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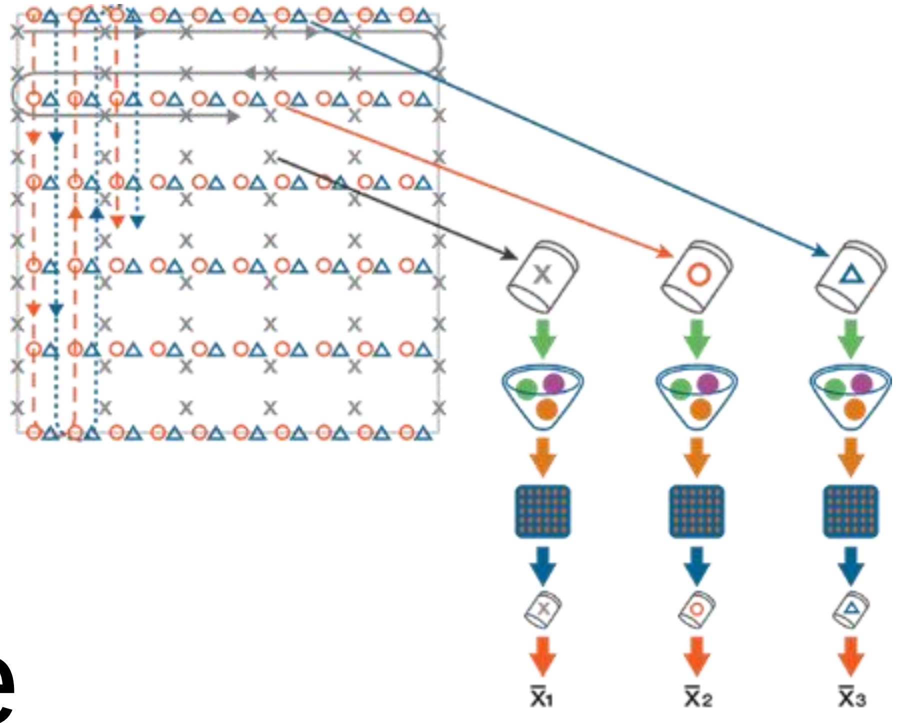

Incremental Sampling Methodology (ISM) Update (ISM-2, 2020)

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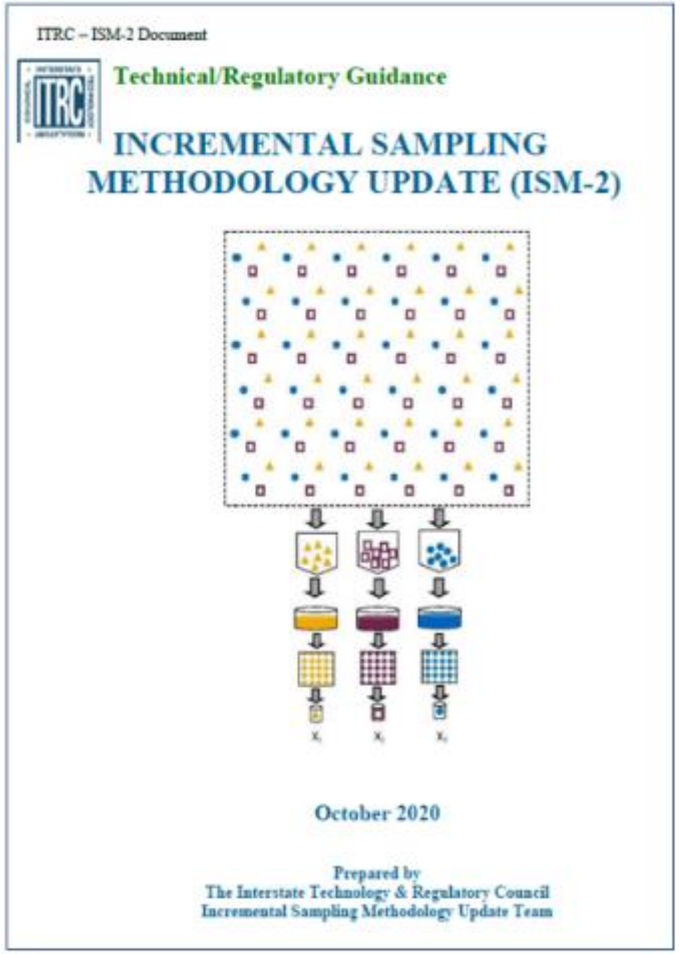
ISM Terms

- Key concept review: DU, SU, EU, Increments, Replicates
- Importance of Planning
- Importance of Conceptual Site Model (CSM)
- How do you setup your decision unit?


ITRC – ISM-2 Document

Technical/Regulatory Guidance

INCREMENTAL SAMPLING METHODOLOGY UPDATE (ISM-2)

October 2020

Prepared by
The Interstate Technology & Regulatory Council
Incremental Sampling Methodology Update Team

Source: ITRC, 2020 ISM Guidance

ISM Terms: Core Concept of ISM = DUs

- **Decision Unit (DU)** = scale of decision, volume of soil (area and depth)
  - DU for Risk-based decision making = Exposure Unit (EU)
- **Sampling Unit (SU)** = scale of observation, smallest volume of soil with a concentration value
  - SU is either equal in size to, or a subdivision of, the DU
  - Spatial Correlation and patterns
  - Spatial Differences - Sub-areas of expected higher or lower concentrations OR exposures
- **Conceptual Site Model** - Key in determining the size and distribution of DUs and SUs
- **Replicates** – used to make sure the number of increments and total mass of the sample are sufficient (RSD 20 – 30%)

Section 3.1 Examples

- Section 3.1.6 - Examples illustrating planning and design for ISM
- Illustrate a range of situations and approaches
  - an agricultural field, settling pond, and drainage swale (Example 1)
  - former agricultural field and establishing exposure DUs (Example 2)
  - former industrial facility that is to be redeveloped (Example 3)

Example 1:
Agricultural field, settling pond, and drainage swale

- Four different ISM topics addressed:
  - estimating average concentrations in a defined
  - evaluating the vertical profile of contamination
  - evaluating the horizontal extent of contaminatio
  - estimating average concentrations in stockpiled management decisions

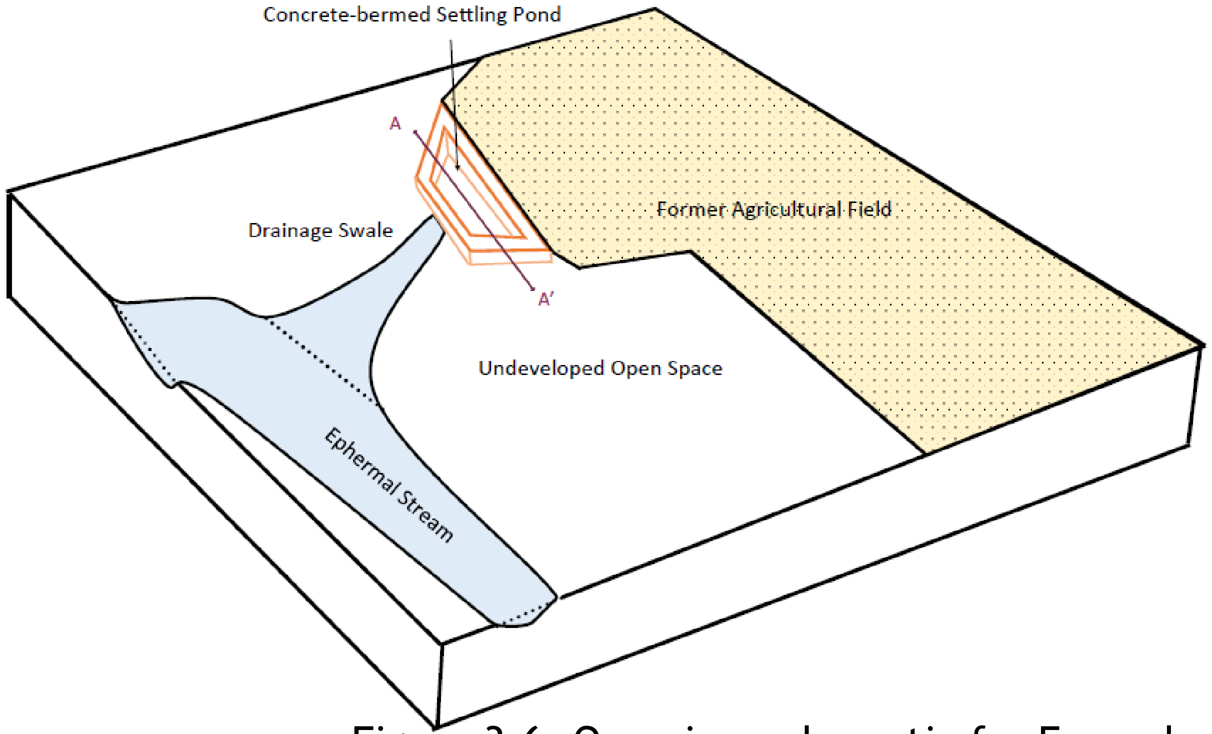


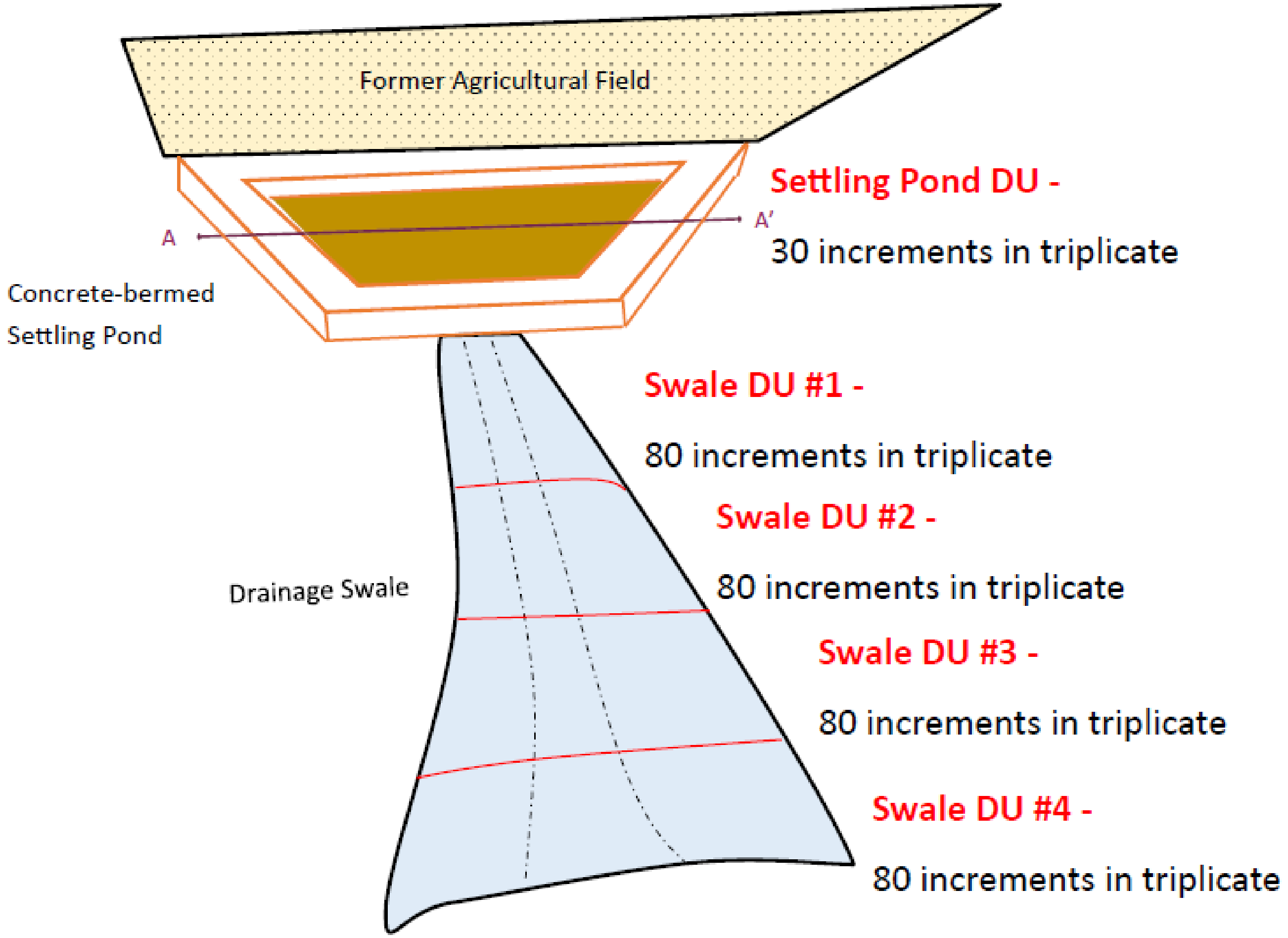
Figure 3-6. Overview schematic for Example 1.

Source: ITRC ISM Update Team, 2020.

Example 1 - ISM design for surface sampling

Figure 3-7. ISM design for surfac interval sampling in Example 1.

Source: ITRC ISM Update Team, 202



Example 2:
Former agricultural field and establishing exposure DUs

- Focuses on developing and delineating EUs for human health risk-based study questions.
- Guides through the development of ISM sampling plans with successively more complex site CSMs.
- Current and potential future residential land use, no ecological receptors.
  - DU size is ¼ acre, the assumed size of a future residential lot.

ISM Concepts Contained in Example 2

- Example 2A covers four concepts:
  - establishing **replicate heterogeneity limits** in the **DQOs** as an **MQO** in Specific Study Goal data needs
  - assessing the **assumption of homogeneous contaminant distribution** (low heterogeneity) by **defining a RSD of 20% in a Decision Rule**.
  - **extrapolating to unsampled DUs** within a large study area
  - designing **ambient background DUs**
- Example 2B covers three additional concepts:
  - Designing source area N&E DUs within EUs
  - **Designing SUs within DUs** (for example, a children's play area within an adult residential DU)
  - Designing for weighted averaging of 95% UCL

Example 2A – Conceptual Site Model (CSM)

- Agricultural use area, **30-acres**, farmed since the early 1900s
- Legal broadcast application of **OCPs and arsenical pesticides, including lead arsenate**, (the only suspected potential source of soil contamination)
- Limited to **surface soil** contamination (no migration of COPCs to the subsurface).
- Flat topography, except for furrows between rows of plants.
- **Thorough Phase I Environmental Site Assessment (ESA):** No localized areas of potentially heavy contamination, no known or suspected pesticide mixing areas, no existing structures and historical aerial photographs show no evidence of structures back to the 1920s.
- County records - in recent years no use of triazine herbicides, carbamates, or organophosphate pesticides.
- Planned **residential development**.

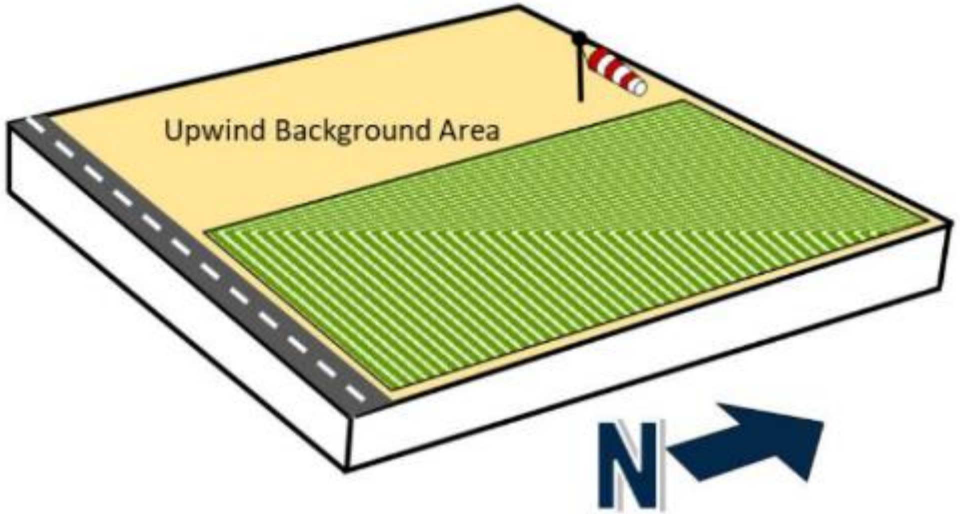


Figure 3-9a. Agricultural field investigation in Example 2A.
Source: ITRC ISM Update Team, 2020.

Large Study Area with CSM-Equivalent DUs

- **Extrapolating to unsampled DUs** within a large study area
- Extrapolating conclusions from a **subset of sampled DUs** to a larger group of *CSM-equivalent DUs* (described in more detail in Section 3.2.8.2)
- **Pilot study** typically very beneficial - assess variability and obtain preliminary COPC concentration ranges

Example 2A DUs

- 30-acre study area
- divided into contiguous equally-sized DUs
- 120 DUs - ¼ acre (based on the residential lot size in the area)

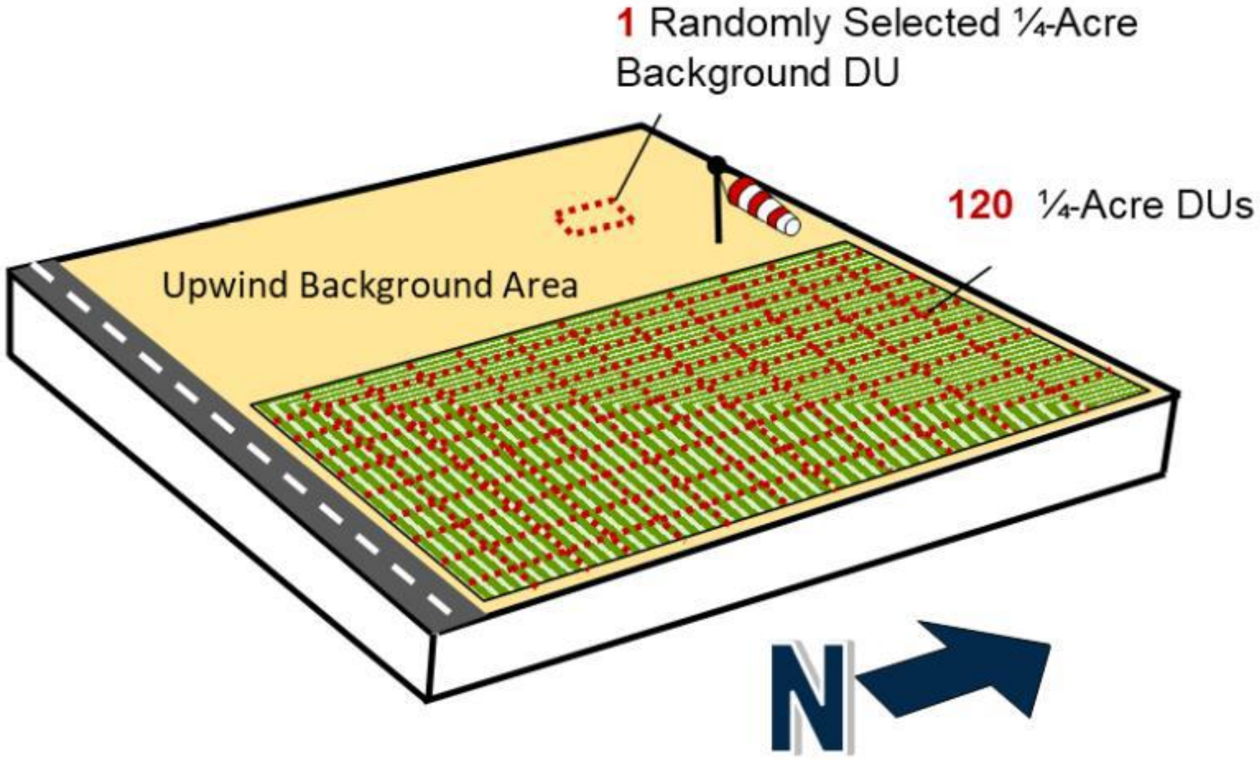


Figure 3-9b. Depiction of DUs in Example 2A.
Source: ITRC ISM Update Team, 2020.

How Many and Which DUs to Sample?

- ***Extrapolating to unsampled DUs within a large study area can be achieved in a scientifically defensible manner with ISM.***
- Option 1: Randomly select a subset of DUs for sampling (such as with a random number generator).
- Option 2: Modified random selection - to ensure that all regions of the 30-acre area are sampled in a proportional manner to reduce the uncertainty from extrapolation if the subset of DUs identified for sampling are grouped too closely together. For modified random selection, the 120 DUs would be allotted into spatial groups and equal numbers of DUs for sampling selected from each group.

Not To Exceed Determination

- **At least 59 DUs must be sampled to conclude that at least 95% of the site area is in compliance with 95% confidence (0.05 = α)**
  - Section 3.2.8.2
  - When there are a large number of DUs (more than 100).
  - Based on the statistical equations for upper tolerance limits (UTLs) using nonparametric methods.
  - Confidence in correct decisions for a large-area site increases as proportion of site area included in ISM sampling increases.
  - CAVEAT – Goodrum and Mendelsohn, 2018:

Not To Exceed Determination - Caveat

- CAVEAT – Goodrum and Mendelsohn, 2018:
  - Based on numerical simulation studies and statistics
  - Conditions when compliance can be achieved by sampling a small portion of the study area (for example, 10% to 30%).
  - Number of small-area DUs to sample should be based on
    - spatial coverage (representativeness) of the site area
    - likely degree of variability in soil concentrations across entire large site area
    - likely proximity of soil concentrations to Action Levels

Number of Increments = 30 - 100

It is generally accepted that between 30 and 100 increments is appropriate for many applications, with a larger number of increments being driven by a larger degree of distributional heterogeneity.

- Actual # of increments needed for representative DU true mean concentration depends on three things, that are key components of CSM and DQO development:
  - the degree of **within-DU heterogeneity** when variations are more or less random across the DU
  - the presence of **significantly large sections** within the DU that have **higher or lower concentrations**
  - the **presence and size of small** pockets of **higher or lower concentrations** within the DU

Number of Increments to Help Control Heterogeneity

Figure 3-4. Variables to consider in deciding on the number of increments to collect from a DU.

- **Factors** = green arrows
- Arrow direction and color gradient
- **Consequential** effect on variability = parallel light orange arrow.
- **Related association** for each variable to # increments = parallel dark orange arrow.

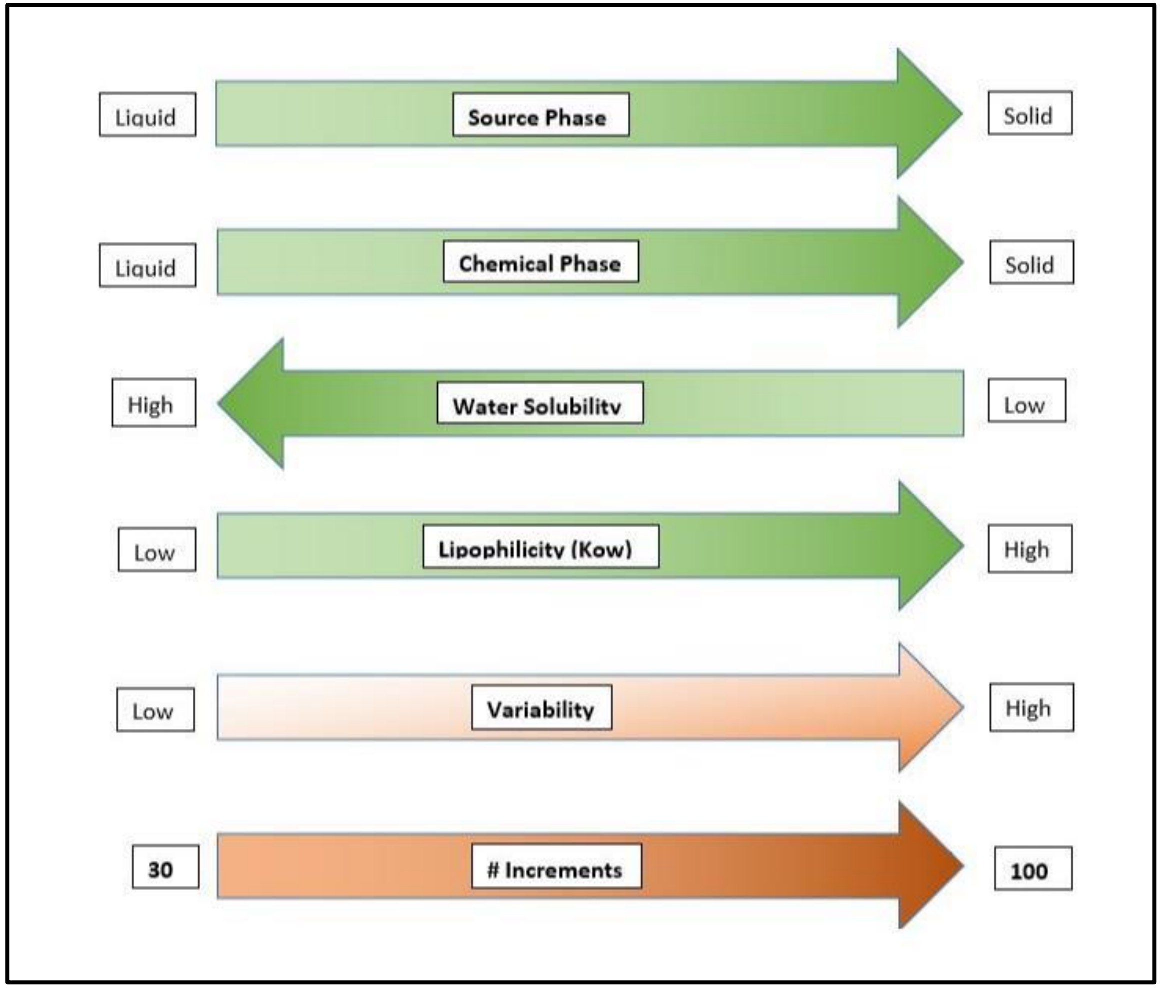


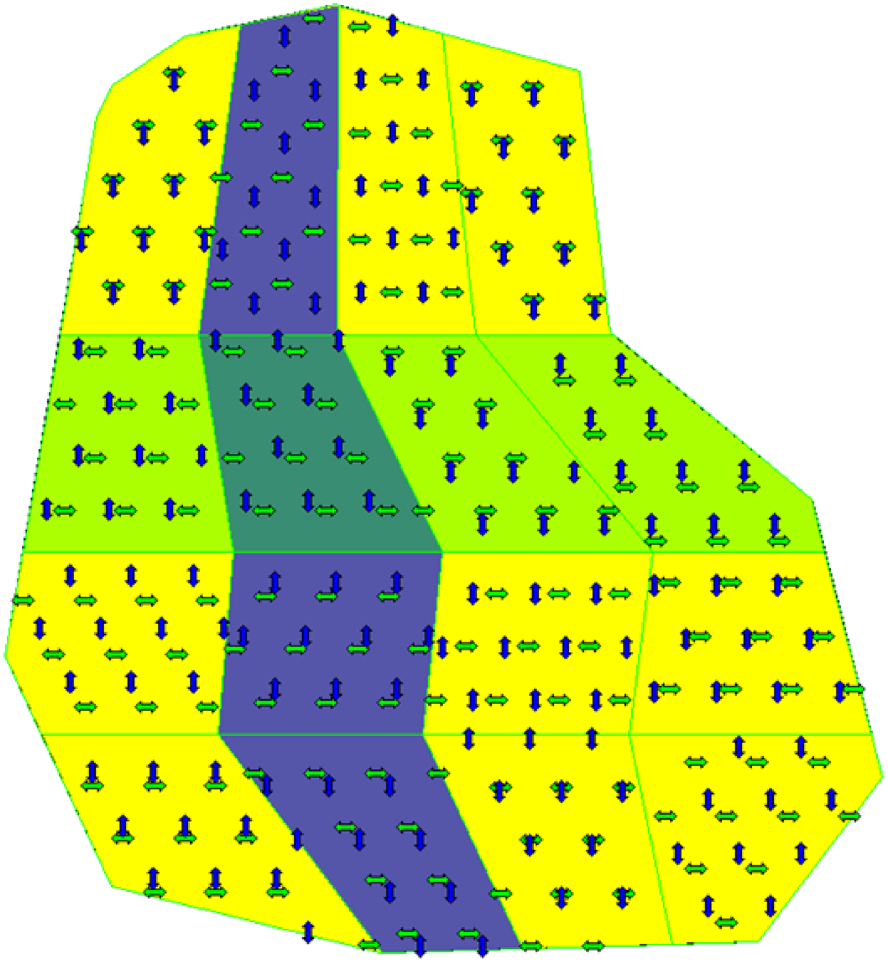
Table 3-1. Variables considered in determining the number of increments per DU for Example 2.

Source: ITRC ISM Update Team, 2020.

Area	Source(s)	COPCs	# Increments	Rationale
Agricultural Field	Pesticides application (lead arsenate)	Arsenic	30	• Water based pesticides
	Pesticides application (OCPs)	OCPs	50	• Hydrophobic COPCs
Pesticide Mixing	Spills or ground surface disposal	Full Suite of Pesticides & petroleum fractions	70	• Brewer et al., 2016 (PCBs n>60) • n=70-100
Residential Area Current (Ex. 2B-1)	Paint Chips	Metals (lead)	80	• Hawaii DOH, 2016 (n≥75)
	Termiticides	OCPs	80	• Brewer et al., 2016 (PCBs n>60) • n=70-100
	Pesticide drift (lead arsenate & OCPs)	Arsenic & OCPs	80	• Efficiency of one sampling strategy • Unknown heterogeneity (n=50, Hawaii DOH, 2016)
Residential Area Future (Ex. 2B-2)	Paint Chips	Metals (lead)	80	• Hawaii DOH, 2016 (n≥75)
	Termiticides	OCPs	80	• Brewer et al., 2016 (PCBs n>60) • n=70-100
	Pesticide drift (lead arsenate & OCPs)	Arsenic & OCPs	50	• Efficiency DUs 1-4 for one sampling strategy • Unknown heterogeneity (n=50, Hawaii DOH, 2016)
Dumb Area Debris	Tires, 55-gallon drums of unknown contents, ash, oil stained soil, debris	Metals, OCPs, full suite of pesticides, SVOCs, PAHs, dioxins/furans, petroleum fractions	80	• Brewer et al., 2016 (PCBs n>60, ash lead n=50-60) • Sources and COPCs suggest high heterogeneity • n=70-100

Visual Sample Plan (VSP) – Elevated Regions Module

- Free software program developed by Pacific Northwest National Laboratory (PNNL)
- To determine the *increment spacing for the DU grid* to NOT miss sampling from a significant small area of elevated concentrations within the DU (VSP 2019).
- Elevated Regions Module
  - Sampling pattern and design differs from the typical ISM sampling pattern and design described in ISM2 and presented in ISM2 examples in both Section 3.1.6 and the case studies in Appendix A.
  - Employs a pattern of rows and columns to design increments for an ISM sample in such a way that they can be combined into ISM samples but still used to spatially locate areas of high contamination.
  - Figure 3-3, on the right, depicts a VSP 4 x 4 ISM row-column design with 16 cells.
  - VSP can **calculate** either the **number of incremental samples** to achieve a desired power of detecting contamination above a specified level **or the probability** of detecting an elevated concentration, given a specified number of increment samples.



Designing ISM Background DUs

- **ISM to ISM**
- Site and Background DUs – same
  - Volume of increments
  - density of increments
  - number of increments and replicates
  - size/volume DUs (ideally)

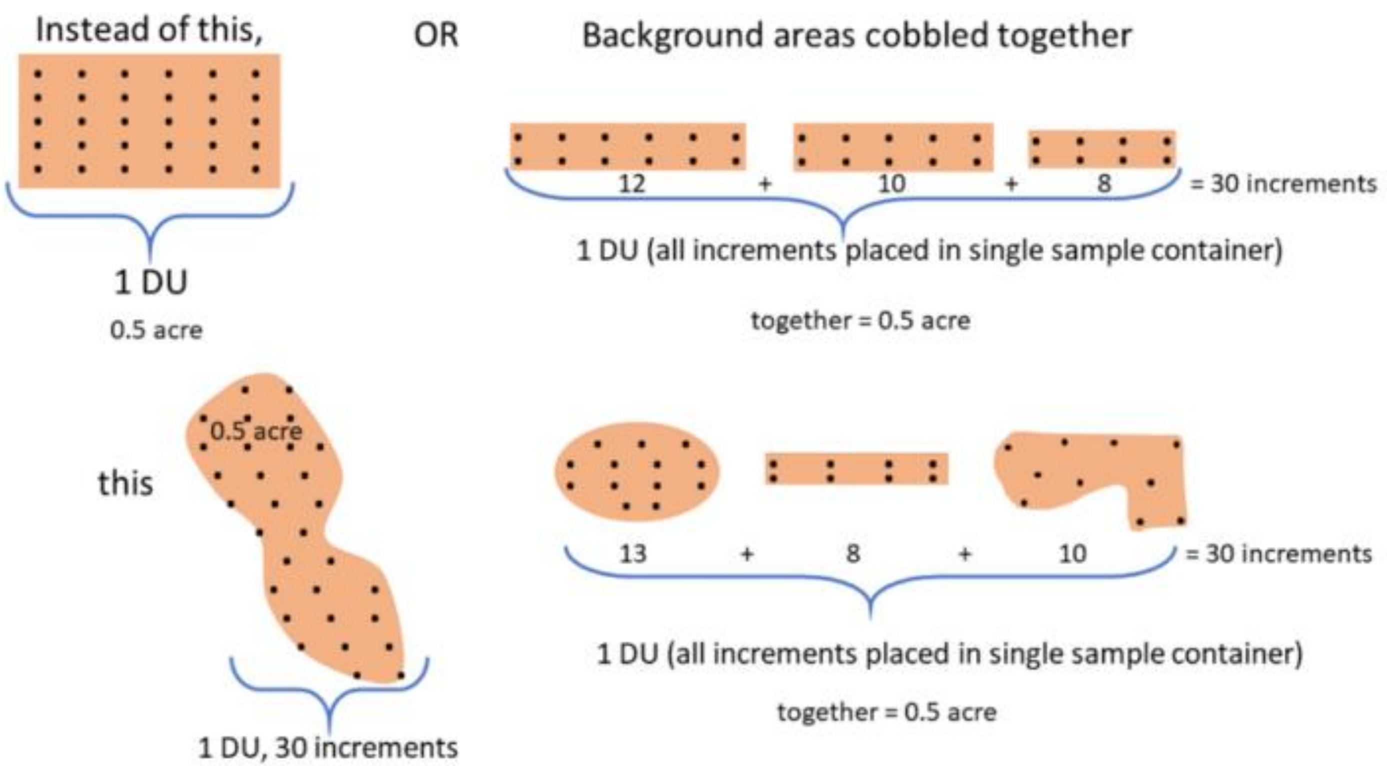


Figure 3-10. Alternative background DUs.
Source: ITRC ISM Update Team, 2020.

Field Planning (Section 4.2)

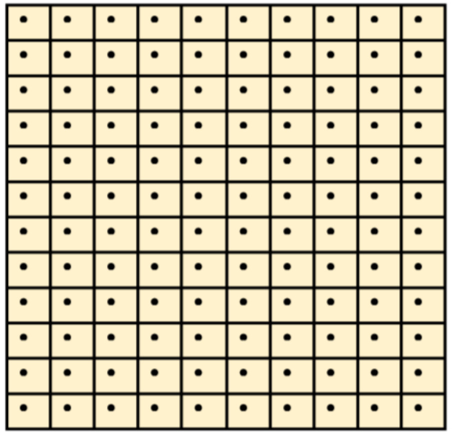
- Staffing
- Training
  - ISM
  - Site Specific
- Site Conditions
  - Aerial photos / Google Earth
  - Site access
  - Sampling techniques

Photos Source: Todd Miller, 2020, Used with permission

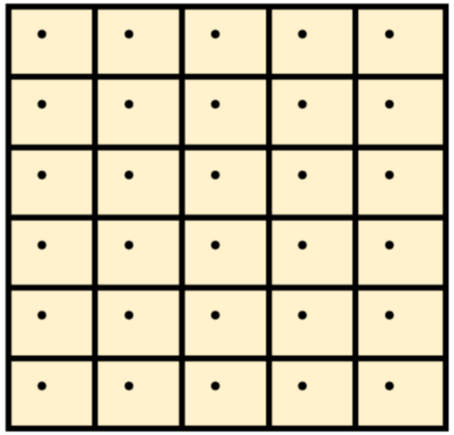
Field Planning (continued)

- Increment Sizing
  - Sampling tools
  - Sample containers
- COC-specific Procedures
- Schedule
  - Days in field
  - Sampling delays
- Subsurface Investigation

Large Sample Size



Small Sample Size



Source: Todd Miller, 2020, Used with permission

Sampling (Section 4.4)

- Sampling Tools
  - Hand Auger
  - Slide Hammer
  - Rotohammer
  - Push Probe
  - Drill Rigs

Hand Auger

Push Probe

Rotohammer

Source: ITRC ISM-2 Update Team Figure 4-2, 2020

The Sample Processing Options

- Common options include air drying, disaggregation, sieving, milling, subsampling, digestion and extraction

Air drying

Sieving

Milling

Subsampling

Digestion

Source: Mark Bruce, Eurofins, 2019. Used with permission.

ISM for Risk Assessment

Section 8

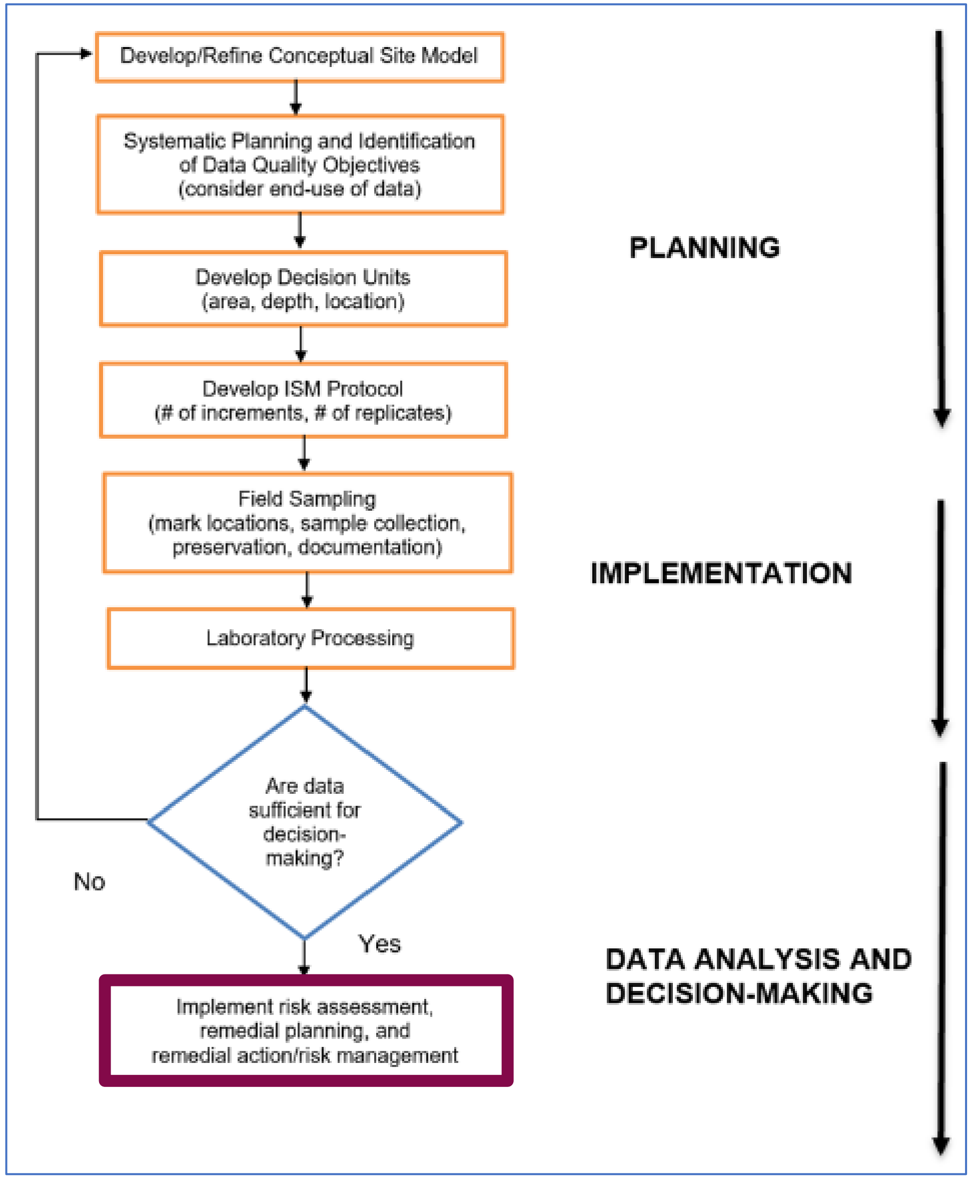
- Focuses on the generation and use of ISM data for human health and ecological risk assessment
- Key issues:
  - Planning
  - Development of Exposure Point Concentrations (EPCs)
  - Risk-based decision making

Yes – You Can use ISM for Risk Assessment!

- **Technically sound** sampling approach for a **scientifically defensibly** risk assessment and risk-based decision making.
- Provides an **accurate** estimate of the true mean concentration for use as the **EPC**.
- **Minimum of three ISM replicates** are necessary to calculate the 95% UCL.

Yes – You Can use ISM for Risk Assessment!

- **Technically sound** sampling approach for a **scientifically defensibly** risk assessment and risk-based decision making.
- Provides an **accurate** estimate of the true mean concentration for use as the **EPC**.
  - ISM 95% UCL generally much closer to the measured sample mean than grab samples and avoids high bias of typically placed discrete samples
- **Minimum of three ISM replicates** are necessary to calculate the 95% UCL.
  - Statistically reliable 95% UCL with three samples (replicates) - need at least 10 with discrete grab samples



The Conceptual Site Model (CSM) underlies the entire risk ISM process and must be fully developed.

Planning is key! – be sure to include the risk assessment team from the start.

Risk assessment study questions can help guide the decision unit development, which will be the basis of the EPCs.

Source: ITRC ISM Update Team, 2020.

Conceptual Site Model

- Describes the relationship between and paths of potential chemical sources to **current** and **future** receptor groups.
- Presents the current understanding of the project area
- Reevaluate and update throughout the life cycle of the project.
- Helps identify data gaps and focus the data collection efforts.
- Key in determining the size and distribution of DUs and SUs

EPCs from ISM Data

- In order to calculate a 95% UCL on the mean, at least **3** replicates are needed from a DU

Updated UCL Calculator (Download file) - ISM 95% UCL Calculator

Do Not Use Maximum Concentration

Section 8.3.3 – various EPC estimates for RA using ISM Data

UCL Calculator

Calculation of Weighted 95% UCLs for a Combined Decision Unit (DU) from Several Smaller DUs Having Replicate Incremental Samples

Enter information in green highlighted cells. See the "Instructions" tab for detailed instructions.

Project ID:	
Property/Sample ID:	
Date of calculations:	
Calculator completed by:	
Analyte:	
Analyte units:	
DU metric units:	
Notes:	

Click in green cell below to select from drop-down menu

DU size metric: area, volume, or depth interval: Area

Note: Assumes all replicates have the same number of increments

Number of increments per replicate:

Row #	IDs/Names of the Smaller DUs	DU Area ()	Replicate field sample concentrations						Number of Replicates	Weight	Arithmetic Mean	SD of Replicates	calc'd SD of Increments	calc'd CV for the DU	Adj Factor	adj'd SD of Increments	adj'd CV for DU	SE of DU	95% UCL			
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6											Student's-t	Chebychev	CV of Increments	95% UCL
1															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
2															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
3															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
4															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
5															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
6															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
7															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
8															#N/A	#VALUE!	#VALUE!				#VALUE!	#VALUE!
9																						
10																						
Sum:			--	--	--	--	--	--							NA		#VALUE!				#VALUE!	#VALUE!

df by Welch-Satterthwaite approximation:

Recommended UCL: **#VALUE!** 0 #VALUE!
#VALUE!

*Student's t UCL is acceptable if adj'd CV for DU is "Low" (e.g., CV ≤ 1.5). The User should consult the instructions for additional guidance on which 95% UCL is recommended for specific data sets.

Notes

adj'd	= adjusted	df	= degrees of freedom	SD	= arithmetic standard deviation
calc'd	= calculated	DU	= decision unit	SE	= standard error
CV	= coefficient of variation	RSD	= relative standard deviation	95% UCL	= 95% upper confidence limit for arithmetic mean

Updated ISM UCL Calculator

Row #	IDs/Names of the Smaller DUs	DU Area (acres)	Replicate field sample concentrations					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
1	DU-1	2.0	10	12	14			
2	DU-2	2.5	10	12	14	19		
3	DU-3	3.0	10	13	15	16	18	
4	DU-4	1.2	12	14	15			
5	DU-5	1.0	13	15	14	15		
6	DU-6	1.3	16	25	28			
7	DU-7	3.6	29	30	34	43		
8	DU-8	1.2	16	18	19	23	45	
9								

Combining SUs or EUs - 95% UCL calculation of EPC

- **Each SU or EU** has **three replicate** ISM samples with either the same or different spatial coverage.
  - ISM Updated 95% UCL Calculator
- **Triplicates** from **one or more** random **SUs or EUs**; a **singlet** from **all others**
- **Very large CSM-equivalent EU** divided into many SUs or EUs ISM samples from **random subset** of **SUs or EUs**

Weighted 95% UCL

Playground Area	Area (Acres)	Sample Statistics		95% UCL	
		Replicates	Mean	Chebyshev	Student's-t
DU1 (Kindergarten)	0.25	120, 100, 140	120	170	154
DU2 (Older Children)	1.0	22, 25, 30	25.7	35.8	32.5
Equal Weight	1.25	120, 100, 140, 22, 25, 30	72.8	168	117
Proportionately Weighted	1.25	120, 100, 140, 22, 25, 30	44.5	57.5	50.9

Table 6-3. Summary statistics used to combine DUs. (Modified with addition of color)

Source: ITRC ISM Update Team, 2020.

Combining SUs or EUs - 95% UCL calculation

Triplicates from **one or more** random **SUs or EUs**; a **singlet** from **all others**

Options for calculating the 95% UCL for the larger scenario-specific EU:

- Use **pooled variances** from SUs or smaller scenario-specific EUs with three replicates that are applied to calculate 95% UCLs for the singlet SUs or EUs. This method is appropriate for CSM-equivalent SUs and EUs where a statistical test that compares variances demonstrates that the differences in variances are not significantly significant [Section 3.2.6.2]
- **Random selection of one** replicate **result** from **each SU or EU with multiple** replicates (for example, the first replicate) [Section 3.3.3]
- **Apply measured RSD** from **one triplicate SU** or smaller scenario-specific EUs to each of the SU or EU results (when similar variation is expected across the SUs or smaller scenario-specific EUs), then ISM 95% UCL calculator. [Section 6.2.4]
- **Other** possibilities [Section 3.3.2]

Combining SUs or EUs - 95% UCL calculation

Very large CSM-equivalent EU divided into many SUs or EUs ISM samples from **random subset** of **SUs or EUs**

- ***Random sampling subset of SUs or EUs to characterize a very large EU or project area*.**
- Singlet ISM samples from some SUs or smaller EUs of equal size
- Collect at least one set of three or more replicates
- ProUCL when n = 10 or more SUs singlets [Section 3.2.8.1; Section 8.2.2.2]
- Different Study Question - Not-to-exceed determination [Section 3.2.8.2]
    - determine whether a proportion of the DU exceeds a threshold
    - very different from concluding the mean of the DU is below the threshold
    - **many more samples are required**
    - 3 replicates from all or a percentage of the smaller SUs – pooled variance for 95%UCL

Comparing ISM Site to Background DUs

- Multiple Lines of Evidence - Qualitative and statistical
- Qualitative
  - Graphs / Figures of distributions – scatter plots, histograms, box plots
  - RSD among replicates – contaminated site may have higher variability (to identify release occurred, NOT for Site within background concentrations)
- Statistical tests
  - Hypothesis testing of means
  - ANOVA – need statistician or professional well versed in environmental statistics, minimum of 5 replicates
  - Upper tails of distributions – need minimum of 8 replicates
  - Include power analysis in planning - determine number of increments needed

Reduce Variability to Reduce 95% UCL Uncertainty

Causes:

- too few increments or replicates
- and/or concentration of contaminant is highly variable

Solution: additional phase of investigation

- redesigned DUs
- and/or more increments per DU

Decision Errors

- Stem from UCL uncertainty

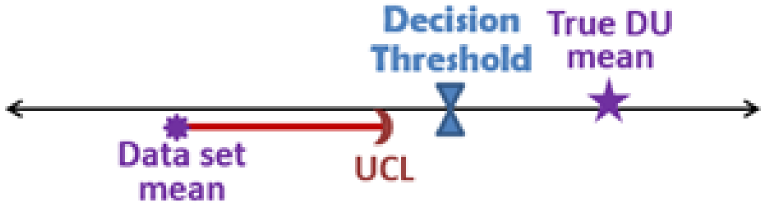


Figure 3-23.

Source: ITRC ISM Update Team, 2020.

Uncertainty could cause the **UCL** to be **below** the **true mean**.

The **key source** of **uncertainty** is the **variance** of the increments (CV of the underlying distribution).

A **possible cause** of variance and resulting poor representation could be an **insufficient number** of **increments** over a large study area or EU.

Use of Background ISM Data in Risk Assessment

- Proper planning for background ISM comparison in a risk assessment
  - **ISM to ISM** with same
    - size/volume DUs (ideally)
    - density of increments
    - number of increments and replicates
- Brief description of comparison methods
- Section 8.4 – See also Sections 3.1.6.2, 3.3.4 and 6.3

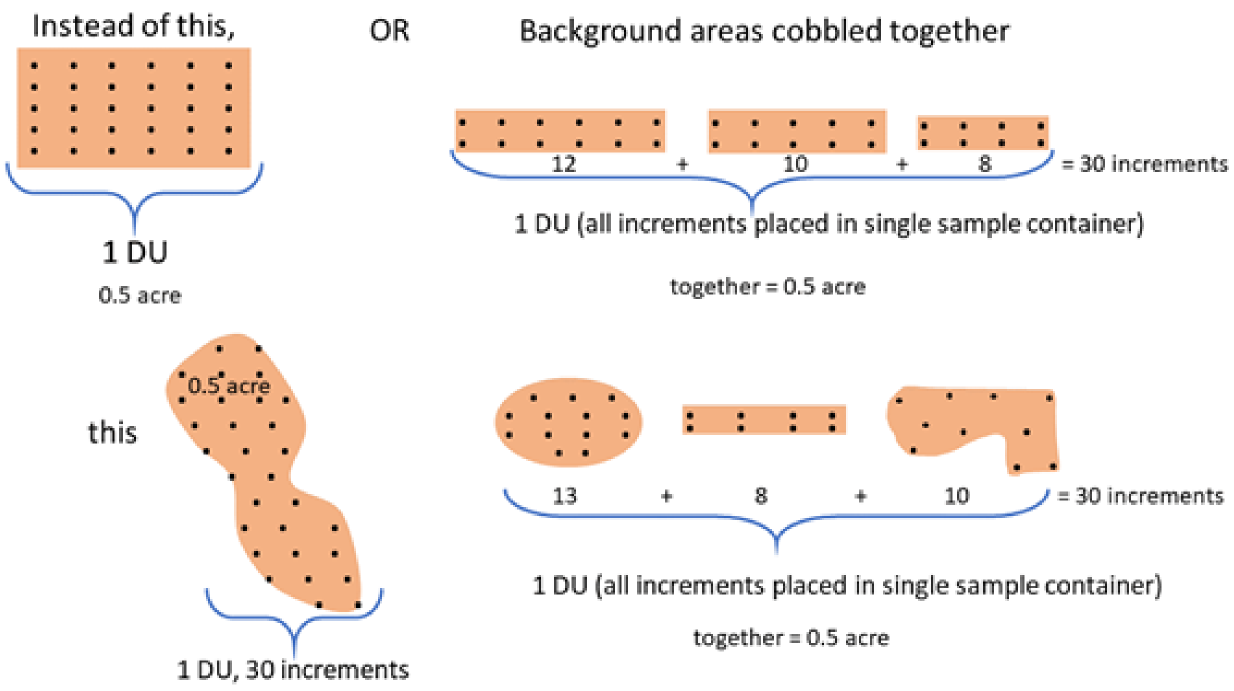
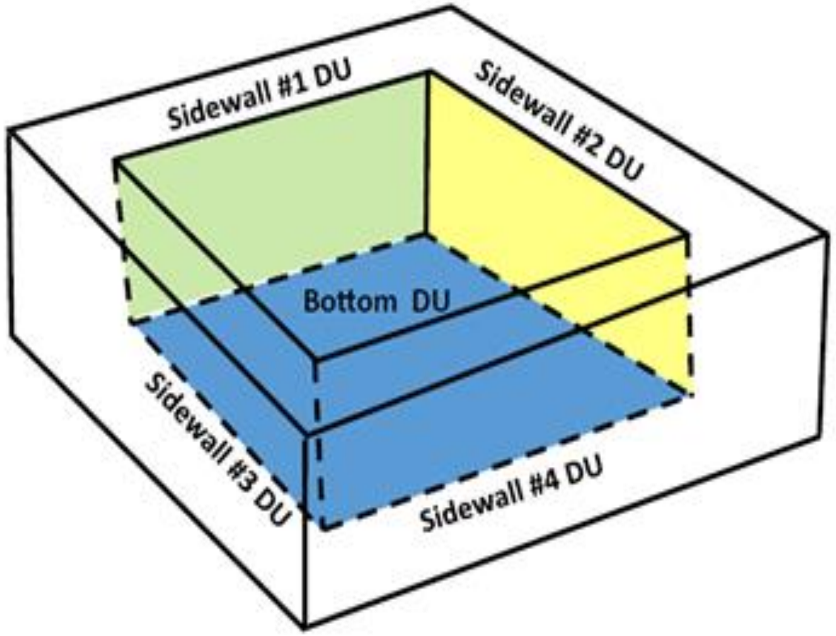


Figure 3-10.
Source: ITRC ISM Update Team, 2020.

Use of ISM for Post-Remediation Risk-Based Confirmation Sampling

- To evaluate if a remedial action meets risk-based benchmarks
- Properly designed ISM sampling plan
- A very robust estimate of mean residual contaminant concentrations in a DU
- True DU mean concentration < the remedial goal
- Comparison of a 95% UCL to the remediation goal Section 3.2.5
- Statistical confidence and scientifically defensible risk-based decision-making

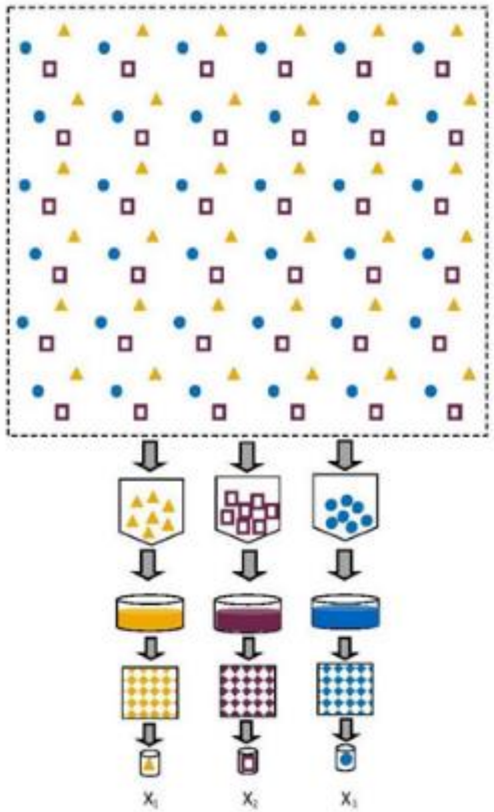


Section 3.4, Figure 3-31. ISM sampling for remedial excavation confirmation sampling.

Source: ITRC ISM Update Team, 2020.

Risk Communication for ISM

- Address common misconceptions about ISM
- Refines Exposure Assessment
  - Risk = Exposure x Hazard
  - Reduces uncertainty in the mean
  - Provides a representative EPC
- Additional Resources
  - ITRC RISK-3 (ITRC 2015) https://www.itrcweb.org/risk-3/
  - ITRC Risk Communication Toolkit https://rct-1.itrcweb.org/



Source: ITRC ISM Update Team, 2020.

Using the UCL Calculator

Enter information in green highlighted cells. See the "Instructions" tab for detailed instructions.

Project ID:	ABC Oil Field
Property/Sample ID:	OU 1 and OU 2
Date of calculations:	August 23, 2020
Calculator completed by:	Jane Doe
Analyte:	Pb
Analyte units:	mg/kg
DU metric units:	acres
Notes:	Example

Click in green cell below to select from drop-down menu

DU size metric: area, volume, or depth interval: Area

Note: Assumes all replicates have the same number of increments

Number of increments per replicate: 30

Row #	IDs/Names of the Smaller DUs	DU Area (acres)	Replicate field sample concentrations						Number of Replicates	Weight	Arithmetic Mean	SD of Replicates	calc'd SD of Increments	calc'd CV for the DU	Adj Factor	adj'd SD of Increments	adj'd CV for DU	SE of DU	95% UCL			
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6											Student's-t	Chebychev	CV of Increments	95% UCL
1	DU-1	2.0	10	12	14				3	0.13	12.0	2.00	10.95	0.91	1.15	12.65	1.05	1.15	15.4	17.0	Low	15.4
2	DU-2	2.5	10	12	14	19			4	0.16	13.8	3.86	21.15	1.54	1.16	24.47	1.78	1.93	18.3	22.2	Med	22.2
3	DU-3	3.0	10	13	15	16	18		5	0.19	14.4	3.05	16.70	1.16	1.09	18.19	1.26	1.36	17.3	20.3	Low	17.3
4	DU-4	1.2	12	14	15				3	0.08	13.7	1.53	8.37	0.61	1.13	9.49	0.69	0.88	16.2	17.5	Low	16.2
5	DU-5	1.0	13	15	14	15			4	0.06	14.3	0.96	5.24	0.37	1.11	5.83	0.41	0.48	15.4	16.3	Low	15.4
6	DU-6	1.3	16	25	28				3	0.08	23.0	6.24	34.21	1.49	1.22	41.89	1.82	3.61	33.5	38.7	Med	38.7
7	DU-7	3.6	29	30	34	43			4	0.23	34.0	6.38	34.93	1.03	1.11	38.72	1.14	3.19	41.5	47.9	Low	41.5
8	DU-8	1.2	16	18	19	23	45		5	0.08	24.2	11.90	65.20	2.69	1.36	88.87	3.67	5.32	35.5	47.4	High	47.4
9																						
10																						
	Sum:	16	--	--	--	--	--	--	31	1.00	19.8	2.00	10.93	0.55	NA	12.86	0.65	0.98	21.7	24.1	Low	21.7

df by Welch-Satterthwaite approximation: 8.7

Recommended UCL: 21.7 mg/kg >> Student's t 95% UCL

Note: Student's-t or Chebychev 95% UCL may be appropriate.

Source: ISM 95% UCL Calculator (https://www.itrcweb.org/FileCabinet/GetFile?fileID=21884).

Weighted UCL Example

Kindergarten Playground
DU1 - 0.25 acres

Elementary Playground
DU2 - 1 acre

DU3 - Maintenance worker
1.25 acres

Playground Area	Area (Acres)	Mean	Chebyshev	Student's-t
DU1 (Kindergarten)	0.25	120	170	154
DU2 (Older Children)	1.0	25.7	35.8	32.5
Equal Weight	1.25	72.8	168	117
Proportionately Weighted	1.25	44.5	57.5	50.9

Figure 3-8

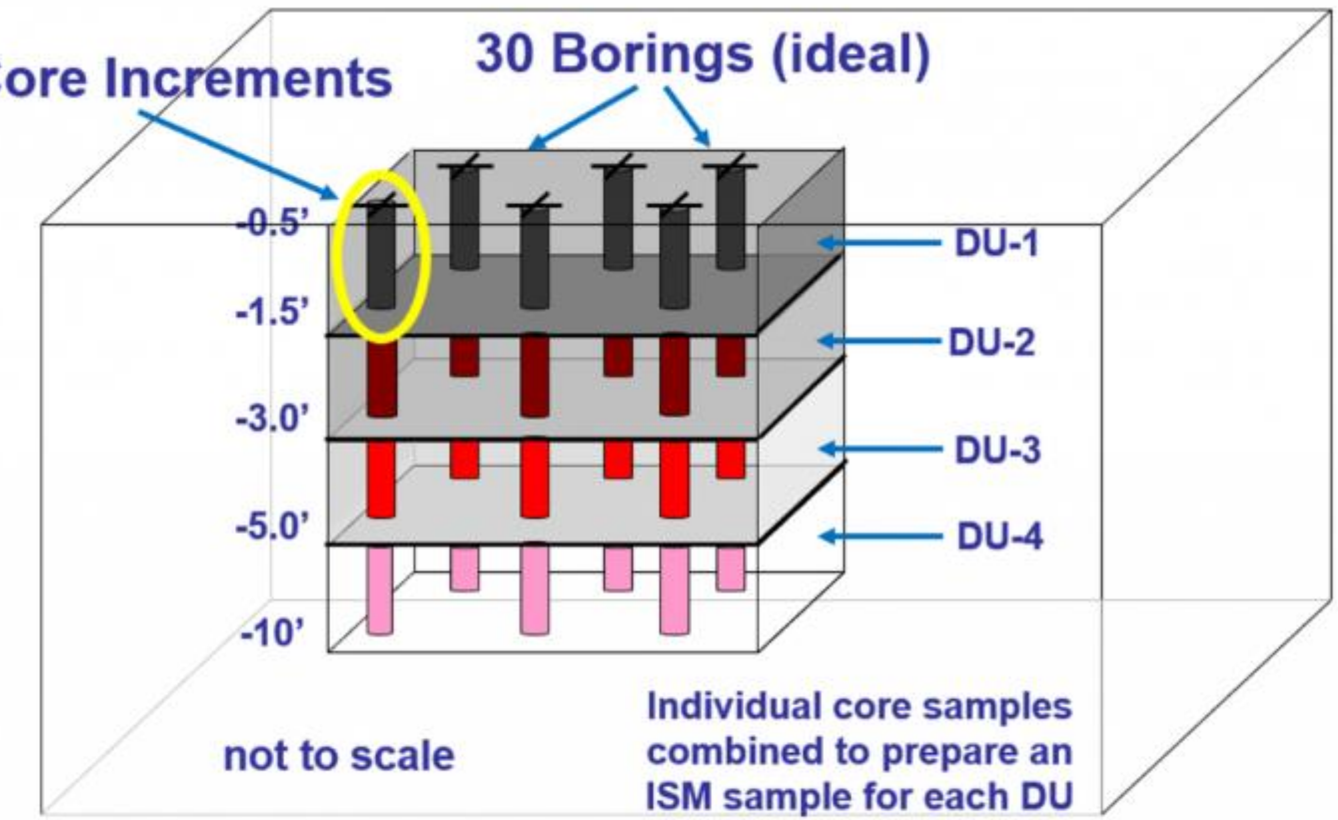


Figure 3-8. ISM design for subsurface interval sampling in Example 1

Source: ITRC ISM-1 Team, 2012.

Table 3-1

Table 3-1. Variables considered in determining the number of increments per DU for Example 2.
Source: ITRC ISM Update Team, 2020.

Area	Source(s)	COPCs	# Increments	Rationale
Agricultural Field	Pesticides application (lead arsenate)	Arsenic	30	Water-based pesticides
	Pesticides application (OCPs)	OCPs	50	Hydrophobic COPCs
Pesticide Mixing	Spills or ground surface disposal	Full suite of pesticides and petroleum fractions	70	Brewer et al., 2016 (PCBs $n > 60$) $n = 70$ to 100
Residential Area: Current (Example 2B-1)	Paint chips	Metals (lead)	80	Hawaii DOH, 2016 ($n > 75$)
	Termiticides	OCPs	80	Brewer et al., 2016 (PCBs $n > 60$) $n = 70$ to 100
	Pesticide drift (lead arsenate and OCPs)	Arsenic and OCPs	80	Efficiency of one sampling strategy Unknown heterogen eity ($n = 50$, Hawaii DOH, 2016)

Figure 3-11b

Figure 3-11b. Selection of SUs and EU for risk to human health in Example 2B-1.
Source: ITRC ISM Update Team, 2020.

Figures 3-11c1 & 3-11c2

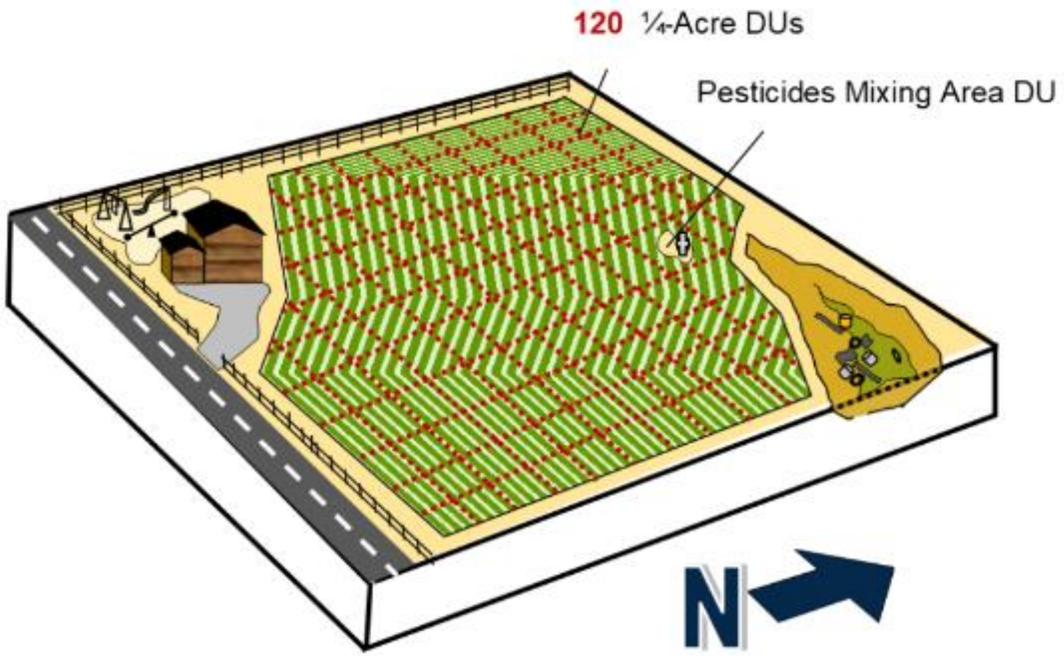


Figure 3-11c1. Future residential scenario in Example 2B-2.
Source: ITRC ISM Update Team, 2020.

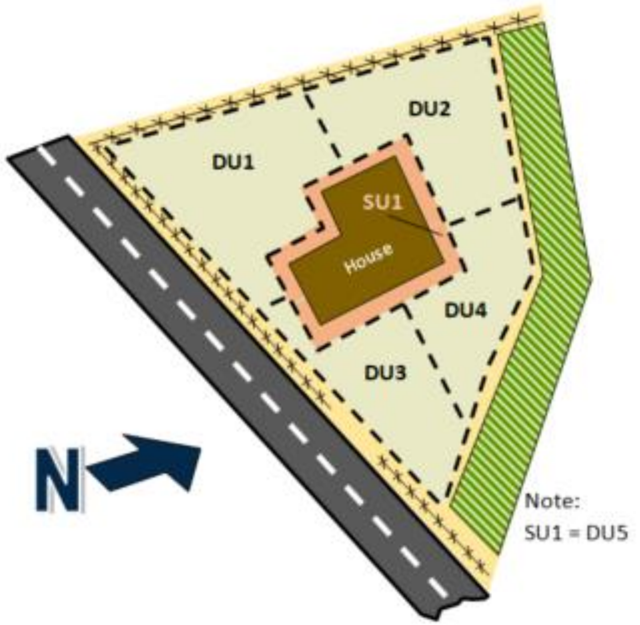


Figure 3-11c2. Selection of DUs and SUs for future residential scenario in Example 2B-2.
Source: ITRC ISM Update Team, 2020.

Figure 3-11c3

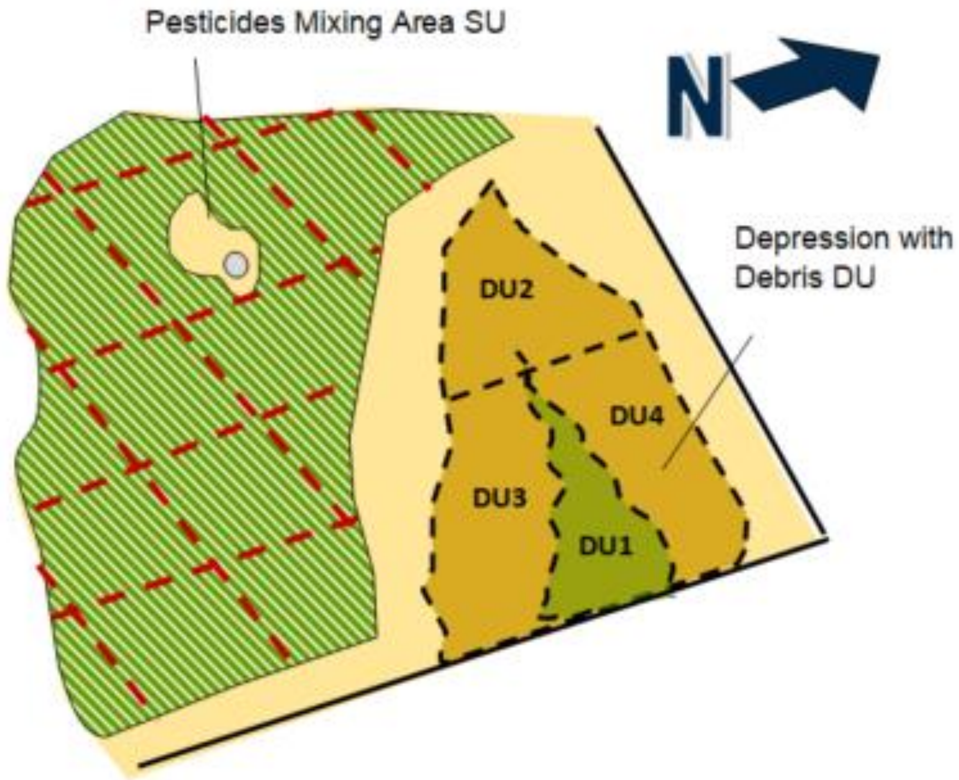


Figure 3-11c3. Selection of DUs for future residential scenario at surface depression in Example 2B-2.
Source: ITRC ISM Update Team, 2020.

Table 3-3

Table 3-3. Likelihood that ISM achieves coverage depending on dispersion (*r* = 3 replicates).
Source: ITRC ISM Update Team, 2020.

Degree of Dispersion >>		**Low**	**Medium**	**High**
Dispersion Metric	CV of replicates	< 0.23	0.23 < CV < 0.40	> 0.40
	CV of increments (no adjustment)	< 1.26	1.26 < CV < 2.19	> 2.19
	CV of increments (with adjustment)	< 1.5	1.5 < CV < 3	> 3
95% UCL Method	Student's-*t*	Yes	No	No
	Chebyshev	Yes	Yes	Maybe