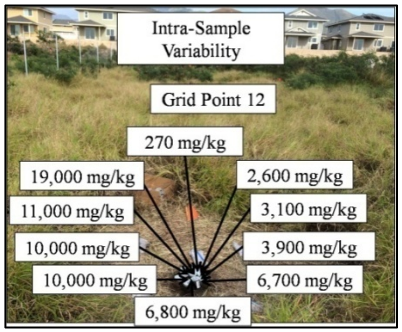
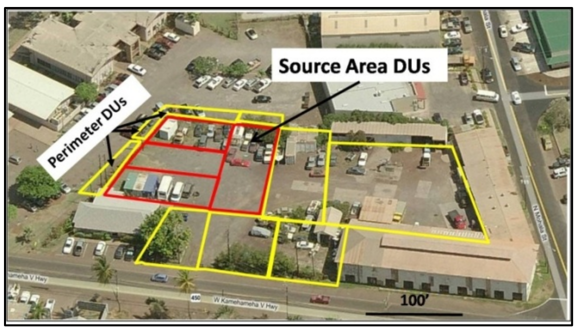
Use of Decision Unit and Incremental Sampling Methods to Improve Site Investigations





2015 M2S2 Webinar Series – Munitions Constituents

Roger Brewer and Steve Mow

Hawai‘i Department of Health

December 2014

Key References:

Sampling Theory:

Francis Pittard, 1993, *Pierre Gy's Sampling Theory and Sampling Practice*, 1993, CRC Press.

Incremental Sampling Methodology (ISM) Overview:

ITRC, 2012, *Incremental Sampling Methodology*: Interstate Technology Regulatory Council.

Field Implementation ("Multi-increment Sampling"):

***Technical Guidance Manual* (2009 and updates): Hawai'i Department of Health, HEER Office, http://www.hawaiidoh.org/**

Incremental Sampling Training Courses

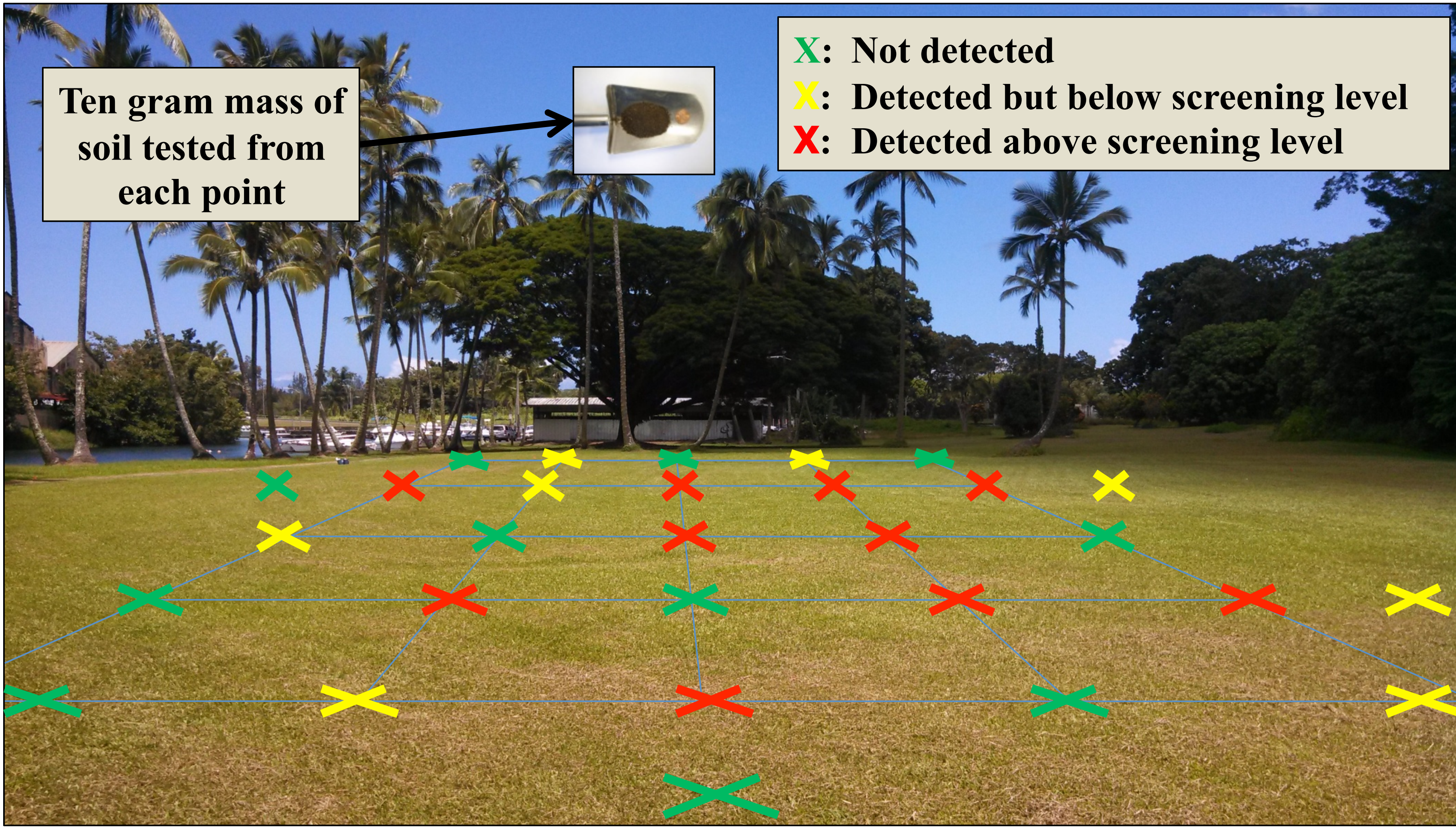
1. ITRC: Incremental Sampling Methodology (ISM)
Introduction to basics of incremental sampling

2. Envirostat, Inc.: Chuck Ramsey *(www.envirostat.org)*
Four-day, detailed introduction to sampling theory and Multi-Increment Sample ("MIS") site investigations;

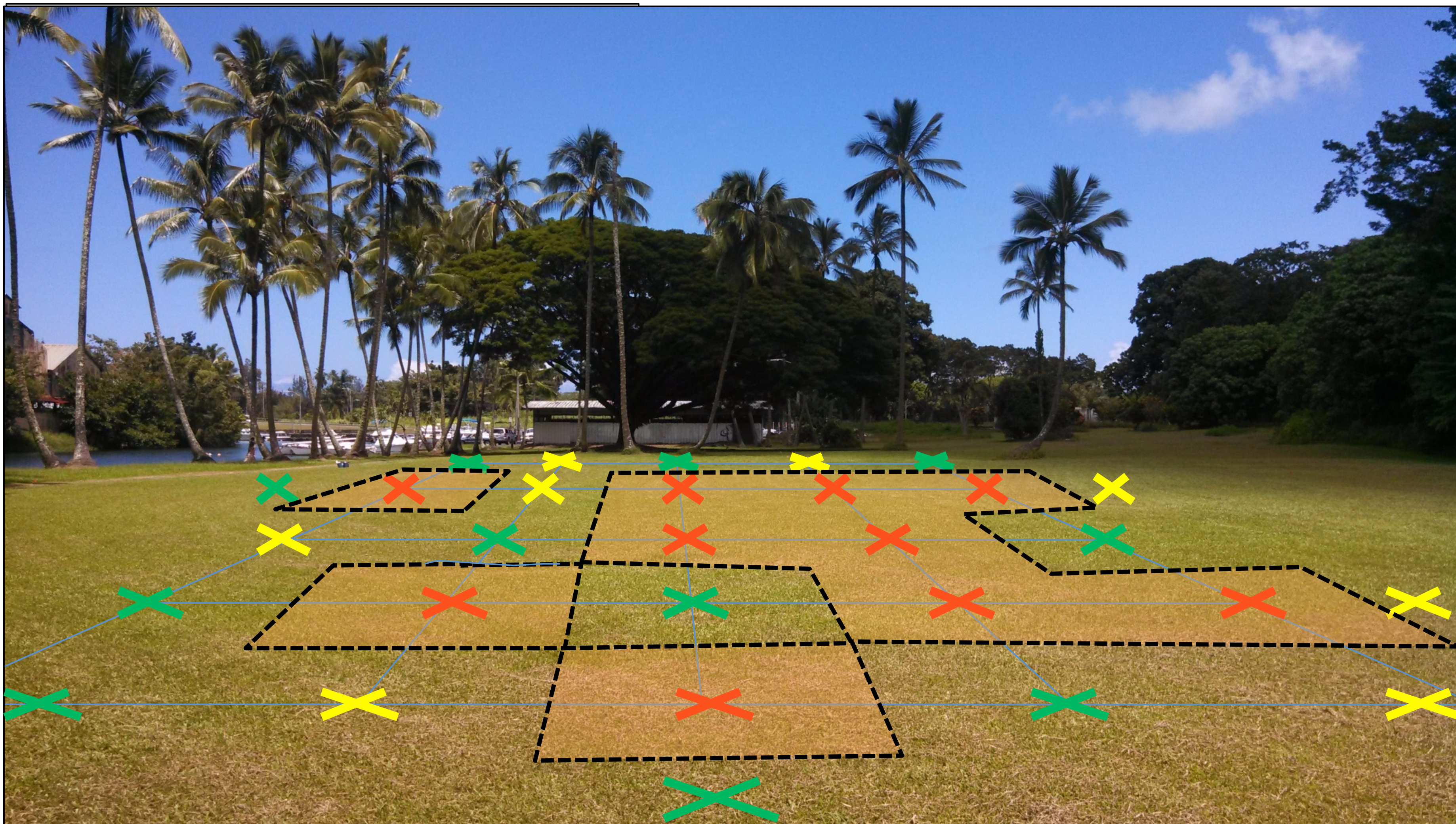
3. Francis Pitard Sampling Consultants, LLC: Francis Pitard *(www.fpscsampling.com)*
Advanced statistical sampling concepts with a focus on optimization of sampling protocols and mining exploration.

4. Field Practice!

Hypothetical Contaminated Soil Investigation

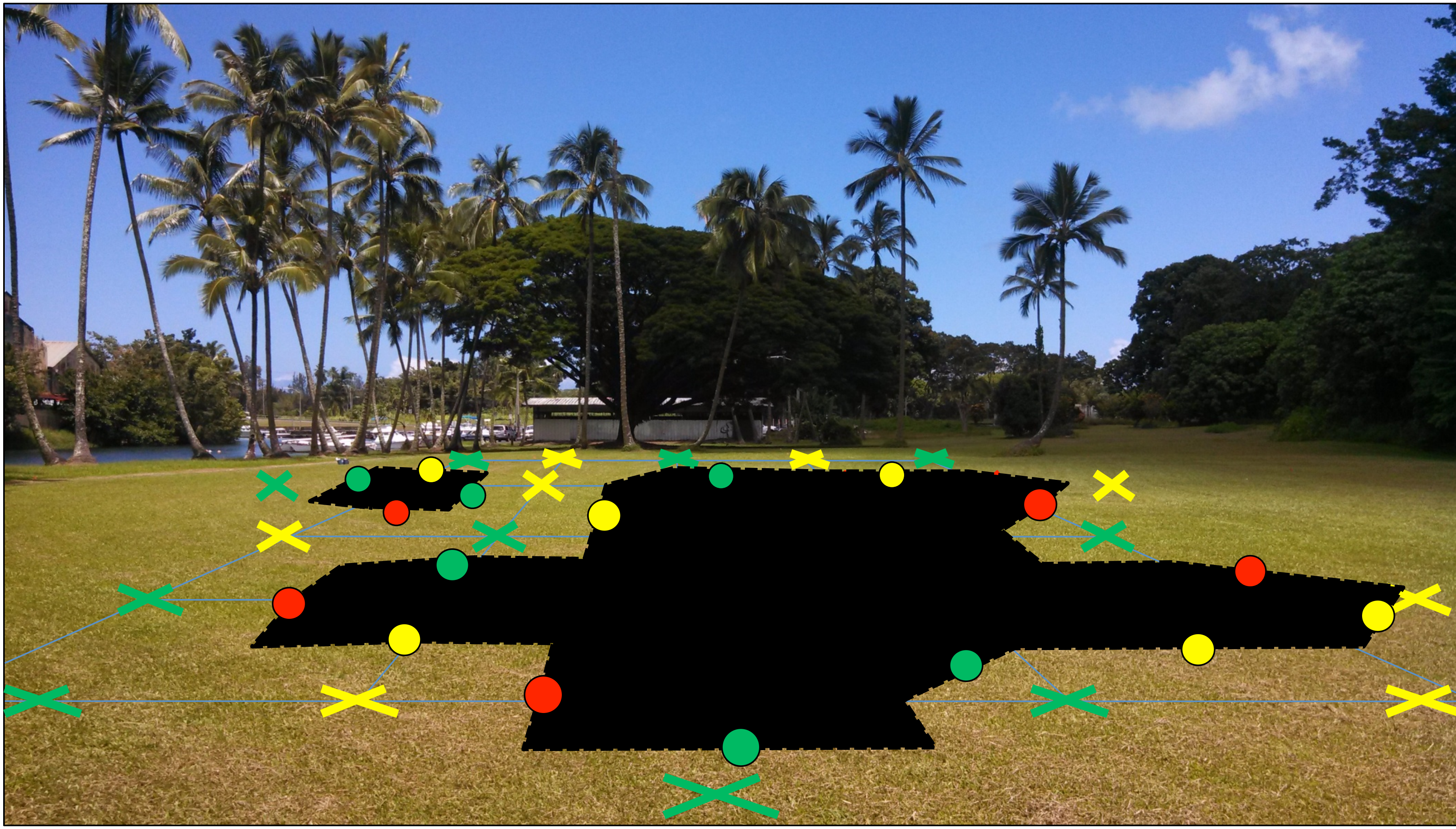


Soil Excavation Plan



Apparent
Isolated Cold Spot

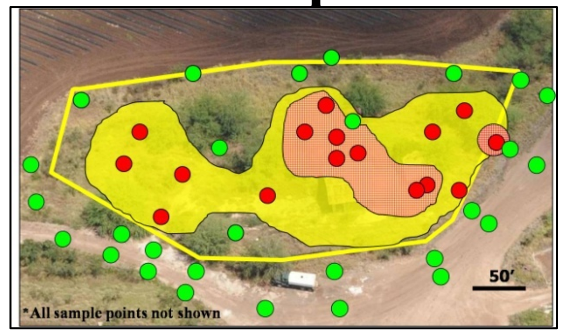
Failed Excavation Confirmation Samples??



What's Going On?

Need for multiple remobilizations and "step-out" investigations

→



Failed confirmation samples and over excavations

→

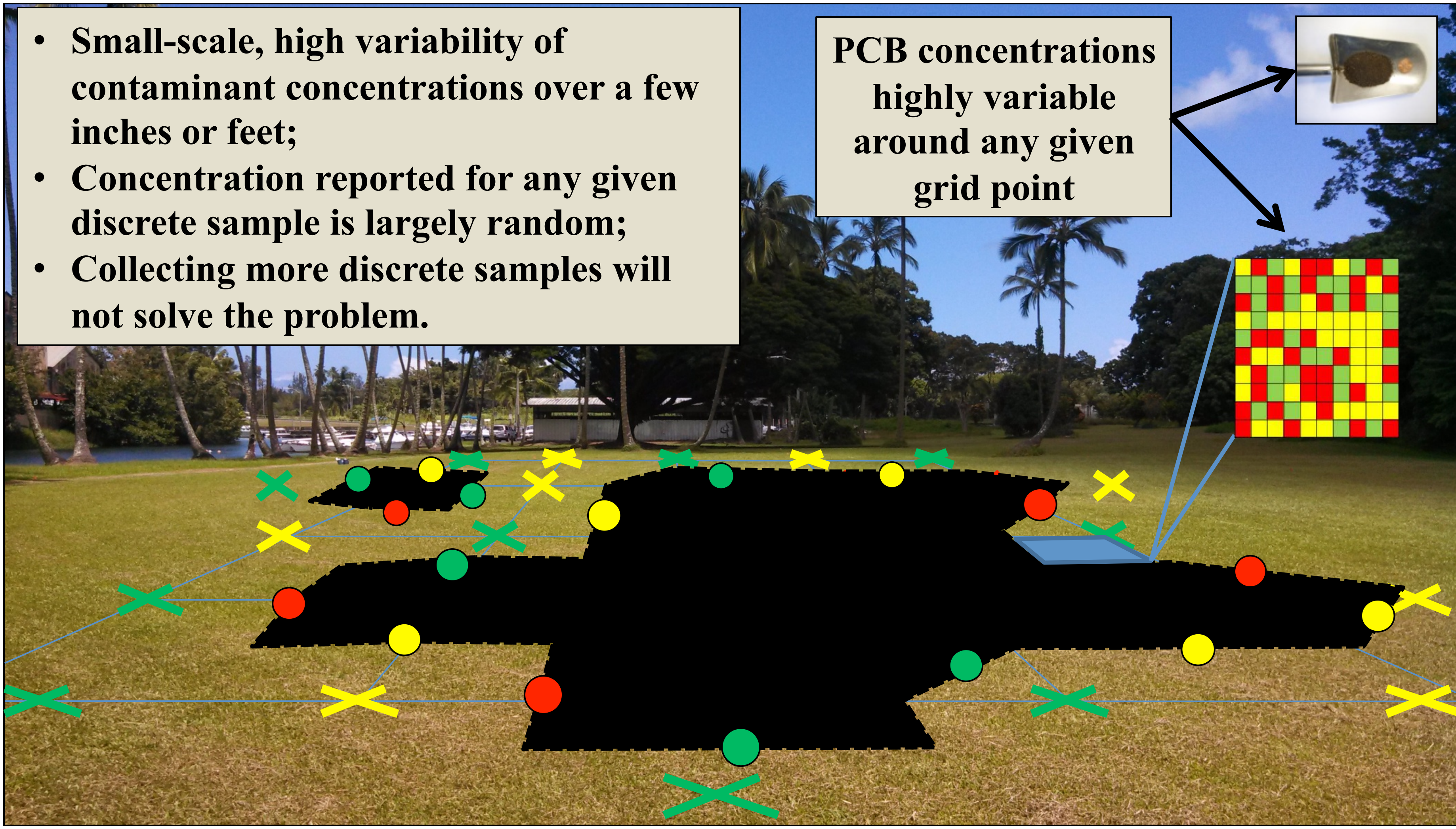
Failed *in situ* remediation and underestimation of mass

→

- Initially est benzene mass = 5 tons;
- 30 tons removed by SVE;
- Estimated remaining mass = 75 tons

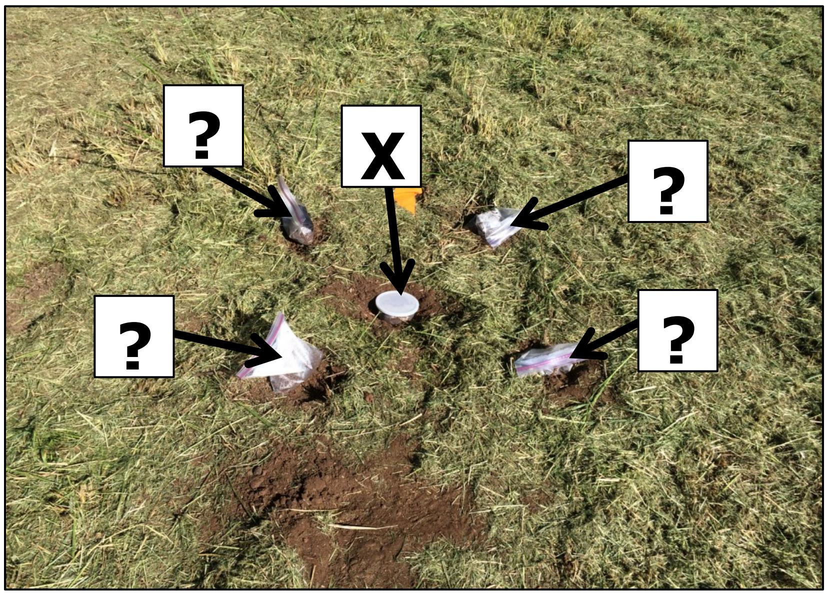
PCBs Concentrations in Soil Highly Variable over Short Distances

- Small-scale, high variability of contaminant concentrations over a few inches or feet;
- Concentration reported for any given discrete sample is largely random;
- Collecting more discrete samples will not solve the problem.



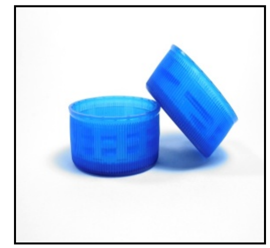
Every wonder...

"What if I moved my sample point over a few feet?



"What if the lab tested a different subsample?

Metals:
0.5-1.0 grams



VOCs:
5 grams

PCBs, Pesticides, Dioxins, TPH, PAHs:
10-30 grams

Hawai'i DOH Field Study (2014)

Detailed discrete sample collection at three sites with known contamination:

- **Arsenic (wastewater and/or sprayed pesticides)**
- **Lead (incinerator ash in fill material)**
- **PCBs (waste electrical oil)**

Decision Error Associated with the use of Discrete Soil Sample Data in Environmental Investigations

****Part 1: Field Investigation of Discrete Sample Variability*** **(October 2014 - posted)**

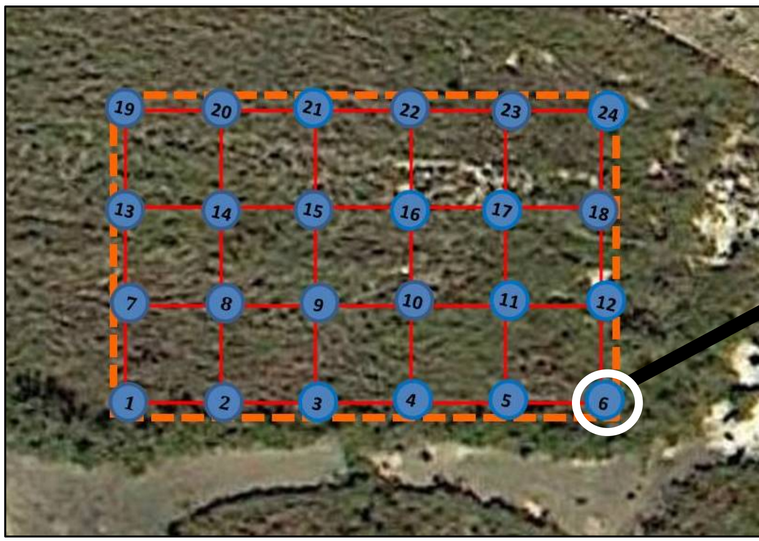
Part 2: Causes and Implications of Small-Scale Discrete Sample Variability **(in prep)**

http://eha-web.doh.hawaii.gov/eha-cma/Org/HEER/

See "What's New" postings

PCB Study Site
(small-scale variability probably similar to explosives compounds)

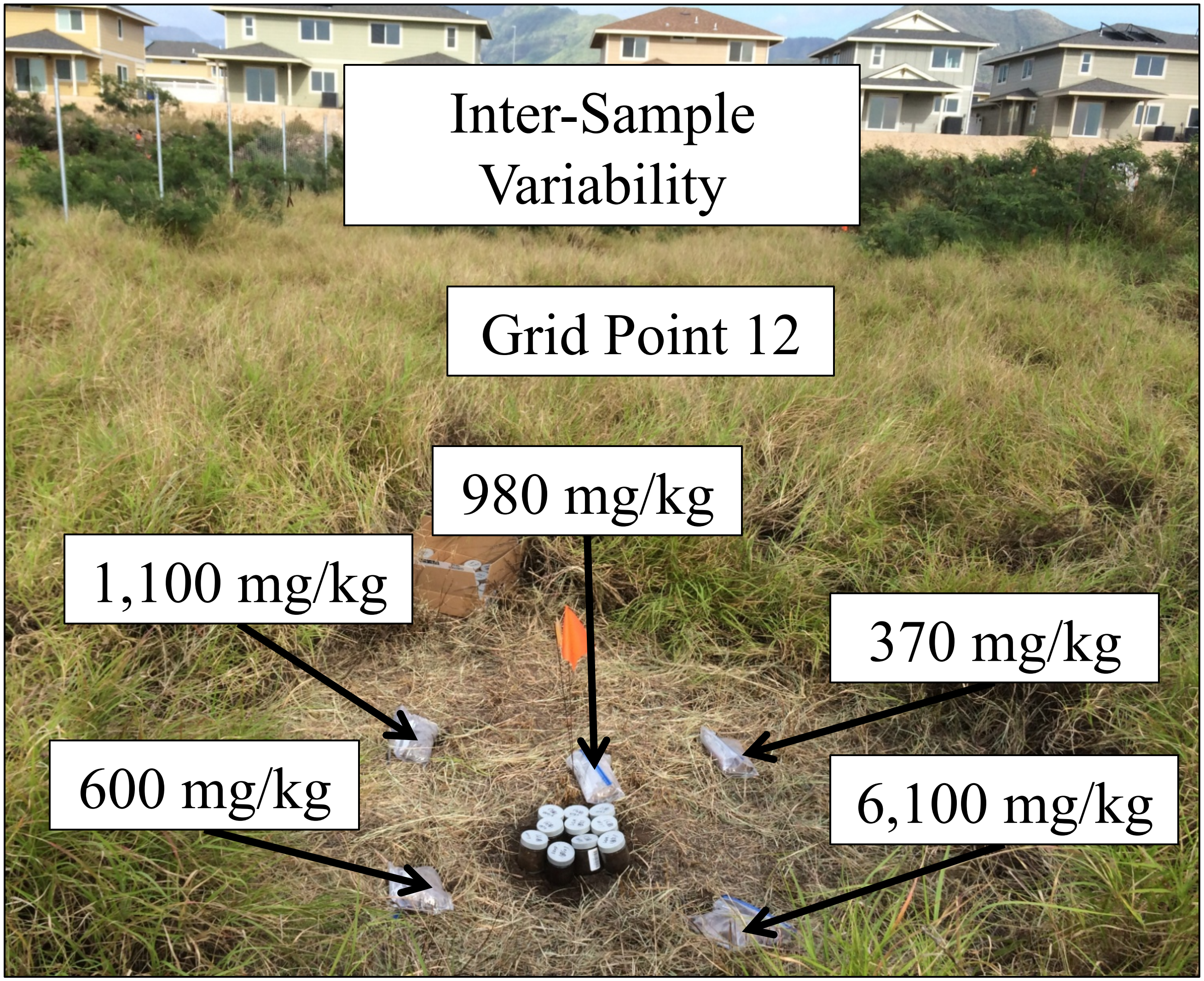
- 6,000 ft^2 area
- 24 grid points
- Known PCB contamination



Each Grid Point:

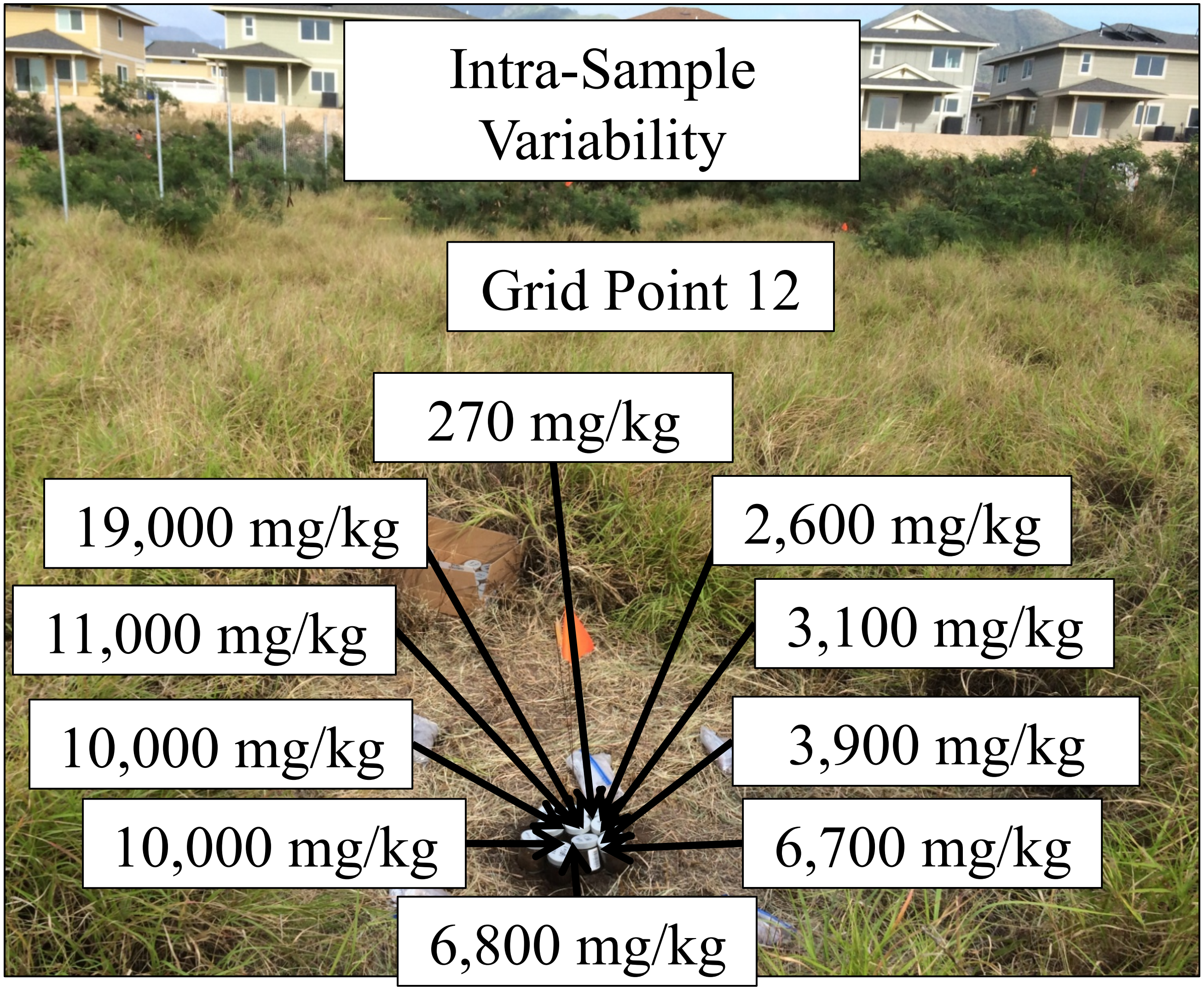
- Five co-located discrete samples ("inter-sample" variability)
- Sixth discrete sample split into ten subsamples for independent testing ("inter-sample" variability)

PCB Concentration Variability in *IS Processed* Discrete Samples
(Grid Point #12)



*Similar variability at lower concentrations

PCB Concentration Variability in Ten Subsamples from One Unprocessed Discrete Sample (Grid Point #12)



*Similar variability at lower concentrations

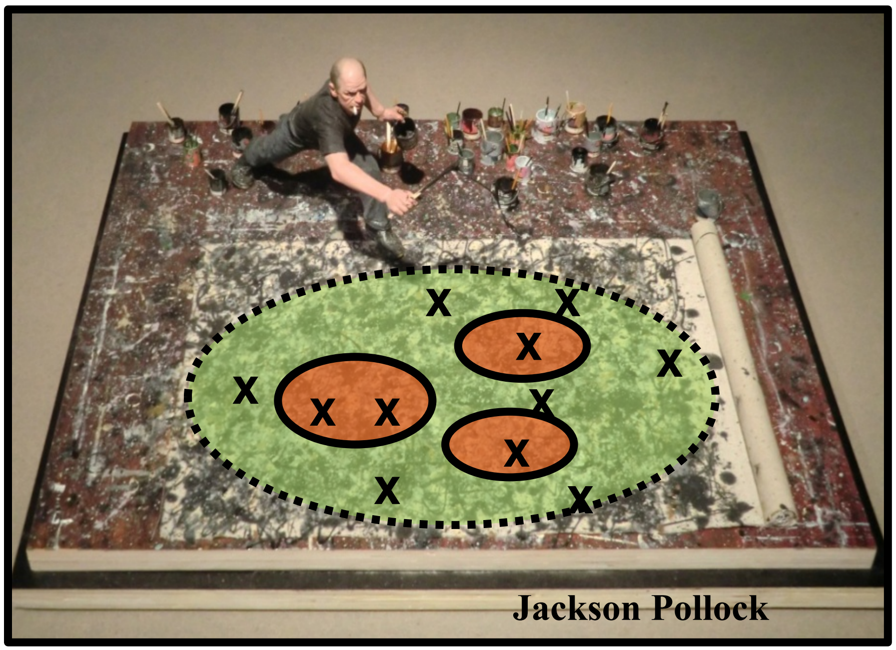
Estimated Average *Minimum* Variability of Discrete Sample Concentrations Around a Single Grid Point

Arsenic Site: 2X (study max 4X)
Lead Site: 8X (study max 40X)
PCB Site: 120X (study max 1,200X)

Think about the implications…

- Estimating the extent of contamination;
- Reliability of confirmation samples;
- Meaning of isolated hot spots & cold spots;
- Usefulness of isoconcentration maps;
- Adequacy of laboratory “homogenization”;
- Estimation of in situ contaminant mass;
- Data set representativeness for calculation of means and 95% UCLs…

Fooled by randomness…



Step back and look at the bigger picture…

Decision Unit (DU) and Multi-Increment Sampling (MIS)

- Designed to address small-scale variability/heterogeneity;
- Used in mining and agricultural industries for decades;
- Hawai’i began use of DU-MIS approaches in 2004;
- First guidance published in 2008 (updated 2011, 2015);
- Similar to ITRC’s “Incremental Sampling Methodology” (ISM)
- 15,000+ MIS samples collected in Hawai’i to date;
- Used at close to 100% of sites (surface, subsurface, non-VOCs and VOCs, etc.);
- Discrete data sometimes used to assist in designation of DUs.

Decision Units (DUs)

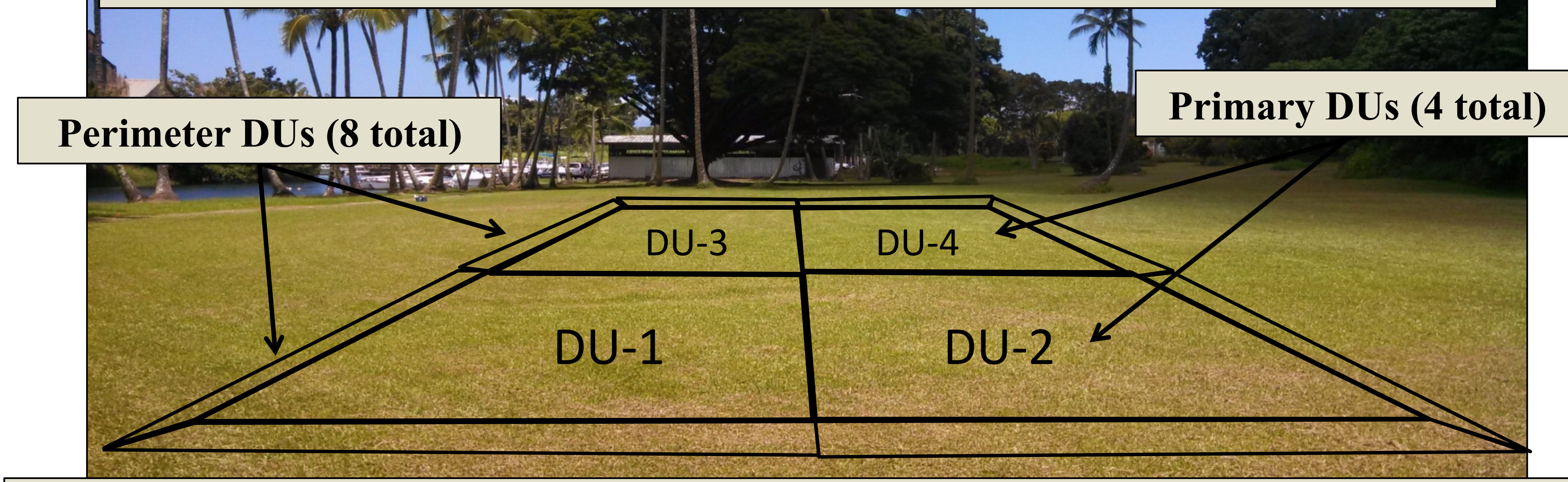
- Used to designate scale of decision making up front;
- "Area and volume of soil that you would send to the lab as a single sample if you could;"
- Objective: Estimate mean contaminant concentration within each designated DU.

Spill Areas

Exposure Areas

Decision Unit (DU) & Multi-Increment Sample (MIS) Approach

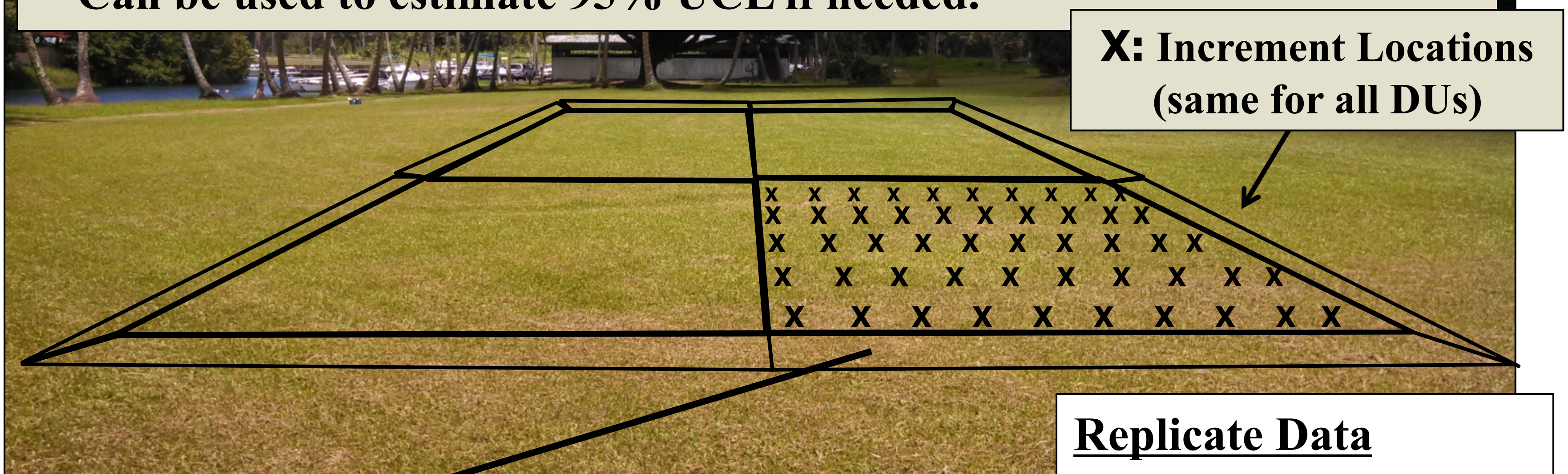
- Site divided into DUs based on agreed upon exposure areas or suspect, high-concentration areas (e.g., few 100 to few 1,000 ft^2);
- Objective to estimate average COPC concentration within DU;
- Perimeter DUs designated to confirm anticipated clean boundaries;
- Compare to risk-based screening levels.



- Primary Decision Units designated based on:
  - Locations of suspected spill areas,
  - Targeted exposure areas, and/or
  - Resolution desired for potential remediation.
- Perimeter DUs designated in anticipated clean areas to confirm extent.
- Similar to placement of discrete sample locations but much higher data quality.

Decision Unit (DU) & Multi-Increment Sample MIS Approach

- Sampling Theory: Very large (1-2+kg) soil sample collected in each DU from 30 to 100 locations (10-50 grams per "increment");
- Systematic random grid easiest to sample (and more representative);
- Processed at laboratory and tested as single sample;
- Two replicate MIS samples collected from different locations in select DUs to test representativeness of original sample;
- Can be used to estimate 95% UCL if needed.

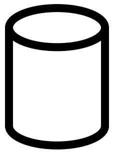


<u>Replicate Data</u>
Sample A: 140 mg/kg
Sample B: 179 mg/kg
<u>Sample C: 135 mg/kg</u>
RSD = 16% (good!)
95% UCL: 192 mg/kg

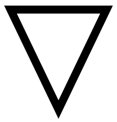
Field Tools

(soft soil vs gravel, silt vs sand, surface vs subsurface, etc.)

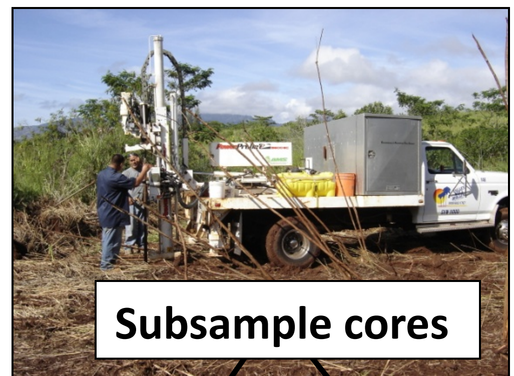
Increment Shape



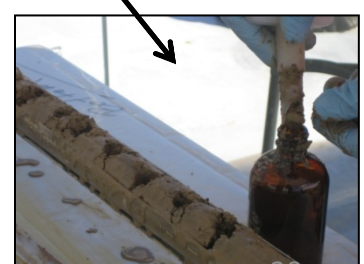
Good



Not good




Core wedges

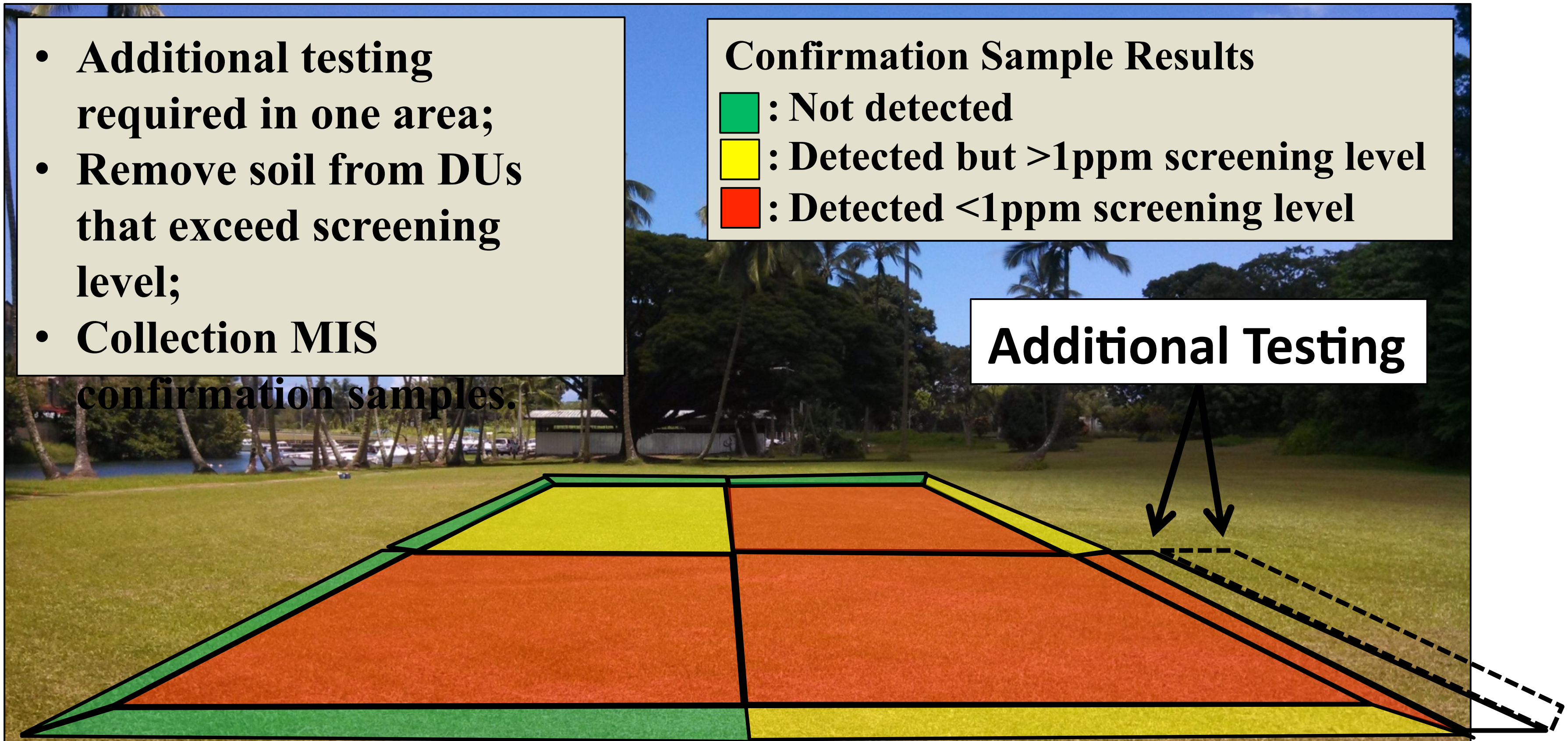

Plugs (+/- COH_4)

Decision Unit (DU) & Multi-Increment Sample MIS Approach

- Additional testing required in one area;
- Remove soil from DUs that exceed screening level;
- Collection MIS confirmation samples.

Confirmation Sample Results

- : Not detected
- : Detected but >1ppm screening level
- : Detected <1ppm screening level



- Slightly higher initial field costs (e.g., 700 "soil increments" collected vs 25 discrete samples);
- Expedites decision making and minimizes need for remobilizations;
- More defensible data and greater confidence in decision making (e.g., PCBs do not exceed risk-based screening level for defined exposure areas);
- More cost and time efficient in the long run.

Mixed Source Area & Exposure Area DUs
(former power plant)

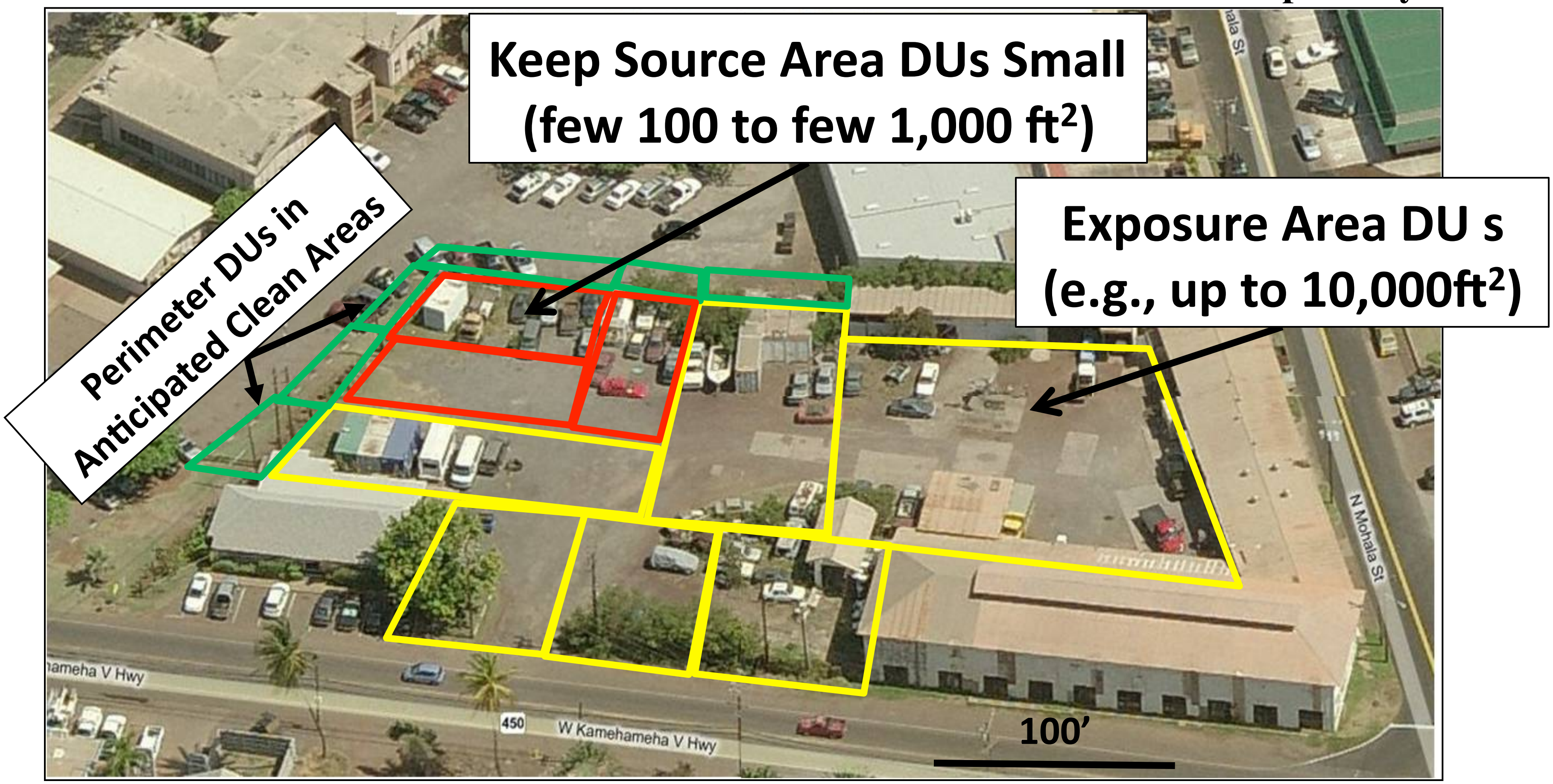
For example only

100’

Former Power Plant Decision Unit Designation

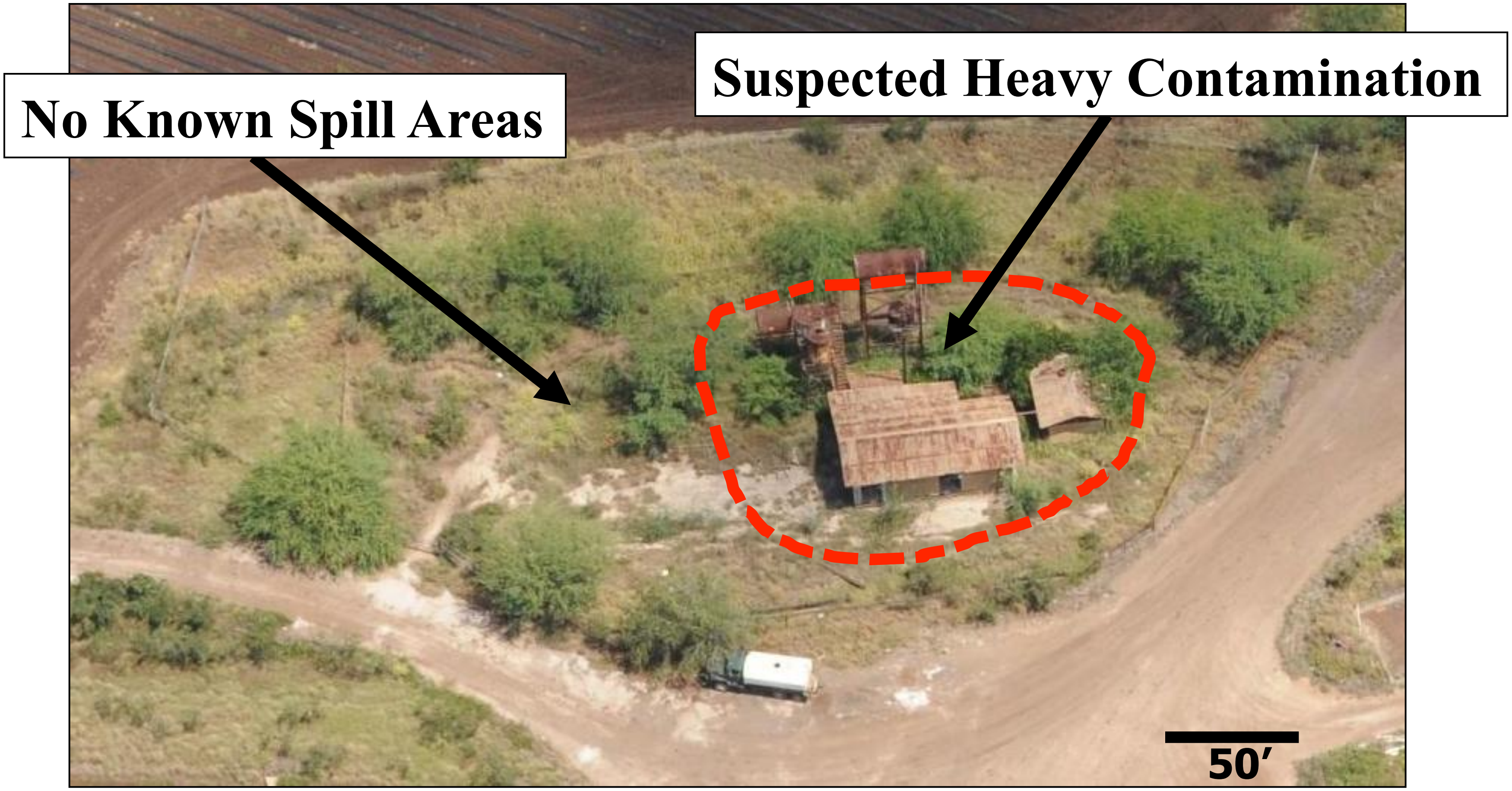
(entire property usually tested)

For example only



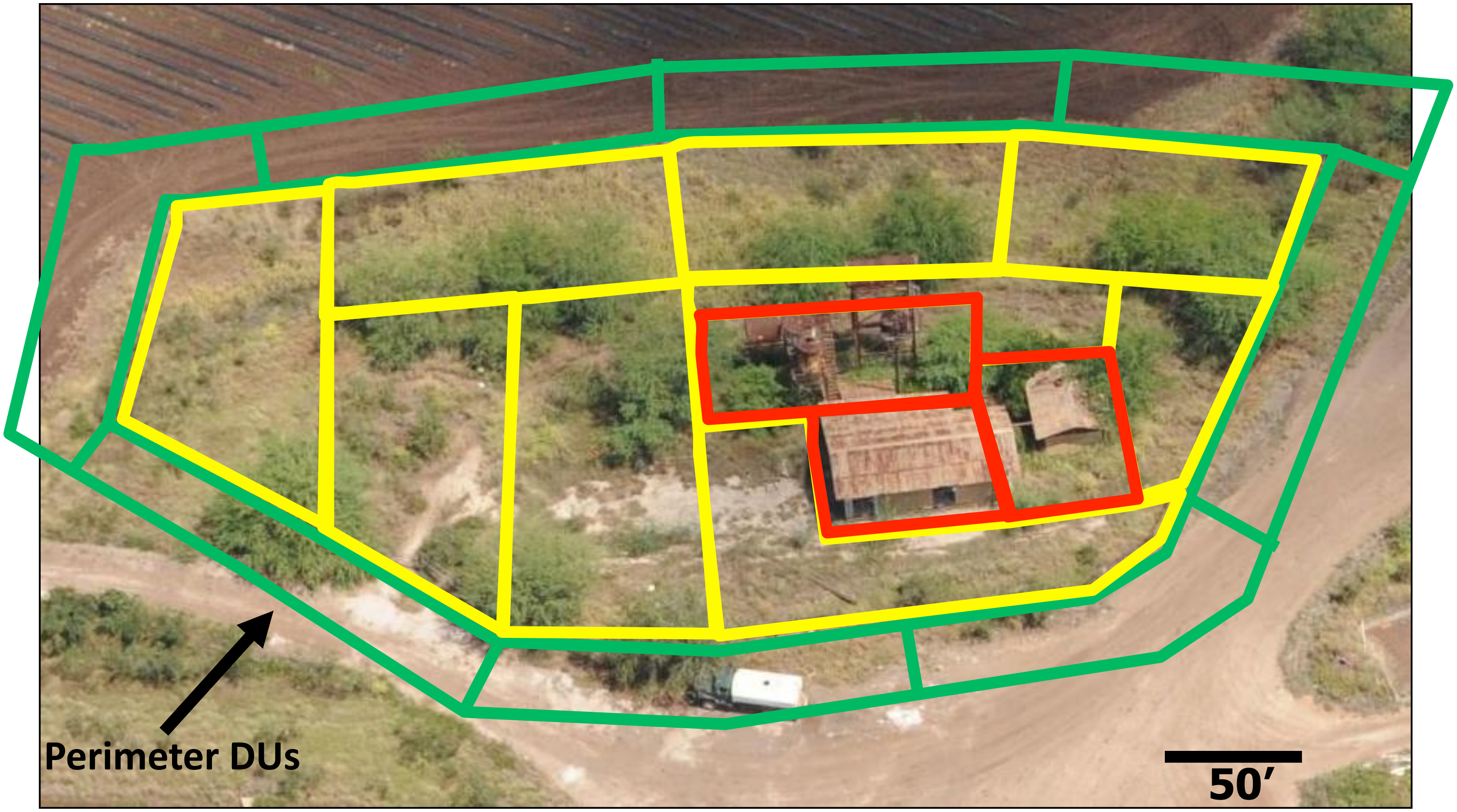
Former Pesticide Mixing Area
(surrounding field redeveloped for residential homes)

For example only



Former Pesticide Mixing Area Decision Unit Designation

For example only



Source Area DUs: Heavy contamination anticipated

Exposure Area DUs: Hypothetical house lots

Source Area & Direct Exposure DU Designation

Smaller Source Area DUs (Triazine Pesticides; leaching hazards)

Larger Exposure Area DUs (Arsenic & Dioxins; direct exposure hazards)

Use of Discrete Data to Assist in DU Designation

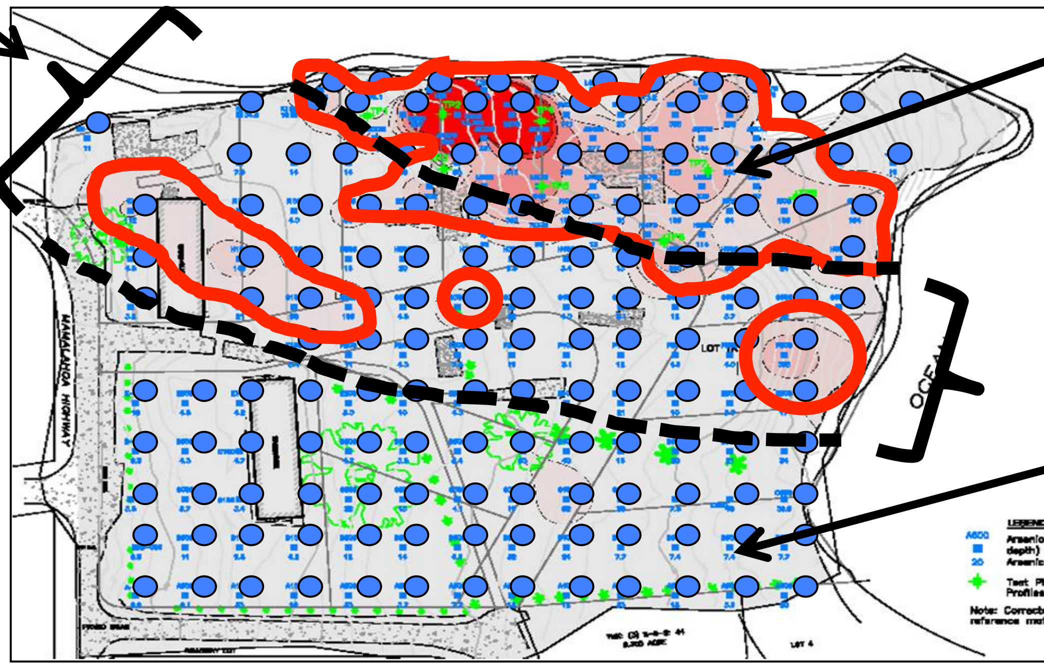
(9-acre former pesticide mixing site)

DANGER ZONE!

Zone of isolated "cold spots" and "hot spots" reflecting random, small-scale variability above and below screening level.

Arsenic Isoconcentration Map

Obviously Contaminated



Obviously Clean

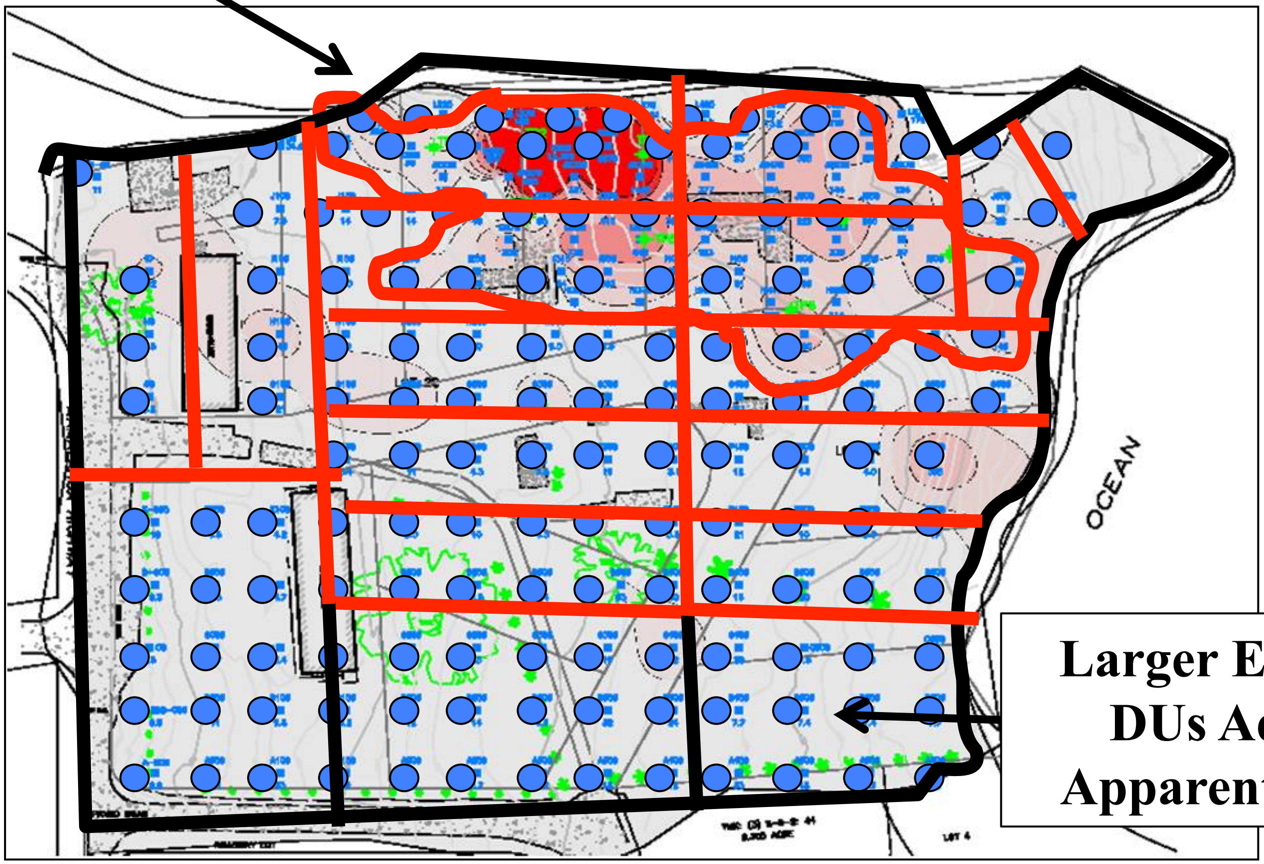
● Discrete Sample

For example only

Use of Discrete Data to Assist in DU Designation

(9-acre former pesticide mixing site)

Small DUs in Source Area (tens to few hundred cyds)



Larger Exposure Area DUs Adequate for Apparent Clean Areas

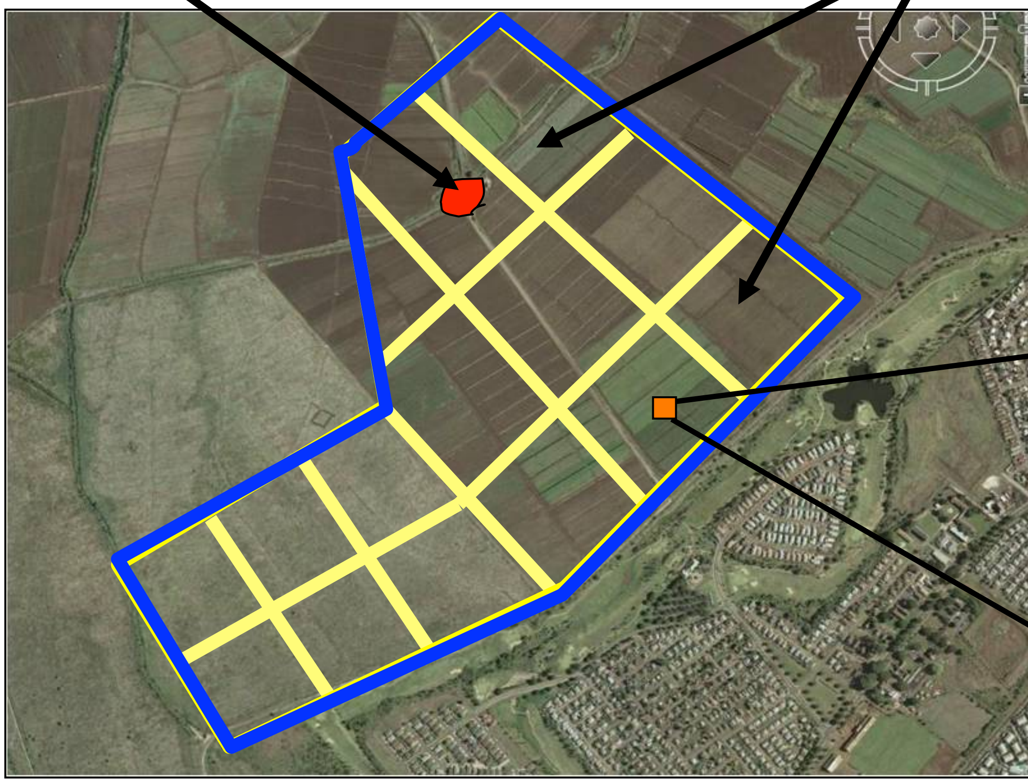
One-acre house lots planned

Really Big Decision Units!
(400-acre former sugarcane field)

Former Pesticide Mixing Area (investigated separately)

Large-Scale Screening (15 DUs)

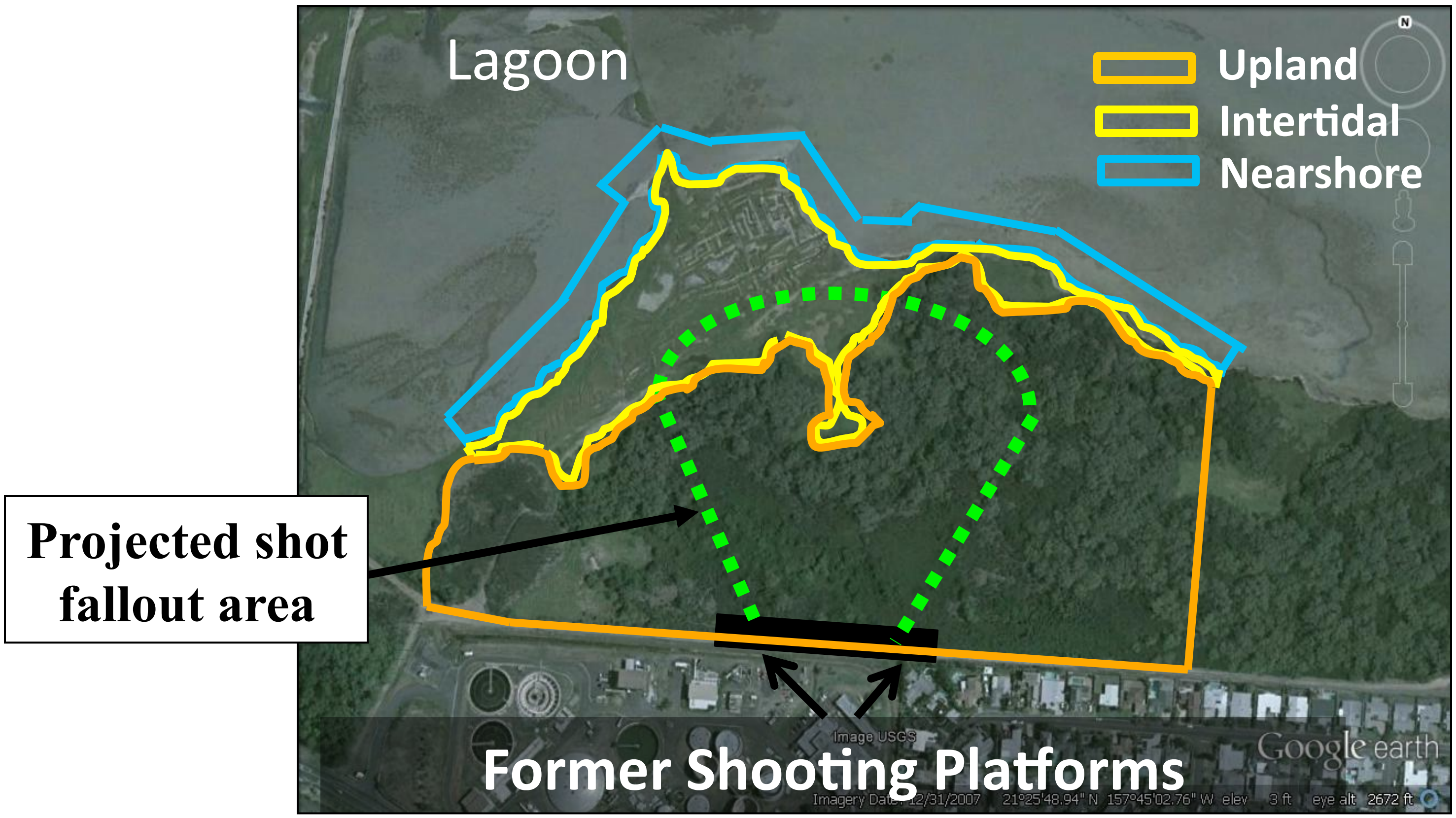
- **Residual pesticides in former ag field?**
- **MC in former bombing range?**



Higher Resolution

- **Test hypothetical lots;**
- **e.g., fifty-nine random, 5,000 ft² Exposure Area DUs.**

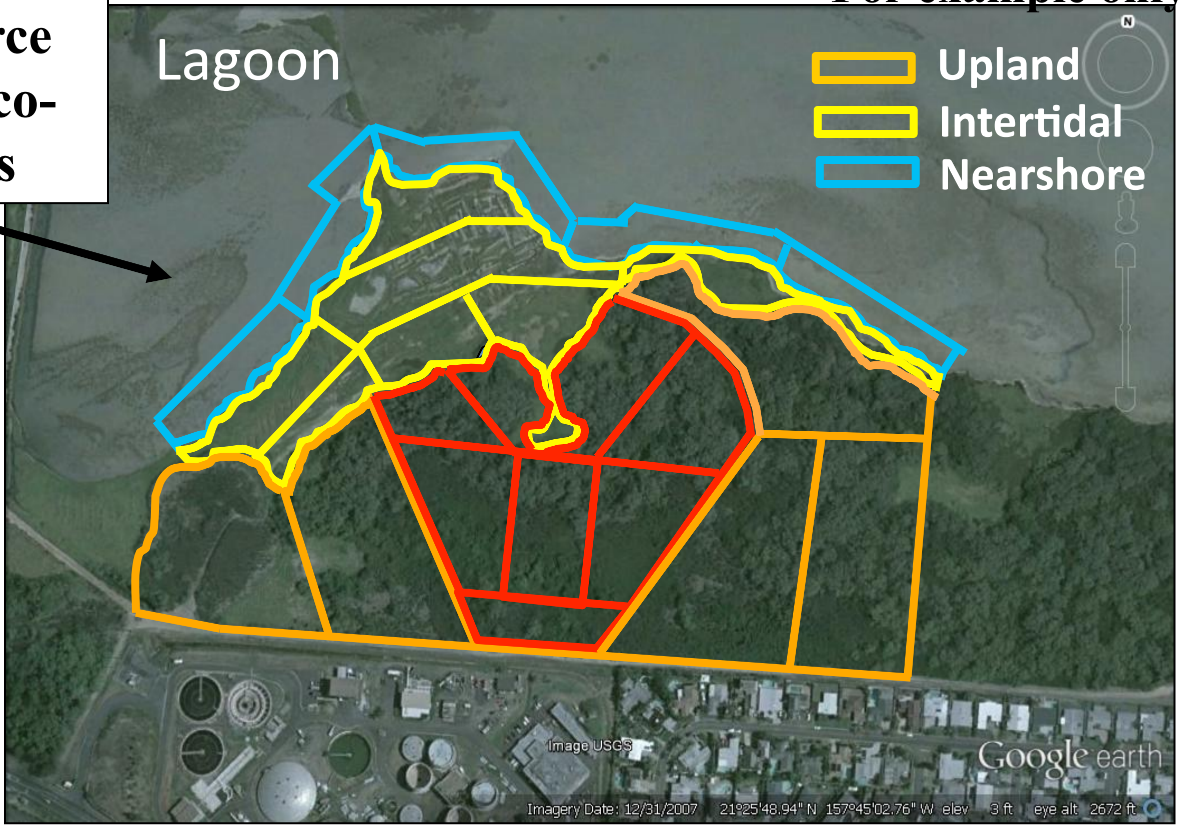
Former Skeet Range
(Source Area Plus Ecological Habitat Based DUs)



Former Trap-Skeet Range
Decision Unit Designation

For example only

Mix of Source Area and Eco-Based DUs

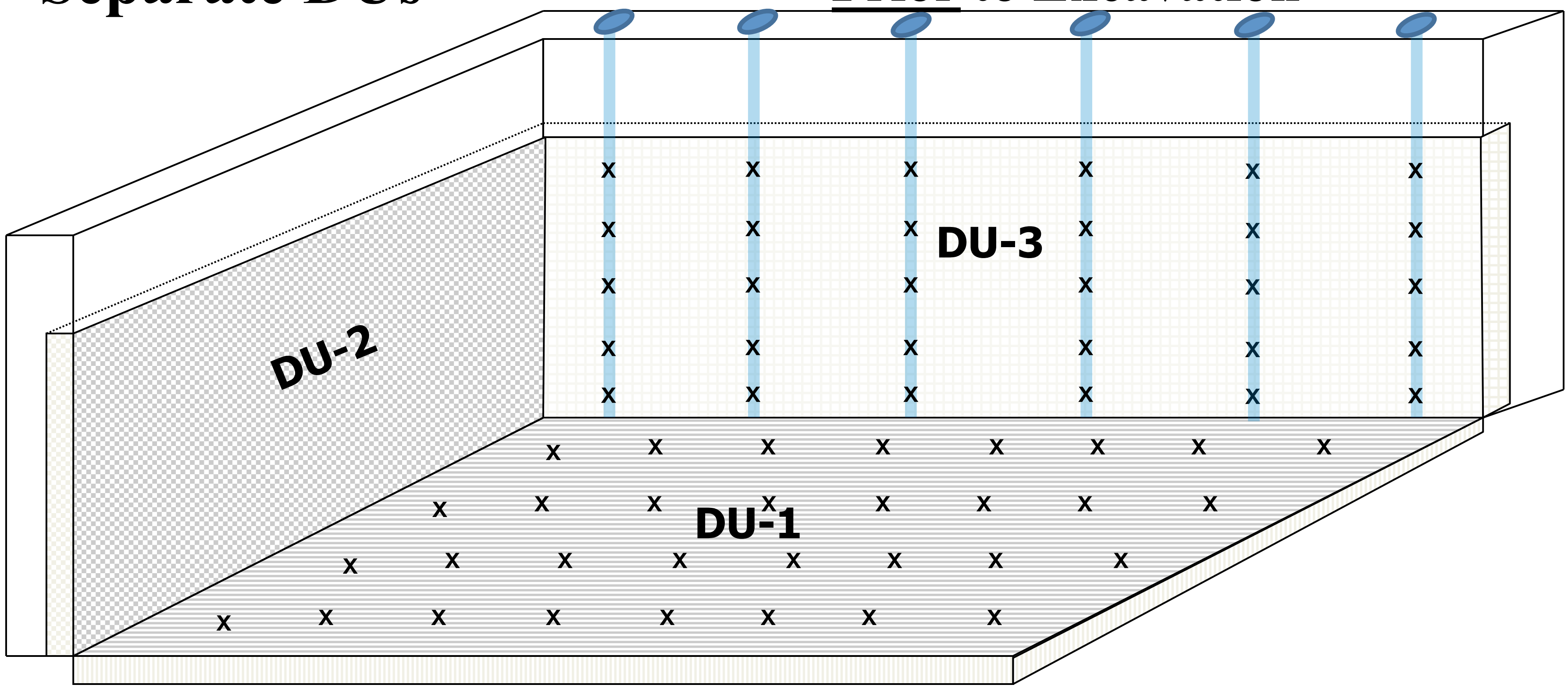


- **Rectangular DUs are easier to sample;**
- **Approximate increment spacing can be calculated based on DU area and desired number of increments (HDOH TGM Section 4).**

Excavation Decision Units

Floor and Sides Tested as Separate DUs

Sidewall MI Confirmation Sample Collected from Borings <u>Prior</u> to Excavation



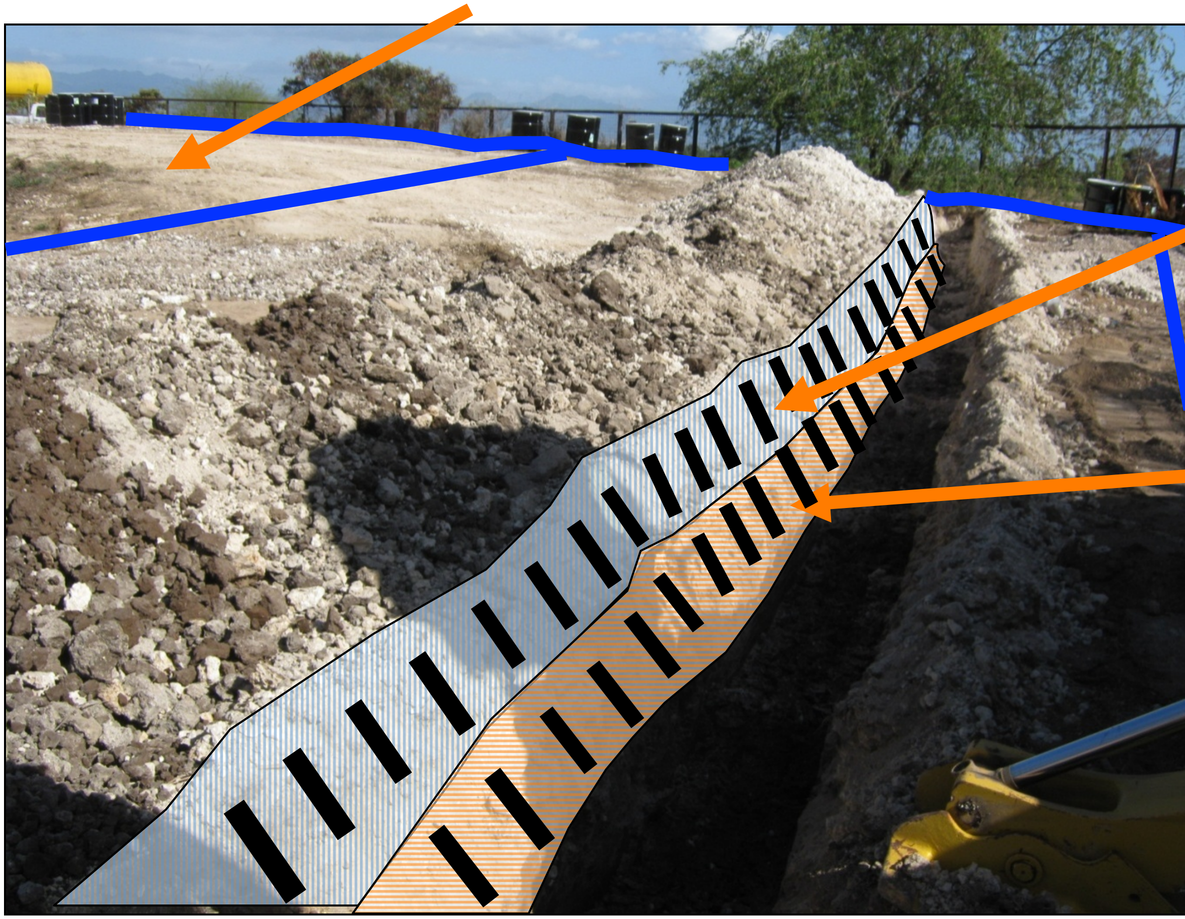
Stockpile Decision Units

***Unrestricted Use: Maximum DU volume 100-400 cubic yards**
Restricted Use: Maximum DU volume up to 2,000 cubic yards

*Residential Exposure Area DU: 100 cubic yards covers a 5,000 ft^2 lot to a depth of six inches

Subsurface MI Samples From Trenches

Surface DU (0-6”)



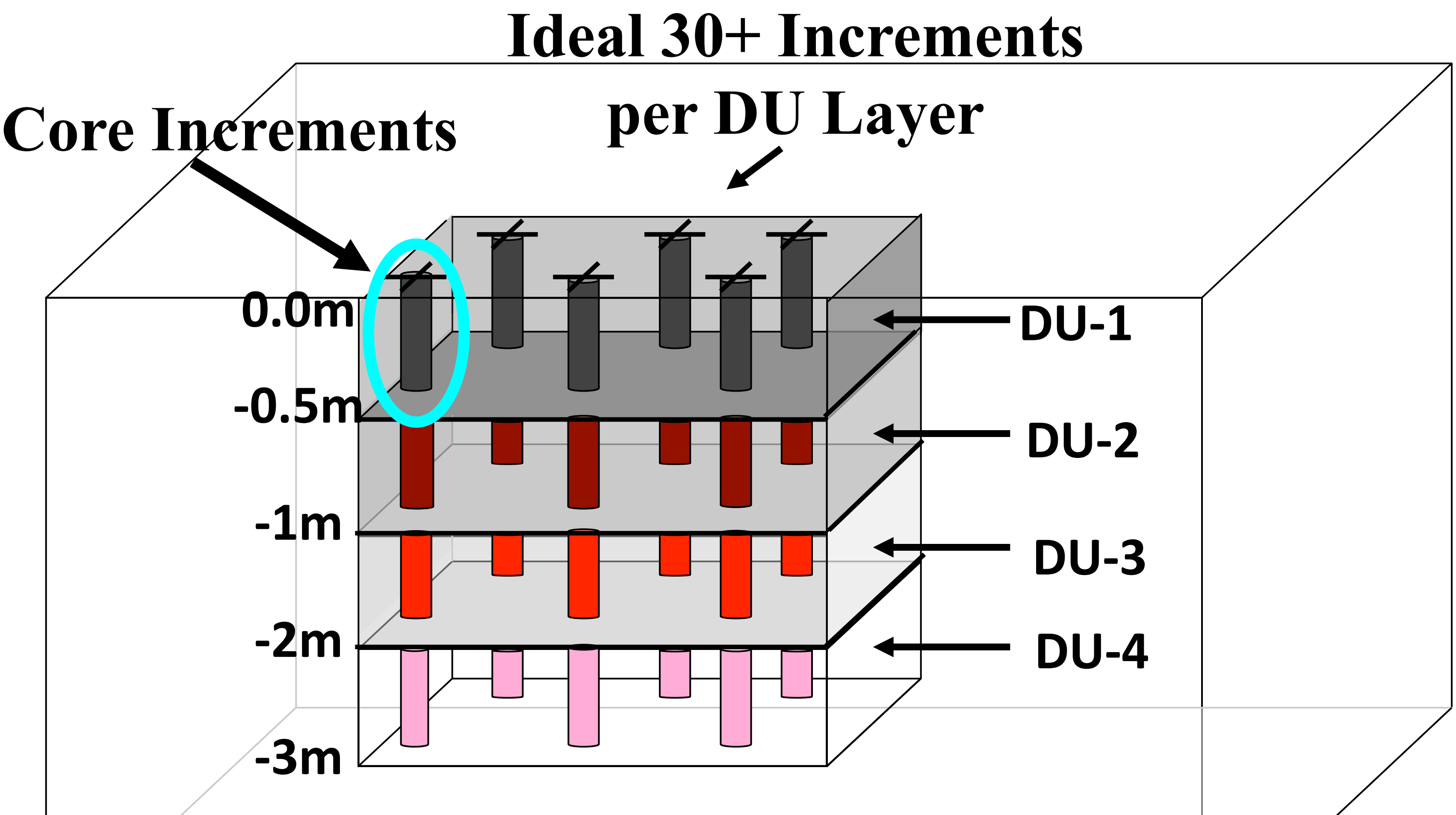
Subsurface DU Layer (6”- 1 ft)

Subsurface DU Layer (1 ft – 3 ft)

Floor too mixed to sample

Soil Increment (elongated for better coverage)

Collect MI Samples From Target DU Layers

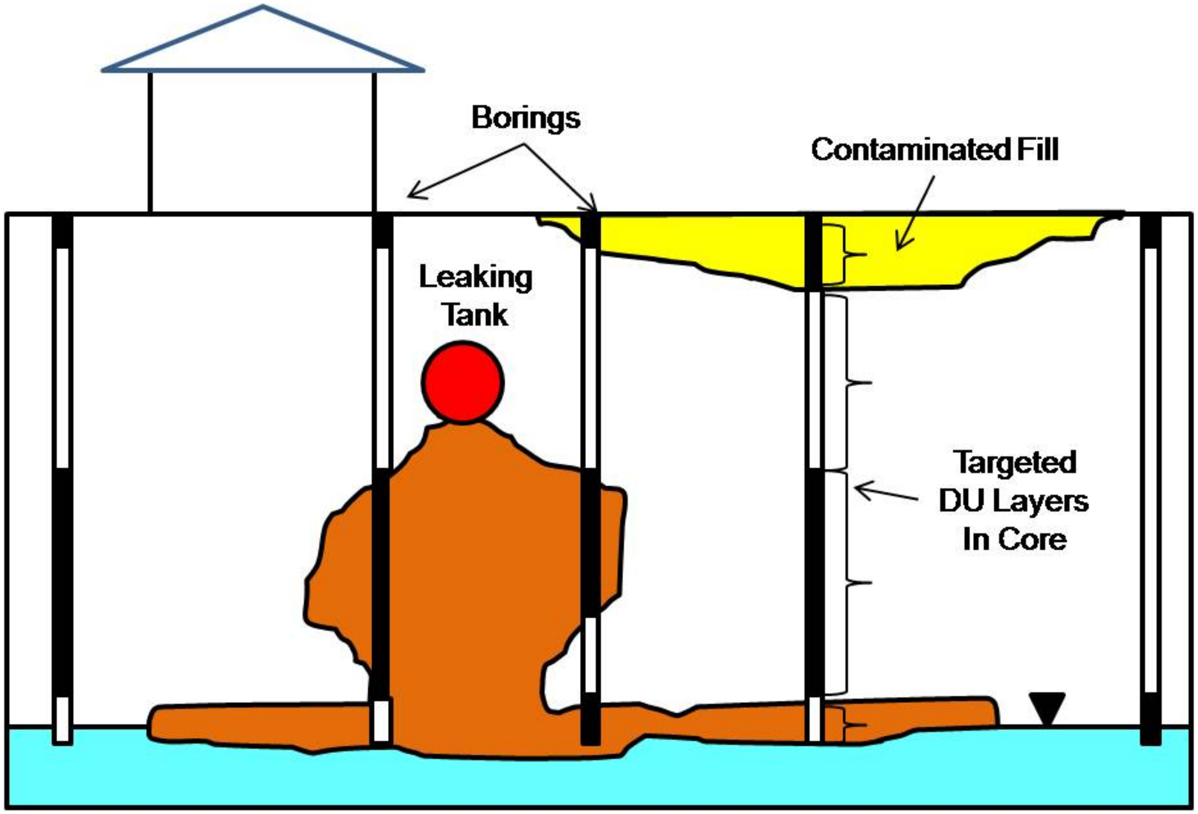


- DU Layers designated based on spill characteristics and to optimize remedial actions;
- Core increments for targeted DU Layers subsampled and combined to prepare a bulk MIS sample.

Push Rig Collection of Subsurface Increments (300+ feet/day in easy soil)

- **Core increments subsampled using regularly spaced plugs or continuous wedge;**
- **Combined into bulk MIS sample for targeted DU layer.**

Single Boring "DUs"



- Estimate lateral or vertical extent of contamination;
- Boring divided into <u>targeted intervals</u> (*not* discrete depths);
- Entire core interval sent to lab for processing;
- Presence or absence only;
- Risk of false negatives.

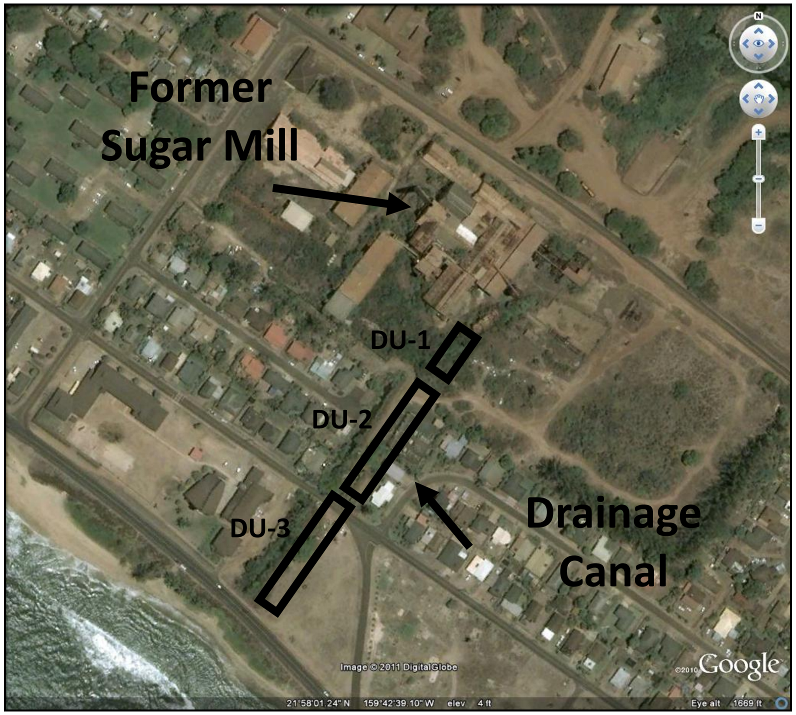
Multi-Increment Samples for VOCs

Traditional 5-gram VOC sample

Planned 50- to 150-gram VOC sample

- **Pre-weighed sample jars with methanol provided by laboratory (1:1 anticipated soil mass to methanol);**
- **Five gram plugs from targeted DU (or core) combined and preserved in methanol in field (alt: individually frozen and sent to lab for combining in methanol);**
- **Use Single Ion Methodology (SIM) for lower reporting limits;**
- **Allows for testing of very large soil samples for VOCs.**

Sediment Sampling



Long, narrow DUs

DU-MIS Site Investigation Approaches
-You get what you pay for-

- Increased time in site history research and collection of samples;
- Decreased laboratory costs;
- More defensible and reliable data for decision making;
- Decreased uncertainty in future environmental liability (reduced future liability);
- Expedited final cleanup and closure;
- More cost and time efficient in the long run.

MIS at Munitions Sites in Hawaii

- **MIS is an effective tool for munitions sites as DUs can be easily identified by usage (i.e.- target fans, impact areas, bombing targets, berms, etc.).**
- **Given the potential size of the DUs, MIS is more cost effective than discrete sampling.**
- **MIS is logistically feasible and easy to do as most MC contamination is on the surface.**

Lessons Learned from MC Sampling Using MIS

- **MC contamination is not the major risk driver at impact areas, bombing targets, and maneuver areas. The EHE score consistently outweighs the HHE score at these types of MMRP sites.**
- **MIS is effective at delineating MC contamination at small arms (pistol, rifle, and skeet) ranges.**

Conclusions Drawn From MC Sampling Efforts

- **Chemical (explosives and metals) contamination is virtually non-existent at sites where large MEC items (e.g.- 155mm, 105 mm) were found or utilized.**
- **Lead is the typical driver of MC risk at small arms ranges.**
- **The degradation of underwater munitions does not appear to present a chemical hazard to the environment.**
- **MC sampling is most effective at small arms ranges and at depots where munitions are manufactured.**