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REPORT ON MINIMUM CRITERIA TO ASSURE DATA QUALITY

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1.0 INTRODUCTION

It is the goal of the U.S. Environmental Protection Agency's (EPA's) quality assurance (QA) program to ensure that all data be scientifically valid, defensible, and of known precision and accuracy. The data must be of sufficient known quality to withstand scientific and legal challenge relative to the use for which the data are obtained. The QA program is management's tool for achieving this goal.

For RCRA analyses, the minimum requirements for a QA program and the associated quality control (QC) procedures are provided in this chapter. Any QA program which does not meet the minimum requirements in this chapter must be approved by the Agency. Method-specific procedures are incorporated in the individual methods since the wide variety of sampling and analytical conditions in the RCRA program make it impossible for all of the necessary QC procedures to be applied universally. The data acquired from QC procedures are used to estimate the quality of analytical data, to determine the need for corrective action, and to interpret results after corrective action procedures are implemented.

A total program to generate data of acceptable quality must include both a QA component, which encompasses the management procedures and controls, as well as an operational day-to-day QC component. This chapter defines fundamental elements of such a data collection program. Data collection efforts involve:

1. design of a project plan to meet the DQOs;
2. implementation of the project plan; and
3. assessment of the data to determine if the DQOs are met.

The minimal QC components to be used in the performance of sampling and analyses are identified , including the QC information which must be documented. Guidance is provided to construct QA programs for field and laboratory work conducted in support of the RCRA program.

The words "must", "shall", "may", and "should" are used to reflect the importance placed on the activities described in this chapter. The words "must" and "shall" denote activities that are mandatory for any RCRA-related data collection effort. The words "may" and "should" denote activities that, while not mandatory, are recommended. Certain activities that are recommended but not required in this chapter may, in fact, be necessary to satisfy the data quality objectives (DQOs) of a specific project, or to satisfy specific requirements in a facility permit.

2.0 QA PROJECT PLAN

All projects which generate environmentally related data in support of RCRA require a QA Project Plan (QAPjP). In some instances, a sampling and analysis plan may include the necessary information, and will suffice. The QAPjP shall detail the QA/QC goals and protocols for a specific data collection activity to ensure that the data generated by sampling and analysis activities are of a quality commensurate with their intended use. QAPjP elements shall include a description of the project and its objectives; a statement of the DQOs of the project; identification of those involved in the data collection and their responsibilities and authorities; reference to (or inclusion of) the specific sample collection and analysis procedures that will be followed for all aspects of the project; enumeration of QC procedures to be followed; and description of project documentation. Elements may be added or removed, as required by the project or the end-user of the data (see U.S. EPA, 1980 -- QAMS-005/80 for an example).

Development of DQOs and project documentation are discussed below, while discussion of sampling and analysis procedures (along with required QC procedures) are provided in Sections 3 and 4. Management and organization play a critical role in determining the effectiveness of a QA/QC program and ensuring that all required procedures are followed. Section 2.7 discusses the organizational elements of a QA program that have been found to ensure an effective program.

2.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) for the data collection activity describe the uncertainty that a decision maker is willing to accept in results derived from environmental data. This uncertainty is used to specify the quality of the measurement data required, usually in terms of precision, bias, representativeness, comparability and completeness. The DQOs shall be defined prior

to the initiation of the field and laboratory work. The field and laboratory organizations performing the work should be aware of the DQOs so that their personnel may make informed decisions during the course of the project to attain those DQOs. More detailed information on DQOs is available from the Quality Assurance Management Staff (QAMS).

2.2 PROJECT OBJECTIVES

A statement of the project objectives and how the objectives are to be attained shall be concisely stated and sufficiently detailed to permit clear understanding by all parties involved in the data collection effort. This includes a statement of what problem is to be solved and the information required in the process. It also includes appropriate statements of the DQOs (i.e., the acceptable level of uncertainty in the information).

2.3 SAMPLE COLLECTION

Sampling procedures, locations, equipment, and sample preservation and handling requirements shall be specified. Further details on the procedures for field operations are described in Section 3 of this chapter.

2.4 ANALYSIS AND TESTING

Analytical and testing procedures to be employed, analytes and properties of concern, required detection limits, and required precision and bias shall be specified. Regulatory requirements and DQOs shall be considered when developing the specifications. Further details on the procedures for analytical operations are described in Section 4 of this chapter.

2.5 QUALITY CONTROL

The quality assurance program shall address both field and laboratory activities. Quality control procedures must be specified for estimating the precision and bias of the data.

Certain minimum requirements for QC samples have been established by EPA and must be adhered to in order to satisfy minimum criteria for acceptable data quality. Further details on procedures for field and laboratory operations are described in Sections 3 and 4 of this chapter.

2.6 PROJECT DOCUMENTATION

Documents shall be prepared and maintained in conjunction with the data collection effort. Project documentation shall be sufficient to allow review of all aspects of the work being performed. In addition to the previously described QAPjP, other required documentation is addressed in Sections 3 and 4.

The length of storage time for project records shall comply with regulatory requirements, organizational policy, or project requirements, whichever is more stringent. At a minimum, documentation shall be stored for three years from submission of the project final report.

Documentation shall be securely stored in a facility that adequately addresses/minimizes its deterioration for the length of time it is to be retained. A system allowing for the expedient retrieval of information should exist.

Access to archived information shall be controlled to maintain the integrity of the data.

All access to archived information should be documented. This documentation should include the name of the individual, the date, the reason for accessing the data, and all changes, deletions, or withdrawals that may have occurred.

2.7 ORGANIZATION

Proper organization is a very valuable tool for effective implementation of a quality assurance program. Proper design and structure of the organization facilitates effective and efficient transfer of information and prevents required procedures from being

overlooked. There are many organizational structures that are suitable and appropriate.

The organizational structure, functional responsibilities, levels of authority, job descriptions, and lines of communication for activities should be established and documented. While one person may cover more than one organizational function, the organization should be structured such that each member of the organization has a clear understanding of his or her duties and responsibilities and the relationship of those responsibilities to the total effort.

The management of the organization(s) (e.g., waste management facility, field organization, or laboratory organizations, if these are separate entities) should establish the organization's operational and QA policies. This should be documented in the Quality Assurance Project Plan (QAPjP) (see QAMS 005/80). The management should ensure that (1) the appropriate methodologies are followed as documented in the project plans; (2) personnel clearly understand their duties and responsibilities; (3) each staff member has access to appropriate project documents; (4) any deviations from the project plan are communicated to the project management and documented; and (5) communication occurs between the field, laboratory, and project management, as specified in the project plan.

The management of the organization should establish personnel qualifications and training requirements for all positions. Each member of the organization should have the education, training, technical knowledge, and experience, or a combination thereof, to enable that individual to perform assigned functions. Training should be provided for each staff member as necessary to properly perform their functions. Personnel qualifications should be documented in terms of education, experience, and training, and periodically reviewed to ensure adequacy to current responsibilities.

The organization should have a designated QA function to monitor field and lab operations to ensure that the equipment, personnel, activities, procedures, and documentation are in conformance with the QAPjP. To the extent possible, the QA monitoring function should be entirely separate from, and independent of, personnel engaged in the work being monitored. The QA function should be responsible for the QA review.

2.7.1 Performance Evaluation

Performance evaluation studies are used to measure the performance of the laboratory on unknown samples. Performance evaluation samples are typically submitted to the laboratory as blind samples by an independent outside source. The results are compared to predetermined acceptance limits. Performance evaluation samples can also be submitted to the laboratory as part of the QA function during internal assessment of laboratory performance. Records of all performance evaluation studies should be maintained by the laboratory. Problems identified through participation in performance evaluation studies should be immediately investigated and corrected.

2.7.2 Internal Assessment

Personnel responsible for performing field and laboratory activities are responsible for continually monitoring individual compliance with the QAPjP. The QA function should review procedures, results and calculations to determine compliance with the QAPjP. The results of this internal assessment should be reported to management with requirements for a plan to correct observed deficiencies.

2.7.3 External Assessment

The field and laboratory activities may be reviewed by personnel external to the organization. Such an assessment is an extremely valuable method for identifying overlooked problems.

The results of the external assessment should be submitted to management with requirements for a plan to correct observed deficiencies.

2.7.4 On-Site Evaluation

On-site evaluations may be conducted as part of both internal and external assessments. The focus of an on-site evaluation is to evaluate the degree of conformance of project activities with the applicable QAPjP. On-site evaluations may include, but are not limited to, a complete review of facilities, staff, training, instrumentation, SOPs, methods, sample collection, analyses, QA policies, and procedures related to the generation of environmental data. Records of each evaluation should include the date of the evaluation, location, the areas reviewed, the person performing the evaluation, findings and problems, and actions recommended and taken to resolve problems. Any problems identified that are likely to affect data integrity should be immediately brought to the attention of management.

The review of records should be conducted by one or more persons knowledgeable in the activities being reviewed, evaluating at a minimum the following subjects:

2.7.4.1 Field Activities

Completeness of Field Reports -- This review determines whether all requirements for field activities in the project plan have been fulfilled, that complete records exist for each field activity, and that the procedures specified in the project plan have been implemented. Emphasis on field documentation will help assure sample integrity and sufficient technical information to recreate each field event. The results of this completeness check should be documented, and environmental data affected by incomplete records should be identified.

Identification of Valid Samples -- This review involves interpretation and evaluation of the field records to detect problems affecting the representativeness of environmental samples. Examples of items that might indicate potentially invalid samples include improper well development, improperly screened wells, instability of pH or conductivity, and collection of volatiles near internal combustion engines. The field

records should be evaluated against the project plan and SOPs. The reviewer should document the sample validity and identify the environmental data associated with even poor or incorrect field work.

Correlation of Field Test Data -- This review involves comparing any available results of field measurements obtained by more than one method. For example, surface geophysics may be surveyed using both ground penetrating radar and a resistivity survey.

Identification of Anomalous Field Test Data -- Anomalous field test data should be identified. For example, a water temperature for one well that is 5 degrees higher than any other well temperature in the same aquifer should be noted. The reviewer should evaluate the impact of anomalous field measurement results on the associated environmental data.

Validation of Field Analyses -- All data from field analysis that are generated *in situ* or from a mobile laboratory should be validated and documented as specified in section 4.7. The reviewer should document whether the QC checks meet the acceptance criteria, and whether corrective actions were taken for any analysis performed when acceptance criteria were exceeded.

2.7.4.2 Laboratory Activities

The evaluation of laboratory data should be conducted by one or more persons knowledgeable in laboratory activities evaluating, at a minimum, the following subjects:

Completeness of Laboratory Records -- This review determines whether: (1) all samples and analyses required by the project plan have been processed, (2) complete records exist for each analysis and the associated QC samples, and that (3) the procedures specified in project plan and procedures have been implemented. The results of the completeness check should be documented, and environmental data affected by incomplete records should be identified.

Evaluation of Data with Respect to Detection Limits -- The reviewer should compare analytical results to required detection limits and document any detection limits that exceed regulatory limits or action levels, as specified in the QAPjP.

Evaluation of Data with Respect to Control Limits -- The reviewer should compare the results of QC and calibration check samples to control criteria. Data not within control limits require corrective action, and the reviewer should

check that corrective action reports, and the results of reanalysis, are available. The review should determine whether samples associated with out-of-control QC data are identified in a written record of the data review, and whether an assessment of the utility of such analytical results is recorded.

Review of Holding Time Data -- This review compares sample holding times to those required by the QAPjP, and notes all deviations.

Review of PE Results -- PE study results can be helpful in evaluating the impact of out-of-control conditions. This review should document recurring trends or problems evident in PE studies and evaluates their effect on environmental data.

Correlation of Laboratory Data -- This review should determine whether the results of data obtained from related laboratory tests, such as Purgeable Organic Halides (POX) and Volatile Organics, are documented, and whether the significance of differences is discussed in the reports.

2.7.5 QA Reports

There should be periodic reporting of pertinent QA/QC information to management to allow assessment of the overall effectiveness of the QA program. There are three major types of QA reports to management:

Periodic Report on Key QA Activities -- Provides summary of key QA activities during the period, stressing measures that are being taken to improve data quality; describes significant quality problems observed and corrective actions taken; includes information regarding any changes in certification/accreditation status; involvements in resolution of quality issues with clients or agencies; QA organizational changes; and provides notice of the distribution of revised documents controlled by the QA organization (i.e., procedures, QAPP).

Report on Measurement Quality Indicators -- Includes the assessment of QC data gathered over the period, the frequency of analyses repeated due to unacceptable QC performance, and if possible, the reason for the unacceptable performance and corrective action taken.

Reports on QA Assessments -- Includes the results of the assessments and the plan for correcting identified

deficiencies; submitted immediately following any internal or external on-site evaluation or upon receipt of the results of any performance evaluation studies.

3.0 FIELD OPERATIONS

The field operations must be conducted in such a way as to provide reliable information that meets the DQOs. To achieve this, certain minimal policies and procedures must be implemented. Supplemental information and guidance is available in the Technical Enforcement Guidance Document (TEGD). The project documentation shall contain the information specified below.

3.1 FIELD LOGISTICS

The project plan shall describe the type(s) of field operations to be performed and the appropriate area(s) in which to perform the work. The project plan shall address ventilation, protection from extreme weather and temperatures, access to stable power, and provision for water and gases of required purity.

Whenever practical, the sampling site facilities shall be examined prior to the start of work to ensure that all required items are available. The actual area of sampling should be examined to ensure that trucks, drilling equipment, and personnel have adequate access to the site.

The determination as to whether sample shipping is necessary should be made during planning for the project. This need is established by evaluating the analyses required, sample holding times, and location of the site and the laboratory. Shipping or transporting of samples to a laboratory must be done within a timeframe such that recommended holding times are met.

Samples should be packaged, labelled, preserved (e.g., preservative added, iced, etc.), and documented in an area which is free of contamination and provides for secure storage. The level of custody and whether sample storage is required shall be outlined.

Storage areas for solvents, reagents, standards, and reference materials shall be adequate to preserve their identity, concentration, purity, and stability prior to use.

Decontamination of sampling equipment may be done at the location where sampling occurs, prior to going to the sampling site, or in designated areas near the sampling site. Project documentation shall specify where and how this work is accomplished. If decontamination is to be done at the site, water and solvents of appropriate purity shall be available. The method of accomplishing decontamination, the materials, solvents, and water purity shall be specified.

During the sampling process and during on-site or in situ analysis, waste materials are sometimes generated. The method for storage and disposal of these waste materials shall be specified. Adequate facilities should be provided for the collection and storage of all wastes, and these facilities should be operated so as to minimize environmental contamination. Waste storage and disposal facilities shall comply with applicable Federal, State, and local regulations.

The location of long-term and short-term storage for field records, and the measures to ensure the integrity of the data shall be specified.

3.2 EQUIPMENT/INSTRUMENTATION

The equipment, instrumentation, and supplies at the sampling site shall be specified and must be appropriate to accomplish the activities planned. The equipment and instrumentation shall meet the requirements of pertinent specifications, methods, and SOPs.

3.3 OPERATING PROCEDURES

The QAPjP shall describe or make reference to all field activities that may affect data quality. For routinely performed activities, standard operating procedures (SOPs) are often prepared to ensure consistency and to save time and effort in preparing project plans. Any deviation from an established procedure during a data collection activity must be documented. The procedures

shall be available for the indicated activities, and shall contain, at a minimum, the information described below.

3.3.1 Sample Management

The numbering and labeling system, chain-of-custody procedures, and how the samples will be tracked from collection to shipment or relinquishment to the laboratory shall be specified. Sample management procedures shall also specify the holding times, volumes of sample required by the laboratory, required preservatives, and shipping requirements.

3.3.2 Reagent/Standard Preparation

The procedures describing how to prepare standards and reagents shall be specified. Information concerning specific grades of materials used in reagent and standard preparation, appropriate glassware and containers for preparation and storage, and labeling and record keeping for stocks and dilutions shall be included.

3.3.3 Decontamination

The procedures describing decontamination of field equipment before and during the sample collection process shall be specified. These procedures shall include cleaning materials used, the order of washing and rinsing with the cleaning materials, requirements for protecting or covering cleaned equipment, and procedures for disposing of cleaning materials.

3.3.4 Sample Collection

The procedures describing how the sampling operations are actually performed in the field shall be specified. A simple reference to standard methods is not sufficient, unless a procedure is performed exactly as described in the published method. Methods from source documents published by the EPA, ASTM, U.S. Department of the Interior, National Water Well Association, American

Petroleum Institute, or other recognized organizations with appropriate expertise should be used, if possible. The procedures for sample collection should include at least the following:

- Applicability of the procedure,
- Equipment required,
- Detailed description of procedures to be followed in collecting the samples,
- Common problems encountered and corrective actions to be followed, and
- Precautions to be taken.

3.3.5 Field Measurements

The procedures describing all methods used in the field to determine a chemical or physical parameter shall be described in detail. The procedures shall address criteria from Section 4, as appropriate.

3.3.6 Equipment Calibration And Maintenance

The procedures describing how to ensure that field equipment and instrumentation are in working order shall be specified. These describe calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, and service arrangements for equipment. Calibration and maintenance of field equipment and instrumentation shall be in accordance with manufacturers' specifications or applicable test specifications and shall be documented.

3.3.7 Corrective Action

The procedures describing how to identify and correct deficiencies in the sample collection process shall be specified. These should include specific steps to take in correcting deficiencies such as performing additional decontamination of equipment, resampling, or additional training of field personnel. The procedures shall specify that each corrective action must be

documented with a description of the deficiency, the corrective action taken, and should include the person(s) responsible for implementing the corrective action.

3.3.8 Data Reduction and Validation

The procedures describing how to compute results from field measurements and to review and validate these data shall be specified. They shall include all formulas used to calculate results and procedures used to independently verify that field measurement results are correct.

3.3.9 Reporting

The procedures describing the process for reporting the results of field activities shall be specified.

3.3.10 Records Management

The procedures describing the means for generating, controlling, and archiving project-specific records and field operations records shall be specified. These procedures shall describe record generation and control and the requirements for record retention, including type, time, security, and retrieval and disposal authorities.

Project-specific records relate to field work performed for a project. These records may include correspondence, chain-of-custody records, field notes, all reports issued as a result of the work, and procedures used.

Field operations records document overall field operations and may include equipment performance and maintenance logs, personnel files, general field procedures, and corrective action reports.

3.3.11 Waste Disposal

The procedures describing the methods for disposal of waste materials resulting from field operations shall be specified.

3.4 FIELD QA AND QC REQUIREMENTS

The QAPjP shall describe how the following required elements of the field QC program shall be implemented.

3.4.1 Control Samples

Control samples are QC samples that are introduced into a process to monitor the performance of the system. Control samples, which may include blanks, duplicates, spikes, analytical standards, and reference materials, can be used in different phases of the data collection process beginning with sampling and continuing through transportation, storage, and analysis.

For each sampling batch, when appropriate for the method, at least one field duplicate and one equipment rinsate must be collected. In addition, for each batch, enough volume must be collected for at least one sample to allow the laboratory to prepare one matrix spike and either one matrix duplicate or one matrix spike duplicate per analytical batch. Additional control samples may be necessary in order to assure data quality to meet the project-specific DQOs.

3.4.2 Acceptance Criteria

Procedures shall be in place for establishing acceptance criteria for field activities described in the project plan. Acceptance criteria may be qualitative or quantitative. Field events or data that fall outside of established acceptance criteria may indicate a problem with the sampling process that should be investigated.

3.4.3 Deviations

All deviations from plan shall be documented as to the extent of, and reason for, the deviation. Any activity not performed in accordance with procedures or project plans is considered a deviation from plan. Deviations from plan may or may not affect data quality.

3.4.4 Corrective Action

Errors, deficiencies, deviations, certain field events, or data that fall outside established acceptance criteria require investigation. In some instances, corrective action may be needed to resolve the problem and restore proper functioning to the system. The investigation of the problem and any subsequent corrective action taken shall be documented.

3.4.5 Data Handling

All field measurement data shall be reduced according to protocols described or referenced in the QAPjP. Computer programs used for data reduction shall be validated before use and verified on a regular basis. All information used in the calculations shall be recorded to enable reconstruction of the final result at a later date.

Data shall be reported in accordance with the requirements of the end-user as described in the project plan.

3.5 QUALITY ASSURANCE REVIEW

The QA Review consists of internal and external assessments to ensure that QA/QC procedures are in use and to ensure that field staff conform to these procedures. The QAPjP shall specify the requirements for internal, external, and on-site assessment, including the frequency and documentation of these assessments.

3.6 FIELD RECORDS

Records provide the direct evidence and support for the necessary technical interpretations, judgments, and discussions concerning project activities. These records, particularly those that are anticipated to be used as evidentiary data, must directly support current or ongoing technical studies and activities and shall provide the historical evidence needed for later reviews and

analyses. Records shall be legible, identifiable, and retrievable and protected against damage, deterioration, or loss.

Field records generally consist of bound field notebooks with prenumbered pages, sample collection forms, personnel qualification and training forms, sample location maps, equipment maintenance and calibration forms, chain-of-custody forms, sample analysis request forms, and field change request forms. All records should be completed with indelible ink.

Procedures for reviewing, approving, and revising field records must be clearly defined, with the lines of authority included. At a minimum, all documentation errors shall be corrected by drawing a single line through the error so it remains legible and shall be initialed by the responsible individual, along with the date of change. The correction is written adjacent to the error.

Field records shall include (but are not limited to) the following:

Calibration Records & Traceability of Standards/Reagents -- Calibration is a reproducible reference point to which all sample measurements can be correlated. A sound calibration program shall include provisions for documentation of frequency, conditions, standards, and records reflecting the calibration history of a measurement system. The accuracy of the calibration standards is important because all data will be in reference to the standards used. A program for verifying and documenting the accuracy of all working standards against primary grade standards shall be routinely followed.

Sample Collection -- To ensure maximum utility of the sampling effort and resulting data, documentation of the sampling protocol, as performed in the field, is essential. Sample collection records shall contain, at a minimum, the names of persons conducting the activity, sample number, sample location, equipment used, climatic conditions, documentation of adherence to protocol, and unusual observations. The actual sample collection record is usually one of the following: a bound field notebook with prenumbered pages, a pre-printed form, or digitized information on a computer tape or disc.

Chain-of-Custody Records -- Chain-of-custody records involving the possession of samples from the time they are obtained

until they are disposed or shipped off-site shall be documented as specified in the QAPjP and should include the following information: (1) the project name; (2) signatures of samplers; (3) the sample number, date and time of collection, and grab or composite sample designation; (4) signatures of individuals involved in sample transfer; and (5) if applicable, the air bill or other shipping number.

Maps and Drawings -- Project planning documents and reports often contain maps. The maps are used to document the location of sample collection points and monitoring wells and as a means of presenting environmental data. Information used to prepare maps and drawings is normally obtained through field surveys, property surveys, surveys of monitoring wells, aerial photography or photogrammetric mapping. The final, approved maps and/or drawings should have a revision number and date and shall be subject to the same controls as other project records.

QC Samples -- Documentation for generation of QC samples, such as field, trip, and equipment rinsate blanks, duplicate samples, and any field spikes shall be maintained.

Deviations -- All deviations from procedural and documents and the QAPjP shall be recorded in the site logbook.

Reports -- A copy of any report issued and any supporting documentation shall be retained.

4.0 LABORATORY OPERATIONS

The laboratory must conduct its operations in such a way as to provide reliable information. To achieve this, certain minimal policies and procedures must be implemented.

4.1 FACILITIES

The project plan shall address all facility-related issues that may impact project data quality. Each laboratory should be of suitable size and construction to facilitate the proper conduct of the analyses. Adequate bench space or working area per analyst should be provided. The space requirement per analyst depends on the equipment or apparatus that is being utilized, the number of samples that the analyst is expected to handle at any one time, and the number of operations that are to be performed concurrently by a single analyst. Other issues to be considered include, but are not limited to, ventilation, lighting, control of dust and drafts, protection from extreme temperatures, and access to a source of stable power.

Laboratories should be designed so that there is adequate separation of functions to ensure that no laboratory activity has an adverse effect on the analyses. The laboratory may require specialized facilities such as a perchloric acid hood or glovebox.

Separate space for laboratory operations and appropriate ancillary support should be provided, as needed, for the performance of routine and specialized procedures.

As necessary to ensure secure storage and prevent contamination or misidentification, there should be adequate facilities for receipt and storage of samples. The level of custody required and any special requirements for storage such as refrigeration and lighting should be described in planning documents.

Storage areas for reagents, solvents, standards, and reference materials should be adequate to preserve their identity, concentration, purity, and stability.

Adequate facilities should be provided for the collection and storage of all wastes, and these facilities should be operated so as to minimize environmental contamination. Waste storage and disposal facilities shall comply with applicable Federal, State, and local regulations.

The location of long-term and short-term storage of laboratory records and the measures to ensure the integrity of the data shall be specified.

4.2 EQUIPMENT/INSTRUMENTATION

Equipment and instrumentation shall meet the requirements and specifications of the specific test methods and other SOPs. The laboratory should maintain an equipment/instrument description list that includes the manufacturer, model number, year of purchase, accessories, and any modifications, updates, or upgrades that have been made.

4.3 OPERATING PROCEDURES

The QAPjP shall describe or make reference to all laboratory activities that may affect data quality. For routinely performed activities, standard operating procedures (SOPs) are often prepared to ensure consistency and to save time and effort in preparing project plans. Any deviation from an established procedure during a data collection activity must be documented. The procedures shall be available for the indicated activities, and shall contain, at a minimum, the information described below.

4.3.1 Sample Management

The procedures describing the receipt, handling, scheduling, and storage of samples shall be specified.

Sample Receipt and Handling -- These procedures describe the precautions to be used in opening sample shipment containers

and how to verify that chain-of-custody has been maintained, examine samples for damage, check for proper preservatives and temperature, and log samples into the laboratory sample streams.

Sample Scheduling -- These procedures describe the sample scheduling in the laboratory, which includes procedures used to ensuring that holding time requirements are met.

Sample Storage -- These procedures describe the storage conditions for all samples, verification and documentation of daily storage temperature, and how to ensure that custody of the samples is maintained while in the laboratory.

4.3.2 Reagent/Standard Preparation

The procedures describing how to prepare standards and reagents shall be specified. Information concerning specific grades of materials used in reagent and standard preparation, appropriate glassware and containers for preparation and storage, and labeling and recordkeeping for stocks and dilutions shall be included.

4.3.3 General Laboratory Techniques

The procedures describing all essentials of laboratory operations that are not addressed elsewhere shall be specified. These techniques shall include, but are not limited to, glassware cleaning procedures, operation of analytical balances, pipetting techniques, and use of volumetric glassware.

4.3.4 Test Methods

Procedures for test methods describing how the analysis is actually performed in the laboratory and not a simple reference to standard methods, unless the analysis is performed exactly as described in the published method, shall be specified. Whenever methods from SW-846 are not appropriate, recognized methods from

source documents published by the EPA, American Public Health Association (APHA), American Society for Testing and Materials (ASTM), the National Institute for Occupational Safety and Health (NIOSH), or other recognized organizations with appropriate expertise should be used, if possible. The procedures for analytical methods should include the following:

Sample Preparation and Analysis Procedures -- These include applicable holding time, extraction, digestion, or preparation steps as appropriate to the method; procedures for determining the appropriate dilution to analyze; and any other information required to perform the analysis accurately and consistently.

Instrument Standardization -- This includes concentration and frequency of analysis of calibration standards, linear range of the method, and calibration acceptance criteria.

Sample Data -- This includes recording requirements and documentation including sample identification number, analyst, data verification analyst, date of analysis and verification, and computational method(s).

Detection and Reporting Limits -- This includes all analytes in the method.

Test-Specific QC -- This describes QC activities applicable to the specific test and references any applicable QC procedures.

4.3.5 Equipment Calibration and Maintenance

The procedures describing how to ensure that laboratory equipment and instrumentation are in working order shall presented. These procedures include calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, service arrangements for all equipment, and spare parts available in-house. Calibration and maintenance of laboratory equipment and instrumentation shall be in accordance with manufacturers' specifications or applicable test specifications and shall be documented.

4.3.6 QC

The type, purpose, and frequency of QC samples to be analyzed in the laboratory and the acceptance criteria shall be specified. Information should include the applicability of the QC sample to the analytical process, the statistical treatment of the data, and the responsibility of laboratory staff and management in generating and using the data. Further details on development of project-specific QC protocols are described in Section 4.4.

4.3.7 Corrective Action

The procedures describing how to identify and correct deficiencies in the analytical process shall be specified. These should include specific steps to take in correcting the deficiencies such as preparation of new standards and reagents, recalibration and restandardization of equipment, reanalysis of samples, or additional training of laboratory personnel in methods and procedures. The procedures shall specify that each corrective action must be documented with a description of the deficiency, the corrective action taken, and the person(s) responsible for implementing the corrective action.

4.3.8 Data Reduction and Validation

The procedures describing how to review and validate the data shall be specified. They shall include procedures for computing and interpreting the results from QC samples, and independent procedures to verify that the analytical results are reported correctly. In addition, routine procedures used to monitor precision and bias, including evaluations of reagent, field, and trip blanks, calibration standards, control samples, duplicate and matrix spike samples, and surrogate recovery, should be detailed in the procedures. The bias determined from the matrix spike information shall be used to correct the measured values. Details on the calculations are provided in the glossary under the definition of bias.

4.3.9 Reporting

The procedures describing the process for reporting the analytical results shall be specified.

4.3.10 Records Management

The procedures describing the means for generating, controlling, and archiving laboratory records shall be specified. The procedures shall detail record generation and control, and the requirements for record retention, including type, time, security, and retrieval and disposal authorities.

Project-specific records may include correspondence, chain-of-custody records, request for analysis, calibration data records, raw and finished analytical and QC data, data reports, and procedures used.

Laboratory operations records may include laboratory notebooks, instrument performance logs and maintenance logs in bound notebooks with prenumbered pages; laboratory benchsheets; software documentation; control charts; reference material certification; personnel files; laboratory procedures; and corrective action reports.

4.3.11 Waste Disposal

The procedures describing the methods for disposal of chemicals including standard and reagent solutions, process waste, and samples shall be specified.

4.4 LABORATORY QA AND QC PROCEDURES

The QAPjP shall describe how the following required elements of the laboratory QC program shall be implemented.

4.4.1 Method Proficiency

The laboratory shall have procedures for demonstrating proficiency with each analytical method routinely used in the laboratory. These shall include procedures for demonstrating the

precision and bias of the method as performed by the laboratory and procedures for determining the method detection limit (MDL). All terminology, procedures and frequency of determinations associated with the laboratory's establishment of the MDL and the reporting limit shall be well-defined and well-documented. Documented precision, bias, and MDL information shall be maintained for all methods performed in the laboratory.

4.4.2 Control Limits

Procedures shall be in place for establishing and updating control limits for analysis. Control limits shall be established to evaluate laboratory precision and bias based on the analysis of control samples. Typically, control limits for bias are based on the historical mean recovery plus or minus three standard deviation units, and control limits for precision range from zero (no difference between duplicate control samples) to the historical mean relative percent difference plus three standard deviation units. Procedures shall be in place for monitoring historical performance and should include graphical (control charts) and/or tabular presentations of the data.

4.4.3 Laboratory Control Procedures

The laboratory shall have procedures for demonstrating that the laboratory is in control during each data collection activity.

Laboratory Control Samples -- Laboratory control samples shall be analyzed for each analytical method when appropriate for the method. A laboratory control sample consists of a control matrix, spiked with analytes representative of the target analytes, or a certified reference material. Laboratory control sample(s) shall be analyzed with each batch of samples processed to verify the precision and bias of the analytical process. The results of the laboratory control sample(s) are compared to control limits established for both precision and bias to determine usability of the data. Analytical data generated with laboratory control samples that fall within prescribed limits are judged to be generated while the laboratory was in control. Data generated with laboratory control samples that fall outside the established control limits are judged to be generated during an "out-of-control"

situation. These data are considered suspect and must be repeated or reported with qualifiers.

Method Blank -- When appropriate for the method, a method blank shall be analyzed with each batch of samples processed to assess contamination levels in the laboratory. The laboratory shall have guidelines in place for accepting or rejecting data based on the level of contamination in the blank.

The laboratory shall have procedures for documenting the effect of the matrix on method performance. When appropriate for the method, there shall be at least one matrix spike and either one matrix duplicate or one matrix spike duplicate per batch. Additional control samples may be necessary in order to assure data quality to meet the project-specific DQOs.

Matrix-Specific Bias -- Procedures shall be in place for determining the bias of the method in the matrix. These procedures should include analysis of matrix spikes, use of surrogates for organic methods, and the method of standard additions for metal and inorganic methods. When the concentration of the analyte in the sample is greater than 0.1%, no spike is necessary.

Matrix-Specific Precision -- Procedures shall be in place for determining the precision of the method in the matrix. These procedures should include analysis of matrix duplicates and/or matrix spike duplicates. The frequency of use of these techniques shall be based on the DQOs of the data collection activity.

Matrix-Specific Detection Limit -- Procedures shall be in place for determining the MDL in a specific matrix. When analytical data are used to demonstrate compliance with a regulation, DQO, or other study objectives, any and all values reported as less than a specific regulatory threshold must be verified. If no regulatory threshold is mandated for the analyte of interest, any and all values reported as less than the MDL must be verified. The analyst must demonstrate the method's ability to detect the analyte of concern in the sample matrix at the prescribed threshold.

4.4.4 Deviations

Any activity not performed in accordance with laboratory procedures or project plans is considered a deviation from plan. All deviations from plan shall be documented as to the extent of, and reason for, the deviation.

4.4.5 Corrective Action

Errors, deficiencies, deviations, or laboratory events or data that fall outside of established acceptance criteria require investigation. In some instances, corrective action may be needed to resolve the problem and restore proper functioning to the analytical system. The investigation of the problem and any subsequent corrective action taken shall be documented.

4.4.6 Data Handling

Data resulting from the analyses of samples shall be reduced according to protocols described in the laboratory procedures. Computer programs used for data reduction shall be validated before use and verified on a regular basis. All information used in the calculations shall be recorded in order to enable reconstruction of the final result at a later date. This information may include weight or volume of sample used, percent dry weight for solids, extract volume, dilution factor used, and blank- or background-correction protocols followed.

All data should be reviewed by a second analyst or supervisor according to laboratory procedures to ensure that calculations are correct and to detect transcription errors. Spot checks should be performed on computer calculations to verify program validity. Errors detected in the review process should be referred to the analyst(s) for corrective action. Data should be reported in accordance with the requirements of the end-user. The supporting documentation shall include as a minimum:

- Laboratory name and address.

- Sample information (including unique sample identification, sample collection date and time, date of sample receipt, and date(s) of sample preparation and analysis).
- Analytical results reported with appropriate significant figures.
- Detection limits that reflect dilutions, interferences, or correction for equivalent dry weight.
- Method reference.
- Appropriate QC results.
- Data qualifiers with appropriate references and narrative on the quality of the results.

4.5 QUALITY ASSURANCE REVIEW

The QA review consists of internal and external assessments to ensure that QA/QC procedures are in use and to ensure that laboratory staff conform to these procedures. The QAPjP shall specify the requirements for internal, external, and on-site assessment, including the frequency and documentation of these assessments.

4.6 LABORATORY RECORDS

Records provide the direct evidence and support for the necessary technical interpretations, judgements, and discussions concerning project activities. These records, particularly those that are anticipated to be used as evidentiary data, must directly support technical studies and activities, and provide the historical evidence needed for later reviews and analyses. Records shall be legible, identifiable, and retrievable, and protected against damage, deteriorations, or loss.

Laboratory records generally consist of bound notebooks with prenumbered pages, sample collection forms, personnel qualification and training forms, sample location maps, equipment maintenance and calibration forms, chain-of-custody forms, sample analysis request

forms, and analytical change request forms. All records should be completed with indelible ink.

Procedures for reviewing, approving, and revising laboratory records must be clearly defined, with the lines of authority included. As a minimum, all documentation errors shall be corrected by drawing a single line through the error so it remains legible and shall be initialed by the responsible individual, along with the date of change. The correction is written adjacent to the error.

Strip-chart recorder printouts should be signed by the person who performed the instrumental analysis. If corrections need to be made in computerized data, a system parallel to the corrections for handwritten data should be in place.

Records of sample management should be available to permit the re-creation of an analytical event for review in the case of an audit or investigation of a dubious result.

Laboratory records shall include, but are not limited to, the following:

Operating Procedures -- Procedures should be available to those performing the task outlined. Any revisions to laboratory procedures shall be written and distributed to all affected individuals to ensure implementation of changes. Areas covered by operating procedures are given in Section 3.5 and 4.5.

Quality Assurance Plans -- The QAPjP shall be on file.

Equipment Maintenance Documentation -- A history of the maintenance record of each system serves as an indication of the adequacy of maintenance schedules and parts inventory. When maintenance is necessary, it shall be documented in either standard forms or in logbooks. Maintenance procedures shall be clearly defined and written for each measurement system and required support equipment.

Proficiency -- Proficiency information on all compounds reported shall be maintained and shall include (1) precision; (2) bias; (3) method detection limits; (4) spike recovery, where applicable; (5) surrogate recovery, where applicable; (6) checks on reagent purity, where applicable; and (7) checks on glassware cleanliness, where applicable.

Calibration Records & Traceability of Standards/Reagents -- Calibration is a reproducible reference point to which all sample measurements can be correlated. A sound calibration program shall include provisions for documentation of frequency, conditions, standards, and records reflecting the calibration history of a measurement system. The accuracy of the calibration standards is important because all data will be in reference to the standards used. A program for verifying and documenting the accuracy of all working standards against primary grade standards shall be routinely followed.

Sample Management -- All required records pertaining to sample management shall be maintained and updated regularly. These include chain-of-custody forms, sample receipt forms, and sample disposition records.

Original Data -- The raw data and calculated results for all samples shall be maintained in laboratory notebooks, logs, benchsheets, files or other sample tracking or data entry forms. Instrumental output should be stored in a computer file or a hardcopy report.

QC Data -- The raw data and calculated results for all QC and field samples and standards shall be maintained in the manner described in the preceding paragraph. QC samples include, but are not limited to, control samples, method blanks, matrix spikes, and matrix spike duplicates.

Correspondence -- Project correspondence can provide evidence supporting technical interpretations. Correspondence pertinent to the project should be kept and placed in the project files.

Deviations -- All deviations from procedural and planning documents shall be recorded in laboratory notebooks. Deviations from project plans are to be reviewed and approved by the authorized personnel who performed the original technical review or by their designees.

Final Report -- A copy of any report issued and any supporting documentation should be retained.

5.0 DEFINITIONS

The following terms are defined for use in this document:

Accuracy

The closeness of agreement between an observed value and an accepted reference value. When applied to a set of observed values, accuracy will be a combination of a random component and of a common systematic error (or bias) component.

Batch

A group of samples which behave similarly with respect to the testing procedures being employed and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch (i.e., for each batch, one method blank, one equipment rinsate, one matrix spike, and either one matrix duplicate or one matrix spike duplicate will be analyzed).

Bias (B)

The deviation of the measured value (x_t) from an accepted reference value (T) or a known spiked amount (K). Bias can be assessed by comparing a measured value to an accepted reference value in a sample of known concentration or by determining the recovery of a known amount of contaminant spiked into a sample. Thus, the bias is calculated as:

$$B = x_t - T$$

or

$$B = (x_s - x_u) - K$$

where x_t = measured value for reference value,
x_s = measured value for spiked sample,
x_u = measured value for unspiked sample, and
K = known value of the spike in the sample.

Using the following equations yields the percent recovery (%R). The value of %R is then used to correct the measured values for that batch of data. Thus,

$$\%R = 100\ (x_t/T),$$

or

$$\%R = 100\ (x_s - x_u)/\ K,$$

and

$$x_c = 100\ (x_u/\%R),$$

where x_c = corrected value.

Blank

see Equipment Rinsate, Method Blank, Trip Blank.

Control Sample
A QC sample introduced into a process to monitor the performance of the system.

Data Quality Objectives (DQOs)
Statements of the level of uncertainty that a decision maker is willing to accept in results derived from environmental data (see EPA/QAMS, July 16, 1986). This is qualitatively distinct from quality measurements such as precision, bias, and detection limit.

Duplicate
see Matrix Duplicate, Field Duplicate, Matrix Spike Duplicate.

Equipment Blank
see Equipment Rinsate.

Equipment Rinsate
A sample of analyte-free media which has been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. This blank is useful in documenting adequate decontamination of sampling equipment.

Field Duplicate
Independent samples which are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently. These duplicates are useful in documenting the precision of the sampling and analytical process.

Laboratory Control Sample
A known matrix spiked with compound(s) representative of the target analytes. This is used to document laboratory performance.

Matrix Duplicate
An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.

Matrix Spike
An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Matrix Spike Duplicates

Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

Method Blank

An analyte-free media to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank must be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Method Detection Limit (MDL)

The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

For operational purposes, when it is necessary to determine the MDL in the sample matrix, the MDL shall be determined by multiplying by 7 the standard deviation obtained from the triplicate analyses of a matrix spike containing the analyte of interest at a concentration three to five times the estimated MDL.

Estimate the MDL as follows:
Obtain the concentration value that corresponds to:

a) an instrument signal/noise ratio within the range of 2.5 to 5.0, or
b) the region of the standard curve where there is a significant change in sensitivity; i.e., a break in the slope of the standard curve.

Determine the variance (S^2) for each analyte as follows:

$$S^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} x_i^2 - \frac{1}{n} \left(\sum_{i=1}^{n} x_i\right)^2$$

where x_i = the ith measurement of the variable x, and
$\bar{x}$ = the arithmetic mean of the x_i measurements.

Determine the standard deviation (s) for each analyte as follows:

$$s = (S^2)^{1/2}$$

Determine the MDL for each analyte as follows:

$$MDL = t_{(n-1,\ \alpha = .99)}(s)$$

where $t_{(n-1,\ \alpha = .99)} = 6.965$ for three replicates as determined from the table of Student's t-values at the 99 percent level.

Practical Quantitation Limit

The lowest analyte concentration in a given matrix that the Agency believes a competent laboratory can be expected to achieve consistently.

Precision

The agreement among a set of replicate measurements without assumption of knowledge of the true value. Precision is estimated by means of duplicate/replicate analyses. These samples should contain concentrations of analyte above the PQL, and may involve the use of matrix spikes. The most commonly used estimates of precision are the relative standard deviation (RSD) or the coefficient of variation (CV),

$$RSD = CV = 100\ S/\bar{x}$$

and the relative percent difference (RPD) when only two samples are available,

$$RPD = 100\ [(x_1 - x_2)/((x_1 + x_2)/2)].$$

Project

Single or multiple data collection activities that are related through the same planning sequence.

Quality Assurance Project Plan (QAPjP)

An orderly assemblage of detailed procedures designed to produce data of sufficient quality to meet the data quality objectives for a specific data collection activity.

RCRA

The Resource Conservation and Recovery Act.

Reagent Grade

Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents which conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

Reagent Water

Water that has been generated by any method which would achieve the performance specifications for ASTM Type II water.

Reference Material

A material containing known quantities of target analytes in solution or in a homogeneous matrix. It is used to document the bias of the analytical process.

Split Samples

Aliquots of sample taken from the same container and analyzed independently. In cases where aliquots of samples are impossible to obtain, field duplicate samples must be taken for the matrix duplicate analysis. These are usually taken after mixing or compositing and are used to document intra- or interlaboratory precision.

Standard Addition

The practice of adding a known amount of an analyte to a sample immediately prior to analysis. It is typically used to evaluate matrix effects.

Standard Curve

A plot of concentrations of known analyte standards versus the instrument response to the analyte. Calibration standards are prepared by diluting the expected range of the samples being analyzed. Standards should be prepared at the frequency specified in the appropriate section. The calibration standards must be prepared using the same type of acid or solvent and at the same concentration as will result in the samples following sample preparation. This is applicable to organic and inorganic chemical analyses.

Surrogate

An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples.

Trip Blank

A sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples.

6.0 REFERENCES

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80, December 29, 1980, Office of Monitoring Systems and Quality Assurance, ORD, U.S. EPA, Washington, DC 20460.

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