GUIDE TO SAMPLING SURVEY DESIGNS

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ABSTRACT

This paper presents a "Generic Guide" for individuals initiating sampling survey design plans for remedial investigation projects. The guide has been developed to present a less intensive, and more practical approach to initiating a sampling survey design(i.e., compared to the approach as defined by EPA and ASTM guides-see EPA and ASTM references). The sampling survey design must follow a logical thought process to effectively achieve project Data Quality Objectives, and provide meaningful information relative to conceptual models and defined action levels. Generic guidance is included to show the "logical flow" of Key elements are provided that need to be considered when developing sampling strategies and sampling design alternatives that are statistically based. Guidance is also included for achieving good data quality by considering analytical interfaces in sampling design, and the overall sampling design assessment.

INTRODUCTION

The guide provides the following "logical order" of minimum steps to be followed when initiating a Sample Survey Design:

Step-1 Assemble Background Information
--geographic,meteorologic,demographic,geologic,chemical,historic, previous investigations,aerial maps

Step-2 Create a Site Conceptual Model or Module
--hydrologic,surface soil,surface water/sediment,air, biological/ecological surveys

Step-3 Utilize the DQO Process in Developing Sampling Designs

Step-4 Establish Roles/Responsibilities
-- geologist,hydrogeologist,environmental engineer,risk assessment, quality assurance,analytical chemist,statistician

Step-5 Incorporate Regulatory Requirements
--Clean Air/Water/Safe Drinking water-Acts,TSCA,RCRA,CERCLA,SARA,NEPA

Step-6 Develop Sampling Designs
--Needed Information for sampling strategies
-regulatory,project objectives,site knowledge,sample population, characteristics of interest,equipment,sample size,sample numbers, sample matrix,analytical methods
-Common Sampling Design
-judgement sampling,systematic sampling,simple random sampling, stratified random sampling,geostatistical sampling
-Combined Sampling

Step-7 Field QA/QC in Sampling Design

Step-8 Consider Analytical Interfaces in Sampling Design
--Project Analytical Statement of Work-Categories
--Analytical Support During Sampling
--Analytical Method Requirements
--Analytical Quality Control Requirements
--Analytical Data Reporting

Step-9 Assess Sampling Design(Achievement of DQOs)

Step-1 Assemble Background Information

Geographic:
Identify the specific site location on a map with specific geographic boundaries(longitude & latitude), indicate north/south/east/west and the specific sites.

Meteorologic:
Identify the specific climatic conditions to be expected at the site(i.e., cold winter, short cool and humid summers, excessive-rainy season, hails, fogs, etc.).

Demographic(population):
Identify the known human and animal/biota population adjacent to the site and the proximity of the site to major highly populated areas nearby.

Geologic(topography,stratigraphy,hydrology):
Identify the site specific geologic characteristics of the site(if known). If they are not known identify the geologic characteristics of adjoining site properties(underlying-unconsolidated units, aquifer, silt/sand aquifer types, surface & ground water flow other).

Chemical(inventories,types,amounts):
Obtain information about existing hazardous or spilled chemical substances from any available historic information on the site. Then, attempt to identify amounts and types of the chemical substances, product names,manufacturers names, shipping labels or manifests, DOT numbers, and other information(MSDS) about materials of on-site.

Historic(types, and times of activities):
Identify known activities that have taken place in the past on the site. Conduct a literature search for technical information which will allow sampling personnel to make such judgements as what type of protective equipment, type of sampler, sample container, container volume to use, or even whether to take a sample or not.

Previous Investigations:
Obtain copies of previous site investigations and screen them for health and safety purposes before sampling personnel are permitted to enter or begin work.

Aerial Maps:
Obtain aerial maps that provide a good perspective of the surrounding surface features(i.e.,hilly areas, ponds/lakes/rivers,wooded areas.etc.), roads and buildings so that proposed sampling areas can be viewed.

Step-2 Create a Site Conceptual Model or Models

Each model identifies additional site-specific data required to define the types and extent of contamination, and the pathways for contaminant migration before finalizing the sampling design.
The following types of questions need to be considered:

o If a hydrologic investigation is required, identify site-specific groundwater flow characteristics(horizontal & vertical extent of contamination), choose the right number of samples.

o If a surface soil investigation is required, identify the site-specific horizontal and vertical extent of contaminated soils, then plan for the right quantity of samples to facilitate evaluating the possibility of any off-site migration of contamination.

o If a surface water/sediment investigation is required, evaluate the extent of surface water contamination, then plan for the right quantity of samples to facilitate evaluating the potential for further off-site contamination.

o If an Air investigation is required, plan for the right number and type of samples that may be needed to fully evaluate the potential for any immediate danger that may exist in the air at the site.

o If a biological/ecological survey is required, identify for the types of known species existing at the sampling site, and which ones are to be included in the ecological study.

Step-3 Utilization of the DQO Process in Developing Sampling Designs

When initiating the seven steps of the EPA DQO process, be sure to include all stakeholders(program & project management,technical staff, risk assessment staff, regulators-local,state,federal, and property owners) in the early steps leading up to the decision step. This results in significant cost savings while still allowing acquisition of acceptable results.

Attention to the goal of the Data Quality Objectives(DQOs) process assumes development of a sampling design that reduces the chance of making an unacceptable decision error. Proper DQO planning produces a sampling design which includes enough samples to allow acceptable error rates per specified objective. Utilizing the DQO process in this way(assessing acceptable error rates) facilitate planning documentation.

To establish acceptable limits on decision errors which will be used to identify quality control(QC) requirements, the sampling design must include a mechanism for separating the field site into specific achievable data collection activities. It is be necessary to define specific QC items that pertain to each data generating activity, in order to fully evaluate step seven of the DQO process. Utilizing field screening helps determine what type of contaminants of concern and concentration levels may be present at a specific time.

The type of field sampling and analysis(screening or definitive) to be implemented, the equipment and instruments to be used to produce desired data, should direct how stringent QC requirements need to be for a particular sampling and analysis event. QC items(i.e., sample documentation, number of QC samples needed, etc.) for screening level information may be similar to or the same as QC items for definitive level information(i.e.,CERCLA Remedial Invest); however, in most instances screening level information will be collected with less QC backup and less documentation. This will limit the ability to evaluate the data via traditional verification/validation processes.

The selection of QC items must be linked to the intended use of the data, to fully achieve selecting the optimum acceptable limits on decision errors for the investigation.

Step-4 Roles and Responsibilities

Identify what each discipline contributes to insure success:

Geologist:
Provides technical input for planning the sampling design and drilling operations(i.e., specify required quantity, and type of samples per investigation matrix and population(soil, sediment,groundwater,surface water, etc.) based on his or her knowledge of the geological history of the site and its surroundings.

Hydrogeologist:
Provides direction for developing the sampling design(i.e.,select field site locations, well locations), and supervises implementation of field drilling operations,field sampling operations, and reviewing investigation reports.

Environmental Engineer:
Provides input for planning the sampling design(i.e., identifies applicable regulatory requirements, develops and organizes site specific remediation work plans).
Risk Assessment:
Provides input for planning the sampling design(i.e.,at the initial stages of the DQO process, to ensure adequate samples and measurements will be taken to perform risk assessments, help establish appropriate risk level goals).

Quality Assurance:
Provides input for planning the sampling design(i.e., identifies applicable regulatory requirements for QA/QC to be followed, identifies procedural needs, helps identify interfaces with QA and operational organizations, provides input for conducting audits/surveillances).
Analytical Chemist:
Provides input for planning the sampling design(i.e., establishes the correct analytical protocols to be used for a project, provides input on identifying analytes of concern , establishes analytical laboratory interfaces).
Statistician:
Provides input for planning the sampling design(i.e., provides input on statistical modeling and component variance, such as laboratory error, provides input for any statistical quality control modeling geared toward efficient allocation of sampling and measurement resources, and identifying specific contributors to the overall variability which may need attention).

Step-5 Incorporate Regulatory Concerns

To ensure that Federal, State, Local, and Client(QA/QC) regulatory compliance is achieved, the sample survey designer must specify how the plan for assessing the specific site and facility identifies potential problems and maintains good environmental practices. Past problem areas should be remediated with proof of this action recorded. Controls must be established to ensure proper notification of problems with Federal, State, Local or Client regulatory requirements. A clean, neat, organized and well managed site or facility has a better chance of avoiding problems with regulatory agencies.

The following ia a list Federal Environmental Laws and Regulations that relate to Hazardous Wastes:

The Clean Air Act(CAA)-(November 15, 1990)
- National Ambient Air Quality Standards
- New Source Performance Standards(NSPS)-Minimum Nationwide Emission Limits
- Nat'l Emission Stds. for Hazardous Air Pollutants(NESHAPS)
- Acid Rain Control
- Permits
- Stratospheric Ozone
- Enforcement

The Clean Water Act(CWA)
- National Pollutant Discharge Elimination System(NPDES)-Permits
- Radioactive Discharges-Permits,Authorizations
- Discharge of Dredge or Fill Materials(Per EPA 40CFR-230)-Permits

The Safe Drinking Water Act(SDWA)-(1974)
- Community Water Systems(public water systems)
- Non-Transient, Non-Community Water Systems(work places/hospitals)
- Non-Community Water Systems(campgrounds and gas stations)
- National Primary Drinking Water Regulations(NPDWR)-Max.Cont.Lev's(MCLs)& Goals

The Toxic Substances Control Act(TSCA)-(1976)

- Good Laboratory Practice Stds.(40CFR792)(health,envir.,chemical effects)
- Regulation of Specific Chemicals(40CFR761)(i.e.,PCBs)
- Long Term Maintenance of Health & Envir. Records(40CFR717)

The Resource Conservation & Recovery Acr(RCRA)-(1976)

- Hazardous Waste Generators(EPA notifications & RCRA compliance)
- Materials Regulated under RCRA(solid,liquid,semisolid)

RCRA-Hazardous Waste Amendments(HSWA) of 1984

- Hazardous Waste Management
- State and Regional Solid Waste Plans
- Regulation of Underground Storage Tanks
- Demonstration Medical Waste Tracking Program

The Comprehensive Environmental Response Comp. & Liability Act of 1980

- Treatment, Storage, and Disposal(40CFR270)
- Hazardous and Solid Waste Amendments(HSWA-1984)
- Underground Storage Tanks(40CFR280)
- States with RCRA Authority
- Underground Injection Control

Superfund Amendments and Reauthorization Act(SARA) of 1986

- National Priorities List and Hazardous Ranking
- Preliminary Assessment
- Site Inspection
- Remedial Investigation
- Feasibility Study
- Record of Decision
- Remedial Design
- Remedial Action
- The National Environmental Policy Act(NEPA) of 1969
- Action Forcing Provisions(10CFR1021)(envir.impact-statement,assessment)

Step-6 Sampling Designs

The design of sampling strategies for environmental efforts needs to provide the structure, purpose, and rationale to perform the sampling event. The design should be objective in nature, technically defensible, and practical to implement. It must follow a logical thought process to effectively achieve project objectives(DQOs) and provide meaningful information relative to conceptual models and defined action levels. Table-1 represents a sampling design tool which can be employed to facilitate mapping a sampling effort.

Sampling Design Information

The following elements should be considered during the development of sampling strategies and sampling design alternatives:

Regulatory:

Most environmental projects are driven by regulatory programs, and many regulatory programs(federal,state,local) have established sampling protocols or requirements. State UST programs are a good example where specific numbers and types of samples are required to be collected and analyzed. Regulatory constraints need to be factored into sampling designs.

Project Objectives:

Decision makers need to identify the project goals and objectives. Knowledge of these objectives is paramount in delineating an appropriate sampling design.

Site Knowledge:

It is important to utilize the available site information to obtain an optimum sampling design. This allows clear definition of populations to be sampled or excluded from sampling.Process or prior investigation history will help delineation of the measurements needed.

Sample Population:
Sampling designs must be formulated for the identified environmental population. In order for any relevant conclusions to be drawn, they must be based on the universe actually sampled. Statistically based decisions with identified accuracy, precision, and confidence need to clearly define the associated population sampled. These considerations need to include population boundaries, statistical needs, and acceptable levels of uncertainty.

Characteristic of Interest:
Each identified parameter(chemical,physical,geophysical,meteorological, etc.) measurement needs consideration in the design of a sampling effort to ensure the integrity of the measurement will not be compromised by the design.

Equipment:
Available sampling methods and apparatus for sample collection will impact the design of each sampling effort. The ability to physically collect samples from the identified population may be constrained by current technology development, equipment availability, and method defensibility. Logistical access of equipment to the sampling locations needs consideration and planning(maneuvering ability, power access, terrain, utilities proximity, weight, and motion).

Sample Size:
The mass or volume of a sample to be collected must be determined after consideration has been given to matrices heterogeneity/homogeneity and analytical sample size requirements. Representative samples can only be obtained when the sample size accommodates all individual particle sizes in the population(i.e., fine grained sand to pebbles to boulders, when included in the population).

Sample Numbers:
The number of samples to be collected from each identified population is based on the acceptable decision error, proximity to a threshold/action limit & measured or anticipated population variance.

Sample Matrix:
Sample designs must consider both the physical and chemical properties of each population to ensure sample integrity will not be compromised. Sampling devices must be chemically compatible with the sampled matrix and physically capable of retrieving representative sample of the matrix.

Analytical Methods:
Sampling designs need to be developed in conjunction with selection of appropriate analytical methods. Variables such as sample size, analytical holding time, and required detection limits need to be balanced with the design optimization.

Cost:
Budgets are always a significant factor in balancing available resources, project schedules, data quality, and effective sampling design.

Common Sampling Designs
A sampling design needs to be selected with ultimate consideration for the project objectives, target analytes, population boundaries, decisions to be made, acceptable decision errors, analyte spatial or temporal distributions, practicality, and cost. All need to be accommodated with the selection of the design. Basic sampling designs follow two basic avenues of thought: those which are statistically based and those which are not. Both have application

during environmental studies.

Non-Statistical

<u>Judgement Sampling</u>:
This sampling selects a location(s) because it is considered to be representative of the average, maximum, or minimum conditions of a population, based on historical knowledge of site processes or populations. Samples can be obtained relatively quickly, inexpensively, and provide reasonable analyte estimates relative to the basis for selection.
<u>Authoritive Sampling</u>:
This approach represents directed sampling based on regulatory or supervisory mandates. Regulatory intervention at the sampling location may dictate specific sampling locations and media based on regulatory directives or simply visual evidence. This type of sampling is most effective in documenting the presence or absence of contamination at the selected location, but will not provide sufficient information to determine population statistics. Both judgement sampling and authoritative sampling are considered to be biased.

This does not negate their validity as long as the premise and rationale for sample selection is clearly defined.
<u>Systematic Sampling</u>:
This sampling design involves collection of samples at predetermined, regular intervals, in space or time. The normal implementation of this sampling is based on a systematic grid design for application to spatial aspects. Grid size, selection of initial grid coordinates, and defining population boundaries are integral parts to this design selection. Linear systematic sampling designs can be applied over time or along physical lines, such as, ditches or streams. Although this is placed in a non-statistical category, statistically sound applications can be assigned to the data to provide valid information relative to population statistics.

Statistical

<u>Simple Random Sampling</u>:
This sampling design considers all units in the population equally. Each unit of the population has an equal probability of being selected as a sample, and the selection of that unit does not impact the probability for selection of unit for additional samples. A predetermined number of samples is obtained from the population in order to generate statistically representative information with regard to the population mean, distribution, and variance. Bias relative to selection of samples is minimized.
<u>Stratified Random Sampling</u>:
Simple random sampling is applied to clearly identified non-overlapping subgroups of the population, called strata. This allows analyte concentrations to be determined within and between strata of a given population. Overall population statistics can be derived based on weighted averages relative to the determined strata sizes.
<u>Geostatistical Sampling</u>:
Historical data or past experience allows initial estimates of the spatial intercorrelation within the population. The population can then be mathematically modeled to optimize the next round of sampling locations. As data are obtained, model estimates are updated to maximize the utility of new sampling locations and their related information. Employing this iterative technique allows maximum information to be obtained while collecting a minimum number of samples. This technique is particularly useful in studying large areas.

Combined Sampling Designs

Many areas subject to environmental investigations can use a combination of statistical and non-statistical sampling. The effective combination of the known advantages and disadvantages for each commonly used design will enable optimum utilization of site resources to attain project objectives.

Step-7 FIELD QA/QC IN SAMPLING DESIGN

The determination of field QA/QC for a specific sampling design should be mainly based on the type of field sampling application to be implemented, and the equipment and instruments that are to be used to produce the desired field data. The following types of field QC should be selected for routine sample collection and analysis to verify that the sample collection and handling process has not
affected the quality of the samples: o Trip Blanks-usually (one) analyte-free water sample per cooler(to detect induced contaminants) which come from the laboratory, travel to the sampling site and return to the laboratory with volatile organic(VOA) samples, o Equipment Rinseate Blanks-usually (one) final analyte-free water rinse from equipment cleaning collected daily per sampling event, which are analyzed for the same parameters as the related sample, o Field Duplicates/Splits-usually (5% or 10% per sample matrix) to ensure sample collection/handling practices do not affect the quality of the samples. The best way to utilize the results of the analysis of blanks, is to come up with a sampling design(for each field site) that will allow for "quick" analysis of the very first blanks obtained at the initiation of sample collection, so that the source of any contamination is quickly detected/identified and corrective action taken before a large amount of costly re-sampling is required. Field blank information is used to document field processes and qualify data sets, it is not directly applicable to individual sample analysis correction.

Step-8 CONSIDERATION OF ANALYTICAL INTERFACES IN SAMPLING DESIGN

A vital part of obtaining quality environmental data resides in the communication between the project and analytical laboratory. It is essential that the project clearly identify its objectives to the laboratory and that the laboratory understand the scope of the project requirements. It is necessary for the project to be knowledgeable of the analytical process and aware of its application and limitations regarding the data produced. Successful completion of an environmental project must include an aggressive interactive program between project managers and analytical laboratories(on-site or off-site).

Issues to be considered of include: project specific laboratory statements of work which focus on project and program requirements; analytical support during project sampling; analytical method requirements; regulatory certification and quality control requirements; and analytical data reporting needs.

Project Analytical Statement of Work

The environmental project's analytical Statements of Work(SOW) and the Project Work Plan are the fundamental communication tools for the analytical laboratory. However, even when explicit directions are written, they may be interpreted in various ways. It behooves each project and laboratory to establish a very precise understanding of expectations, so that the team can be successful. Critical laboratory SOW categories are outlined below:

1. Points of reference and communication must be clearly defined in the project planning and documentation. These include the project identification, the technical project manager, the project contractor officer, and data receiving individual.

2. Project references are of particular importance. They should include: the Project Work Plan(Sampling and Analysis Plan and Quality Assurance Project Plan); primary long term operational agreements; and higher-tier program documentation, such as Quality Assurance Program Plans, Federal Agency Guidance, State Programmatic Criteria, etc.

3. The project description should be a brief excerpt from the Work Plan, which highlights the project data objectives and goals.

	Program or Project Title								
	Investigation Phase (Initial, I, II, Final, etc.)								
	Project Location (SWMU, AOC, etc.)								
	Data Need								
Media	Remedial Investigation			Feasibility Study		Sampling			
	N&E	HHRA	ERA	Alt. Dvlp.	Treat.Study	Method/Location	Depth	Interval	Fld. QC
Surface Soil									
Subsurface Soil									
Sediment									
Groundwater									
Surface Water									
Biota									

	Continued							
	Analytical					Other		
	Metals	VOCs	SVOCs	Pest/PCB	Anions	Geotech	Fld. GC	Fld. Meas.
Surface Soil								
Subsurface Soil								
Sediment								
Groundwater								
Surface Water								
Biota								

When the laboratory is aware of the goals, it will be capable of contributing to achievement of the objectives. Clear identification of project schedules will enable the laboratory to properly facilitate analysis, maximize analytical sample batches, and provide a uniform product throughout the projects duration. The analytical SOW should not only attempt to identify the time frames for collection of samples, but also define the frequency of sample collection and delivery during that time frame. If the project anticipates collection of 100 samples per week for the first month and 10 samples per week for the remainder of the project, this needs to be conveyed to the laboratory, so they have not assumed the samples would be evenly distributed across the life of the project.

4. Appropriate communication must be established with the analytical laboratory for delivery of sample shipments. Project failures can occur when sample shipments are made on the last day of the work week and the analytical laboratory is not prepared to receive a weekend delivery. Such lack of communication, project planning, and documentation results in project failures and unnecessary cost for re-sampling and re-analyses.

5. Services required prior to collection of samples must be identified in the SOW. Many environmental projects require sample bottles, coolers, and preservatives to be supplied by the analytical facility. Some projects require in-field laboratory support, either in the context of personnel or equipment.

6. The laboratory analytical work scope includes clearly defined analytical methods, quality control, and deliverables. It is imperative that the SOW define not only the numbers of samples to be received by the analytical facility, but that it define the specific methodology to be employed, the specific quality control required by the project, and the deliverables necessary to properly validate the data toward project objectives. Specific detection levels(per analyte, per matrix) and reporting requirements(hard-copy and electronic deliverables) must be identified and addressed in project documentation. Project requirements must be understood by all the team members and every attempt must be made to achieve each requirement.

7. The laboratory must be informed of all contractual conditions relative to the work being performed. These include: contract type; invoicing requirements; payment terms; change clauses; default provisions; subcontracting conditions; liability; propriety information; period of performance; primary client flow-down clauses; or performance bond requirements.

8. The laboratory should also be informed of particular project information which may affect the analysis of the laboratory working conditions. This includes relevant historical information, addressing known areas of high contamination which may interfere with the analytical process or endanger the analyst if improperly handled.

Analytical Support During Sampling

During planning, mobilization and implementation of a project, the laboratory must be kept fully informed. Field team leaders and sample managers should have clear and open lines of communication with laboratory personnel. This will allow immediate notification, on either end of sample shipments, relative to arrival times, shipping difficulties, and documentation errors or corrections. Active communication between sampling and laboratory personnel needs to be designed into projects to achieve success through: (1) enlightening field personnel of the various analytical requirements; (2) allowing laboratory personnel to be aware of field limitations; (3) promoting a team effort to achieve project goals; and (4) correcting and documenting errors in a timely fashion. Project design and implementation should establish and promote this communication process between sampling and analysis.

Analytical Method Requirements

Analytical method requirements must be considered during the sampling design. Sample quantities required to complete analysis for the various project parameters must be matched to the sampling devices employed to obtain them.

Sample quantities obtained must not only consider the amount required to analyze each parameter of interest, but must also consider the project specific quantitation levels, quantities needed to complete laboratory QC, and the potential need for repeat analyses.

Various environmental media(soil types, sediments, sludges, waters, biota, etc.) can be sampled employing a multitude of sampling devices. These devices are designed to collect various amounts of material(i.e., geoprobes, 2-4 inch cores, hand-augers, clamshells, gravity cores, peristaltic pumps, submersible pumps, bailers, dippers, etc.). The amount of material obtained over a prescribed depth or time interval must be adequately matched to the analytical method needs and sensitivities required to meet project objectives. Compromises may need to be reached during design which will optimize the value of the analysis obtained relative to the quantity of sample material available. Decision trees may be an effective means for the project to identify analytical priority based on the volume of sample obtained. For example; if a low recharge well permits collection of only minimal water volumes, the project should have designed priorities(i.e., collect analyte "a" and "c" next at one half volumes and adjust analytical methods in order to achieve project quantitation levels; collect analytes "d-h" at one tenth standard volumes and accept elevated quantitation levels; finally omit "i-k" and do not consider the location relative to field or laboratory duplicate volume needs).

Sample size relates not only to the quantity of material, but also to the targeted sample population(particle size relative to solids, dissolved/suspended/total relative to waters, fillet/organ/bone/total relative to biota). Project designs need to consider and define not only what sample population will be collected, but what will be analyzed. Often collection devices and methods provide or include extraneous material not intended to be part of the targeted population. Each sampling design must include adequate communication to the sampler and laboratory what material should be excluded from analysis(i.e., rocks/grass/twigs from soil, silt/sediment from water, metal frame from filter, bone from fish, etc.). An often overlooked aspect of project planning appears at the beginning of sample analysis, during sub-sampling of the collected field sample. Analyzed sample sizes vary greatly dependent on the parameter and analytical method. As the sample size decreases sample homogeneity increases in importance and representativeness may become questionable. Sampling designs must consider how each analytical sub-sampling effort impacts the representativeness of the analysis to the target population and compensate, if necessary, to achieve the desired project objectives.

Analytical Quality Control Requirements

Quality control requirements need to be clearly identified by each project for each parameter of interest. QC measurements are intended to provide critical information relative to the accuracy, precision, representativeness, and integrity of each analysis. Generalized terms, such as "matrix spikes", are useful, however, their implementation can not be universally applied to all methods and matrices. It is therefore necessary during planning to review the purpose and use of QC measures relative to project goals and document required frequencies, criteria, and action levels.

Analytical Data Reporting

Design consideration should also include the form, format and content of the analytical data deliverable. This deliverable must be consistent with the project objectives, project data management design, project electronic data base, and project records documentation requirements. When comprehensive laboratory information is not requested for a project, the laboratory needs to be specifically directed to retain this information in a retrievable fashion for a specified time interval.

Step-9 SAMPLING DESIGN ASSESSMENT(achievement of DQOs)

The sampling design data quality assessment(DQA) or satisfactory achievement of DQOs is usually done after all environmental data have been collected and validated in compliance with the site-specific QA project plan. The process should include the application of statistical tools to evaluate if the project data collected meets the assumptions(i.e., decision error) under which the DQOs and sampling design were developed, or if the total decision error is of a magnitude that will allow the data results to be used to support decisions made(i.e., assessing acceptable error rates) by the decision maker.

A statistical evaluatiion must be made to determine how well the sampling design data support the conclusion based on assumptions(i.e., decision error selected). The statistical evaluation must conclusively show that each parameter of interest(i.e.,TCE level) is above or below the "action level". At this point the DQA assessor must determine if conclusions can be supported in accordance with the selected sampling design DQOs. The DQA assessor must determine if the resulting data is sufficient to support the conclusion or if the original DQOs need revision and require additional supporting data.

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