
Decision Quality *versus* Measurement Quality

Tom Johnston/Dan Michael

NEPTUNE AND COMPANY, INC.

Definition of Quality

- “The degree to which an item or process meets or exceeds the user’s requirements or expectations.”*
 - » Presupposes a set of requirements or expectations
 - » Implies that a means of measuring or estimating quality exists

*source: US Dept. of Energy “Methods for Evaluating Environmental and Waste Management Samples”

NEPTUNE AND COMPANY, INC.

Decision and Measurement Quality

- Decision Quality:
 - » The degree to which a decision represents the correct decision (e.g., how often the correct decision is, or will be, made)
- Measurement Quality:
 - » The degree to which a measured value represents the true, or accepted, value (the bias and precision of the measurement)

NEPTUNE AND COMPANY, INC.

Example Errors

- Decision Errors:
 - » Decide no action is needed based on incorrectly concluding that a contaminant concentration ([COC]) is (or is not) increasing
 - » Decide action is needed based on incorrectly concluding that a [COC] is increasing and/or exceeds (does not exceed) Risk Reduction Levels
- Measurement Errors:
 - » Introduce negative bias when sampling volatiles
 - » Heterogeneity of material within a sample results in concentration variability

NEPTUNE AND COMPANY, INC.

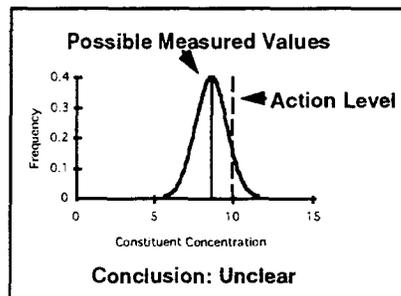
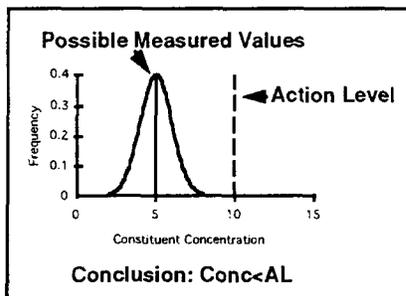
Important Concepts

- Decision error (incorrect decision) is not the same as measurement error (bias and precision)
- Decision error is affected by total study error
- Total study error comprises population variability (spatial and temporal), and measurement error (sampling and analytical variability and bias)
- Often, measurement error is a small contributor to total error

NEPTUNE AND COMPANY, INC.

Why Consider Total Study Error?

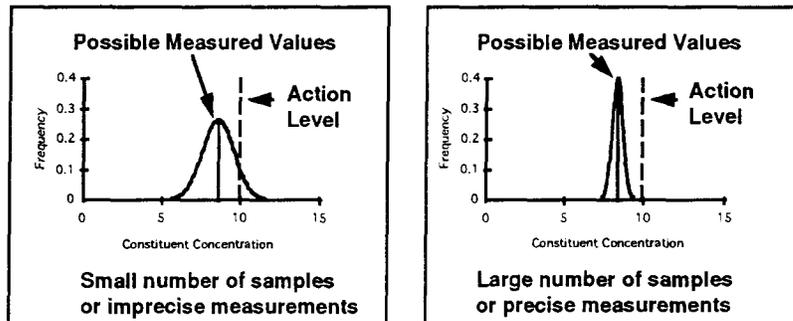
- Concentration variability can lead to an incorrect decision



NEPTUNE AND COMPANY, INC.

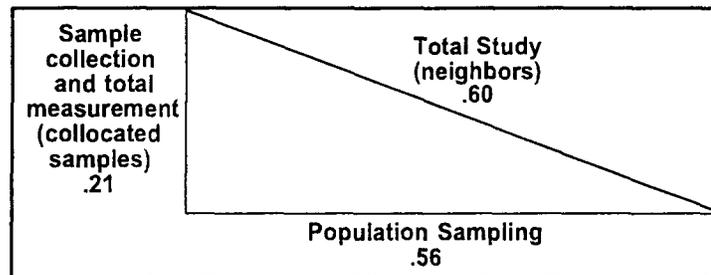
Statistical Theory

- As more samples are collected or analyzed, or more precise measurement methods are used, uncertainty in the result (total study error) decreases. Thus, the probability of decision errors decreases.



NEPTUNE AND COMPANY, INC.

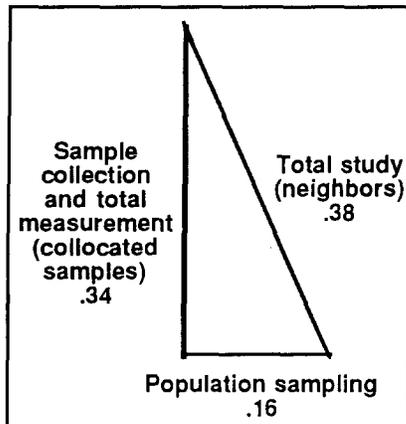
Relative Contributions of Error Components in Uranium Data



Note: Population sampling component dominates

NEPTUNE AND COMPANY, INC.

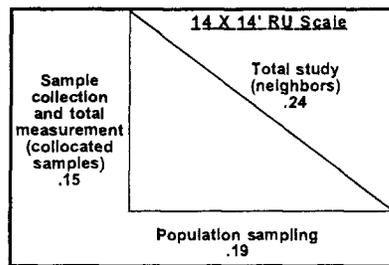
Relative Contributions of Error Components in Arsenic Data



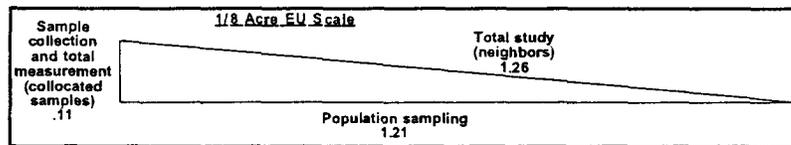
Note: Sample collection and total measurement components dominate

NEPTUNE AND COMPANY, INC.

Relative Contributions of Error Components in Dioxin Data



Note: Population sampling variability dominates in estimates of larger units, but not in estimates of smaller scale units



NEPTUNE AND COMPANY, INC.

Important Concepts (Cont'd)

- Population variability cannot be changed - it is "truth"
- Measurement errors (bias and precision) are undesirable because they confound the ability to assess "truth"
- Measurement errors can be assessed and "controlled," but not necessarily eliminated

NEPTUNE AND COMPANY, INC.

Why QA/QC?

- Why Quality Assurance?
 - » to put processes in place that ensure data meet user needs
 - processes for: planning, implementation, data analysis, decision making
- Why Quality Assessment?
 - » to ensure that data quality can be determined
 - » to provide information to support future SAP design
- Why Quality Control?
 - » to detect and correct problems in sampling and measurement systems ("real-time")

NEPTUNE AND COMPANY, INC.

Elements of an Effective Quality Assurance Program

- Quality Management Plan (QMP)
- Clearly negotiated permit requirements
- Quality Assurance Project Plan (QAPP)
- Site-Specific QA elements in SAPs or monitoring designs
- Standard operating procedures (SOPs)
- Training Program

NEPTUNE AND COMPANY, INC.

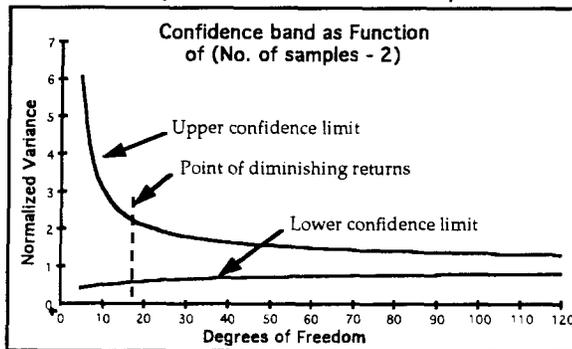
Essential Elements of Quality Control Programs

- Audits
 - » sampling operations
 - » field measurements
 - » laboratory measurements
- Data Review
 - » verification and validation
- Assessment and feedback (control)

NEPTUNE AND COMPANY, INC.

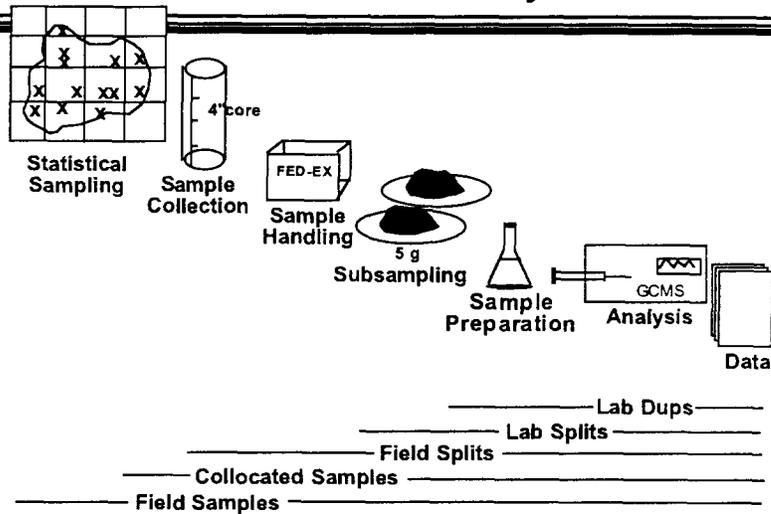
Quality Assessment Design

- QA samples can provide information on components of total study error
- Confidence depends on no. of samples:



NEPTUNE AND COMPANY, INC.

Quality Assessment Samples to Detect Variability



NEPTUNE AND COMPANY, INC.

What kinds of variance estimates are needed from QA data?

- The combined effects of sample collection and analytical measurement variability
 - » field samples (population variability)
 - » collocated samples (combined sampling + handling + analysis variability)
- The degree of variability due to analytical measurement alone
 - » laboratory duplicates (prep. & analysis precision)
 - » PE sample results (preparation & analysis bias and precision)

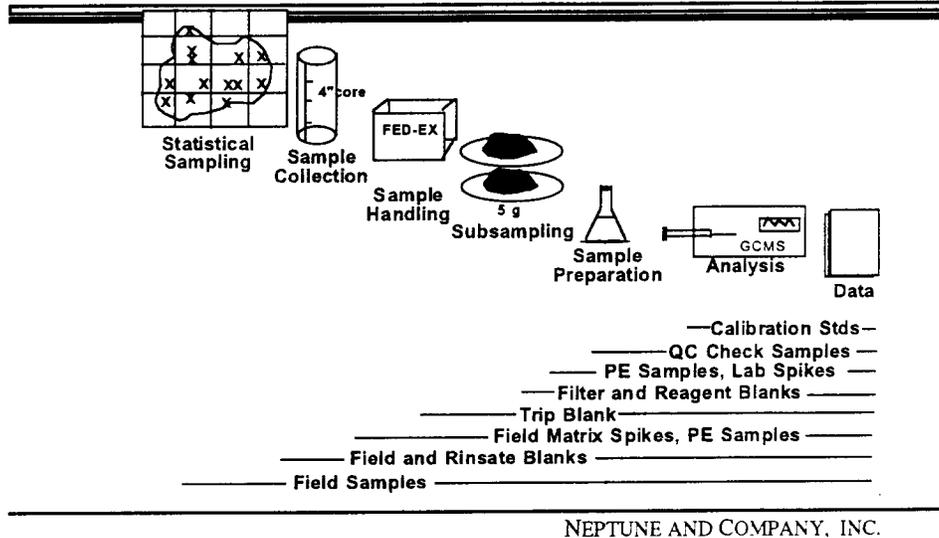
NEPTUNE AND COMPANY, INC.

Treatment and Control of Random Errors (Variance)

- Random errors are treated statistically
- Control random errors by:
 - » Using adequate sample sizes
 - » Replicating measurements
- Understanding relative contributions of sources of variability can facilitate optimization of SAP design

NEPTUNE AND COMPANY, INC.

Quality Assessment Samples to Detect Bias



Recommended Use of Blanks in the Field

- Rinsate Blanks
 - » none unless contamination problem is suspected from reusable equipment
- Trip Blanks
 - » use field blanks instead
- Field Blanks
 - » 20 soil/water field blanks per facility/field season (recall diminishing returns)
 - » broad scan analyses

NEPTUNE AND COMPANY, INC.

Treatment and Control of Measurement Bias

- Systematic errors (biases) may be treated through quantitation and compensation
- Control systematic errors through:
 - » Good Laboratory Practices (GLP)
 - » Vigilant management oversight
 - » Selection of appropriate methods

NEPTUNE AND COMPANY, INC.

Be Efficient: Don't Waste QA/QC Data

- Only collect data that are used to assess or control quality
- Use assessment data to evaluate performance after work is completed
- Use control data to affect quality in real time
- Planning for quality rather than checking for quality

NEPTUNE AND COMPANY, INC.

The Paper Trail

- Documentation is necessary to:
 - » attribute responsibility
 - » provide for legal defensibility
 - » maintain consistency of operations
 - » expedite troubleshooting
- Expect and ensure complete documentation
 - » Review documentation at all phases of the operation before it's too late

NEPTUNE AND COMPANY, INC.

Recap

- Control All Errors by:
 - » Planning effectively
 - » Using SOPs, training effectively
 - » Conducting audits, inspections, surveillances
- Control Decision Errors by:
 - » Collecting an adequate number of samples
 - » Collecting the correct samples
- Control Measurement Errors by:
 - » Using customary assessment/control samples wisely
- Document for defensibility

NEPTUNE AND COMPANY, INC.