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The Role of Incremental Sampling in Final Status Survey Strategies for WVDP Phase 1 Activities

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Phase 1 Final Status Survey Work

- Consistent with MARSSIM
- Applicable to the floors of the WMA 1 and WMA 2 deep excavations
- Applicable to other areas of the site where there is the potential for turning “grey” areas to green
- Desire is to make the FSSP work as efficient and effective as possible
- Incremental/composite sampling potentially plays a very useful and important role

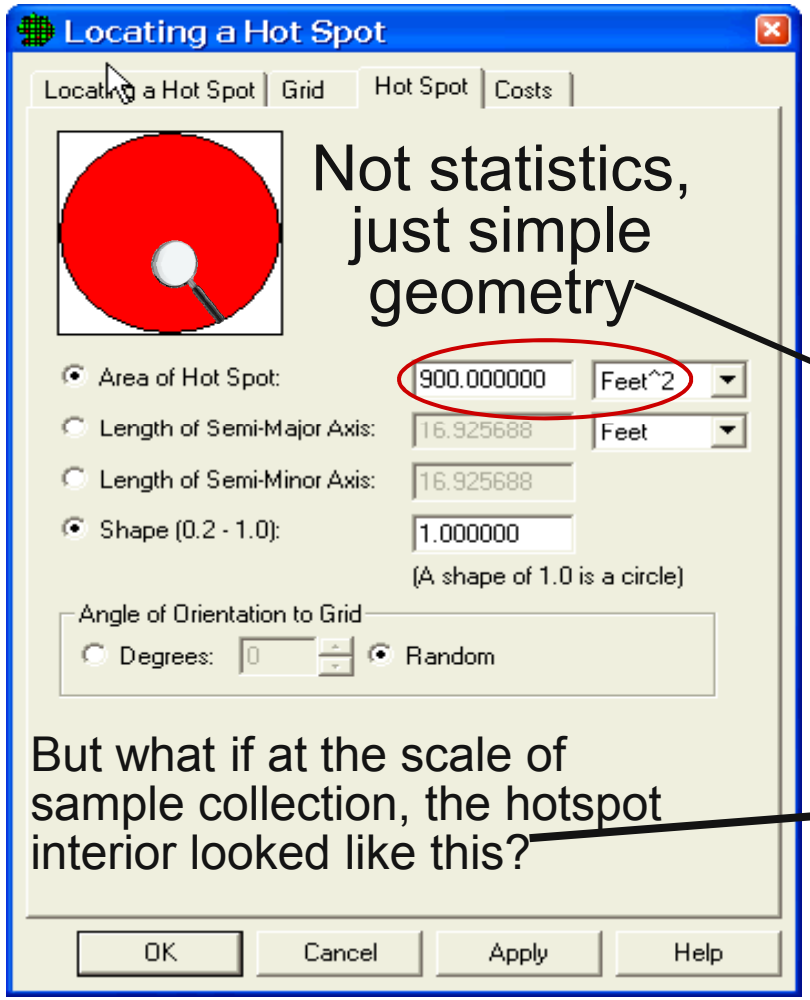
Some WVDP Radionuclides Not Amenable to Scanning Technologies

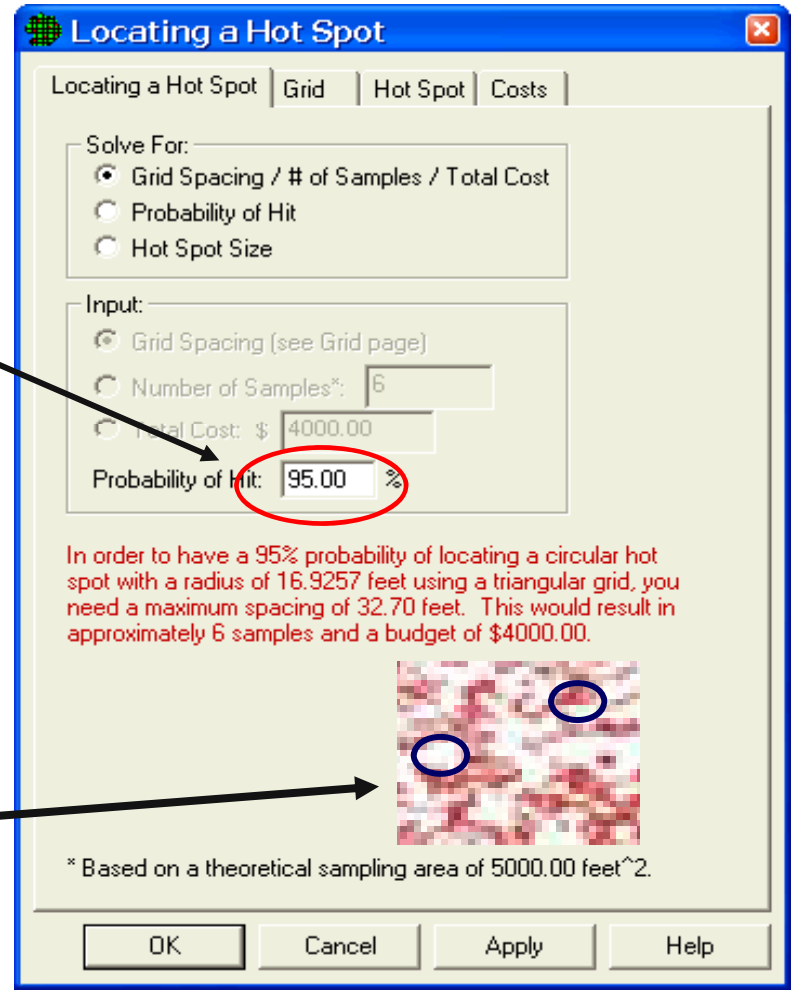
- Several of the eighteen radionuclides of interest (ROI) are not detectable with gross activity scans at DCGL levels
- It is unlikely that these radionuclides will be consistently collocated with gamma emitting radionuclides such as Cs-137
- Demonstrating DCGL compliance ($DCGL_w$ and $DCGL_{emc}$) will require soil sampling

Discrete Grab Samples Are Not the Most Effective Means for Identifying $DCGL_{emc}$ Concerns

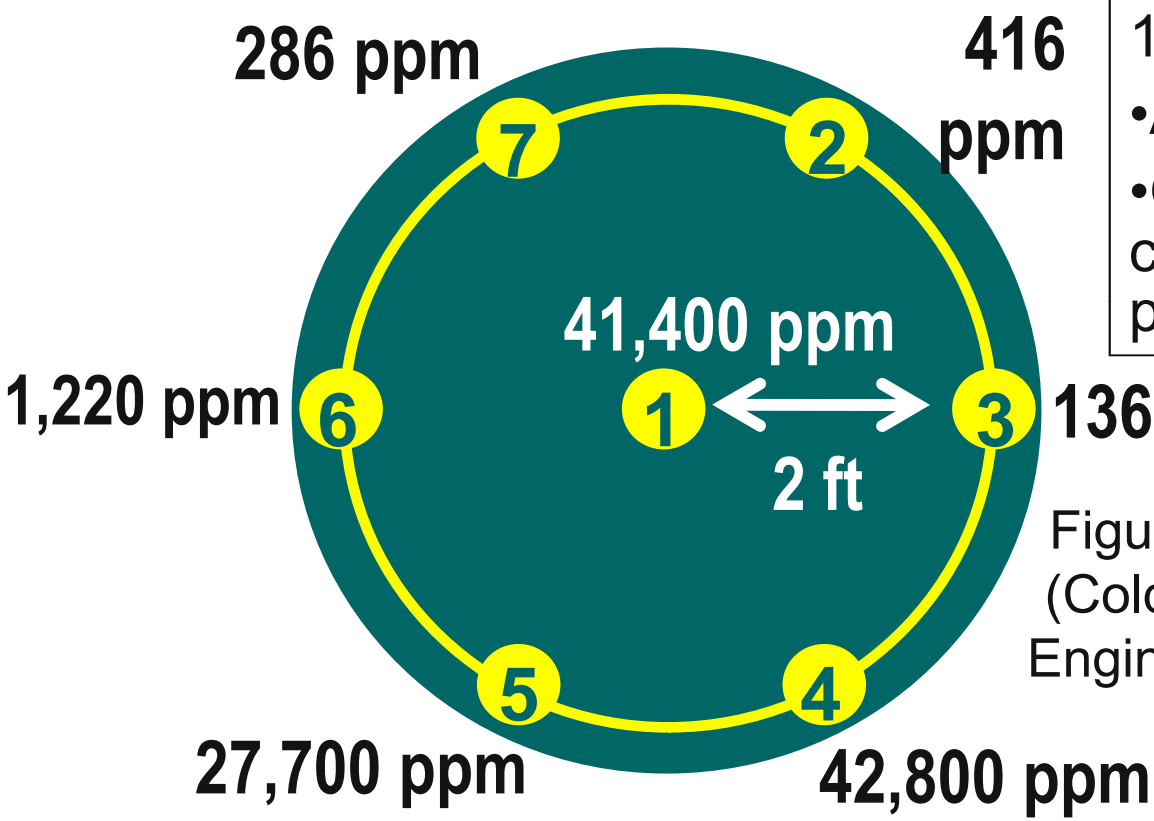
- When no scanning technology is available, MARSSIM recommends using samples to establish $DCGL_{emc}$ compliance
- "Hot Spot" searches based on discrete soil samples are one means for determining sampling density
- Algorithms for determining sampling density (e.g., Visual Sample Plan) assume if a hot spot exists, a discrete sample from its footprint will reliably identify it
- This is not the most effective way to identify hot spot concerns with soil samples

Hot Spot Search Methods Neglect Short Scale Heterogeneity…





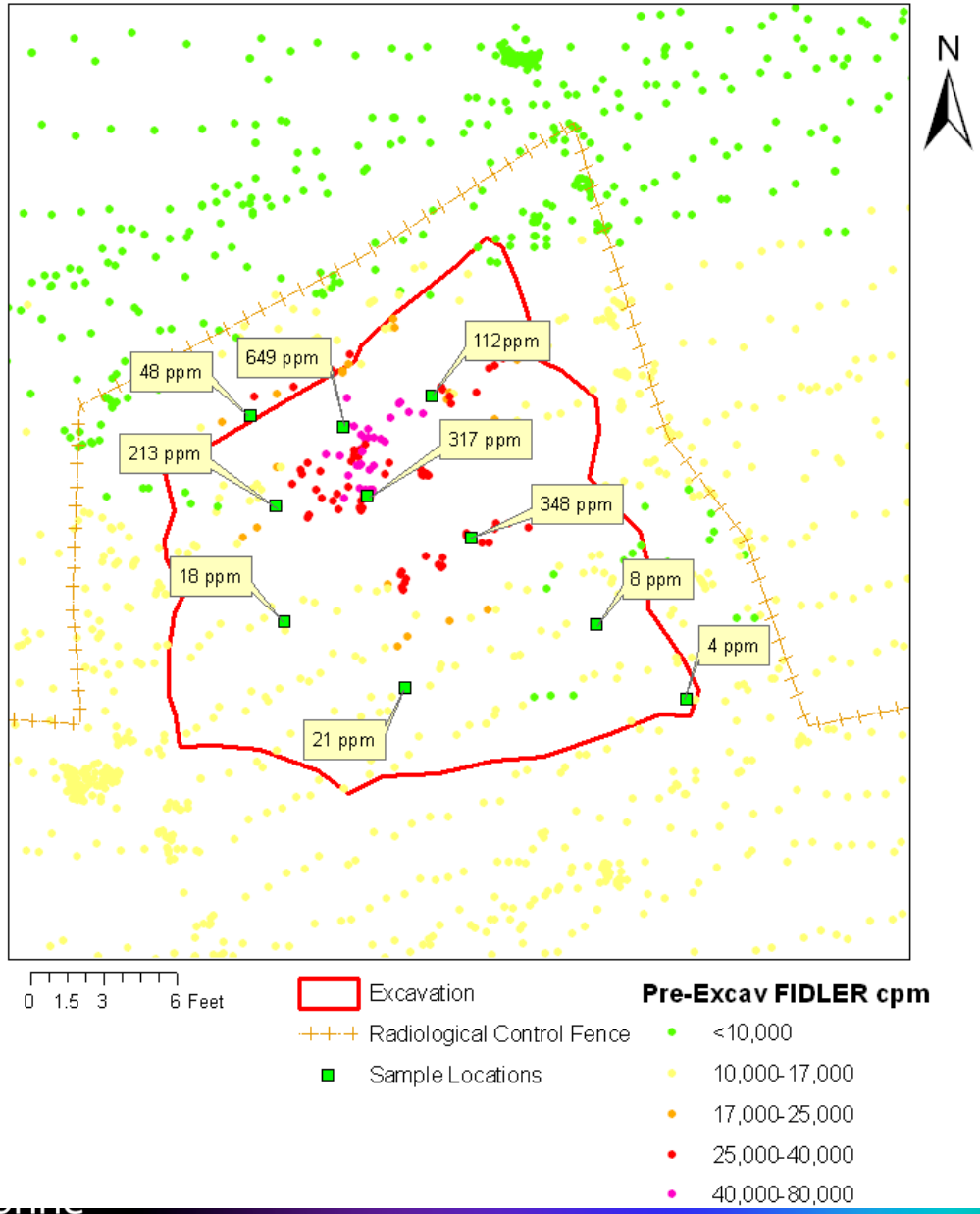
…at the Risk of Missing $DCGL_{emc}$ Exceedances…



- Assume level of concern: 1,000 ppm
- Average: 16,280 ppm
- One sample has a 43% chance of missing the presence of the "hot spot"!

Figure adapted from Jenkins (Cold Regions Research and Engineering Laboratory), 1996

…and a Uranium Example…



- 25 m^2 area
- 98 ppm total U $DCLG_{emc}$
- ~ 200 ppm total U average for area
- 5 of 10 samples would have missed it (50% detection rate based on discrete samples)

The Solution:
Use Incremental/Composite Sampling

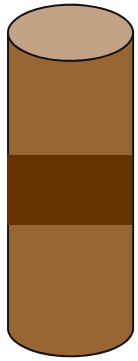
Incremental Sampling?
Compositing?

"I'm the consultant they brought in to create some new statistical buzzwords."

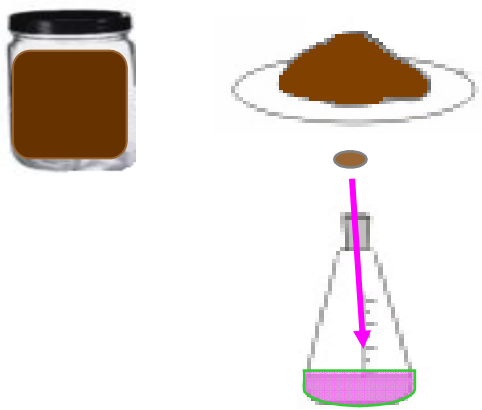
"Compositing" and "Incremental Sampling" Are the Same

- Compositing and incremental sampling refer to the same thing and are used interchangeably
- Both refer to collecting soils from physically separate locations ("increments") and forming one homogenized sample ("composite") that is submitted for analysis
- Multi-increment sampling (MIS) is similar in concept, but refers to a very specific incremental sampling/compositing protocol
- What is being proposed for WVDP Phase I FSS work is NOT MIS

All Soil Samples Are "Composites"



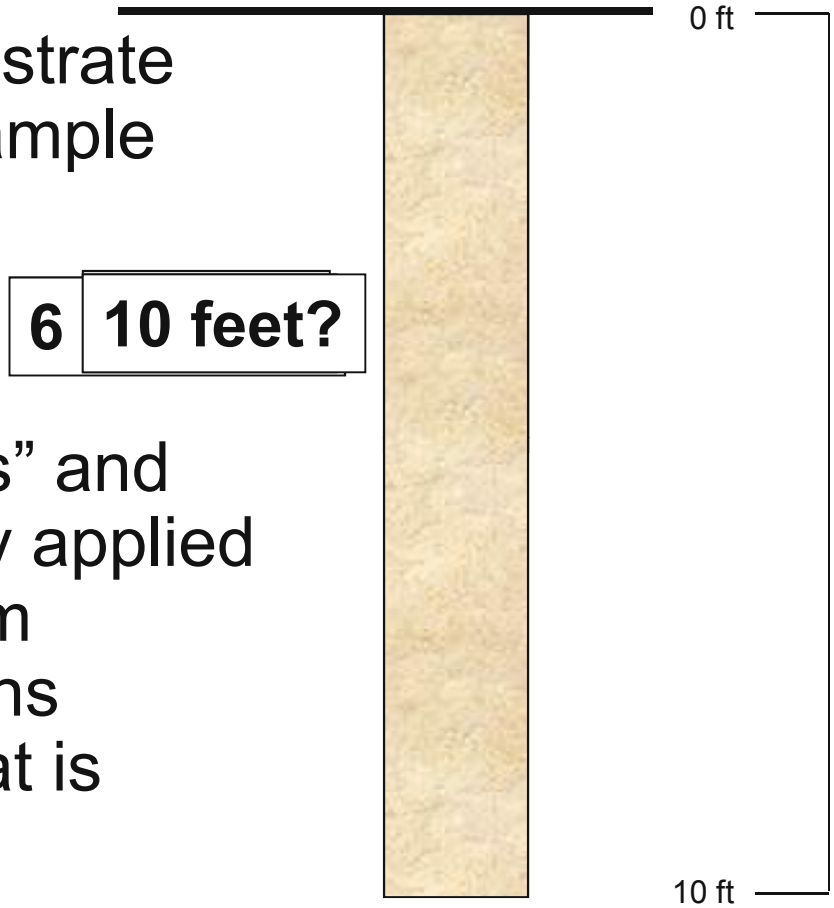
- The source of the jar contents is a composite
- The contents of the jar is a composite
- The heap scoop of soil taken from a jar is a composite
- The pinch of soil extracted or digested for analysis is a composite



All Soil Samples Are "Composites"

- Sampling depth intervals illustrate this reality…when does a sample switch from "discrete" to "composite"?

- Terms "incremental samples" and "composite samples" usually applied to situations where soils from physically separated locations contribute to one sample that is homogenized for analysis



MARSSIM is Silent Regarding Compositing, But…

- EPA PCB TSCA guidance has encouraged the use of compositing since its inception in the mid-1980s
- Compositing strategies play a prominent role in EPA QA/G-5S (2002) "Guidance on Choosing a Sampling Design for Environmental Data Collection"
- A variant (MIS) has been found to be effective for explosives in firing range soils and has been incorporated in EPA SW-846 Method 8330b
- It has gained significant attention from state agencies, with the ITRC currently developing guidance
- Compositing has been used successfully as part of final status survey work at the FUSRAP Rattlesnake Creek site in New York and part of soils uranium cleanup work at the DOE Paducah site

What About Dilution Concerns?

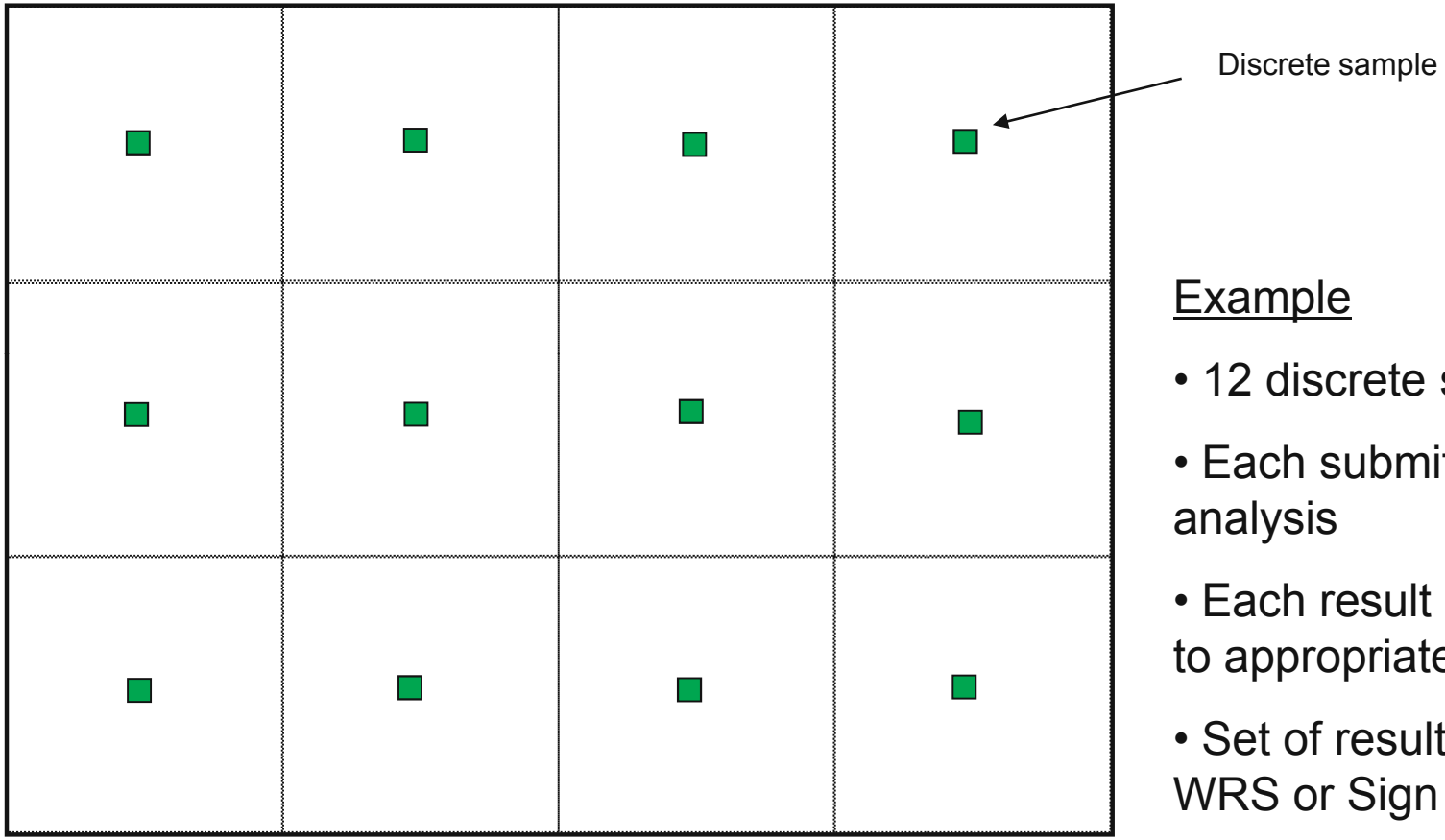
- Resistance to compositing usually based on dilution concerns
- For $DCGL_w$, dilution concerns don't apply
  - Goal is to get an accurate estimate of average concentration over survey unit
  - Doesn't matter if 10 samples are collected, analyzed individually, and their results mathematically averaged OR if they are homogenized in one composite and the composite analyzed – final result will be the same
- For $DCGL_{emc}$ identification, compositing actually works *against* dilution:
  - $DCGL_{emc}$ also an average concept, only over smaller area
  - As shown previously, compositing, if done right, actually *increases* the likelihood a "hot spot" will be found

FSS Incremental/Composite Sampling

- Used to cost-effectively suppress short-scale heterogeneity, resulting in improved sample representativeness
- Multiple soil increments contribute to a composite that is homogenized and analyzed
- Increments systematically distributed over an area equivalent to or less than elevated area definition (or over the area represented by a single discrete $DCGL_w$ sample)

FSS Traditional Approach

Final Status Survey Unit

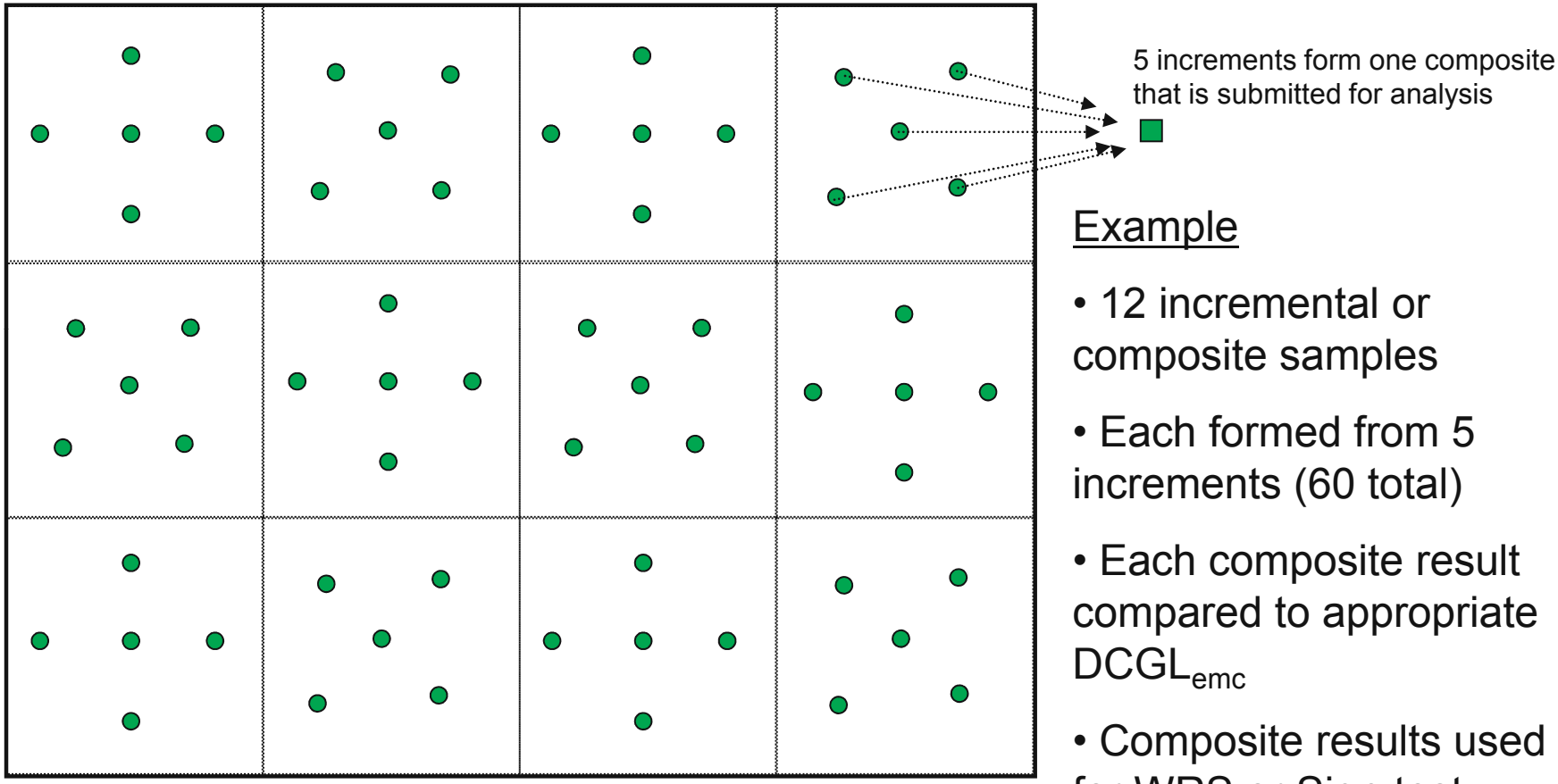


<u>Example</u>

- 12 discrete samples
- Each submitted for analysis
- Each result compared to appropriate $DCGL_{emc}$
- Set of results used for WRS or Sign test

FSS Incremental Sampling Approach

Final Status Survey Unit



Example

- 12 incremental or composite samples
- Each formed from 5 increments (60 total)
- Each composite result compared to appropriate $DCGL_{emc}$
- Composite results used for WRS or Sign test

Incremental Sampling Performance

- Elevated area detection significantly improved as compared to individual discrete sample performance for a given elevated area size

- $DCGL_w$ Sign test or WRS test performance also greatly improved
  - In the case of example, equivalent to performance from 60 discrete samples
  - "Performance" measured by Type II error rate (note that Sign and WRS test are designed to provide a given Type I error rate regardless of the number of samples)

- In case of WRS test, best if reference area is sampled with the same incremental sampling protocols as used for the final status survey units

How Many Increments Required to Improve $DCGL_{emc}$ Performance?

- In explosives case (concentration 16 times $DCGL_{emc}$):
  - 1 discrete sample: 57% detection rate
  - 2-increment sample: 86% detection rate
  - 3-increment sample: 98% detection rate

- In uranium case (concentration 2.5 times $DCGL_{emc}$):
  - 1 discrete sample: 50% detection rate
  - 2-increment sample: 66% detection rate
  - 3-increment sample: 74% detection rate
  - 4-increment sample: 78% detection rate
  - 5-increment sample: 85% detection rate

- Bottom line: any # of increments out-performs discrete sampling

Any Questions?