

# **Session 3**

# **Applications and Implementation Strategies**

**Strengthening Capacities in the Western Balkans Countries to Address Environmental Problems  
through Remediation of High Priority Hot Spots**



# Content

This session explores the development of sampling programs to characterize site conditions. Emphasis will be placed on trade-offs encountered in the effort to obtain data that are representative, sufficiently complete (adequate for the intended purposes), and affordable.

The session will examine:

- precision and accuracy,
- detection limits,
- significant figures,
- background versus baseline,
- methods to estimate sample size requirements,
- statistical power,
- placement of sampling stations, and
- frequency of sampling.

# Learning Objectives

This module will provide details on application and implementation strategies in the design of a sampling/monitoring program. Specific objectives are:

- to be able to justify the following components of a sampling plan:
  - number of samples,
  - placement of sampling stations, and
  - frequency of sampling;
- to be able to construct the elements of a project-specific
  - and affordable sampling and analysis plan (SAP), and
  - quality assurance project plan QAPP).

# Balancing Data Needs and Cost

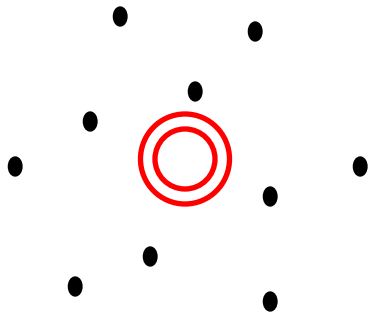
- How do more and better data improve the ability to make a sound decision?
- Do the costs of improved detection limits and improved delineation of the spatial distribution of contaminants make a substantive difference in the decisions to be made?

# Sampling and Analysis Plan (SAP)

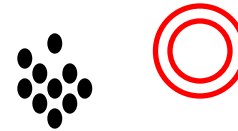
A SAP (or Workplan) provides project-specific details pertaining to all phases of

- acquiring data
  - type of sample
  - number of samples
  - location of samples
  - methods used to measure parameters
- analyzing data
  - verification of authenticity of data (chain-of-custody as appropriate)
  - processing (entry, simple descriptive statistics)
  - statistical assumptions
  - statistical methods
  - presentation form (e.g., tables, graphs)
  - interpretation/decision criteria

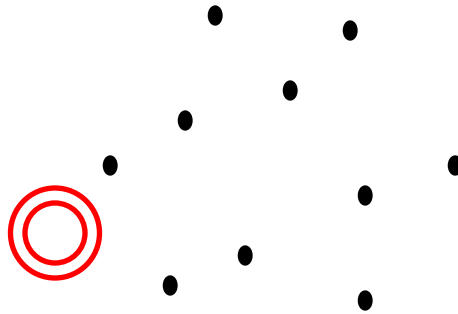
# Precision and Accuracy



High Accuracy, Low Precision



Low Accuracy, High Precision



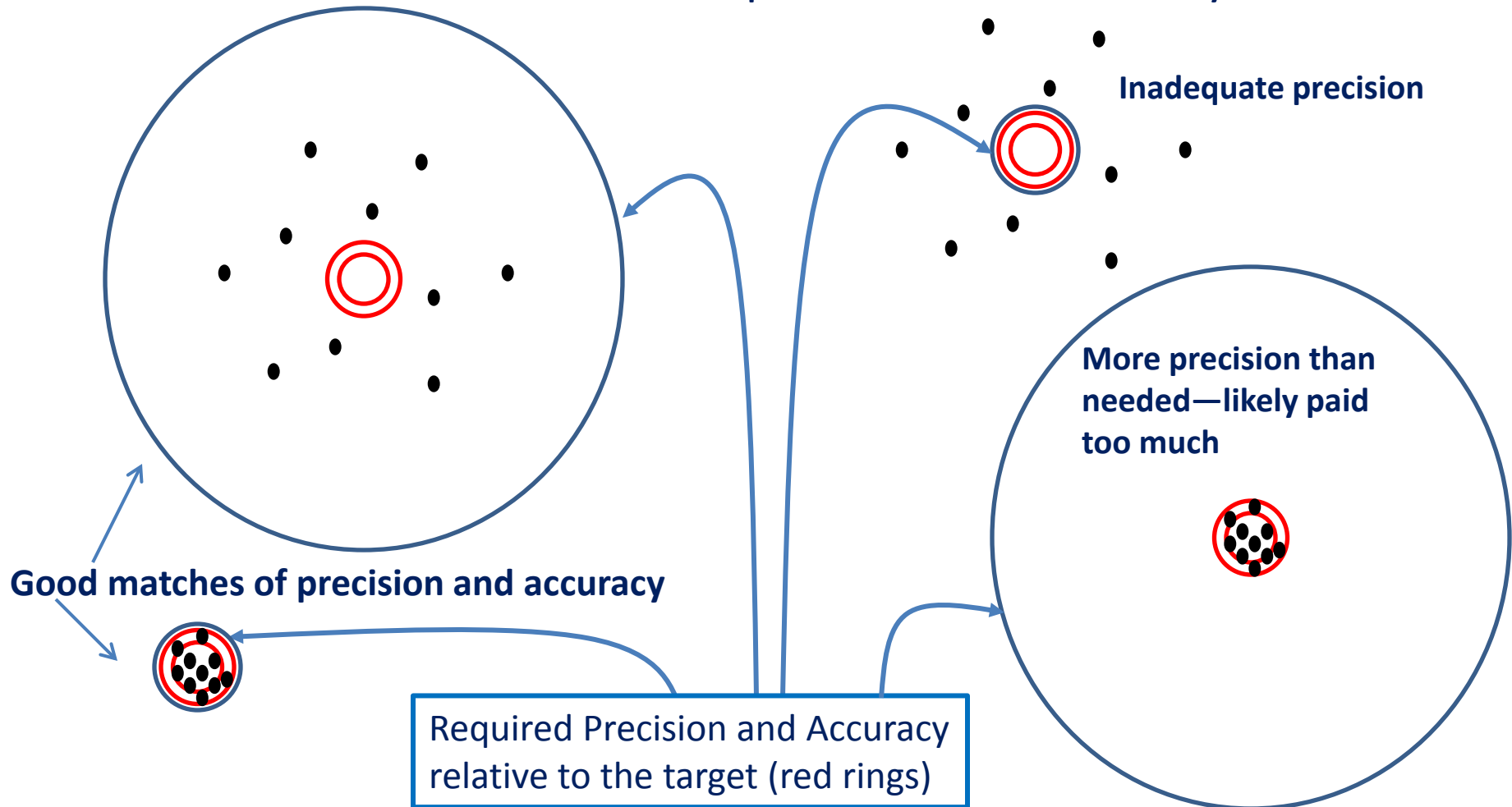
Low Accuracy, Low Precision



High Accuracy, High Precision

# Data Quality Objectives

- How accurate and how precise do we need to be?
- What is the cost of increased precision and accuracy?



## DQO [Continued]

General rule—detection limit should be one order of magnitude lower than the value used as a standard

- Soil screening concentration for arsenic = 18 mg/kg
- DQO ~2 mg/kg soil
- If the Practical Quantitation Limit for the method and instrumentation is 2.5 mg/kg, okay
- If greater accuracy is required, then special analytical procedures may be needed at considerably greater cost.

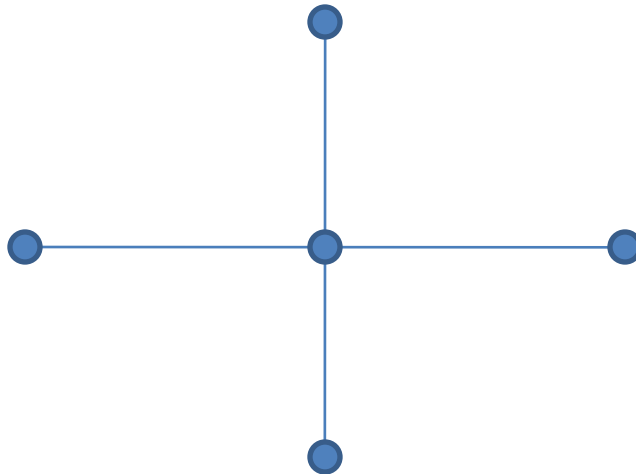
# Placing Sampling Stations Across a Landscape

How does one determine how many sampling stations are needed?

- The desired number may be estimated using the
  - known or assumed statistical variance based on preliminary sampling or inferred from similar situations
  - desired statistical assurance (e.g.,  $\alpha=0.5$ )
  - allowable error (i.e., how much error are you willing to accept? 20%? 30%?, 50?% ...)
- Various statistical reference sources or on-line calculators available
- But beware that in hazardous waste site projects one rarely will have a sufficient budget to achieve great accuracy

# Placing Sampling Stations Across a Landscape

Use composite samples to finesse the problem of sample number, especially if you are interested in characterizing the average concentration at a particular location



Combine material collected at the five points, mix well, send the composite sample to the laboratory for analysis.

# Placing Sampling Stations Across a Landscape

How does one determine where to place sampling stations?

1. Are you interested in documenting the maximum concentration at the site?
  - Appropriate for initial characterization of waste piles
  - Be aware that this approach generally will overestimate risk, but can be useful in identifying likely adverse effects resulting from acute exposures
  - Likely requires return to the site for follow-up sampling
2. Are you interested in characterizing the distribution of substances across a specified landscape?

# Placing Sampling Stations Across a Landscape

Three primary considerations if the objective is to characterize the spatial distribution of substances across the site

- Type—a mappable unit (i.e., a polygon) defined by landscape attributes (e.g., vegetation cover, soil type, known areas of contamination)\*
- Scale
  - Grain—the resolution or minimum recognizable dimension to be characterized\*\*
  - Extent—the spatial expanse being mapped
- Frequency—interval between sampling events
- Estimates of the number of samples to be measured apply to each type

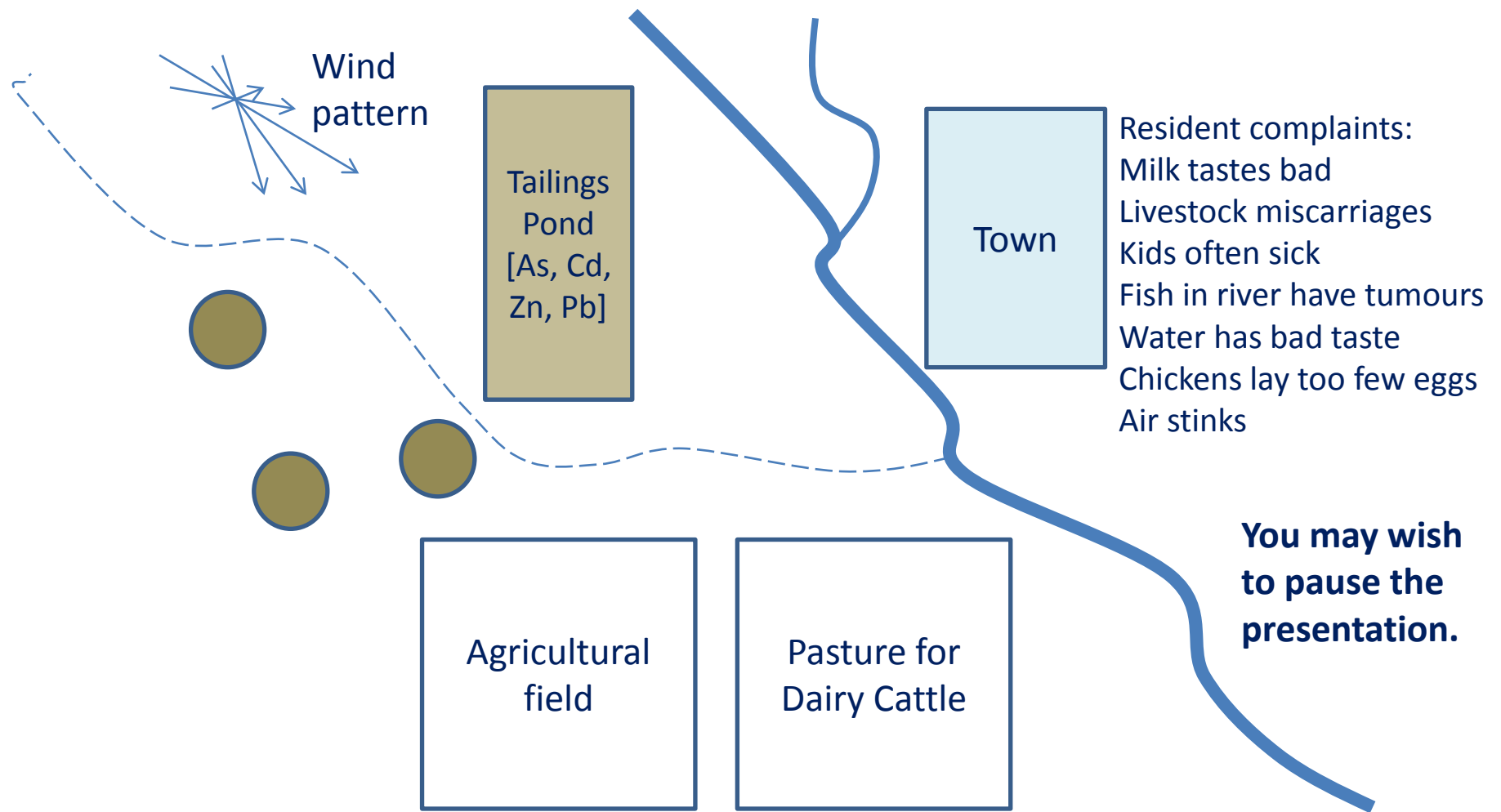
\*\* High resolution (i.e., fine detail) data may be aggregated to lower resolution, but low resolution data (i.e. coarse detail) cannot be “disaggregated.”

# Example Problem

The following slide contains an hypothetical situation that resembles many real-world situations:

- Sketchy information, that may be unrelated to putative sources of contamination
- Inadequate funds to nailed down the real concerns

The challenge is to devise an effective and efficient plan of attack to gather site-specific information to evaluate the situation.



Blue lines (solid and dashed) designate streams

Brown circles are miscellaneous waste piles from mining operations, oil drums, includes tires, electrical transformers, etc.

**Design a sampling plan to determine if there are real problems.  
Initial budget: 10,000 Euros**

# **Supplemental Information**

Regional Training on Environmental  
Monitoring and Field Survey  
Becici, Montenegro

# Quality Assurance Project Plan (QAPP)

A QAPP provides project-specific, written guidelines for the identification and management of potential sources of error with general procedures for the production of data of known and accepted quality. The QAPP provides for the review of all activities that could directly or indirectly influence data quality.

# QAPP Content

- Project description
- Project organization and responsibility
- QA objectives for the measurement of data (e.g., precision, accuracy, completeness, representativeness, and comparability)
- Sampling procedures
- Sample custody and chain-of-custody procedure
- Calibration procedures and frequency
- Analytical procedures
- Data reduction, validation, and reporting
- Internal quality control checks and frequency
- Performance and system audits and frequency
- Preventive maintenance procedures and schedules
- Specific routine procedures used to assess data precision, accuracy, and completeness of specific parameters involved
- Corrective actions to be taken as indicated by audits and reviews

# Precision

**Precision** describes the degree to which data generated from replicate measures differ.

- the quantitative measure of the variability of a group of measurements as compared to their average value
- precision of toxicity tests is determined by comparison of treatment replicates
- Comparable procedures for field measurements provide precision estimates derived from statistical distributions of values.
- Variance, standard deviation, or standard error terms are reported in defining precision.

# Accuracy

**Accuracy** is defined as the bias in a measurement system and is the difference between the value of the measured data and the true value

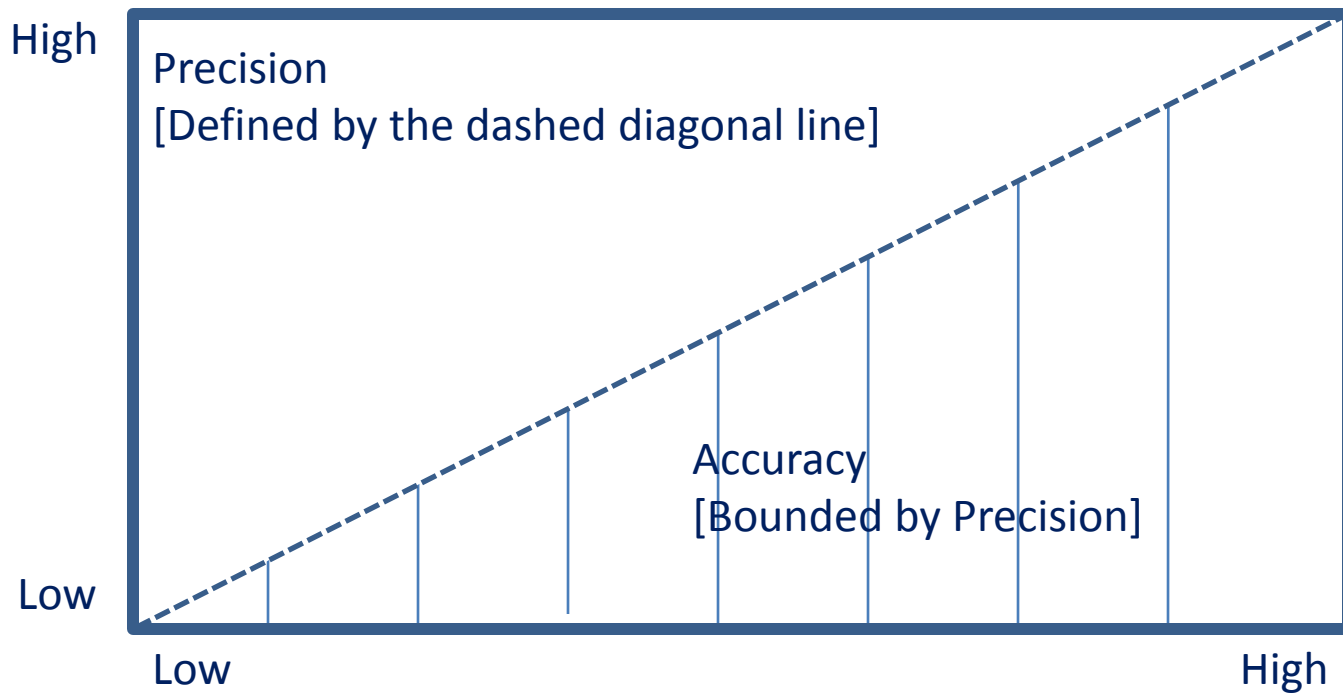
- Variance, standard deviation, or standard error terms are reported in defining precision
- Determining the accuracy of the toxicity tests for environmental samples is not possible because the true values cannot be known. No methods directly measure the accuracy of the toxicity tests. Therefore, accuracy is indirectly estimated by testing the sensitivity of organisms used in the toxicity tests with reference toxicants and by the use of bioassay control blanks.

# Sampling Considerations

- **Completeness** is defined as the percentage of measurements or amount of data required in order to make a management decision concerning a project. The completeness goal is essentially the same for all data uses where it is necessary to judge the validity of a study.
- **Comparability** is an expression of the confidence with which one data set can be compared with another. Sample data are comparable with other measurement data if consistent documented procedures are used for similar samples, sampling methods, and test conditions (for example ceriodaphnid tests performed using different standard methods approved for different jurisdictions).
- **Representativeness** is an indication of how well the sample data reflects the true nature of the statistical population being described
- **Adequacy** indicates whether the data are sufficient to make the required decisions

# Important Rules relating Accuracy and Precision

- Accuracy cannot exceed precision, that is precision defines the upper limit of accuracy.
- Accuracy need not correlate with precision.



# Significant Figures

For any computation, the number of significant figures is determined by the value having the fewest significant figures! How many significant figures are there in the following examples:

The value 1 has one significant figure

- 1
  - One significant figure
- 1.00
  - Three significant figures
- 0.02001
  - Four significant figures—note that leading zeros do not count
- $1.00 + 0.02001$ 
  - =1.02 with three significant figures

In screening assessments that use hazard quotients (HQ, or PEC/PNEC) , dietary proportions typically have two significant figures, thus the resulting HQ should be limited to 0.1, 0.2, ... 0.9, 1.0, 10, etc.

# Background versus Baseline

- **Background**—the concentration of a substance in a medium (e.g., air, water, soil, sediment) resulting from parent material. Often considered to be the concentration that would occur had humans not altered the landscape
- **Baseline**—the concentration of a substance in a medium (e.g., air, water, soil, sediment) that represents pre-project conditions (i.e., background plus the quantity added by neighbouring activities)

# Check-List for Analytical Laboratory Reports

1. Ensure that the lab has included their QA/QC report with the data, including
  - precision that is backed up with regular checks against standards and duplicates),
  - frequently of calibration runs
  - performance on calibration runs,
  - performance on method blanks,
  - percentage recovery for extractions,
  - proper citation of methods
  - Verification of proper storage method and storage time for - depends upon the analyte)
2. Examine the data to make sure detection limits remain consistent and are reported
3. Check that units are reported correctly
  - Verify that percentage moisture is reported
  - Determine whether raw data are reported as wet weight or dry weight [be certain that in any subsequent use of the data the correct units are retained
4. Check for anomalies – a value that differs markedly from other data in the series may indicate
  - Sampling for a different statistical population
  - Contamination of sample due to handling or processing
  - Instrument malfunction
  - Calculation error
  - Entry error
5. If blind duplicates, trip blanks, or sample blanks were submitted , track these results by your initial sample codes and make sure that the data conform to your data quality objectives [In subsequent use of these data be certain to follow rules you established (i.e., use a pre-selected code or geometric mean of duplicates.)]
6. Verify that data are provided for all samples submitted; cross-reference against the chain-of-custody information.
7. Verify that all signatures and dates were entered on the Chain-of-Custody forms], and that the analyses requested match the original study design.
8. Contact appropriate persons at the laboratory and sampling crew to resolve any concerns.
9. Document any deviations from the original study design.