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Multi-Increment Soil Sampling: Application to FUDS MMRP SIs

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Presentation Overview

- Military Munitions Response Program (MMRP) Site Inspections (SI) at Formerly Used Defense Sites (FUDS)
- Multi-Incremental Sampling (MIS)
  - AKA the "CRREL Method"*
- Decision Units and why they're critical
- Implementing MIS in the SI Program
- Conclusions

* Army Corps of Engineers Cold Regions Research and Engineering Laboratory

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The FUDS MMRP SI Program

- To complete site inspections or equivalent for 100% of all munitions response sites by the end of 2010
- Scope is restricted to evaluating
  - the presence of Munitions and Explosives of Concern (MEC)
  - Munitions Constituents (MC) –

    "Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions."

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MMRP FUDS SI Objectives

- Primary objective
  - determine if further response action is warranted
- MC Sampling Objective
  - **"Collect adequate samples to assess the presence/absence of MC, and to eliminate from further consideration those releases that pose no significant threat to human health or the environment."**

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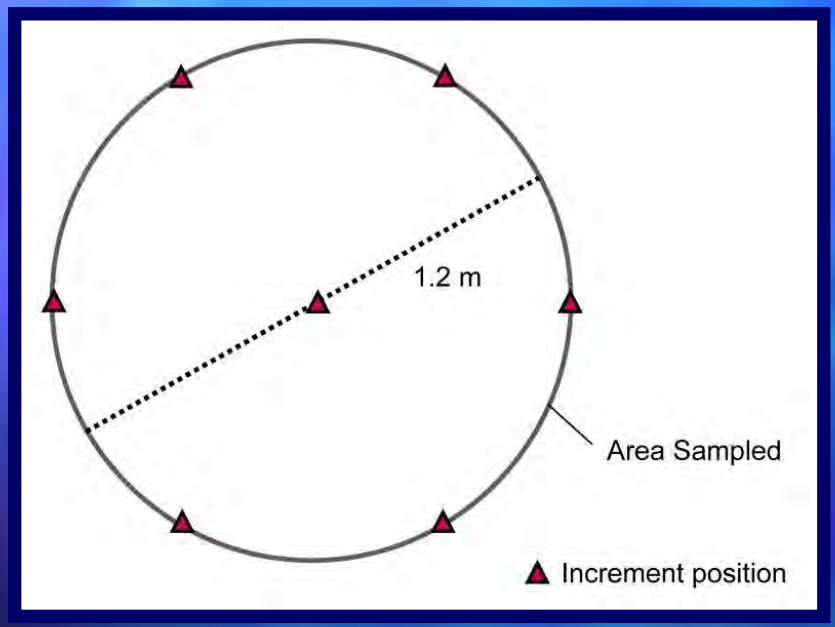
Soil Sampling for MC



- Until mid-2007, the most commonly used soil sampling approach was the 7-point wheel composite sample.
- Sample locations are judgmental – i.e. "authoritatively" biased to areas of most likely contamination.

- A few state agencies have requested that only discrete samples be collected.

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SI MC Results

- Using the 7-point wheel (or discrete sampling):
  - Very few FUDS have explosives detected; fewer have them detected above screening criteria.
  - Decisions regarding MC metals results are often problematic due to inadequate natural background metals concentration data.
  - Although sampled locations are most likely to have contamination, the small area sampled, and the small number of samples contributes to decision uncertainty.

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Implementation of MIS into the SI Program

- Why?
  - Regulatory agencies are asking for it.
    - Hawaii
    - Idaho
    - EPA Region 6 and states - Texas, New Mexico, Oklahoma, Arkansas
    - Massachusetts (soon?)
- It can provide more representative and reproducible data from a larger area than the 7-point wheel method.
- MIS reduces chances of missing or underestimating significant contamination.
- How is use being decided?
  - Project teams decide when and how it's use is appropriate.

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What is Multi-Incremental Sampling?

- A structured composite sampling protocol
  - that reduces sampling error due to heterogeneity
  - by compositing increments of *uniform* size
  - collected from throughout an appropriately delineated area
    - i.e. a decision unit (DU)
  - to provide a reproducible mean concentration for the decision unit

- The objective is to obtain a sample having analytes in exactly the same proportions as the entire decision unit.

- Appendix A of EPA Method 8330B (November 2006) – AKA "the CRREL method" – describes specific applications of MIS.

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Misconceptions

- "MI sampling dilutes out hot spots."
  - Project teams need to guard against inappropriately large decision units that may, indeed, dilute out significant contamination.
- "MI sampling loses the spatial resolution achieved with discrete sampling."
  - The appearance of "spatial resolution" from only a *few* discrete or 7-point wheel samples may be illusory, due simply to the large range of variability between individual samples.

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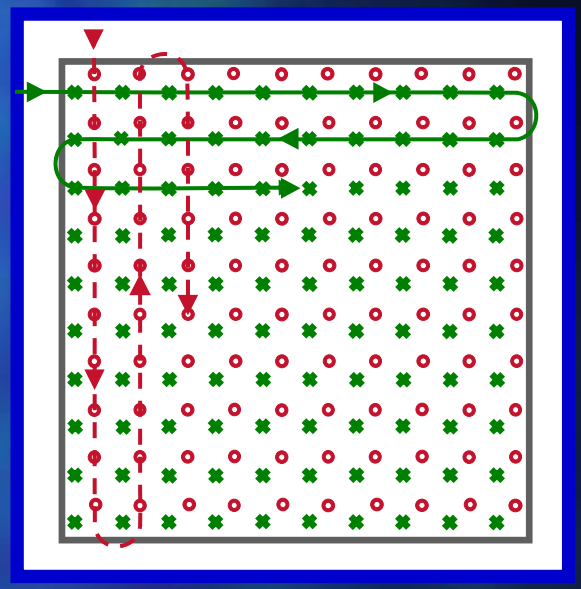
MIS is a two-part process



- Field Sample Collection
  - Collect multiple (> 30 to 100) increments
  - of uniform size
  - from the entire area to be represented
    (i.e. the Decision Unit).
  - Composite increments into a single sample
    (1 to 2 kilogram)

- Laboratory Processing and Sub-sampling
  - Air drying and sieving entire sample
  - Particle size reduction (grinding) of entire sample
  - Multi-increment sub-sampling (>30 increments) to provide representative ~10 gram aliquot for extraction and analysis

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Field Strategy

- "Stratify" the site into functional units based on
  - Past use
  - Future use
  - Other?

- Delineate Decision Units - the specific area to be represented by each multi-increment sample. They define the target population (Step 4 of the DQO Process).

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Why is selection of proper DUs critical?

- The size of the Decision Unit:
  - Defines the scale of observation.
  - Constrains the appropriate end uses of the data
- Changing the scale of observation changes the results (for heterogeneous media)
- Sampling inappropriate DUs can yield high quality results, but those results may not meet the DQOs.

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How big should a Decision Unit be?

(What is the appropriate scale of observation?)

(What is the smallest area of concern?)

(What is an appropriate shape?)

- It depends on the end use of the resulting values
  - Basis of values against which results are to be compared
  - Future use – (e.g. development for residential subdivision)
  - To simply identify presence or "absence" of an analyte?
  - Past use - the degree and likely extent of possible contamination
  - To evaluate potential for leaching to groundwater?
  - To identify localized areas of high concentrations?

- Valid direct comparison of results to regulatory or screening values requires that the basis of the screening criterion be understood and considered in designing decision units.

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How Many Increments ?

- The number of increments required to reduce sampling variability to an acceptable level depends primarily on:
  - Distributional Heterogeneity of analytes of interest in the Decision Unit.
  - DQO (precision required)
- Secondarily, the sample must have sufficient mass to overcome compositional heterogeneity within the sample itself – typically 1 kg or more for soil.

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The CRREL Multi-Increment Sampling Tool

Available From:

GPL Laboratories, LLP
7210A Corporate Court
Frederick, MD 21771
301-694-5310

<http://www.gplab.com>

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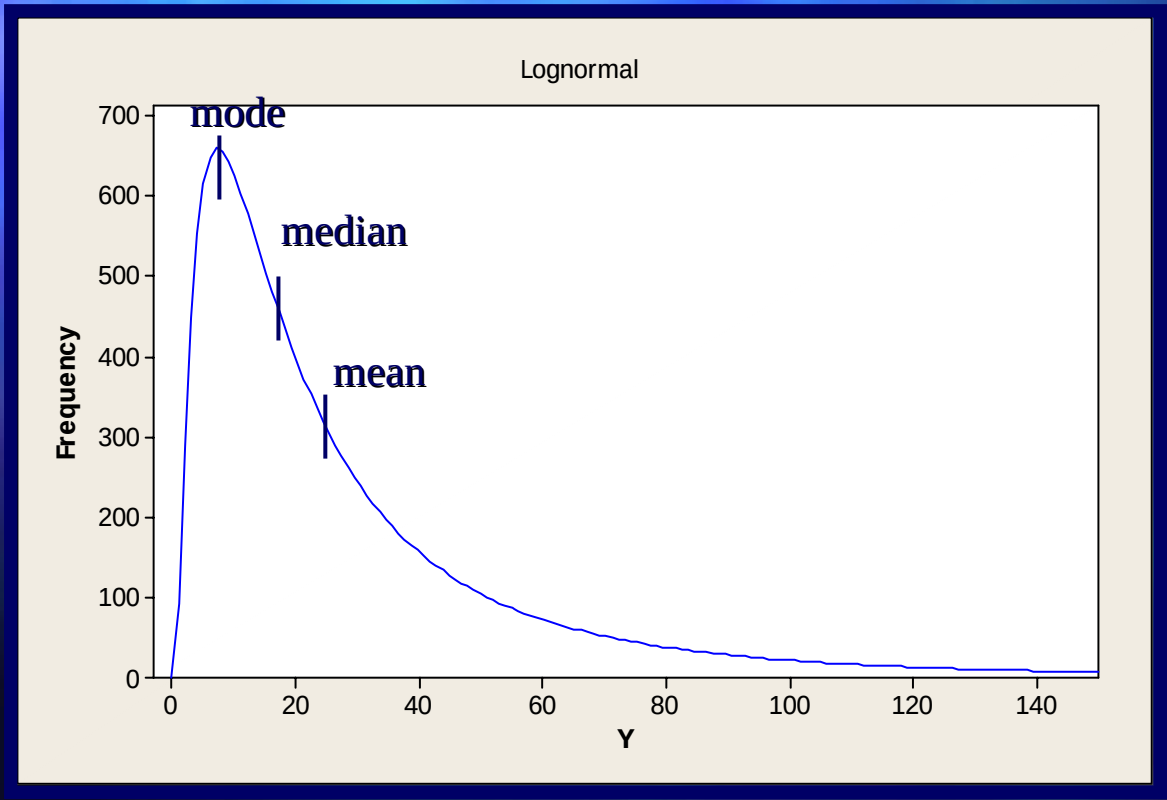
Comparison to Discrete or 7-point wheel samples

Analyte concentrations in heterogeneous environmental media tend to have a positively skewed distribution.



- A small number of discrete or 7-point wheel samples will tend to occur at the mode and under-represent the mean.
- Replicate MIS data distributions are closer to normal.

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Implementing MIS into the SI Program

A hybrid sampling approach

- Continue using a judgmental (authoritative) sampling approach to locate Decision Units.
  - i.e. target the areas most likely to have contamination

- Integrate probabilistic (stratified random or systematic random) MIS collection and processing protocols
  - increase the DU from the 1 m circle having 7 increments to a more appropriate size for sampling objectives.

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Active Ranges vs. FUDS SI

- Most CRREL Studies
  - Location of activities is known
  - Contamination is known to exist and may be evident
  - Explosives and propellants are the only COCs
  - Results generally not compared to regulatory or other screening values
  - Vegetation (grass, etc.) included in sample
- FUDS
  - Location of activities uncertain
  - Contamination may no longer be present
  - Metals are potential COCs - background metals concentrations are required
  - Anthropogenic compounds having non-munitions sources may need to be evaluated (e.g. PAHs)
  - Sample depth may need to be different

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Requirements for Implementing MIS

- Follow the EPA DQO Process
  - (Guidance on Systematic Planning Using the Data Quality Objective Process, EPA QA/G4, 2006)
- Valid objectives for MI sampling must be able to be simplified to:

"What is the mean concentration of a particular analyte, over a specific area or areas?"

- Multiple decision units must be sampled to begin to assess the spatial distribution of analytes.

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Different Sampling Objectives

- CRREL Objectives
  - To determine mass loading of explosive or propellant compounds at active military ranges.
  - To observe distribution of contaminant concentrations
  - To demonstrate the MI sampling methodology
    (results generally weren't compared to screening levels)

- FUDS SI Objectives
  - To demonstrate presence / "absence" of contaminants above levels of concern (screening levels) at old sites.
  - Comparison of results with:
    - Human Health Screening Levels
    - Ecological Screening Levels
    - Natural background metals concentrations
    - Ambient non-munitions-related anthropogenic concentrations (e.g. PAHs)
    - Groundwater Protection soil concentrations

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Quality Control

- Triplicate QC samples are strongly recommended for
  - a portion of the Decision Units
  - Determination of site-specific background concentrations

- %RSD for MIS*
  - for laboratory triplicates should be <20%
  - for MIS field replicates should be <30%
  - Acceptable values should depend on site-specific sampling objectives (DQOs).

- Replicates become most important when results are close to decision limits, or in establishing decision limits (e.g. site-specific background)

*recent consensus from EMCX, CRREL, and EnviroStat, Inc.

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Difficulties for Implementation

- Regulatory barriers to acceptance of “composite samples”
- Lack of guidance
  - The knowledge base for applying MIS is still evolving: - There are no standard templates.
- Shortage of accredited commercial laboratory services
  - Test America - Denver has provisional USACE approval
  - GPL has submitted SOP
  - APPL ? other labs?

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Conclusions

- MIS promises to be a practical, cost-effective way to reduce sampling error, and obtain representative, reproducible MC data for the FUDS SI Program.

- Whether or not these better data lead to better decisions depends on having well-formulated and clearly articulated
  - Sampling objectives (DQOs)
  - Decision units (Step 4 of the EPA DQO Process)
  - Decision criteria (especially background/ambient values)

- Well-informed regulators have increased confidence in decisions based on MIS data.

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Questions?

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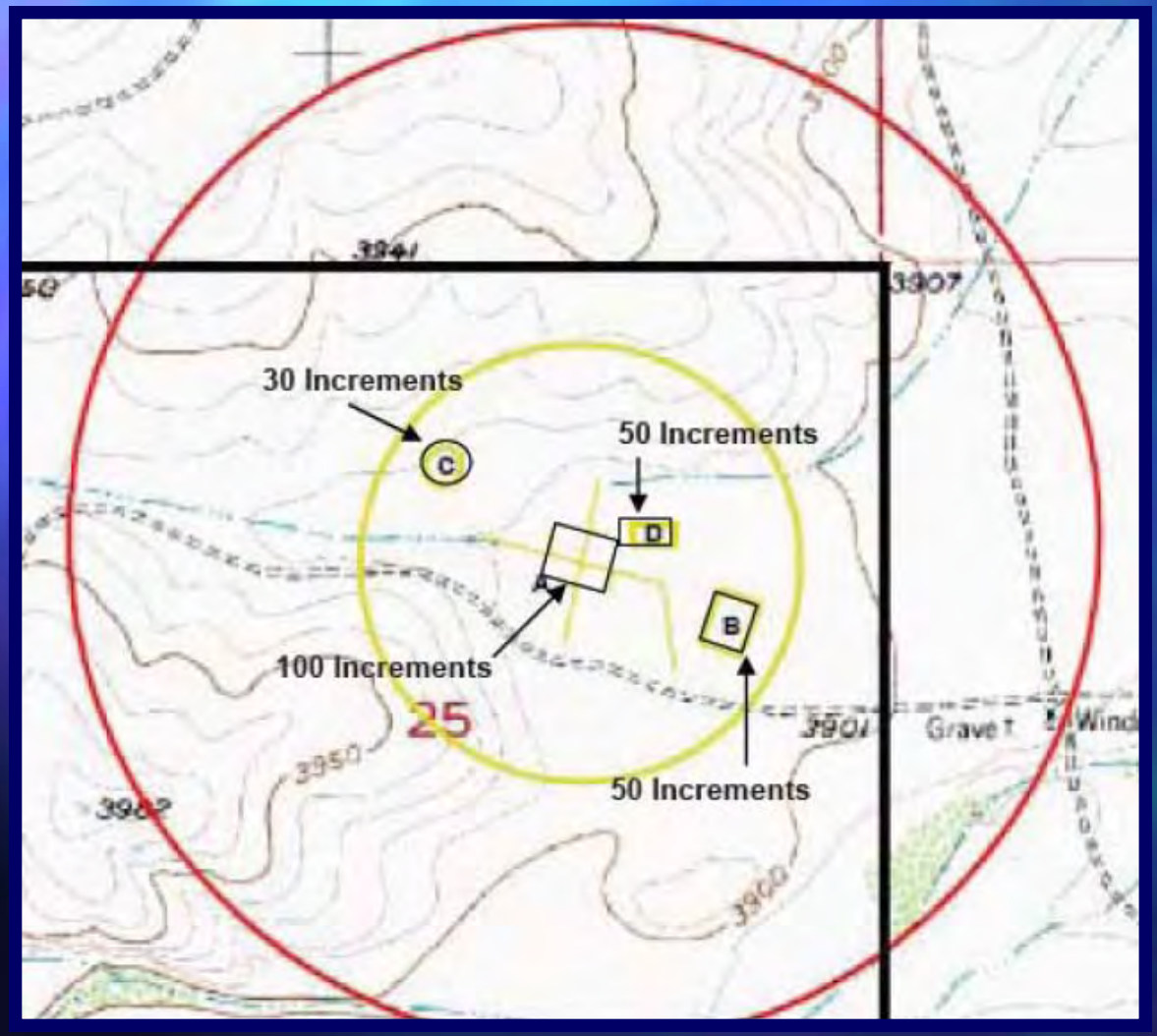
Roswell PBR #34



DUs

100x100 m, 100 incr.

at center

50x50 m, 50/30 incr.

at B, C, & D

Explosives only,

no metals

no background

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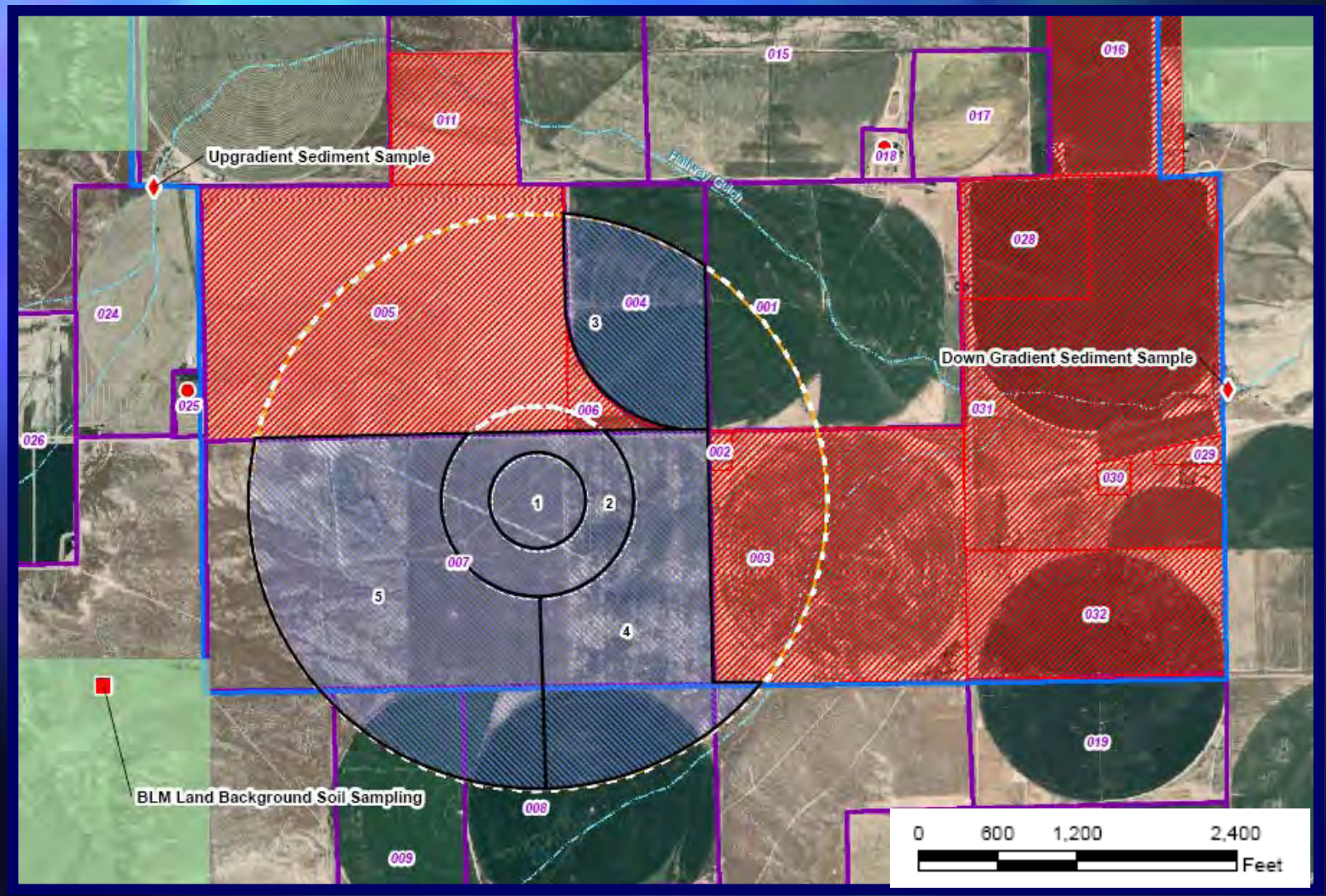
Bruneau PBR No. 2



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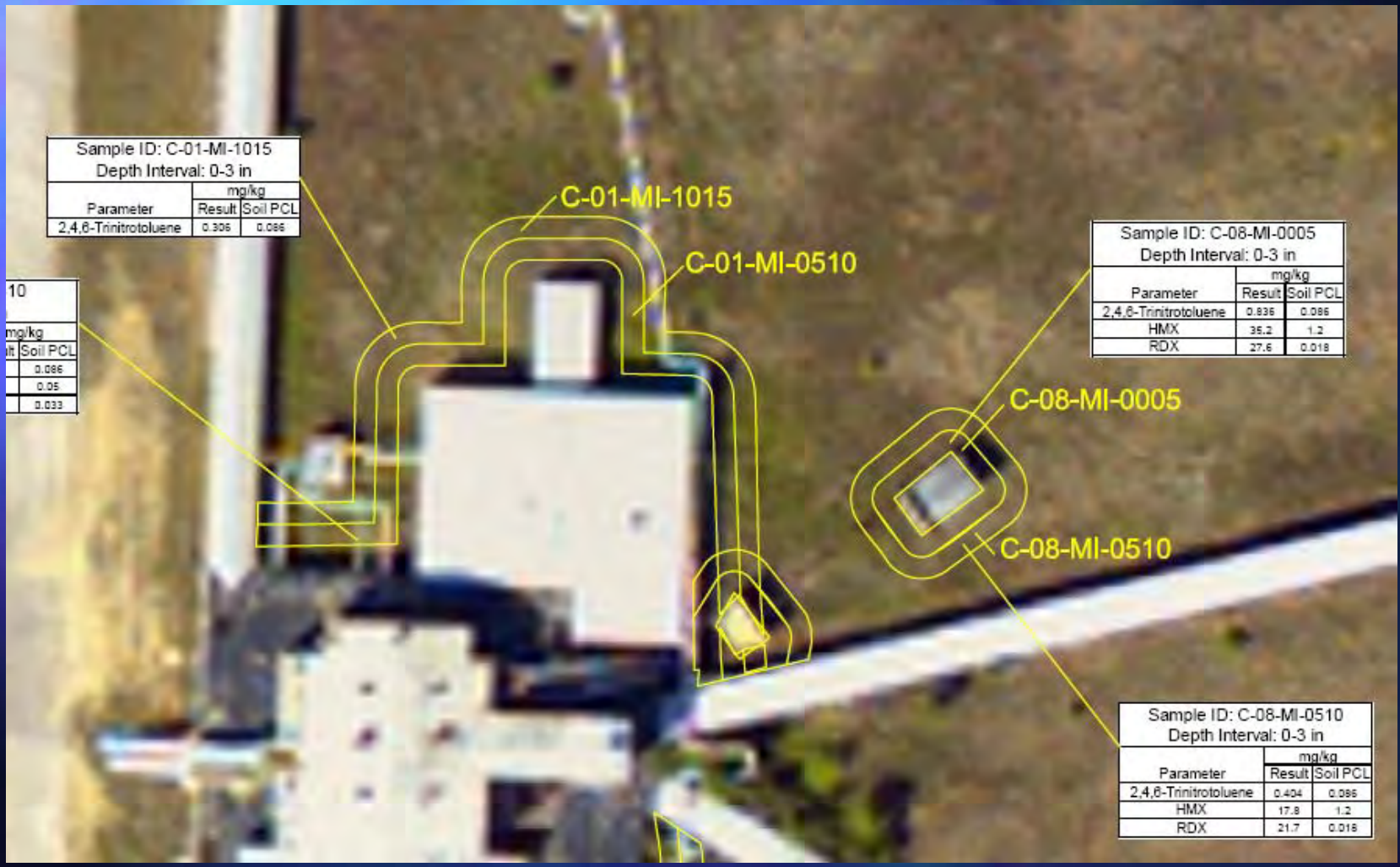
Lone Star AAP



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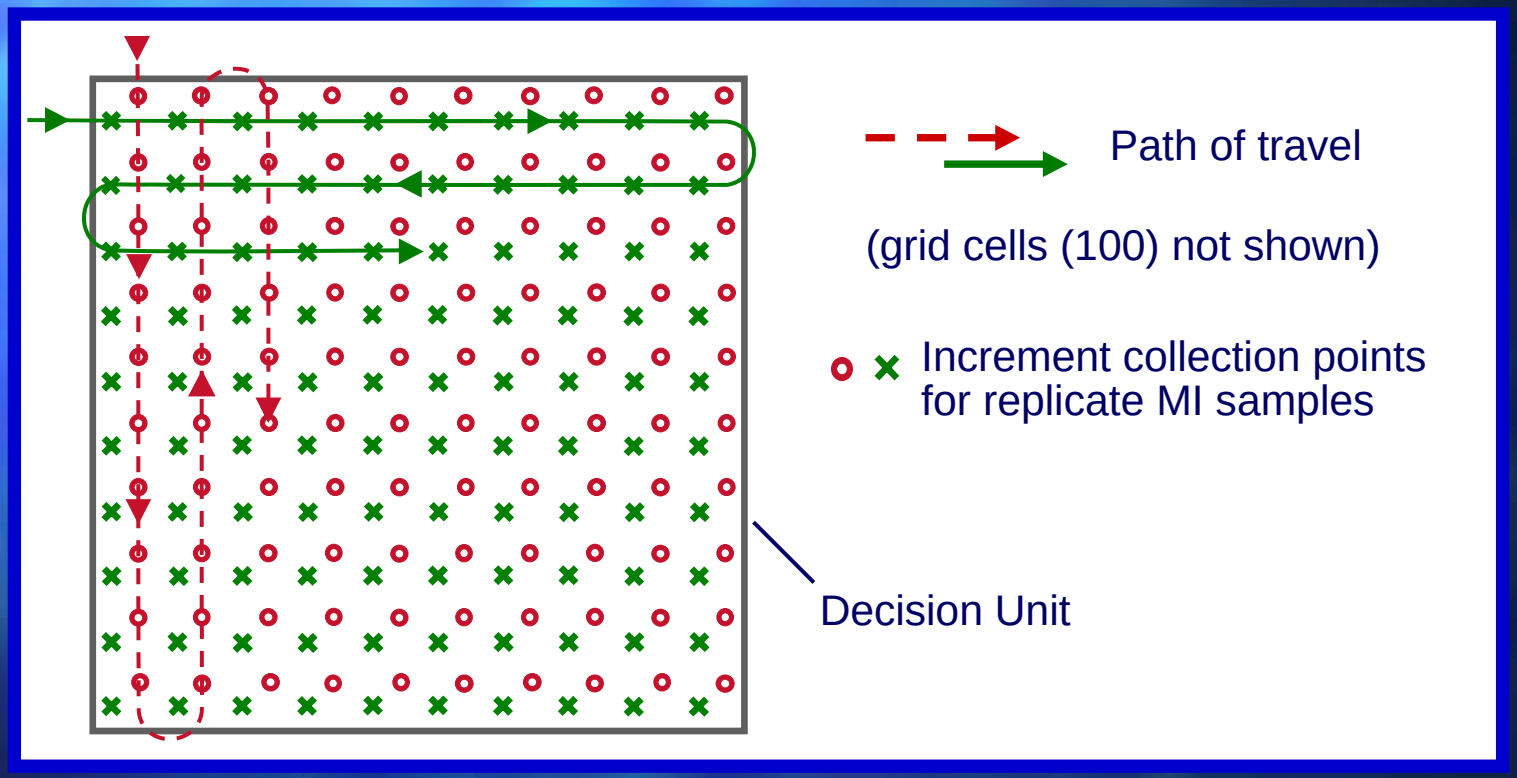
Systematic Random Mode*

The most reproducible sampling mode



Note: Usage per Pitard (1993, Figure 21.8), CRREL, EnviroStat, Inc. There are nomenclatural differences in sampling modes between those references and EPA 1995 (540/R-95/141) and EPA 1989 (EPA/230/02-89/042).

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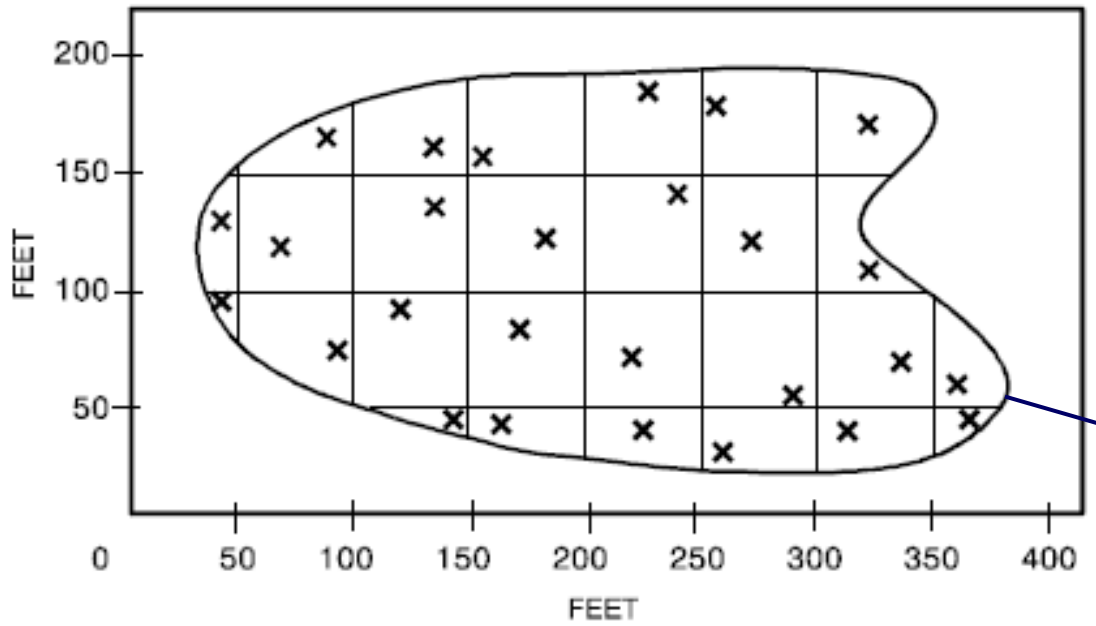
Stratified Random Mode*



Increment collection points (selected sample location)

Decision Unit

after EPA (540/R-95/141, Figure 5)

* Usage per Pitard (1993, Figure 21.9), EnviroStat, Inc., CRREL. EPA (1995, Figure 5) calls this systematic random sampling.

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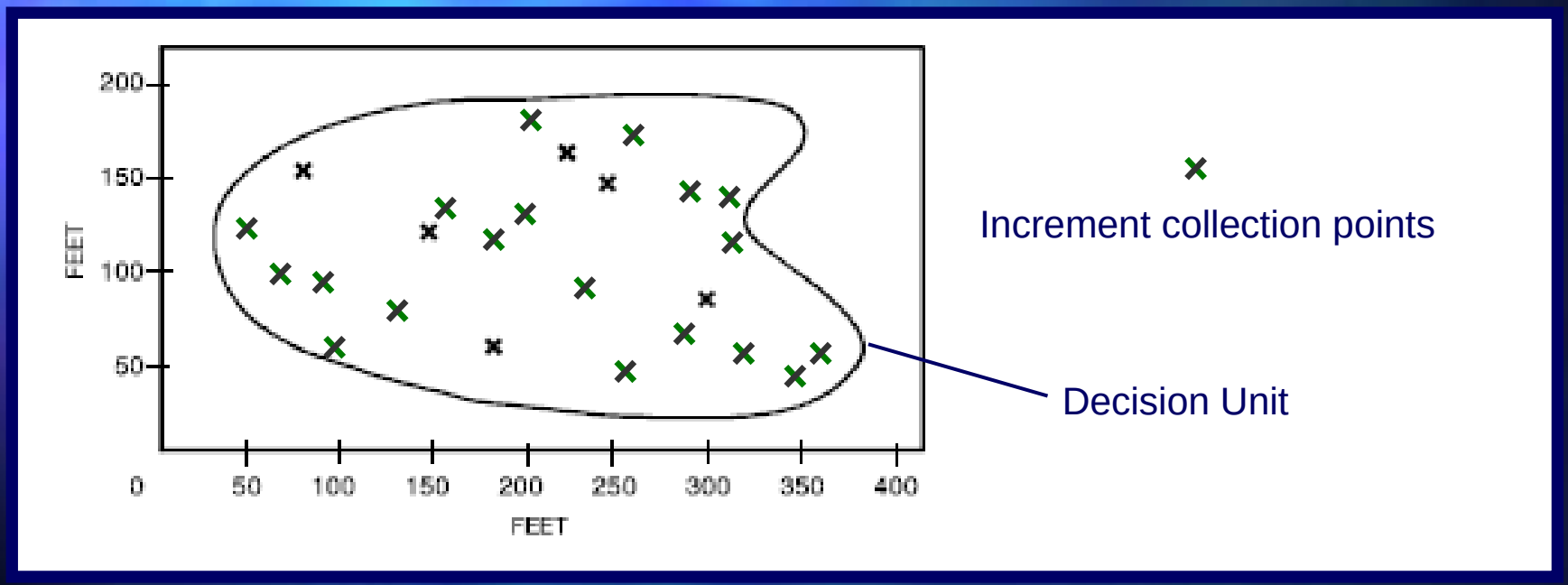
Random Mode

The least reproducible MIS mode



after EPA (540/R-95/141, Figure 2)