APPENDIX J
Comparison of Discrete, Five-Point Composite, and Incremental Sampling

Table J-1. Comparison of discrete, Five-Point Composite, and Incremental Sampling

Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Discrete	A set of grab samples collected and analyzed individually. A mean and UCL may be calculated for the set, but if any single sample exceeds a decision threshold, a "hot spot" is assumed to exist for some poorly defined region around the sample's location.	• Sampling error due to soil heterogeneity is a negligible source of data error (misleading sample results). • In other words, short-scale field heterogeneity is assumed NOT to cause collocated samples to have significantly different results, and micro-scale heterogeneity is assumed NOT to cause lab duplicate QC samples to have significantly different results.	• Since the amount of variability in the data set contains sampling variability, it is possible to use that variability to statistically calculate the number of grab samples needed to compensate for sampling error. • If sufficient sampling-related QC data (collocated samples and lab duplicates) are gathered and evaluated, it is possible to calculate the amount of data error contributed by field and subsampling variability for discrete sampling designs. This information can be used to improve critical aspects of the sampling and analysis design. • Sampling can be used to pinpoint source of contamination and inform cleanup efforts.	• The high number of samples required to manage sampling error for most lead-contaminated sites is cost-prohibitive. • Since sampling-related QC data are seldom sufficiently evaluated, the amount of sampling error, the likelihood that it may cause decision error, and what aspects of the design need improvement are usually unknown. • Unless subsampling error is controlled, and short-scale field heterogeneity is measured, there is no scientific basis for assuming a single high discrete sample result represents a meaningful "hot spot." • The small mass and area of a discreet sample does not represent the scale of human exposure. • "Surgical" removals are not effective in reducing mean lead concentration over large exposure areas.

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Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Five-point composite	Five individual samples (increments) are combined to create a single composite sample. Typically, during composite sampling, an investigator will grid off an area and collect a number of samples within the grid.	• Sampling error due to soil heterogeneity is a minor source of data error (misleading sample results). • Short-scale field heterogeneity is assumed to be mild enough that five increments can control that source of variability enough for a reproducible estimate of the mean over the area covered by the five increments. • Micro-scale (within-sample) heterogeneity is usually ignored.	• Five-point composites can be useful for reducing the noise caused by short-scale heterogeneity when trying to detect a concentration trend or boundaries. At each point location along a transect, the composite is collected over a very small area, such as 1–4 square feet. • Triplicate five-point composites (independent composites from the same area) are used as QC to estimate the reproducibility (*e.g.*, coefficient of variance or relative standard deviation) of the five-point composite result.	• Over the spatial scale of DUs, five increments are insufficient to reliably estimate mean concentrations for yard-sized areas with lead contamination. This concern can be tested by taking triplicate five-point composites and examining their precision. • Five-point composites have insufficient increments to invoke the Central Limit Theorem, which is the statistical basis of incremental sampling. • If the five-point composite sample is not sufficiently processed and correctly subsampled, micro-scale heterogeneity will produce high subsampling imprecision in the composite results.

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Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Incremental composite	Sampling consists of a minimum of 30 increments of equal volume (called increments) of soil from a target area (SU or DU) that are composited and subsampled using the sampling pattern in Figure 6.	• Two spatial scales of sampling error are assumed to exist for all contaminated soils, causing decision errors if they are not measured and controlled (Gy, 1992). • Short-scale field heterogeneity is managed by taking 30 or more increments per sample. • Micro-scale heterogeneity in the same jar is managed by sample processing and incremental subsampling.	• Data of known and documented quality when the objective is to estimate the mean concentration for SU or DU (Hathaway et al., 2008). • Lower variability and higher reproducibility (HDOH, 2023)[a]. • More likely to capture a heterogeneous contamination. • Spatial dimensions of DUs or SUs are defined early on, taking into account hot spots (*i.e.*, very small areas within a SU that are highly contaminated). • Incremental composite sampling requires sufficient QC so that the contributions of field variability and subsampling error to total data variability are measured. • Variability information is used to quantify decision errors to ensure decisions are scientifically defensible. • Often assumed to cost more, but experienced practitioners claim better data quality for same or less cost.	• The technique requires training in the details of planning, implementation, and data calculations. Note that training is widely available online[b]. • The specialized sample processing and subsampling techniques are unfamiliar to some labs. • The basic incremental design loses spatial information within a SU/DU. This is why SU/DU must be delineated with care; they should be the largest area where spatial resolution is not needed.

[a] https://health.hawaii.gov/heer/guidance/specific-topics/decision-unit-and-multi-increment-sampling-methods.

[b] Refer to ITRC (2012) for additional information (available online at https://itrcweb.org/teams/training/incremental-sampling-methodology-ism-update); training for incremental composite sampling: www.itrcweb.org; www.clu-in.org/conf/itrc/ISM and http://www.clu-in.org/conf/itrc/ism/.