performance/Measurement Criteria

The overall QASP objective for monitoring is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting that will provide results that meet the characterization and non-endangerment goals of this project. Groundwater monitoring will be conducted during the injection and post-injection phase of the project in shallow and deep monitoring wells. Tables 3 through 7 show the details of the parameters to be analyzed as described in the Testing and Monitoring Plan, along with test equipment gauge specifications and actionable outputs of testing for the Brown 4 GSP. The list of parameters to be analyzed may be reassessed periodically and adjusted to include or exclude parameters based on their effectiveness in achieving the overall monitoring program goals.

Table 1: Summary of testing and monitoring

Activity	Location(s)	Method	Analytical Technique	Lab/Custody	Purpose
Carbon Dioxide Stream Analysis	On Site	Direct Sampling	Chemical Analysis	Airborne Labs International, Inc.	Monitor Injectate
Injection Rate and Volume	Injection Well	Meter	Direct Measurement	N/A	Monitor Rate and Volume
Injection Pressure	Injection Wellhead	Gauge	Direct Measurement	N/A	Monitor Injection Pressure
Annular Pressure	Injection Wellhead	Gauge	Direct Measurement	N/A	Monitor Annular Pressure
Downhole Pressure/ Temperature	Injection Well	Gauge	Direct Measurement	N/A	Monitor Reservoir Pressure and Temperature
Corrosion Monitoring	On Site	Corrosion Loop	N/A	N/A	Monitor Corrosion of Materials
Mechanical Integrity	Injection Well	Approved MIT Method	N/A	N/A	Wellbore Integrity
Pressure Fall Off Test	Injection Well	Gauge	Direct Measurement	N/A	Reservoir Assessment
Vegetation	On Site	Visual/probes	Direct Measurement	Recorded (Gourdie Fraser)	Monitor Vegetation

Table 2: Monitoring well summary

Activity	Location(s)	Method	Analytical Technique	Lab/Custody	Purpose
Fluid Sampling Glacial Drift (USDW)	USDW Monitor Wells	Direct Sampling	Chemical Analysis	ALS Laboratory	Monitor Water Quality
Fluid Sampling Bass Island Dolomite	Viol 1-4 & Viol 3-4	Direct Sampling	Chemical Analysis	ALS Laboratory	Monitor Water Quality
Pressure / Temperature	Viol 1-4 & Viol 3-4	Gauge	Direct Measurement	N/A	Monitor Temperature / Pressure
Mechanical Integrity	Viol 1-4 & Viol 3-4	Approved MIT Method	N/A	N/A	Wellbore Integrity

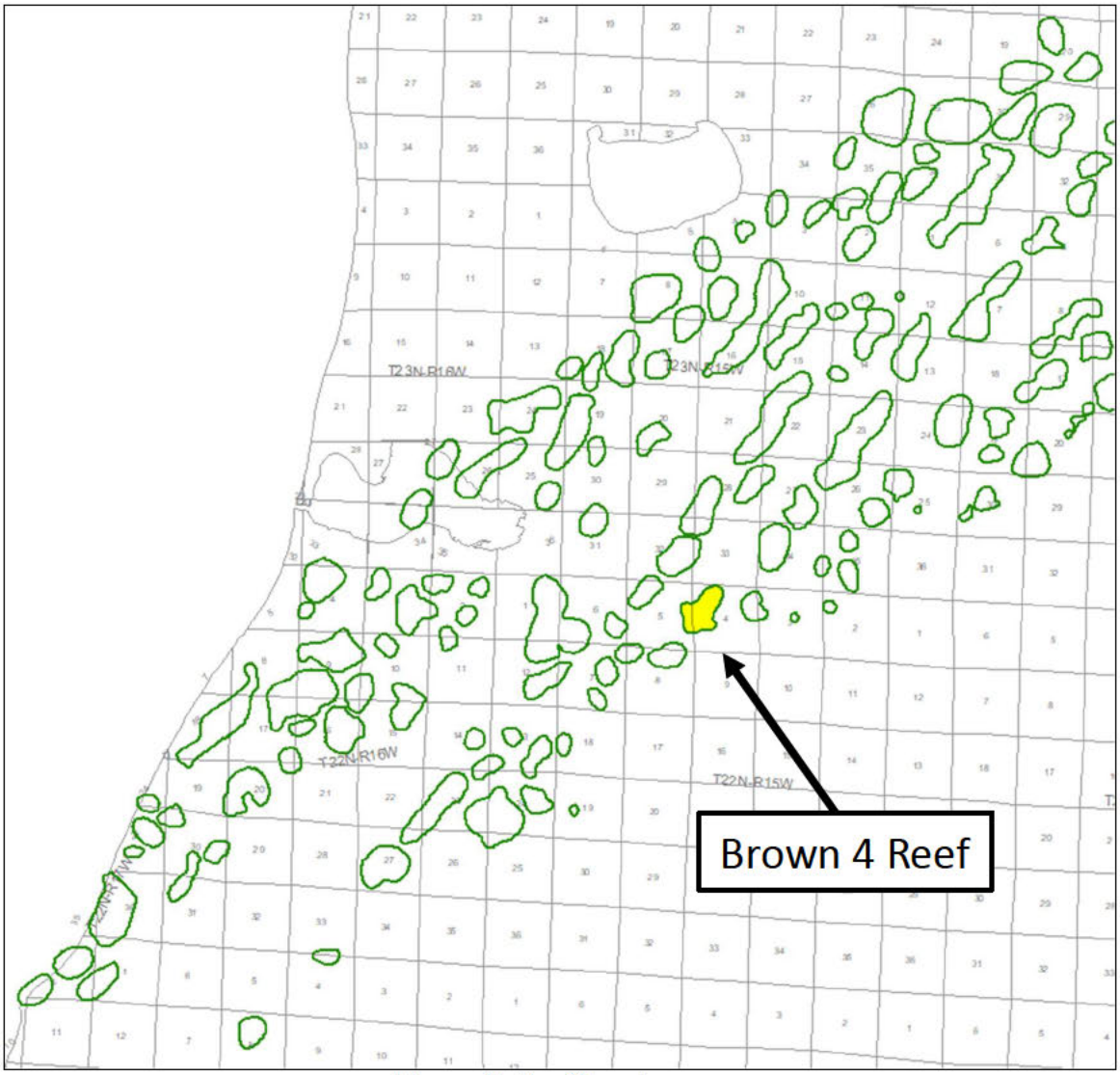

Figure 2: Reef locator map

Table 3: Summary of analytical and field parameters for groundwater samples

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Metals	ICP EPA Method 6010	5 mg/L	+- 20%	Daily calibration of equipment/CCV/ Blank LCS, MS/MSD/QC/ICV
Anions: Chloride	Standard Method 4500E	1 mg/L	+- 20%	Daily calibration/CCV/ Blank LCS, MS/MSD/ QC/ICV
Specific Conductivity (µS/cm)	ASTM Std Method 2510	5 µmhos/cm	+- 5%	Daily Calibration, Duplicates
pH (S.U.)	ASTM Std Method 4500	0.1 s.u.	+- 5%	Daily Calibration, Duplicates
Temperature	Field Test			
Dissolved Carbon Dioxide	EPA Method RSK 175	5 ug/l	+- 20%	Daily Calibration of equip-, CCV, Blank LCS, MS/MSD, ICV
Water Density (Specific Gravity)	ASTM Method D5057	None	+- 20%	
Total Dissolved Solids (TDS) –	ASTM Method 2540	15 mg/l	+- 10%	Daily Balance Calibration, Duplicates, Blanks

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Table 4: Summary of analytical and field parameters for CO_2 Stream

Parameters	Analytical Methods[1]	Limit of Quantitation	ISBT Limit	QC Requirements
Oxygen, Argon, and Hydrogen	ISBT 4.0 [GC/DID]	1 ppm v/v	30 ppm max	Daily calibration/CCV, blank, QC sample
Nitrogen	ISBT 4.0 [GC/DID]	1 ppm v/v	n/a	Daily calibration/CCV, blank, QC sample
Carbon Monoxide	ISBT 5.0 [GC/DID]	1 ppm v/v	10 ppm max	Daily calibration/CCV, blank, QC sample
Total Hydrocarbons	ISBT 10.0	0.1 ppm v/v	50 ppm max	Daily calibration/CCV, blank, QC sample
Methane	ISBT 10.1 [GC]	0.1 ppm v/v	50 ppm max	Daily calibration/CCV, blank, QC sample
CO_2 Purity	ISBT 2.0/SAM 2.0 – Caustic absorption Zahm-Nagel	5% v/v	99.9% min	Daily calibration/CCV, blank, QC sample
Total Sulfur Content	ISBT 14.0	0.01 ppm v/v	0.1 ppm max	Daily calibration/CCV, blank, QC sample
Ammonia	ISBT 6.0 [DT]	0.5 ppm v/v	2.5 ppm max	Daily calibration/CCV, blank, QC sample
Oxides of Nitrogen	ISBT 7.0 [DT]	0.5 ppm v/v	5 ppm max	Daily calibration/CCV, blank, QC sample
Hydrogen Sulfide and Sulfur Dioxide	ISBT 14.0 [GC]	0.05 ppm v/v	1 ppm max	Daily calibration/CCV, blank, QC sample
Water Vapor	ISBT 3.0 [FTIR]	1 ppm v/v	20 ppm max	Daily calibration/CCV, blank, QC sample

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director

Table 5: Summary of Analytical Parameters for Corrosion Coupons.

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Thickness	Ultrasonic	0.025" to 23.0"	+/- 0.5% thickness + 0.001"	Duplicate Analysis; Calibrated
Mass	NACE RP0775 ASTM G1-03	0.001 mg	+/-10%	Duplicate Analysis; Calibrated

Note: An equivalent method may be employed with the prior approval of the UIC Program Director

Table 6: Summary of Measurement Parameters for Field Gauges.

Parameters	Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Booster Pump Discharge Pressure	Gauges	0-3,000	+/- 0.25%	Calibrated
Injection Tubing Temperature	Gauges	-58°F to 302°F	+/- 0.5%	Calibrated
Annulus Pressure	Gauges	0-200	+/- 0.25%	Calibrated
Injection Tubing Pressure	Gauges	0-3,000	+/- 0.25%	Calibrated
Wellhead Pressure	Gauges	0-3,000	+/- 0.25%	Calibrated
Downhole Temperature	Gauges	0-150°C	0.005°C	Calibrated
Injection Mass Flow Rate	Meter	0-2,570 lb/min	+/- 0.35%	Calibrated

Table 7: Actionable Testing and Monitoring Outputs.

Activity or Parameter	Project Action Limit	Detection Limit	Anticipated Reading
External Mechanical Integrity Testing	Action will be taken when MIT indicates a mechanical integrity issue.	Variable	Results will be compared to baseline. Deviation may be indicative of mechanical issue.
Internal Mechanical Integrity (Pressure)	Action will be taken when pressure test indicates a mechanical integrity issue.	+/- 3 psi	0 psi change
Surface and Downhole Pressure	Action will be taken when pressure is outside of expected or modeled range.	+/- 0.25%	No greater than the maximum operating pressure.
Water quality (Glacial Drift and BILD)	Action will be taken when water sample is outside of baseline analysis.	2 mg/L	Results will be compared to baseline. Deviation may be indicative of mechanical issue.

A.4.b. Precision

Field blanks will be collected once per sampling event to assess the water sampling analysis accuracy. Service provider will be responsible for analytical precision per their standard operating procedures.

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.

A.4.d. Representativeness

Lambda's monitoring strategy ensures that samples acquired will be representative of site conditions. Standard operating procedures during acquisition at the wellsite will ensure that samples represent the formation.

A.4.e. Completeness

For ground water 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 percent for ground water 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 percent of the time.

A.4.f. Comparability

Data sets will always be compared to the baseline and previous analyses. Individual threshold changes will be assessed, as well as small trend changes.

A.4.g. Method Sensitivity

The following tables provide detail on gauge sensitivities.

Table 8: Pressure and Temperature—Downhole Gauge Specifications.

Parameter	Value
Calibrated Working Pressure Range	0-3,000 psi
Initial Pressure Accuracy	0.003% F.S.
Pressure Resolution	0.0003% F.S.
Pressure Drift Stability	< 3 psi/yr
Calibrated Working Temperature Range	0-150°C
Initial Temperature Accuracy	0.5°C
Temperature Resolution	0.005°C
Temperature Drift Stability	< 0.1°C/yr
Max Temperature	150°C
Instrument Calibration Frequency	Upon installation

Table 9: Representative Logging Tool Specifications.

Parameter	CBL
Logging Speed	N/A Record data at stops
Vertical Resolution	N/A
Investigation	N/A
Temperature Rating	400 °F
Pressure Rating	30K psi

Table 10: Pressure Field Gauge.

Parameter	Value
Calibrated Working Pressure Range	0-6,000 psig
Initial Pressure Accuracy	0.003% F.S.
Pressure Resolution	0.0003% F.S
Pressure Drift Stability	< 3 psi per year

Table 11: Pressure Field Gauge—Injection Tubing Pressure.

Parameter	Value
Calibrated Working Pressure Range	0-6,000 psig
Initial Pressure Accuracy	0.003% F.S.
Pressure Resolution	0.0003% F.S
Pressure Drift Stability	< 3 psi per year

Table 12: Pressure Field Gauge—Annulus Pressure.

Parameter	Value
Calibrated Working Pressure Range	0-200 psig
Initial Pressure Accuracy	0.003% F.S.
Pressure Resolution	0.0003% F.S
Pressure Drift Stability	< 3 psi per year

Table 13: Temperature Field Gauge—Injection Tubing Temperature.

Parameter	Value
Calibrated Working Temperature Range	0 - 150°C
Initial Temperature Accuracy	0.5°C
Temperature Resolution	0.005°C
Temperature Drift Stability	< 0.1°C per year

Table 14: Mass Flow Rate Field Gauge—CO_2 Mass Flow Rate.

Parameter	Value
Calibrated Working Flow Rate Range	0 - 3,800 lb/min
Initial Mass Flow Rate Accuracy	+/- 0.1%
Mass Flow Rate Resolution	0.1 lb/min
Mass Flow Rate Drift Stability	< 0.5 lb/min per year

A.5. Special Training/Certifications

A.5.a. Specialized Training and Certifications

Lambda will utilize trained company personnel and/or third-party service provider companies to acquire field data samples. The subsequent data will be processed and analyzed according to industry standards.

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

Training for personnel will be provided by Lambda or by the subcontractor responsible for each activity.

A.6. Documentation and Records

A.6.a. Report Format and Package Information

Lambda will prepare and submit semi-annual reports to the EPA. The reports will include all testing, data, and monitoring information as specified in the Testing and Monitoring Plan.

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

Lambda will prepare and provide all necessary documents, records, or electronic files as required.

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

Lambda will store and maintain all required project documentation for the duration of the project, at minimum, for the entire life of the project.

A.6.e. QASP Distribution Responsibility

Lambda will be responsible for ensuring that those on the distribution list, as well as other essential staff, receive the most current copy of the QASP.

B. Data Generation and Acquisition

B.1. Sampling Process Design

B.1.a. Design Strategy

Shallow Groundwater Monitoring Strategy

Two monitoring wells will be drilled in the local USDW for shallow groundwater monitoring. The wells will be drilled adjacent to the two injectors and used for monitoring during both the injection and post injection phases of the project. The wells will be sampled prior to injection to establish a baseline analysis.

Deep Groundwater Monitoring Strategy

The Viol 1-4 and Viol 3-4 wells will be plugged back and converted to monitoring wells in the first permeable layer above the confining zone. These wells will be used for monitoring during both the injection and post injection phases of the project. They will be sampled prior to injection to establish a baseline analysis.

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

The sampling activities are summarized in Table 1.

B.1.c. Site/Sampling Locations

Figure 3 below shows all monitoring and injection wells within the AoR.

B.1.d. Sampling Site Contingency

If a monitor well is damaged and unable to be sampled, it will either be redrilled, or a nearby monitor well with similar screen depths may be utilized. If the sampling array is altered, notice will be given through the proper channels. If weather, personnel, or other unforeseeable event causes a sampling event to be cancelled, it shall be rescheduled accordingly to comply with the conditions of the permit.

B.1.e. Activity Schedule

The sampling activities are summarized in Table 2.

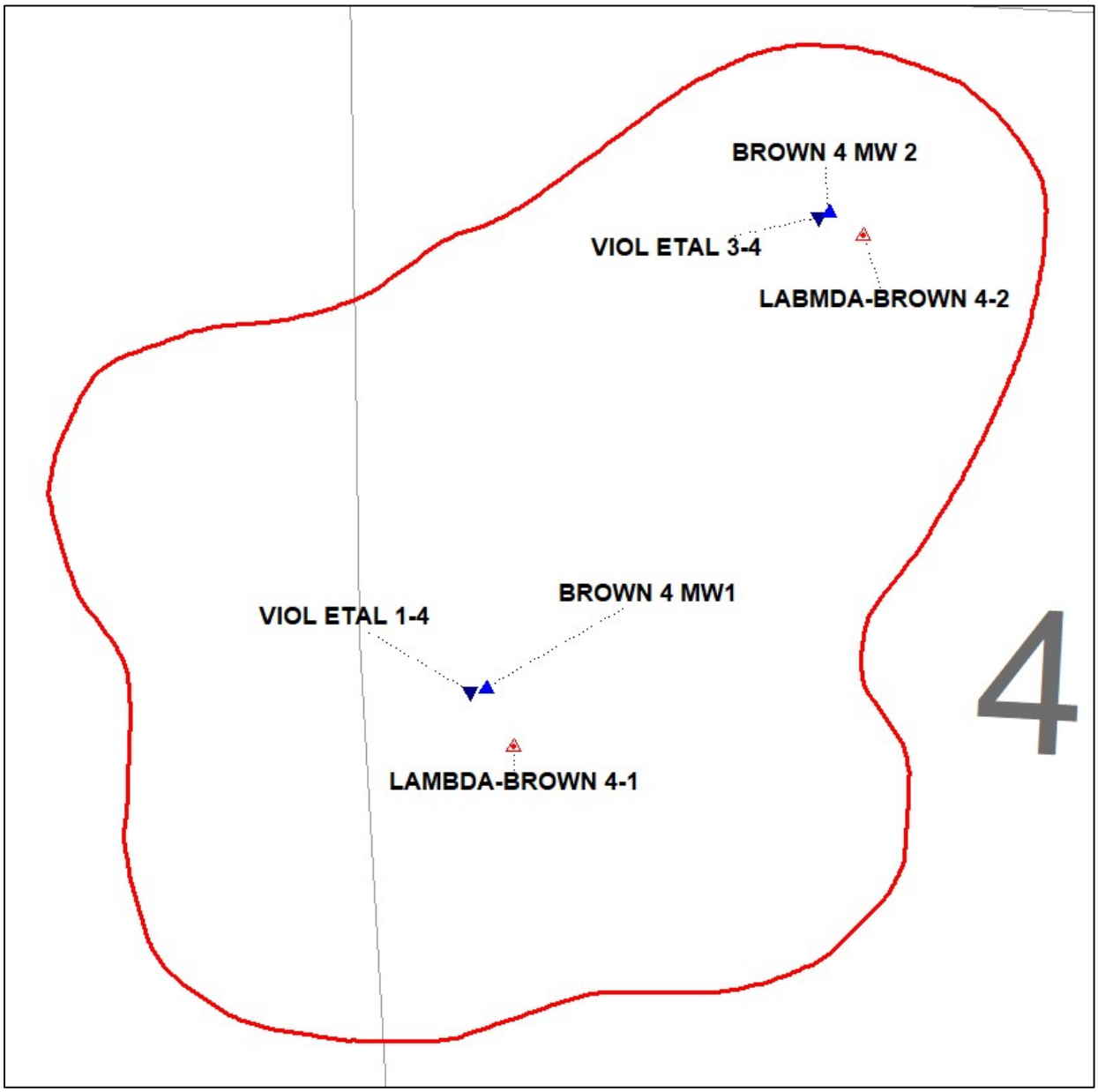

Figure 3: Monitoring and injection wells within the AoR.

B.1.f. Critical/Informational Data

Documentation of information will include the following:

1. Sampling data, which includes sample label, purging time, and other sample collection procedures.

2. Data collected in the field (temperature and pH).

3. Chain of custody.

4. Data and analysis collected in the laboratory.

5. Calibration of instrumentation and equipment.

B.1.g. Sources of Variability

Potential sources of variability include the following:

1. Natural and operational variability in fluid quality, temperature, and pressure.

2. Changes in the sampling methods, service provider, and instrumentation.

Variability will be minimized by the following:

1. Adhering to standard operating procedures.

2. Assessing data and results against baseline and previous results for trend and changes.

3. Service provider staff training.

4. Assessing calibration and calibrating procedures.

5. Quality control checks for samples.

B.2. Sampling Methods

B.2.a/b. Sampling Standard Operating Procedures (SOPs)

Refer to the table below for stabilization criteria during well purging. Laboratory (Standard Operating Procedures) SOPs are developed by the service providers.

Table 15: Stabilization Criteria of Water Quality Parameters During Shallow Well Purging.

Field Parameter	Stabilization Criteria
pH	+/- 0.1
Temperature	+/- 1%
Specific Conductance	+/- 3%
Dissolved Oxygen	+/- 0.3 mg/L
Turbidity	+/- 10%

B.2.c. In-situ Monitoring

In-situ monitoring of water chemistry is not currently planned.

B.2.d. Continuous Monitoring

Pressure and temperature will be continuously monitored.

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

A Peristaltic or bladder pump with inert/dedicated polyethylene or Teflon tubing will be used to collect samples. If a pump cannot be used because the recovery rate is so slow and the volume of the water to be removed is minimal (less than 5 feet of water), then a Teflon® bailer, with a double check valve and bottom-emptying device with a control-flow check valve, will be used to obtain the samples. The polypropylene rope used with the bailer will be disposed of following the completion of sampling at each well.

Sample collection procedures:

- All equipment used will either be new or decontaminated before use.
- A static water level will be obtained to determine the depth to water before sampling begins in order to determine the amount of water within the casing.
- Once the volume of stagnant water is calculated in the well, at least three times that amount will be removed prior to sample collection to ensure a representative sample of the aquifer is being recovered.
- Samples will be collected in clean containers and stored in cool container. Samples will be kept from sunlight and freezing during transport to the lab. As quickly as possible, the samples will either be mailed or dropped off at the laboratory for analysis following chain of custody protocol.

B.2.f. Sample Containers and Volumes

Refer to Table 16 and Table 17 for sample container and volumes.

B.2.g. Sample Preservation

Samples will be preserved as per Table 16 and Table 17.

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

Equipment used for sampling and other activities associated with on-site work will be decontaminated before and after performance of a given activity. Disposable items will be discarded of as solid waste in an approved, permitted client facility.

B.2.i. Support Facilities

Support facilities will be provided by the service provider responsible for sampling and analysis.

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

All incidents, near misses, and unsafe conditions will be documented, investigated, and recorded in report form. A root cause determination will be sought and reviewed by management. If necessary, changes to process, personnel, or other will be implemented in order to prevent recurrence.

B.3. Sample Handling and Custody

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

See Table 16 and 17 for holding times.

Table 16: Summary of Sample Containers, Preservation Treatments, and Holding Times for CO_2 Gas Stream Analysis.

Sample	Volume/Container Material	Preservation Technique	Sample Holding time
CO_2 Gas Stream	1L Stainless Steel Cylinder	None Required	5 days

Table 17: Summary of Anticipated Sample Containers, Preservation Treatments, and Holding Times for Ground Water Samples.

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding Time
Cations: Metals	One 500 ml Plastic	Cool <= 6 deg C	180 days
Anions: Chloride	One 500 ml Plastic	No Preservative	14 to 28 days
Specific Conductivity (µS/cm)	One 500 ml Plastic	No Preservative	28 days
pH (S.U.)	One 500 ml Plastic	No Preservative	Field test 1 Hr
Temperature	Field Test	No Preservative	
Dissolved Carbon Dioxide	(2) 40 ml Vials Neat	No Preservative	14 days
Water Density (Sp Gravity)	One 500 ml Plastic	No Preservative	14 days
Total Dissolved Solids (TDS)	One 500 ml Plastic	No Preservative	7 days

B.3.b. Sample Transportation

Lambda will ensure that samples are delivered to the laboratory for analysis by the service provider as soon as possible following sample collection. Upon arrival at the service provider, the samples will be reviewed to ensure the following:

1. The sample arrived intact without container leakage or breakage.
2. Chain of custody documentation and sample labels agree.
3. Confirmation that the sample was preserved correctly.

B.3.c. Sampling Documentation

Chain of custody form (CCF) will serve as sampling documentation, including sample time, date, and personnel.

B.3.d. Sample Identification

Sample identification will be unique for each sample collected and correspond with the CCF numbering identification system.

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

Chain of custody documentation is completed in full. An example chain of custody form is provided below in Figure 4.

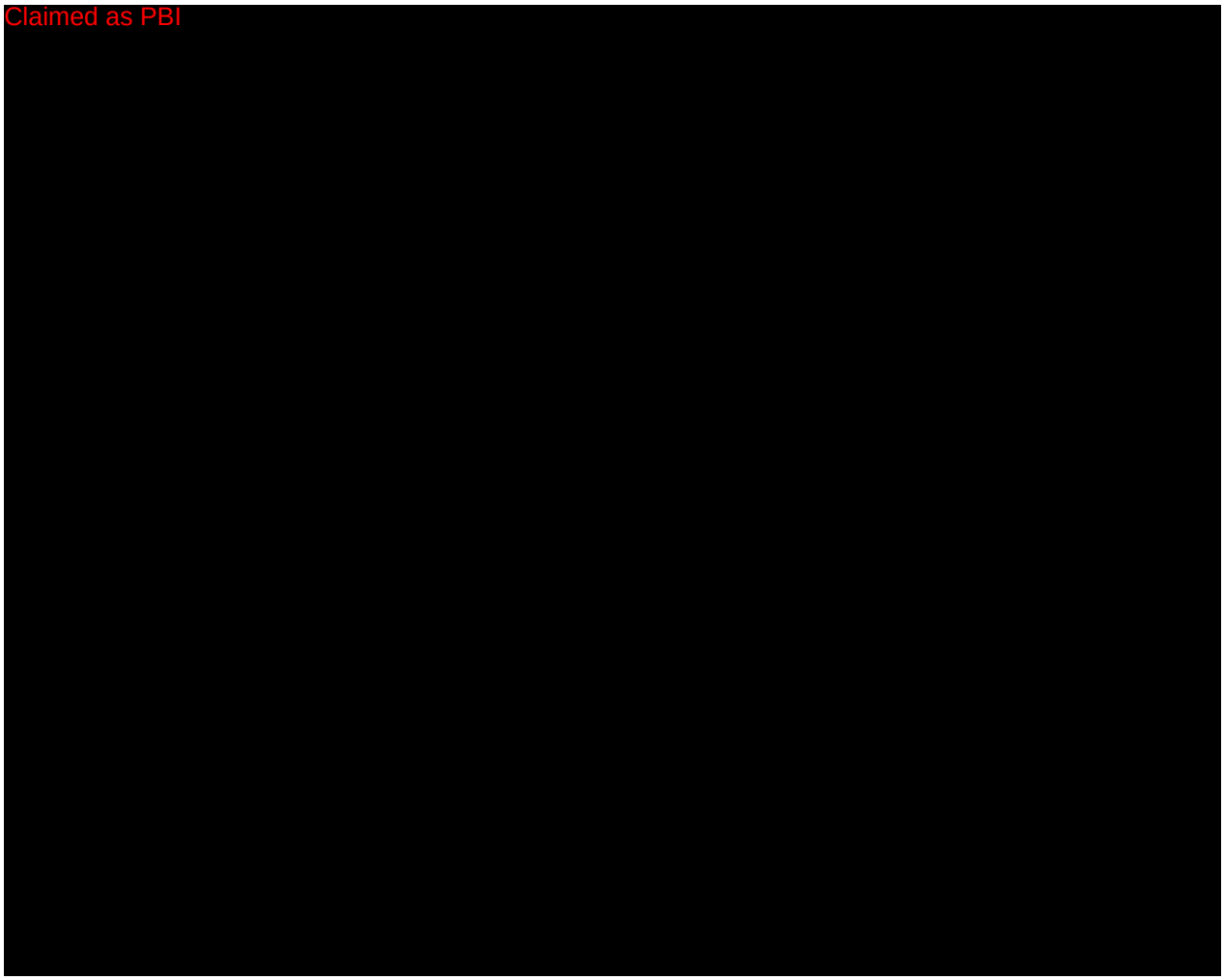

Figure 4: Sample Chain of Custody Form

B.4. Analytical Methods

B.4.a. Analytical SOPs

SOP and quality assurance are maintained under document control procedures described in Australian Laboratory Services, LLC (ALS) SOP HN-QS-014 "Document Control". External documents, such as reference methods, accreditation policies and requirements, and reference manuals, are maintained under document control policies through the use of hardcopy and network drives. Additionally, quality assurance program documents, project plan documents, and

contractual Statement of Work documents generated by a client can be designated as controlled documents at the discretion of the ALS Project Manager, Quality Assurance Manager, or the Laboratory Director.

B.4.b. Equipment/Instrumentation Needed

The following is the equipment to be utilized:

- ICP Atomic Emission Spectrometer
- Discrete Analyzer
- Ion Chromatograph

B.4.c. Method Performance Criteria

Before samples are analyzed, the analytical system must be in a controlled, reproducible state from which results of known and acceptable quality can be obtained. The state is verified through the use of Quality Control (QC) procedures intended to ensure accuracy, precision, selectivity, sensitivity, freedom from interference, and freedom from contamination. The QC procedures performed at ALS include: calibration and calibration verification; analysis and comparison of resultant data to predetermined control limits for method blanks, laboratory control samples, spiked matrix samples, duplicate matrix samples, and surrogates added to samples; analysis of performance evaluation samples; determination of Reporting Limits; and the tracking and evaluation of precision and accuracy. For specific analytical methods, other QC procedures are implemented as required by the method, such as but not limited to the analysis of field blanks, trip blanks, and positive/negative controls. Consult the Quality Control section of the determinative method SOP for guidance.

These QC procedures are performed and evaluated on a batch basis. A preparation batch must not exceed 20 field samples that are of a similar matrix type without additional method QC in the batch, unless specified differently in an SOP or reference method. The samples in a batch are processed together, through each step of the preparation and analysis, to ensure that all samples receive consistent and equal treatment. Consequently, results from the batch QC samples, not including field sample QC, are used to evaluate the results for all samples in the batch.

In general terms, instrument calibration, method quality control, and data evaluation are described in analytical SOP.

All QC parameters set by the applicable ALS SOP or method reference shall not be exceeded without appropriate narration. The hierarchy of quality control requirements begins with:

- Client Requirements (if specified and documented)
- Method and/or SOP requirements

- Guidance from the QAM and other general SOP

Calibration and Calibration Verification

Instrument calibration is a QC measure taken to verify selectivity and sensitivity. Calibration of instruments at ALS is accomplished through the use of reference materials of the highest quality obtainable. ISO or National Metrology Institute (NMI) traceable reference materials are procured and used if they are available. When ISO or National Metrology Institute (NMI) traceable reference materials are not available, certified reference materials from government agencies or reliable vendors are used. In all cases, written records are maintained that allow all analytical results to be traced unambiguously to the reference materials used for calibration.

In general, analytical instruments are initially calibrated with standard solutions made from the reference materials at levels appropriate for the analysis. This is called the initial calibration (ICAL). Low- and mid-point standards are then evaluated against the ICAL for method-specified acceptance. This step is called calibration re-fit. The calibration is then verified with a standard solution independently prepared from a different lot of the reference material, preferably from a different vendor. This step is called initial calibration verification or ICV. At specified intervals throughout the analytical sequence, the calibration is re-verified again through the analysis of a calibration check solution, usually the mid-point standard solution. This process is called the continuing calibration verification or CCV. If the ICAL, the ICV, or any CCV fails criteria in the analytical method, the system is recalibrated or the results are narrated. It is ALS' intention to only report results generated under acceptable calibration conditions. Specific calibration procedures are found in the SOPs associated with each method of analysis. Alternative calibration sequences or procedures will be discussed with clients. Calibration parameters set by the applicable ALS SOP or method reference shall not be exceeded without qualification.

B.4.d. Analytical Failure

Matrix QC samples are generally used to determine acceptability of methods chosen on a field sample and are therefore not used to determine batch acceptability. If the analysis of matrix spike is not possible, a duplicate laboratory control sample (LCS) or QC should be analyzed in the batch.

A known concentration of the analyte(s) of interest is added to a second representative portion of a field sample to prepare a matrix spike. The matrix spike is used to determine acceptability of the method chosen on a specific field matrix. It measures the success of the analysis in recovering the analyte(s) of interest from the type of field sample matrix in the batch. A matrix spike is analyzed with every analytical batch of environmental samples. The results are reported as percent recovery. Laboratory criteria will be used in the absence of client-specified criteria. Failure to meet these criteria will be noted as per client instructions.

Analysis of Duplicate Matrix Samples

Matrix QC samples are generally used to determine acceptability of methods chosen on a field sample and are therefore not used to determine batch acceptability. If the analysis of matrix spike is not possible a duplicate LCS or QC should be analyzed in the batch.

A duplicate matrix spike sample or duplicate matrix sample is used to monitor the precision (repeatability) of the method chosen on a field sample. If a sufficient amount of the analyte(s) of interest is present in the field sample, a matrix duplicate sample is analyzed directly. A pair of duplicate samples (matrix/matrix duplicate or matrix spike/matrix spike duplicate) is analyzed with every analytical batch of environmental samples. The results of the analysis of duplicate samples are reported as relative percent difference (RPD). Laboratory criteria will be used in the absence of client-specified criteria. Failure to meet these criteria will be noted as per client instructions.

Analysis of Surrogates Added to Samples

Surrogates are compounds similar to the analyte(s) of interest but that are known not to be present in the environment. Examples are fluorinated or deuterated homologues of the organic analyte(s) of interest. When appropriate compounds are available, their use is specified in the analytical method SOP. When surrogates are used, they are added to the calibration solutions and to each field and QC sample in the batch.

Surrogate recovery is a measure of the accuracy and selectivity of the method in the sample matrix. Surrogate results are reported as percent recovery. Surrogate criteria set by the applicable ALS SOP or method reference on method QC samples shall not be exceeded without appropriate actions and narration. The same criteria will be used for field samples although failure to meet these criteria will be noted in the report, narrative comments, or as per client requirements.

B.4.e. Sample Disposal

Samples are disposed of according to Federal, State, and local laws and regulations.

B.4.f. Laboratory Turnaround

Standard turnaround time is 5-7 business days. Rush projects may be available and should be confirmed by request to the project manager before samples are sent to the lab.

B.4.g. Method Validation for Nonstandard Methods

Reference methods for environmental samples are drawn primarily from the current version of Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), Online Compendium. Reference methods for water analysis are taken from Methods for Chemical Analysis of Water and Wastes, EPA-600/4- 79-020, March 1983, with its updates, 40 CFR, Part 136, and 40 CFR, Part 141. To a lesser extent, methods referenced in ALS SOP come from ASTM guides, and from Standard Methods for the Examination of Water and Waste Water.

SOP are written for all environmental testing methods, any modified reference methods and any in-house developed methods. SOP may be copies of reference methods that are not modified. All SOP are reviewed using document control procedures as outlined in SOP HN-QS-014, Document Control.

All analytical methods and preparatory method combinations are routinely tracked and ALS maintains statistical control limits and reporting limits. The laboratory can perform testing using limits provided by clients or from referenced sources in the absence of historical data. The ALS SOP HN-QS-004 “Control Charting and Trend Analysis” describes how control limits are established and updated.

ALS policy is that all SOP be compliant with the reference method. In the event that several methods are referenced in an SOP, all procedures must be compliant with all referenced methods. All SOP include a section describing changes and clarifications from the reference method. In the event that an analytical method is modified, the SOP documentation must include a description of the modification, any justification of the method modification which includes, but is not limited to, method performance and recovery data, any other supporting data, and approval from the Technical Managers, Quality Assurance Manager, and Laboratory Director. In the event that an analytical method must be modified or is modified to perform on specific sample matrices, the modification and reason must be stated in the case narrative. All modified methods will be identified on the analytical report.

B.5. Quality Control

B.5.a. QC activities

The QC procedures performed at ALS include: calibration and calibration verification; analysis and comparison of resultant data to predetermined control limits for method blanks, laboratory control samples, spiked matrix samples, duplicate matrix samples, and surrogates added to samples; analysis of performance evaluation samples; determination of Reporting Limits; and the tracking and evaluation of precision and accuracy. For specific analytical methods, other QC procedures are implemented as required by the method, such as but not limited to the analysis of field blanks, trip blanks, and positive/negative controls. Consult the QC section of the determinative method SOP for guidance.

These QC procedures are performed and evaluated on a batch basis. A preparation batch must not exceed 20 field samples that are of a similar matrix type without additional method QC in the batch, unless specified differently in an SOP or reference method. The samples in a batch are processed together, through each step of the preparation and analysis, to ensure that all samples receive consistent and equal treatment. Consequently, results from the batch QC samples, not including field sample QC, are used to evaluate the results for all samples in the batch.

Analysis of Method Blanks

The method blank (or preparation blank) contains no sample material; it is treated as a sample in every other way. It is analyzed to monitor any contamination to which the analytical batch might have been exposed during preparation and analysis. A method blank is analyzed with every analytical batch. Criteria set by the applicable ALS SOP or method reference shall not be exceeded without initiation of a No Change Authorization Required (NCAR).

B.5.b. Exceeding Control Limits

In addition to evaluating individual batch QC results against control limits, QC results from successive batches are also evaluated for possible trends. While a trend is not necessarily an out-of-control situation in itself, it can provide an early warning of a condition that can cause the system to go out of control. ALS SOP HN-QS-004 "Control Charting and Trend Analysis" describes in detail the assessment of QC data in the laboratory. The following conditions are trends that may initiate action and/or monitoring:

- A series of successive points on the same side of the mean.
- A series of successive points going in the same direction.
- A series of successive points between warning limits and control limits.

ALS relies on analytical staff to identify trends in analytical systems. Quality Assurance can produce control charts as needed to assess trends but this activity by QA is not preventive and is only used to verify trends exist. The occurrence of a trend does not invalidate data that are otherwise in control. However, trends do require attention to determine whether a cause can be assigned to the trend so that appropriate preventive action can be undertaken.
Long term trends in control limits are evaluated annually by quality assurance and technical operations.

B.5.c. Calculating Applicable QC Statistics

This is only applicable if doing full anions/cations suite of analyses. ALS does not routinely do Charge/Mass balance on samples unless requested.

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

The service provider will test, inspect, and maintain the instrumentation and equipment used for testing. This will be completed as per the manufacturer's guidelines and the standard operating procedures.

B.7. Instrument/Equipment Calibration and Frequency

B.7.a. Calibration and Frequency of Calibration

Calibration standards for all instruments will be NIST-traceable, within expiration dates of the solutions, and sufficient for daily calibration throughout the sampling collection.

B.7.b. Calibration Methodology

Analytical instruments are initially calibrated with standard solutions made from the reference materials at levels appropriate for the analysis. This is called the initial calibration (ICAL). Low- and mid-point standards are then evaluated against the ICAL for method-specified acceptance.

This step is called calibration re-fit. The calibration is then verified with a standard solution independently prepared from a different lot of the reference material, preferably from a different vendor. This step is called initial calibration verification (ICV). At specified intervals throughout the analytical sequence, the calibration is re-verified again through the analysis of a calibration check solution, usually the mid-point standard solution. This process is called the continuing calibration verification (CCV). If the ICAL, the ICV, or any CCV fails criteria in the analytical method, the system is recalibrated or the results are narrated. It is ALS' intention to only report results generated under acceptable calibration conditions. Specific calibration procedures are found in the SOP associated with each method of analysis.

B.7.c. Calibration Resolution and Documentation

Written records are maintained that allow all analytical results to be traced unambiguously to the reference materials used for calibration.

B.8. Inspection/Acceptance for Supplies and Consumables

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

Processes are designed to ensure that materials and services purchased meet the quality specifications of ALS. Procurement and receiving services are provided at ALS by administrative personnel. Procurement and receiving quality requirements established by ALS are followed. All requisitions for purchase are approved by ALS operations management and specify 1) the level of service required or 2) the quality/specifications of material required. The receipt of materials not meeting specification in the purchase requisition requires investigation.

B.9. Nondirect Measurements

Not applicable.

B.10. Data Management

B.10.a. Data Management Scheme

Lambda will maintain the Brown 4 GSP data internally. Data will be backed up and held on secure servers.

B.10.b. Recordkeeping and Tracking Practices

All data associated with the project will be held securely and maintained to ensure tracking purposes.

B.10.c. Data Handling Equipment/Procedures

Lambda employs data management procedures to continually ensure security of data gathered from the field and external data sources.

B.10.d. Responsibility

Lambda will be responsible for ensuring data management is properly maintained.

B.10.e. Data Archival and Retrieval

Lambda will hold all data associated with the Brown 4 GSP. Lambda maintains data-store redundancies to ensure data archival and retrieval.

B.10.f. Hardware and Software Configurations

Lambda will ensure that software and hardware are appropriate to integrate the multiple data sources and maintain large quantities of data.

B.10.g. Checklists and Forms

Lambda will generate forms, checklists, and procedures as necessary to ensure management, security and quality of all data collected.

C. Assessment and Oversight

C.1. Assessments and Response Actions

C.1.a. Activities to be Conducted

Please refer to Table 1 in section A.3.a/b. Groundwater quality data will be collected at the frequency outlined in that table. After completion of sample analysis, results will be reviewed for QC criteria as noted in section B.5. If the data quality fails to meet criteria set in section B.5., samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria, additional samples may be collected or sample results may be excluded from data evaluations and interpretations. Evaluation for data consistency will be performed according to procedures described in the USEPA 2009 Unified Guidance (USEPA, 2009).

C.1.b. Responsibility for Conducting Assessments

Organizations gathering data will be responsible for conducting their internal assessments. All stop work orders will be handled internally within individual organizations.

C.1.c. Assessment Reporting

All assessment information should be reported to the Lambda distribution list.

C.1.d. Corrective Action

All corrective action affecting only an individual organization's data collection responsibility should be addressed, verified, and documented by Lambda. Corrective actions affecting multiple organizations should be addressed by Lambda and communicated to necessary third parties. Assessments may require integration of information from multiple monitoring sources across organizations (operational, in-zone monitoring, above-zone monitoring) to determine whether correction actions are required and/or the most cost-efficient and effective action to implement. Lambda will coordinate multiorganization assessments and corrective actions as warranted.

C.2. Reports to Management

C.2.a/b. QA status Reports

Lambda will notify the UIC Director if there are changes to the Testing and Monitoring Plan or the QASP.

D. Data Validation and Usability

D.1. Data Review, Verification, and Validation

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

Data validation will include the review of the results, chain of custody information, and review of the blank and duplicate information. All results will be stored in a database and compared to baseline and previous results. Lambda will review third party assessments to inspect for trends and anomalies.

D.2. Verification and Validation Methods

D.2.a. Data Verification and Validation Processes

Data will be verified by Lambda upon receipt of results. If anomalous data is suspected, Lambda and the service provider will review the data associated with the sample to assess whether sampling, collection and the analysis conducted caused anomalous results. In addition, instrument calibration will be reviewed if necessary.

D.2.b. Data Verification and Validation Responsibility

See above.

D.2.c. Issue Resolution Process and Responsibility

Lambda and third-party service provider will review the ground water data handling, management, and assessment process to determine actions required to resolve issues.

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

Lambda will develop checklists and a database to store data, complete surveillance and ensure that permit requirements are met. All information used in the calculations and in preparation of the samples will be recorded and archived in order to enable reconstruction of the final result at a later date.

D.3. Reconciliation with User Requirements

D.3.a. Evaluation of Data Uncertainty

Lambda and its third-party vendor will evaluate and consider the relative contribution of major sources of uncertainty. The uncertainty associated with all processes of sample analysis will be estimated from quality control data. Calculation of uncertainty may use the precision measurement values for duplicate samples when LCS or QC samples are not used in testing. The calculation of uncertainty is not required for qualitative tests. The process is assessed for contributors to uncertainty but the calculation of uncertainty has limited value when empirical values are not available.

D.3.b. Data Limitations Reporting

Service provider management will be responsible for ensuring that analysis in their laboratory is presented with data use limitations for reporting. Lambda will be responsible for ensuring that results are vetted and evaluated to determine if performance criteria are met.

References

Australian Laboratory Service, 2020, SOP HN-QS-004-R08, Standard Operating Procedures Control Charting and Trend Analysis, ALS Inc, 3352 128th Ave, Holland, MI

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