NEIL ABERCROMBIE
GOVERNOR OF HAWAII

DIRECTOR OF HEALTH

STATE OF HAWAI'I
DEPARTMENT OF HEALTH
P.O. Box 3378
HONOLULU, HAWAI'I 96801-3378

In reply, please refer to:
File: EHA/HEER Office

2011-143-RB

March 2011

To: Interested Parties

From: Roger Brewer & John Peard
Hazard Evaluation and Emergency Response (HEER)

Subject: Technical Guidance Manual Notes: Decision Unit and Multi-Increment* Sample Investigations

This technical memorandum presents a compilation of notes and recommendations for Decision Unit (DU) and Multi-Increment Sample (MIS) site investigations based on the experiences of State, Federal and private environmental professionals since publication of the HEER office Technical Guidance Manual (TGM) in 2008 and 2009. This memorandum serves as an addendum to that guidance and to Sections 3, 4 and 5 of the guidance in particular, which discuss Decision Unit designation, Multi-Increment Sample (MIS) collection and soil and sediment sample collection methods. In some cases the information provided is new but in general the memorandum simply expands on and clarifies issues already discussed in the TGM. The information presented in this memorandum will be incorporated in future updates to the TGM along with consideration of additional input from stakeholders.

The HEER TGM will be continually updated as additional experience in DU-MIS investigations is gained. Comments and suggestions from the public are welcome and should be addressed to Roger Brewer (roger.brewer@doh.hawaii.gov) or John Peard (john.peard@doh.hawaii.gov) of the HEER Office.

* *"Multi-increment" is a registered trademark of EnviroStat, Inc.*

Decision Unit Designation and Characterization (see TGM Section 3)

- Phase I Reviews: Refer to historical Sanborn Fire insurance maps (Figure 1; produced between late 1800s to 1970s, available at UH-Manoa library among other sources), historical aerial photos (e.g., R.M. Towill Corp collection), archives for former sugar plantations (e.g., UH-Manoa library and Hawai‘i Agricultural Research Center) and interviews with people familiar with the area to assist in identification of pesticide mixing areas and other former agricultural operations at high risk for contamination (see also TGM Section 9);
- DUs and associated Decision Statements should be established for all investigations, including cases where discrete samples are collected;
- As a default, consider the upper *four to six inches* of soil for surface DUs (variously stated as six or twelve inches in the 2009 TGM) with the need for deeper characterization based on site-specific investigation objectives;
- Other factors that may assist in DU selection include visual observations (i.e., structural remnants, low points/runoff collection points, etc.), site topography (e.g., slopes, pits, ditches), review of other historic records and aerial photos, etc.;
- Consider clearing heavily overgrown DUs prior to sampling or cutting strategically located, access paths into very large, heavily overgrown DUs in order to facilitate field work (Figure 2; reduction in field time and effort generally outweighs cost of clearing).

Multi-Increment Sample Collection (see TGM Sections 4 & 5)

- The distribution of increments within each DU (systematic or stratified random) should be evenly spaced in all directions;
- The following equations can be used to help approximate increment spacing based on the DU area and the desired number of increments (see Table 1; based on rectangular DUs, adjust as needed in field):

$$Increment Spacing = \sqrt{\frac{DU\ Area}{\left(\sqrt{\#\ Increments} - 1\right)^2}}$$

Or for a pre-specified number of increments:

$$Increment Spacing\left(50 increments\right)\right) = \sqrt{\frac{DU\ Area}{37}}$$

$$Increment Spacing\left(40 increments\right)\right) = \sqrt{\frac{DU\ Area}{28}}$$

$$Increment Spacing\left(30 increments\right)\right) = \sqrt{\frac{DU\ Area}{20}}$$

- Targeting 40 increments and rounding off to the nearest foot generally ensures that an adequate number of increments will be collected (see Table 1; rounding the calculated spacing up slightly decreases the number of increments that will be collected while rounding down slightly increases the number of increments);
- Documenting the location of individual increments collected within a DU is not necessary, only the boundaries of the DU need to be mapped;
- The location of each increment doesn't not normally need to be flagged or otherwise marked in the field;
- Flagging the locations of increment rows along the perimeter of a DU is usually adequate to guide collection of increments within the DU itself, with a few rows of flags placed within long DUs as needed;
- Ideal increment is core-shaped (Figure 3);
    - Soil sampling tubes and auger-bit drills produce core-shaped increments;
    - Hand trowels tend to produce wedge-shaped increments, biased towards the upper section of the targeted soil and are generally not recommended or should be used in a manner that extracts a core-shaped increment;
- Both sampling tubes and drills are very effective for surface soil increment collection and generally preferable in soft soils and clay-rich soils that are not rocky (see Figure 4)
- Sampling tubes are very simple and effective in soft soils and serve as a useful backup or alternative to a drill (see Figure 4a-b);
- Slide hammers are also effective for collecting harder packed soils but require considerable effort and energy to use in the field (see Figure 4c-d);
- A cordless drill and paper-plate can be very time- and cost-effective for soft or hard-packed soils without significant gravel but generally requires two people (Figures 4e-h);
    - Use a high-powered cordless drill with a 28V battery or a portable generator and power drill, weaker drills stick in clayey soils and overheat (see Figure 5a; generally up to 100 increments per battery; field chargers available for vehicles);
    - For relatively soft soils, use a one-inch, hollow auger bit or a wide-flight auger bit to improve removal of soil from the ground and control the mass of soil collected (see Figure 5b, generally produce 30 grams of soil per six-inch depth);

    - Drills powered by portable generators can often be rented from local tool rental or hardware stores (Figure 5c-d);
    - For very hard or gravelly soils a masonry bit and hammer-action drill can be used to loosen the soil to the targeted depth but be careful not to grind rock into the soil sample;
- Always take alternative sampling tools to field as a backup and to break through hard surfaces or cut through concrete or asphalt (e.g., mattocks, pick hammer, o'o pry bar, drills with core barrels, trowels, shovels, etc.; see Figure 5e-g);
- Consider furrows, trenching or potholes for sampling of shallow, subsurface DUs or direct-push rigs to collect increments from deeper soils (see Figure 5h-j);
- Consider direct-push rigs for collection of subsurface soil increments (see also *Subsurface Investigations*);
- Use a rope or tape measure to mark increment spacings for long, narrow DUs; collect increments in zig-zag pattern (Figure 6);
- For consistency within and between DUs, carry a pre-weighed, target increment mass of soil in a baggie to ensure consistent increment size (e.g., 30 grams) or use a cup with markings calibrated to specific soil masses;
- Try to keep MI samples to a maximum of 2kg for handling by the lab (labs may charge extra for disposal of excess soil), although this may not be possible for DUs where more than fifty increments are collected;
- Larger MI samples could be sub-sampled in the field if a representative sub-sampling method is included in the field sampling plan (see HEER Office TGM, Section 4.2.1);
- Collect replicate samples in DU with highest anticipated contamination (assumed to also have highest variability).

Discrete Soil Samples (see TGM Section 4)

- DUs and associated Decision Statements should be designated in the same manner as done for MIS investigations;
- Tight grids of discrete samples combined with field screening can be useful for identification of suspected spill areas and designation of Spill Area DUs (e.g., field XRF for arsenic or lead; see TGM Section 5);
- Investigations that propose collection of discrete samples only should be discussed with the HEER office project manager in advance to ensure that an adequate number of samples to characterize designated DUs are collected;
- Decision Units can be characterized with discrete samples provided that an adequate number are collected (e.g., 30+) but analysis of individual samples is generally

unnecessary (and wasteful of lab analysis budgets) since the representative mean for the DU as a whole in general will be used for decision making purposes (see Section 4 of the TGM);

- Contaminant concentrations at the scale of a laboratory subsample for extraction and analysis can range over several orders of magnitude within a targeted, DU volume of soil leading to potential misinterpretation of the resulting data when an inadequate number of samples (or MI increments) is collected (Figure 7, see also TGM Section 5);
    - Thirty to fifty-plus discrete samples points (or MIS increments) generally needed to adequately capture the contaminant heterogeneity within the DU at the scale of a laboratory subsample;
    - Even a small number of discrete samples will, however, identify heavy contamination when the concentration in any given laboratory subsample-size masses of soil exceeds the target action level (Scenario A - "Can't miss", although mean concentration likely to be underestimated);
    - If less than thirty discrete samples (or increments) are collected then a representative number of discrete sample-size "hot spots" (right side of distribution curve) might not be included in the estimate of the DU mean, risking a "false negative" when in fact contamination exceeds the target action level (Scenario B);
    - Improper focus on individual, discrete samples rather than the mean for the targeted DU risks a "false positive" and mistaken and unnecessary attempts to excavate individual sample points when in fact the mean concentration for the DU is below the target action level (Scenario C);
    - Collect independent, replicate sets of discrete samples from within a select number of DUs to confirm that an adequate number of samples were collected.
- Keep in mind that the true size of a discrete sample is the actual extraction and analysis mass removed from the original field sample at the laboratory (e.g., standard commercial lab subsample masses: 0.5g for Hg; 1g for metals, 5g for VOCs, 10g for dioxins, 30g for TPH, pesticides and PAHs);
- For comparison, the cap of a soda bottle holds approximately five grams of soil – this is the size of a laboratory subsample tested for VOCs (Figure 8);
- If collected, discrete samples (including cores) should be dried, sieved and subsampled by the lab for extraction and analysis in the same manner as done for MI samples (may require 1-2kg size samples), with a minimum laboratory subsample mass of 10 grams (5 grams for mercury; see also *VOCs* and *Lab Issues* below and TGM Section 4.2.2);
- Discrete sample data based on targeted DU layers and/or subsampled at the lab in the

same manner as MI samples are not directly comparable to historical discrete data for the site;

- Estimated contaminant mean concentrations from large numbers of discrete samples (e.g., 30+) collected within a single DU can be compared to MI sample data but individual discrete sample data are not directly comparable;
- Historical discrete data based on a small number of samples (e.g., <30) are not directly comparable to MI sample data.

Volatile and Semi-Volatile Chemicals (see TGM Sections 4 & 5)

- See attached Table 2 for a list of volatile and semi-volatile chemicals listed in the HEER office EHE guidance;
- MI samples recommended over traditional, discrete samples;
- Testing for VOCs in surface soil samples generally not recommended or reliable to discount contamination at depth;
- Collect samples to be tested for VOCs (including TPHg) separately from samples to be tested for SVOCs and non-volatile chemicals;
- MI samples to be tested for VOCs:
    - Consider field preservation of increments in methanol (preferred, Figure 9);
    - Hazardous materials shipping regulations restrict the volume of methanol to no more than 30 milliliters per container and a maximum of one liter per cooler;
    - If shipping methanol-preserved samples is not practical then consider freezing individual increments for shipment and having the increments combined in methanol at the lab;
    - Include naphthalene as a VOC;
    - Request Single Ion Method (SIM) analysis for samples preserved in methanol in order to reduce method report levels to target action levels if needed (SIM targets small number of select compounds instead of full, standard VOC list);
- MI samples to be tested for semi-volatile chemicals (see Table 2):
    - Collect samples to be tested for SVOCs separately from samples to be tested or VOCs;
    - Samples do not have to be field-preserved but should be cooled and immediately subsampled for testing upon receipt at the laboratory;
- At the lab:
    - Subsample bulk MI samples to be tested for SVOCs (see Table 2; including TPHd, some PAHs and mercury) *immediately* after the sample is spread out and prior to drying and sieving (see Table 2;

- Methods for "wet sieving" samples are still under development and not required, although an effort should be made to collect <2mm particles in lab sub-samples;
- Collect a separate sample from the wet material and test for soil moisture in order to convert analytical results to dry-weight basis;
- Follow standard drying and sieving methods if additional tests are required for non-volatile chemicals using a different lab analysis
- If both SVOC and non-volatile PAHs are targeted as contaminants of potential concern then include testing for both in laboratory subsamples collected from the MI sample prior to drying and sieving**.**

Subsurface Investigations (see TGM Section 3)

- Follow same approach to designate subsurface DUs as used for surface soil investigations (e.g., site history, field inspection, etc.);
- A small number (e.g., <30) of *Exploratory Borings* are usually advantageous during the initial stages of an investigation, similar to initial field inspections of surface soils to identify potential spill areas:
  - Use to identify the presence or absence of contamination (e.g., visual observation of petroleum contamination, ash layers, etc.);
  - Number of borings needed for initial screening is site- and contaminant-specific;
  - Use to assist in subdivision of subsurface soil into DU Layers for more intensive drilling and characterization as needed (e.g., to isolate subsurface spill areas and/or optimize future remedial actions);
  - MIS-type subsurface soil investigations generally not warranted for evaluation of potential environmental hazards (aka "risk assessment") associated with subsurface solvent- and petroleum-contamination (focus on soil gas and groundwater data);
- A large number of increment points (e.g., ≥30) is needed to accurately estimate the mean concentration and mass of a contaminant in a subsurface DU;
  - This requires thirty or more individual borings for thin, tabular-shaped subsurface DUs (most common);
  - A smaller number of borings would be needed for shaft-like DUs that are deeper than they are wide or long (i.e., increments spread out vertically rather than laterally);
- Sites where additional borings and more refined DU-MIS investigation approaches may be beneficial include:
  - Investigations objectives include estimation of mean contaminant concentration

and mass for targeted soil;
    - Optimization of *in situ* remedial actions (e.g., more precise resolution of contaminant location and mass; see also HDOH 2011);
    - Optimization of *ex situ* remedial actions (e.g., segregation of soil that may require expensive treatment or off-island disposal from soil that can be managed less expensively);
    - Collection of confirmation soil samples from excavation sidewalls and base;
- Consider designating and targeting specific *Depth Intervals* or *DU Layers* for subsurface investigations (Figure 10; e.g., 0-5', 5-10', etc.) or targeted stratigraphic units (e.g., ash layers, etc.) rather than specific depths (e.g., 0' bgs, -5' bgs, -10'bgs, etc.):
    - Discrete samples from widely-spaced, targeted depths or points are unlikely to adequately capture contaminant heterogeneity within the primary contaminant zone and are prone to *underestimate* the representative mean contaminant concentration and mass (see Schumacher 2000, Feenstra 2003);
    - A core collected from a targeted DU layer represents a single *increment* for that layer;
    - Send entire, targeted core interval to lab for subsampling, extraction and analysis (ideal), OR
    - Subsample the core interval in the field to reduce soil mass (e.g, core wedge sample, multiple plugs collected every two inches, spreading and field subsampling of entire core, etc.; see Figure 9 and VOC notes);
    - If contamination is confirmed, designate subsurface DUs and carry out a more extensive investigation as needed;
- VOC options (see also VOC notes; includes TPHg, TPHd and mercury):
    - Collect regularly spaced (e.g., every two to six inches), five-gram plugs from the targeted core interval/DU Layer and place in methanol in the field (see Figure 9, most preferred) OR
    - Collect and immediately freeze individual subsample plugs for shipment and combination in the lab in methanol and analysis OR
    - Chill and ship the entire, undisturbed core and subsample immediately upon receipt in lab without sieving or drying (least preferred);
- Have a plan to modify boring/increment locations due to unanticipated underground utilities or other obstacles or difficult geological conditions (note impediments to sample collection in the investigation report);
- Collect both soil *and* active soil gas samples (e.g., using summa canisters) at sites with significant subsurface releases of volatile chemicals in order to evaluate potential vapor

intrusion hazards (including solvents, gasolines and middle distillate fuels; see TGM Section 7);

- Decontaminating drilling equipment between targeted DU layers within a single boring is generally not necessary, except in cases of significant gross contamination that might be dragged downwards during drilling (continuous cores preferred);
- Drill rods and associated equipment should be decontaminated between individual borings due to a greater risk of cross contamination between individual, boring points in comparison to increment collection from in surface soils).

Perimeter DUs (see TGM Section 3)

- *Perimeter DUs* (new term) should be established around an area of suspected heavy contamination in order to define the outward extent of contamination (Figure 11);
- The number and design of Perimeter DUs is necessarily site-specific and based in part on the confidence that the DUs will be placed in areas that are unlikely to be contaminated (e.g., avoid letting a small area of contamination cause a much larger Perimeter DU fail action levels and require additional investigation).

Sediment Investigations (see TGM Sections 3, 4 & 5)

- DU and MIS approaches (vs discrete samples) are recommended for sediment investigations;
- Designate DUs based on suspect areas of elevated contamination (e.g., wastewater outfalls), ecological habitats, targeted sediment volume (e.g., potential dredging or remedial actions), etc., (Figure 12);
- Consider a tube-shaped sampler for collection of increments to ensure cylindrical-shaped increments (Figures 13 and 14).
- Increments should be core-shaped (Figure 14; see also Figure 3);
- Consider the use of a flat-bottom, scoop sampler for DU with a thin sediment cover (e.g., thin layer of sediment in a concrete culvert; Figure 15);
- Decant excess water from collected sediment MI sample by waiting several minute and then carefully pouring excess water out of the container;
- Use a cellulose, paper filter to catch and replace fine sediment as needed; decontaminate filter holder between samples;
- For sediments that consist primarily of <2mm particles, consider subsampling MI samples in the lab for extraction and analysis *without drying*, in order to reduce sample preparation and analysis time (drying and sieving carried out primarily to remove large particles).

Laboratory Issues (see TGM Section 4)

- Talk to your lab ahead of time to ensure that they are familiar with MIS subsampling requirements as well as minimum, laboratory subsample mass requirements (five grams for mercury and ten grams for all other contaminants, see Figures 8 and 16);
- Both MI and discrete soil samples should be representatively subsampled for the minimum appropriate extraction and analysis mass (Figure 12, TGM Section 4.2.2);
- Laboratories may need to modify EPA methods appropriately to achieve the minimum 10-gram subsample mass for extraction and analysis (e.g. modified extractions for metals analyses), or conduct multiple small subsample extractions and combine them for analysis.
- MI samples should be subsampled without drying and sieving in order to minimize chemical loss or alteration and meet holding times for analysis of (see Table 2 and *Volatile and Semi-Volatile Chemicals* notes above):
    - Semi-volatile chemicals (including some PAHs, TPHg, TPHd and mercury); and
    - Pesticides or other chemicals that are highly biodegradable, chemical unstable or otherwise have with a low persistence (e.g., half-life less than thirty days; refer to TGM Section 9, Table 9A in Appendix 9-A);
- Exceeding target holding times for stable chemicals in order to permit drying, sieving and more definitive subsampling is acceptable but should be minimized to the extent practicable (see Table 2; most metals, dioxins, PCBs, etc.; see also USEPA 2003);
- Soil or sediment samples that consist entirely of <2mm material do not require drying and sieving to address fundamental error concerns, although some degree of drying may be desirable by the laboratory for sample processing or analysis purposes;
- If soil or sediment samples are not dried and sieved before subsampling, a separate subsample to determine moisture content should be taken so results can be reported on a dry weight basis;
- Data for unground samples data are more appropriate for evaluation of chronic health risks under current site conditions;
    - Consider grinding samples anticipated to contain chips, pellets, fragments, etc., of targeted chemicals and comparing the data to unground samples (e.g., lead-based paint, lead pellets, explosives residue, etc.);
    - Data for ground samples can be useful for evaluation of potential acute health risks when the presence of large particles is not obvious (e.g., lead-based paint chips in soil) but may overstate chronic health risks as well as potential leaching hazards (e.g., explosive residues) and shouldn't be directly compared to HDOH

EALs.

- MI samples collected for arsenic analyses that contain > 20 mg/kg total arsenic should subsequently be tested for bioaccessible arsenic; On some sites where numerous DUs exceed 20 mg/kg total arsenic, analyzing a subset of the samples for bioaccessible arsenic may be acceptable – this should be discussed with a HEER Office project manager;
- The same MIS samples collected for total arsenic (e.g. the entire remaining <2mm fraction of these samples) should be further sieved to the ≤ 0.25 mm particle size, representatively sub-sampled and analyzed for bioaccessible arsenic using the SBRC method (requires 1-2 grams; SBRC 1999);
- Results of the total arsenic level in the <0.25 mm (fines) fraction as well as mg/kg of bioaccessible arsenic should be reported by the laboratory.

Data Interpretation (see TGM Section 4)

- When necessary, consider using the *Relative Standard Deviation* (percent) calculated for replicate samples to adjust data for DUs where replicates were not collected, since this can be applied regardless of the actual Standard Deviation value calculated (i.e., when unadjusted concentrations approach target action levels);
- High concentrations of iron and titanium in volcanic soils and calcium in carbonate-rich, coastal soils (or sediments) can interfere with the detection of other metals, resulting in an overestimation of metal concentrations:
    - High levels of iron and titanium can interfere with the detection of arsenic, beryllium and cadmium;
    - High levels of calcium can interfere with the detection of barium**;**
    - Notify laboratory that soil or sediment samples could have high concentrations of these metals and ask them to modify sample preparation procedures to remove the interference as needed to meet target soil action levels (e.g., modified extraction or analysis method);
    - Reduced iron and calcium in the <250um particle fraction can remove the interference (fraction required for bioaccessible arsenic analysis) but be aware that natural background levels of total arsenic in this fraction can approach 50 mg/kg or higher in comparison to the <2mm particle size fraction (generally <20 mg/kg, default HEER background).

Other Issues (see TGM Section 3)

- Consider designation of DUs and collection of MI samples for surface water investigations, rather than traditional discrete samples.

References

Feenstra, S., 2003, Spatial Variability of Non-Aqueous Phase Liquid Chemicals in Soil—Implications for Source Zone Mass Estimates: Environmental & Engineering Geoscience, Vol. IX, No. 1, February 2003, pp. 19–23.

HIDOH, 2008, *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater* (Summer 2008, updated March 2009): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaii.gov/health/environmental/hazard/eal2005.html.

HIDOH, 2009, *Technical Guidance Manual*: Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

HDOH, 2011, *Use of Decision Unit and Multi-Increment Soil Sample Investigation Approaches to Characterize a Subsurface Solvent Plume, Site CG110, Hickam Air Force Base, Honolulu, Hawai'i* (February 2011): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, HEER TGM, Additional Guidance Documents, http://www.hawaiidoh.org/

Schumacher, B.A. and M.M. Minnich, 2000, Extreme Short-Range Variability in VOC-Contaminated Soils: Environmental Science and Technology, Vol. 34, No. 17, pp 3611-3616.

SBRC, 1999, Standard Operating Procedure, In Vitro Method for Determination of Lead and Arsenic Bioavailability: Solubility/Bioavailability Research Consortium, Document 8601-102.001 0601 1099 RN01 (contact Michael Ruby, Exponent, Boulder, Colorado or Dr. John Drexler, University of Colorado-Boulder, Department of Geological Sciences).

USEPA, 2003, *Sample Holding Time Reevaluation* (October 2003): U.S. Environmental Protection Agency, National Exposure Research Laboratory, Environmental Sciences Division, EPA/600/R-05/124, http://www.epa.gov/esd/cmb/research/bs_033cmb06.pdf

Table 1. Approximate increment spacing versus Decision Unit area (see equations in text).

DU Area (ft^2)	*Approximate Increment Spacing vs Desired Number of DU Increments		
	30 Increments	40 Increments	50 Increments
100	2.2	1.9	1.6
200	3.2	2.7	2.3
300	3.9	3.3	2.9
400	4.5	3.8	3.3
500	5.0	4.2	3.7
1,000	7.1	5.9	5.2
2,000	10	8.4	7.4
3,000	12	10	9.0
4,000	14	12	10
5,000	16	13	12
10,000	22	19	16
20,000	32	27	23
30,000	39	33	29
40,000	45	38	33

*For general guidance only. Use to assist in even spacing increments within targeted Decision Unit. Final, appropriate spacing will vary based on DU shape and field conditions.

Table 2a. Recommendations for MIS field preservation or laboratory subsampling based on overall chemical stability (e.g., volatility and half life).

CHEMICAL PARAMETER	[1]Physical State		Molecular Weight	[2]Vapor Pressure mm Hg (25C)	Henry's Law Constant (H) (atm-m^3/mol)
[3]Volatile Chemicals Preserve Samples in Methanol in the Field (or approved alternative, see text)					
ACETONE	V	L	58	2.3E+02	3.9E-05
BENZENE	V	L	78	9.5E+01	5.61E-03
BIS(2-CHLOROETHYL)ETHER	V	L	143	1.6E+00	1.7E-05
BROMODICHLOROMETHANE	V	L	164	5.0E+01	2.1E-03
BROMOFORM	V	S	253	5.4E+00	5.4E-04
BROMOMETHANE	V	G	95	1.6E+03	6.3E-03
CARBON TETRACHLORIDE	V	L	154	1.2E+02	2.7E-02
CHLOROBENZENE	V	L	113	1.2E+01	3.2E-03
CHLOROETHANE	V	G	65	1.0E+03	1.1E-02
CHLOROFORM	V	L	119	2.0E+02	3.7E-03
CHLOROMETHANE	V	G	50	4.3E+03	8.8E-03
CHLOROPHENOL, 2-	V	L	129	2.5E+00	1.1E-05
DIBROMOCHLOROMETHANE	V	S	208	5.5E+00	7.8E-04
DIBROMOETHANE, 1,2-	V	S	188	1.1E+01	6.6E-04
DICHLOROBENZENE, 1,2-	V	L	147	1.4E+00	1.9E-03
DICHLOROBENZENE, 1,3-	V	L	147	2.2E+00	1.9E-03
DICHLOROBENZENE, 1,4-	V	S	147	1.7E+00	2.4E-03
DICHLOROETHANE, 1,1-	V	L	99	2.3E+02	5.6E-03
DICHLOROETHANE, 1,2-	V	L	99	7.9E+01	1.2E-03
DICHLOROETHYLENE, 1,1-	V	L	97	6.0E+02	2.7E-02
DICHLOROETHYLENE, Cis 1,2-	V	L	97	2.0E+02	4.1E-03
DICHLOROETHYLENE, Trans 1,2-	V	L	97	3.3E+02	9.3E-03
DICHLOROPROPANE, 1,2-	V	L	113	5.3E+01	2.9E-03
DICHLOROPROPENE, 1,3-	V	L	111	3.4E+01	3.7E-03
DIOXANE, 1,4-	V	L	88	3.8E+01	4.9E-06
ETHANOL	V	L	46	5.9E+01	6.3E-06
ETHYLBENZENE	V	L	106	9.6E+00	7.8E-03
METHYL ETHYL KETONE	V	L	72	9.1E+01	5.6E-05
METHYL ISOBUTYL KETONE	V	L	100	2.0E+01	1.4E-04
METHYL TERT BUTYL ETHER	V	L	88	2.5E+02	5.9E-04
METHYLENE CHLORIDE	V	L	85	4.4E+02	3.2E-03
STYRENE	V	L	104	6.4E+00	2.7E-03
tert-BUTYL ALCOHOL	V	L	74	4.1E+01	1.2E-05
TETRACHLOROETHANE, 1,1,1,2-	V	L	168	4.6E+00	2.4E-03
TETRACHLOROETHANE, 1,1,2,2-	V	L	168	4.6E+00	3.7E-04
TETRACHLOROETHYLENE	V	L	166	1.9E+01	1.8E-02
TOLUENE	V	L	92	2.8E+01	6.6E-03
TPH (gasolines)	V	L	108	6.8E+02	7.2E-04
TRICHLOROETHANE, 1,1,1-	V	L	133	1.2E+02	1.7E-02

Table 2a (cont.). Recommendations for MIS field preservation or laboratory subsampling based on overall chemical stability.

CHEMICAL PARAMETER	[1]Physical State		Molecular Weight	[2]Vapor Pressure mm Hg (25C)	Henry's Law Constant (H) (atm-m^3/mol)
Volatile Chemicals (cont.)					
TRICHLOROETHANE, 1,1,2-	V	L	133	2.3E+01	8.3E-04
TRICHLOROETHYLENE	V	L	131	6.9E+01	9.8E-03
TRICHLOROPROPANE, 1,2,3-	V	L	147	3.7E+00	3.4E-04
TRICHLOROPROPENE, 1,2,3-	V	L	145	3.7E+00	2.8E-02
VINYL CHLORIDE	V	G	63	3.0E+03	2.7E-02
XYLENES	V	L	106	8.0E+00	7.1E-03
[4]Semi-Volatile or Otherwise Semi-Stable Chemicals [6,7]Subsample MI Bulk Sample at Laboratory Upon Receipt Without Drying					
BIPHENYL, 1,1-	*SV	S	154	8.9E-03	3.2E-04
BIS(2-CHLOROISOPROPYL)ETHER	*SV	L	171	8.5E-01	1.1E-04
CYANIDE (sodium)	*SV	S	27	1.0E+00	-
DALAPON	SV	L	143	1.9E-01	9.0E-08
DIBROMO,1,2- CHLOROPROPANE,3-	*SV	L	236	5.8E-01	1.5E-04
[8]DICHLOROPHENOL, 2,4-	NV	S	163	9.0E-02	2.2E-06
DIMETHYLPHENOL, 2,4-	SV	S	122	1.0E-01	9.5E-07
[8]GLYPHOSATE	NV	S	169	9.8E-08	4.1E-19
HEXACHLOROBUTADIENE	SV	S	261	2.2E-01	1.0E-02
HEXACHLOROETHANE	SV	S	237	4.0E-01	3.9E-03
ISOPHORONE	SV	L	138	4.4E-01	6.6E-06
[9]MERCURY	*SV	L	201	2.0E-03	-
METHYL MERCURY	SV	S	216	-	-
NITROBENZENE	*SV	L	123	2.5E-01	2.4E-05
NITROGLYCERIN	SV	L	227	2.0E-04	9.8E-08
NITROTOLUENE, 4-	SV	S	137	1.6E-01	5.6E-06
NITROTOLUENE, 2-	*SV	S	137	1.9E-01	1.2E-05
NITROTOLUENE, 3-	*SV	S	137	2.1E-01	2.4E-05
[10]PAHs (varies, see Table 2b)	*SV	S			
PHENOL	SV	S	94	3.5E-01	3.4E-07
PROPICONAZOLE	SV	L	342	1.0E-06	4.1E-09
[11]TPH (middle distillates)	*SV	L	170	2 to 26	7.2E-04
TRICHLOROBENZENE, 1,2,4-	*SV	S	181	4.6E-01	1.4E-03
[5]Non-Volatile or Otherwise Stable Chemicals Dry and Sieve MI Samples for Laboratory Subsampling					
ALDRIN	NV	S	365	1.2E-04	4.4E-05
AMETRYN	NV	S	227	2.7E-06	2.4E-09
AMINO,2- DINITROTOLUENE,4,6-	NV	S	197	-	1.6E-10
AMINO,4- DINITROTOLUENE,2,6-	NV	S	197	-	1.6E-10
ATRAZINE	NV	S	216	2.9E-07	2.34E-09
BIS(2-ETHYLHEXYL)PHTHALATE	NV	S	391	1.4E-07	2.7E-07
CHLORDANE (TECHNICAL)	NV	S	410	9.8E-06	4.9E-05

Table 2a (cont.). Recommendations for MIS field preservation or laboratory subsampling based on overall chemical stability.

CHEMICAL PARAMETER	[1]Physical State		Molecular Weight	[2]Vapor Pressure mm Hg (25C)	Henry's Law Constant (H) (atm-m^3/mol)
Non-Volatile Stable Chemicals (cont.)					
CHLOROANILINE, p-	NV	S	128	7.1E-02	1.1E-06
CYCLO-1,3,5-TRIMETHYLENE-2,4,6-TRINITRAMINE (RDX)	NV	S	222	4.1E-09	6.3E-08
DICHLOROBENZIDINE, 3,3-	NV	S	253	2.6E-07	5.1E-11
DICHLORODIPHENYLDICHLOROETHANE (DDD)	NV	S	320	1.4E-06	6.6E-06
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	NV	S	318	6.0E-06	4.1E-05
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	NV	S	354	1.6E-07	8.3E-06
DICHLOROPHENOXYACETIC ACID (2,4-D)	NV	S	221	8.3E-08	3.4E-08
DIELDRIN	NV	S	381	5.9E-06	1.0E-05
DIETHYLPHTHALATE	NV	S	222	2.1E-03	6.1E-07
DIMETHYLPHTHALATE	NV	S	194	3.1E-03	1.1E-07
DINITROBENZENE, 1,3-	NV	S	168	2.0E-04	4.9E-08
DINITROPHENOL, 2,4-	NV	S	184	3.9E-04	8.5E-08
DINITROTOLUENE, 2,4- (2,4-DNT)	NV	S	182	1.5E-04	5.4E-08
DINITROTOLUENE, 2,6- (2,6-DNT)	NV	S	182	5.7E-04	7.6E-07
DIOXINS (2,3,7,8 TCDD)	NV	S	356	1.5E-09	2.2E-06
DIURON	NV	S	233	6.9E-08	5.1E-10
ENDOSULFAN	NV	S	407	1.7E-07	6.6E-05
ENDRIN	NV	S	381	3.0E-06	6.3E-06
HEPTACHLOR	NV	S	373	4.0E-04	2.9E-04
HEPTACHLOR EPOXIDE	NV	S	389	2.0E-05	2.1E-05
HEXACHLOROBENZENE	NV	S	285	4.9E-05	1.7E-03
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	NV	S	291	4.2E-05	5.1E-06
HEXAZINONE	NV	S	252	2.3E-07	2.2E-12
METHOXYCHLOR	NV	S	346	4.2E-05	2.0E-07
PENTACHLOROPHENOL	NV	S	266	1.1E-04	2.4E-08
PENTAERYTHRITOLTETRANITRATE (PETN)	NV	S	316	1.4E-07	1.2E-11
PERCHLORATE	NV	S	117	-	
POLYCHLORINATED BIPHENYLS (Arochlor 1254)	NV	S	326	7.7E-05	2.9E-04
SIMAZINE	NV	S	202	2.2E-08	9.5E-10
TERBACIL	NV	S	217	4.7E-07	1.2E-10
TETRACHLOROPHENOL, 2,3,4,6-	NV	S	232	4.2E-03	8.8E-06
TETRANITRO-1,3,5,7-TETRAAZOCYCLOOCTANE (HMX)	NV	S	296	2.4E-08	8.5E-10
TOXAPHENE	NV	S	414	6.7E-06	6.1E-06
TPH (residual fuels)	NV	L/S	200+	-	
TRICHLOROPHENOL, 2,4,5-	NV	S	198	-	1.6E-06
TRICHLOROPHENOL, 2,4,6-	NV	S	198	-	2.7E-06
TRICHLOROPHENOXYACETIC ACID, 2,4,5- (2,4,5-T)	NV	S	255	<7.5E-5	4.6E-08
TRICHLOROPHENOXYPROPIONIC ACID, 2,4,5- (2,4,5-TP)	NV	S	270	9.7E-07	9.0E-09
TRIFLURALIN	NV	S	335	4.6E-05	1.0E-04
TRINITROBENZENE, 1,3,5-	NV	S	213	6.4E-06	3.2E-09
TRINITROPHENYLMETHYLNITRAMINE, 2,4,6- (TETRYL)	NV	S	287	1.2E-07	2.7E-09
TRINITROTOLUENE, 2,4,6- (TNT)	NV	S	227	8.0E-06	4.6E-07

Table 2a (cont.). Recommendations for MIS field preservation or laboratory subsampling based on overall chemical stability.

CHEMICAL PARAMETER	[1]Physical State		Molecular Weight	[2]Vapor Pressure mm Hg (25C)	Henry's Law Constant (H) (atm-m^3/mol)
[12]Metals (presumed stable but depends on target species)					
ANTIMONY	NV	S	122	-	-
ARSENIC	NV	S	75	-	-
BARIUM	NV	S	137	-	-
BERYLLIUM	NV	S	9	-	-
BORON	NV	S	14	-	-
CADMIUM	NV	S	112	-	-
CHROMIUM (Total)	NV	S	52	-	-
CHROMIUM III	NV	S	52	-	-
CHROMIUM VI	NV	S	52	-	-
COBALT	NV	S	59	-	-
COPPER	NV	S	64	-	-
LEAD	NV	S	207	-	-
MOLYBDENUM	NV	S	96	-	-
NICKEL	NV	S	59	-	-
SELENIUM	NV	S	81	-	-
SILVER	NV	S	108	-	-
THALLIUM	NV	S	204	-	-
VANADIUM	NV	S	51	-	-
ZINC	NV	S	67	-	-

Reference: Appendix 1, Table H in HEER office Environmental Hazard Evaluation guidance (HDOH 2008).

1. Physical state of chemical at ambient conditions (V - volatile, SV - Semi-Volatile, NV - nonvolatile, S - solid, L - liquid, G - gas). *SV: Meets criteria for potential consideration as a "volatile" chemical and inclusion in soil gas investigations for evaluation of potential vapor intrusion hazards (H >0.00001 and MW <200, see Footnote 3).

2. Vapor Pressures from National Library of Medicine TOXNET or ChemID databases.

3. Volatile Chemicals defined by vapor pressure >1 mm Hg at 25C. Collect soil gas samples in additional to soil samples at sites with significant releases of volatile chemicals for evaluation of vapor intrusion hazards.

4. Semi-Volatile and Semi-Stable Chemicals defined as: VP 0.1 to <1.0 OR (H >0.00001 and MW <200) OR Liquid at 25C OR Low Persistence OR Otherwise Semi-Stable. See also Footnote 1 (*SV). TPHd overlaps volatile and semi-volatile categories.

5. Non-Volatile Stable Chemicals defined as: VP <0.1 AND H <0.00001 (or H >0.00001 but MW >200) AND Solid at 25C OR Otherwise Stable.

6. Check with lab to determine feasibility of wet sieving sample to remove >2mm particles prior to subsampling.

7. Soil or sediment samples that consist entirely of <2mm material *do no*t require drying and sieving to address fundamental error concerns, although some degree of drying and sieving may be desirable by the laboratory for testing purposes.

8. Nonvolatile and published half-life less than thirty days or less. Refer to Table 9-A in Section 9 of the HEER TGM.

9. Mercury stability depends on targeted species. Assumed liquid and semi-stable as default.

10. PAHS - See Table 2b.

11. TPH diesel may not be adequately extractable from soil or sediment when placed in methanol, subsamples should be collected and extracted at the laboratory (e.g., using methylene chloride).

12. The stability of a targeted metal depends in part on the species present and can be highly variable. Testing for a specific species of a metal may require alternate collection and preservation methods and should be evaluated on a site-by-site basis with respect to the site investigation objectives.

Table 2b. Recommendations for MIS field preservation or laboratory subsampling of samples to be tested for PAHs.

[1]CHEMICAL PARAMETER	[2]Physical State		Molecular Weight	[3]Vapor Pressure mm Hg (25C)	Henry's Law Constant (H) (atm-m^3/mol)
Semi-Volatile PAHs (H ≥0.00001 AND MW ≤200) [4]Subsample MI Bulk Sample at Laboratory Upon Receipt Without Drying					
ACENAPHTHENE	SV	S	154	2.2E-03	1.8E-04
ACENAPHTHYLENE	SV	S	152	6.7E-03	1.5E-03
ANTHRACENE	SV	S	178	6.6E-06	5.6E-05
FLUORENE	SV	S	166	3.2E-04	9.5E-05
METHYLNAPHTHALENE, 1-	SV	S	142	6.7E-02	5.1E-04
METHYLNAPHTHALENE, 2-	SV	S	142	5.5E-02	5.1E-04
[5]NAPHTHALENE	SV	S	128	8.5E-02	4.4E-04
PHENANTHRENE	SV	S	178	1.2E-04	3.9E-05
PYRENE	SV	S	202	4.5E-06	1.2E-05
Non-Volatile PAHs (H <0.00001 OR MW >200) [4]Dry and Sieve MI Samples for Laboratory Subsampling					
BENZO(a)ANTHRACENE	NV	S	228	5.0E-09	1.2E-05
BENZO(a)PYRENE	NV	S	252	5.5E-09	4.6E-07
BENZO(b)FLUORANTHENE	NV	S	252	5.0E-07	6.6E-07
BENZO(g,h,i)PERYLENE	NV	S	276	-	1.4E-07
BENZO(k)FLUORANTHENE	NV	S	252	9.7E-10	5.9E-07
CHRYSENE	NV	S	228	6.2E-09	5.1E-06
DIBENZO(a,h)ANTHTRACENE	NV	S	278	9.6E-10	1.2E-07
FLUORANTHENE	NV	S	202	9.2E-06	8.8E-06
INDENO(1,2,3-cd)PYRENE	NV	S	276	1.2E-10	3.4E-07

Reference: Appendix 1, Table H in HEER office Environmental Hazard Evaluation guidance (HDOH 2008).

1. PAHS - Eighteen targeted PAHs listed in Section 9 of the HEER TGM (HDOH 2009). Pyrene considered semi-volatile due to Henry's Law Constant >0.00001 even though MW marginally exceeds 200.

2. Physical state of chemical at ambient conditions (V - volatile, SV - Semi-Volatile, NV - nonvolatile, S - solid, L - liquid, G - gas).

3. Vapor Pressures from National Library of Medicine TOXNET or ChemID databases.

4. If target PAHs include both semi-volatile *and* non-volatile PAHs then subsample upon receipt at lab without drying and test for full suite of PAHs. If only non-volatile PAHs are targeted then sieve and dry samples before testing

5. Include naphthalene as a "volatile" chemical of concern in soil gas investigations at sites with significant releases of petroleum fuels (see TGM Section 9). Other petroleum-related SVOCs do not need to be included in soil gas investigations due to minimal presence in fuels and focus on TPH (and/or specific carbon ranges), BTEX and naphthalene as the main risk drivers for vapor intrusion hazards. Inclusion of additional SVOCs may be required for former manufactured gas plants, however, on a case-by-case basis.

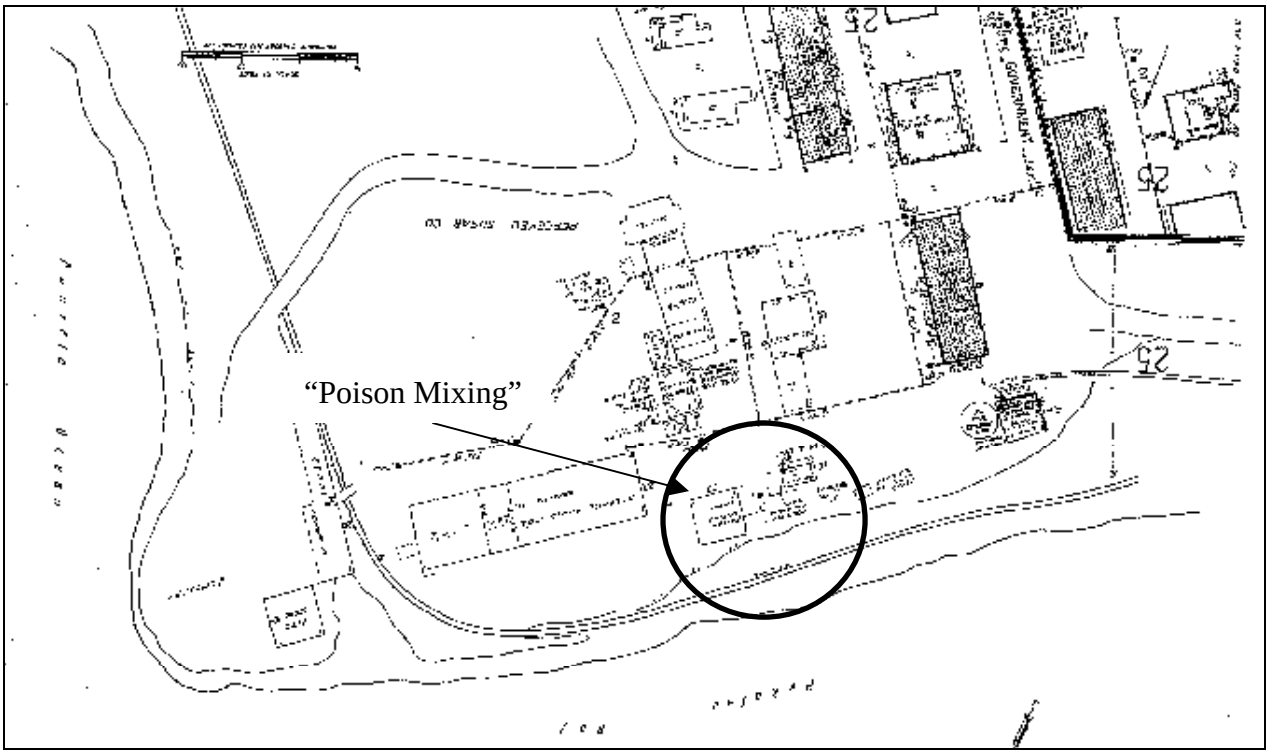


Figure 1a. Portion of Sanborn Fire Insurance map of former sugar mill operations with location of "Poison Mixing" area identified (potential arsenic contamination). Sugarcane seed dipping vats generally not indicated (potential mercury contamination).

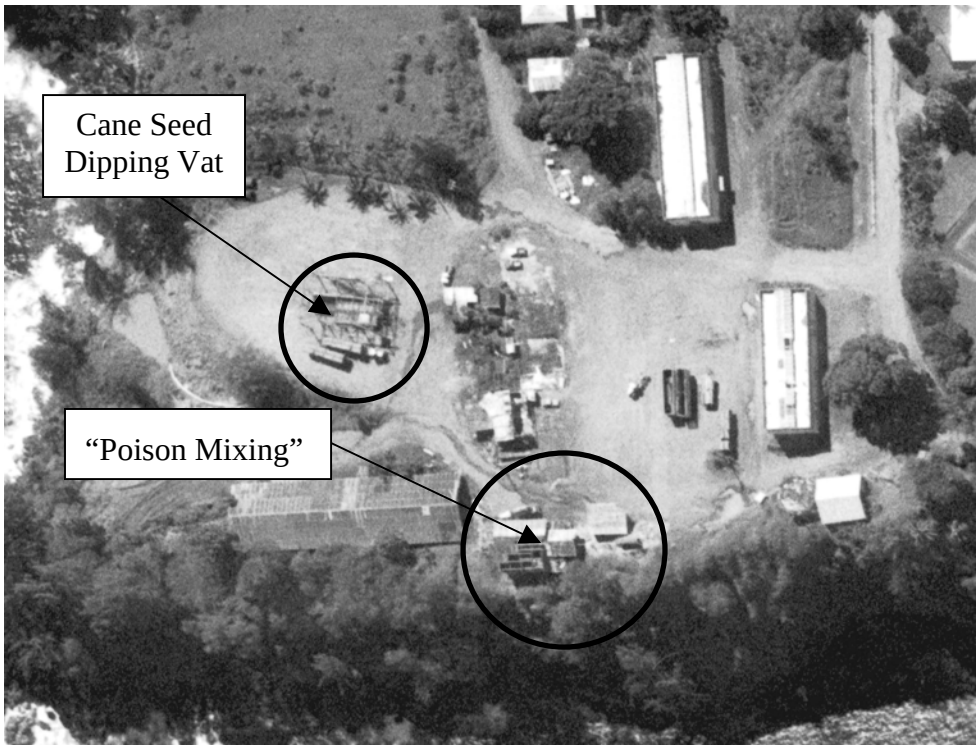


Figure 1b. Historical aerial photo of same area with location of pesticide mixing area identified as well as a sugarcane seed dipping vat.

a) Heavily overgrown, former sugarcane field slated for DU-MIS investigation (photo from Bureau Veritas).

b) Bulldozer used to cut access path into to one of fifty-nine, lot-size DUs within several thousand acre field (photo from Bureau Veritas).

b) Clearing of 5,000ft^2 DU area for collection of MI soil sample (photo from Bureau Veritas).

Figure 2. Clearing of heavily overgrown, former sugarcane field to provide access to targeted DU areas. Time and effort saved in sample collection generally outweighs cost of clearing.

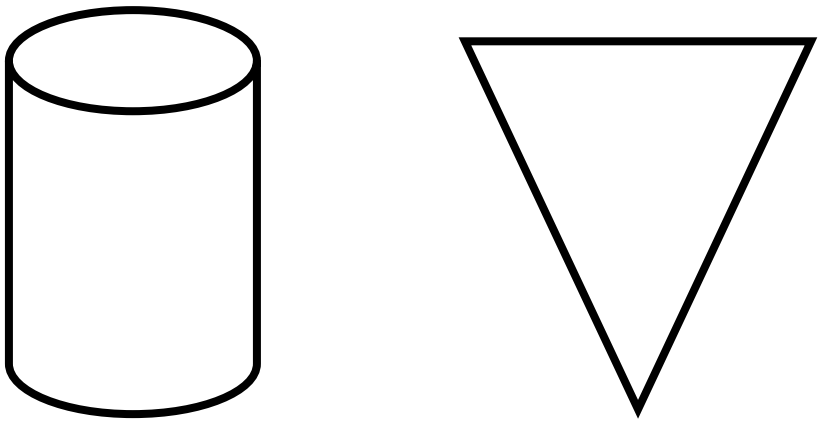


Figure 3. Core-shaped versus wedge-shaped increments. Core-shaped increments provide equal coverage across the entire targeted depth of soil. Hand trowels more likely to produce wedge-shaped increments with most of the soil coming from the upper few inches of the targeted depth.

a) Use of an open-sided, sampling tube to collect surface increments in soft soils.

b) Use a flat-headed screwdriver to remove soil increment from tube.

c) Use of a slide hammer to collect surface increments in hard soils.

d) Core barrel removed and soil sample placed in field container (photo from Bureau Veritas).

Figure 4. Most commonly used tools for surface soils. Sampling tubes are quick and efficient in soft soils and are a good primary sampling tool for quick sampling events (no need to wait for drill batteries to charge), for use in very large DUs where considerable walking is required and in cases where only one person is collecting samples.

e) Drill method to collect increments; plate with one-inch, pre-cut hole placed on top of increment location; center of plate must be held down to keep soil from piling up under plate (second person or something placed across plate for the driller to stand on).

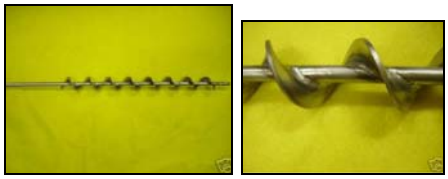
f) Keep drill vertical to ground and advance bit to target depth (mark with tape on bit) as soil piles up on plate; hold drill firmly since gravel or hard soil can cause the drill to suddenly lurch and strike the person holding the plate.

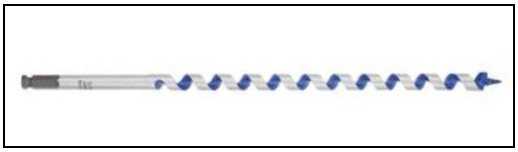
g) Place fingers in hole to prevent soil from spilling out and empty soil into sample container (e.g., decontaminated plastic bucket).

h) One-inch diameter galvanized pipe with T fitting sharpened on one end and used to pre-cut consistent-size drill holes in plates.

Figure 4 (cont.). Most commonly used tools for surface soils. Use a heavy-duty cordless drill (e.g. 28V) with a one-inch drill bit (see Figure 5a,b). Weaker drills are prone to overheat or quickly drain batteries, especially in clayey or hard-packed soils. Heavy-duty plates (e.g., Chinet) are sturdier in the field. Pre-cut holes to save field time; one to two plates needed per DU. Decontaminate drill bit between DUs. Carry sampling tubes or other alternative tool as a back up to dead batteries or broken drills. Demonstration photo – samplers would normally be wearing latex gloves and changing gloves between DUs.

a) Use a 28V cordless rotary hammer drill (e.g., Milwaukee or Grainger models).





b) One-inch diameter wide-flight auger and hollow center auger bits allow better recovery of soil (e.g., Speedbor Ship Auger Bit).

c) Use of hi-powered, Hilti drill with a portable generator (photo from Weston Solutions).

d) Collection of increments with a Hilti drill and paper plate. Wrist braces recommended (photo from Weston Solutions).

e) Narrow spade (root digger), o'o (pry bar) and mattock for collection of increments from hard-packed soil.

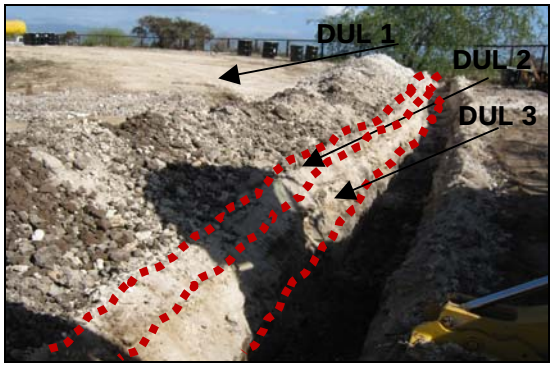
f) Breaker Bar used to cut through old asphalt surface and collect soil increments.

Figure 5. Other useful tools for collection of MI soil samples.

g) Coring through concrete for collection of subslab increments.

h) Cut furrows for collection of increments from hard-packed or gravely surface soil.

i) Trenches and potholes for soils within a few feet of the ground surface (photo by EnviroServices & Training Center, LLC).



j) Accessing subsurface DU Layers in a trench (Du Layer 1 represents 0-6” surface soil).

k) Push-drive rig used to collect subsurface soil increments (photo from Bureau Veritas).

l) Continuous core collected from boring. The core represents an “increment” collected the subsurface portion of the targeted DU soil (photo from Bureau Veritas).

Figure 5 (cont.). Other useful tools for collection of MI soil samples.

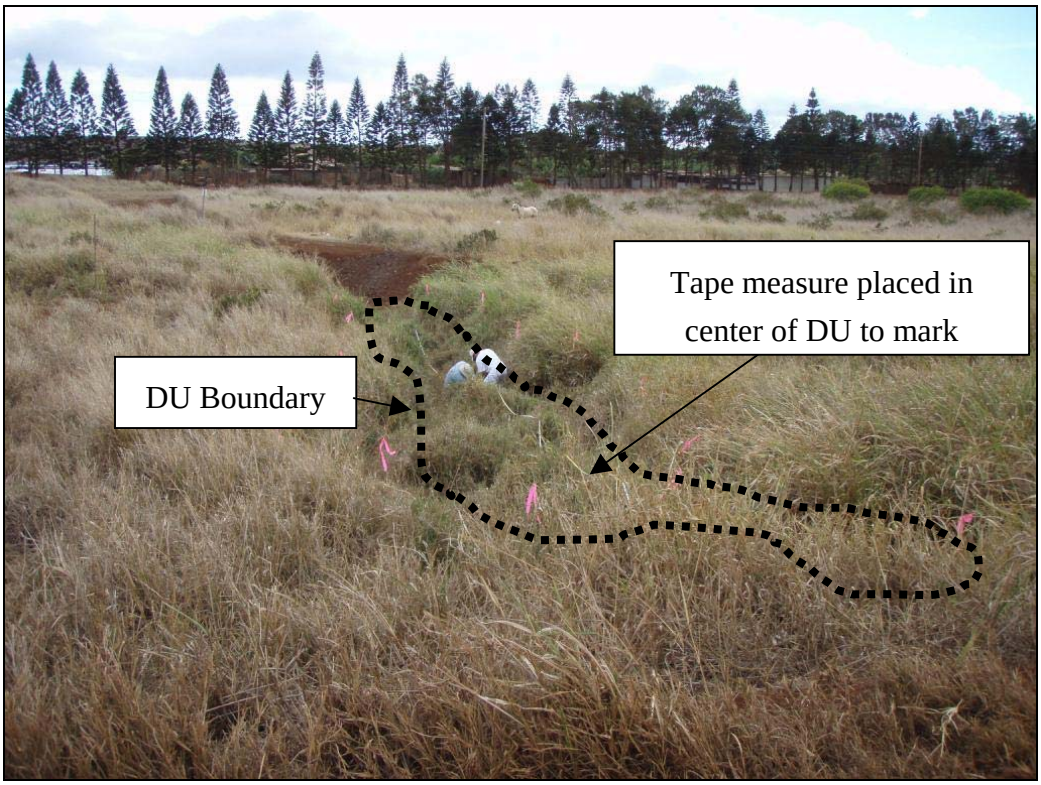


Figure 6a. Collection of MI sediment samples from drainage ditch for pesticide analysis. Tape measure or rope marked at regular spacing (e.g., every three feet) placed in middle of DU to identify increment spacing.

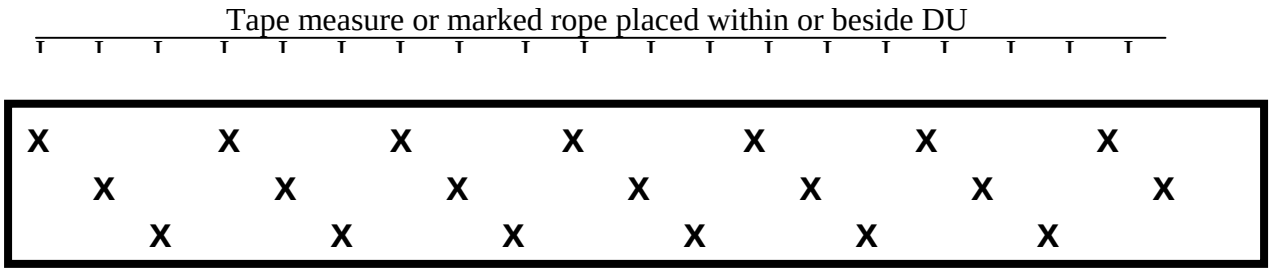


Figure 6b. Example use of a modified, zig-zag" pattern to collect increments from a long, narrow DU. Divide DU length by target number of increments. Alternate collection of increments from top, center and bottom of DU to ensure equal coverage, restarting each time at the top of the DU. See also Figure 12 (DUs for streams and canals).

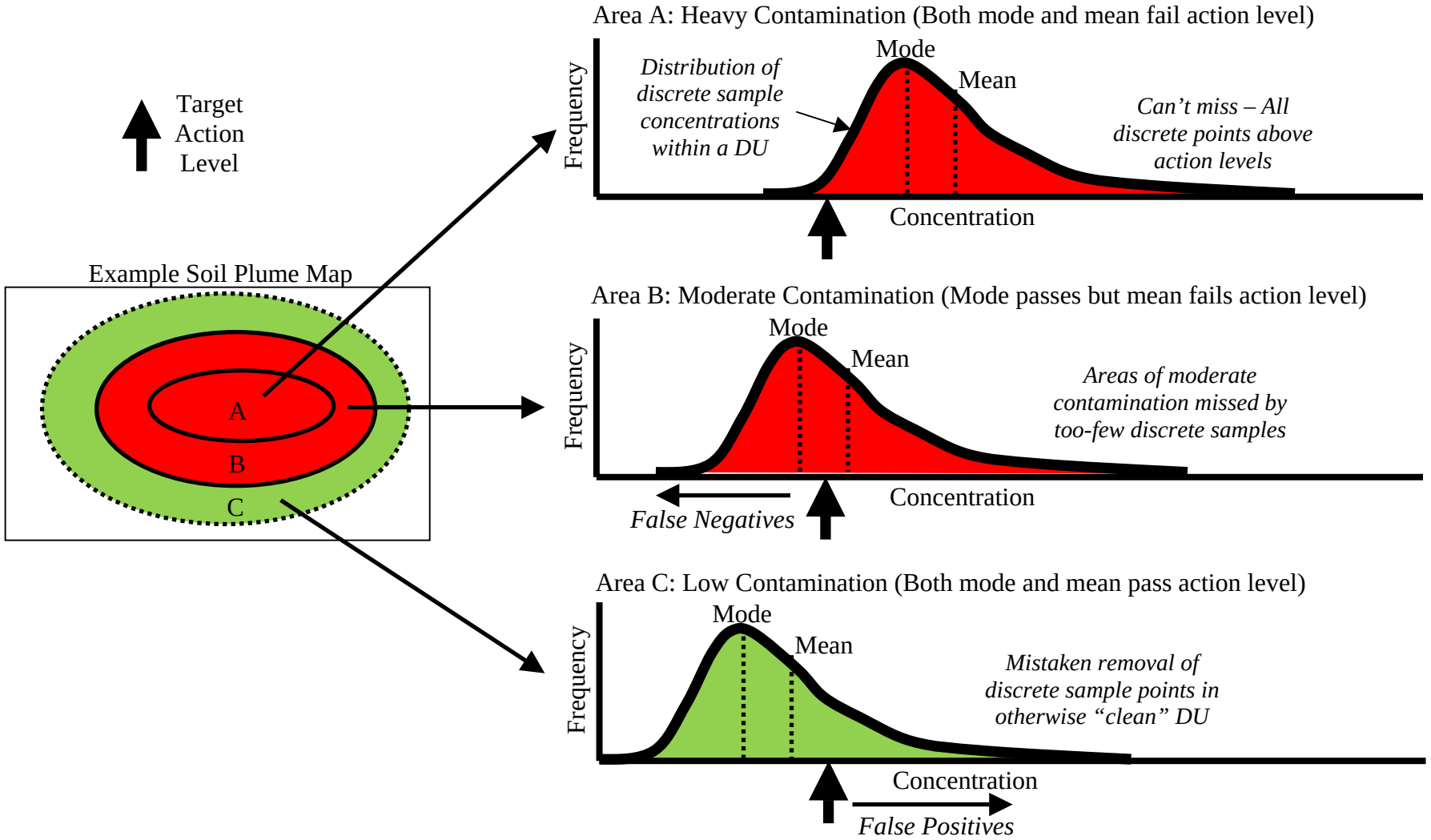
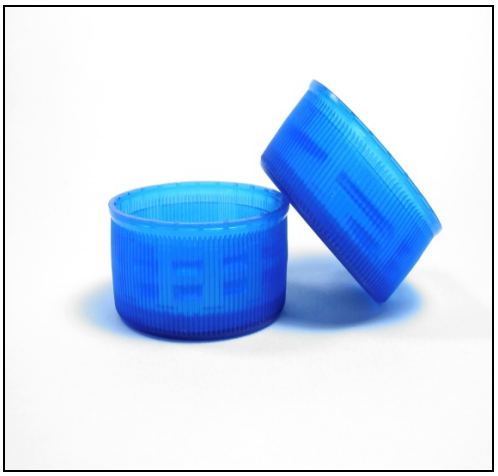


Figure 7. Effect of contaminant heterogeneity at the scale of a discrete laboratory subsample on decision making when using a non-representative number of discrete samples or MI increment points. Initial samples likely to fall around the mode. A minimum of thirty to fifty sampling points (discrete or MI) is required to adequately capture the heterogeneity of contaminant distribution within the DU and estimate a representative contaminant mean (and mass). A small number of discrete samples will identify areas of heavy contamination in Scenario A but could underestimate mean concentration and total mass, leading to failed *in situ* remediation. False negatives in Scenario B can lead to an underestimation of contamination extent and failed excavations or *in situ* treatment. False positives in Scenario C lead to unnecessary soil treatment/removal associated with discrete sample points or borings in otherwise clean DUs.

a) One gram of soil compared to a penny.



b) The plastic cap for a standard soda bottle holds approximately five grams of soil.

c) Thirty grams of soil compared to a penny.

Figure 8. Mass of laboratory subsamples typically extracted and analyzed from a soil sample (e.g., 0.5g for Hg; 1g for metals, 5g for VOCs, 10g for dioxins, 30g for TPH, pesticides and PAHs). This represents the true size of a discrete soil sample in the absence of MIS-type subsampling, regardless of the sample mass actually submitted (see also Figure 15).

a) DU Layers identified in core.

b) Core increment subsampled by collection of 5g plugs at regular spacing (e.g., every two inches).

c) Plugs removed from DU Layer increment and placed in methanol.

d) Total weight of plugs collected from increment monitored to ensure consistency between boreholes.

Figure 9. Subsampling of DU Layer increments from borehole cores and preservation in methanol.

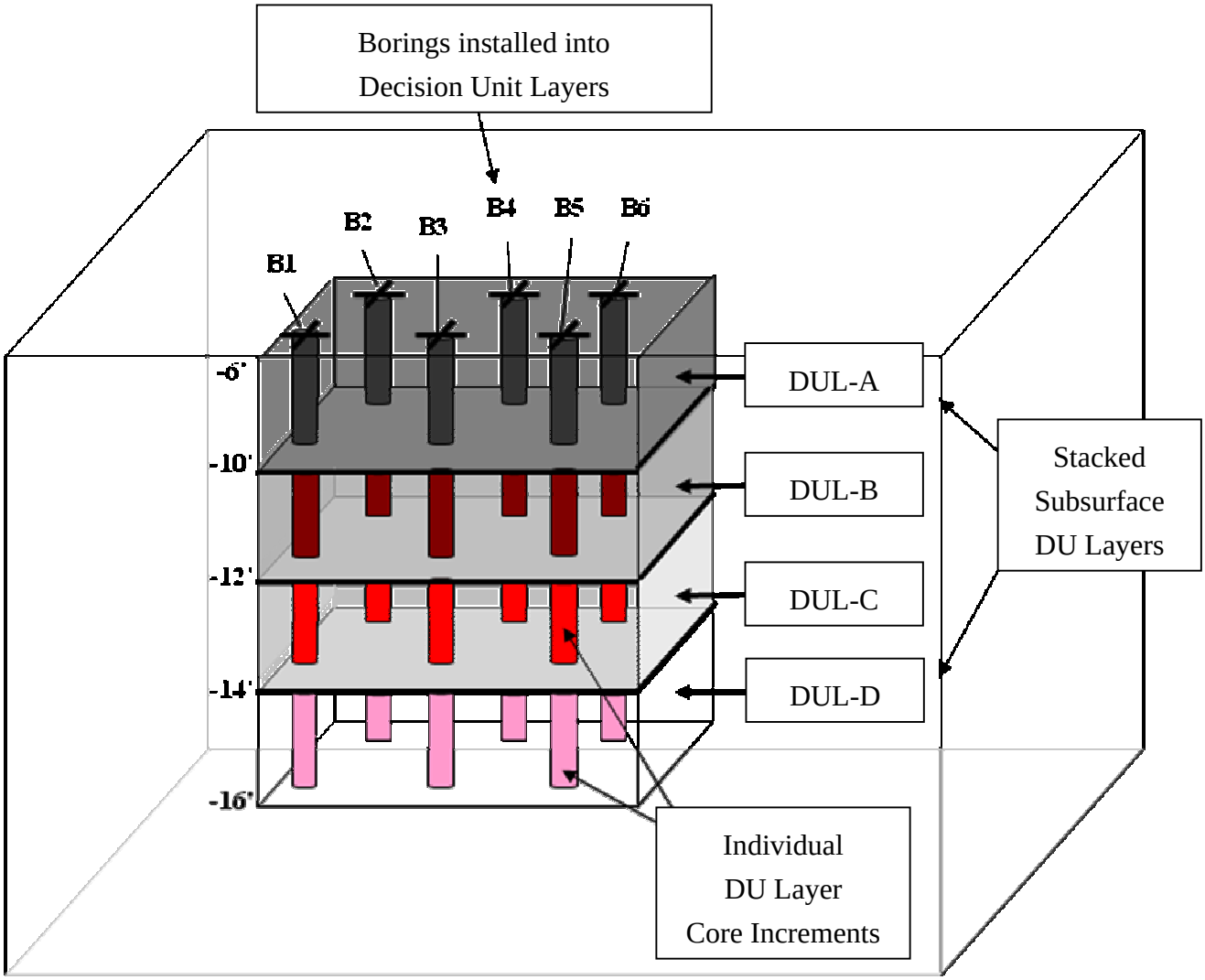


Figure 10. Designation of DU Layers (vs specific depth points) for subsurface investigations. The section of core extracted from a DU Layer represents an "increment" (see also Figures 9 and 13).

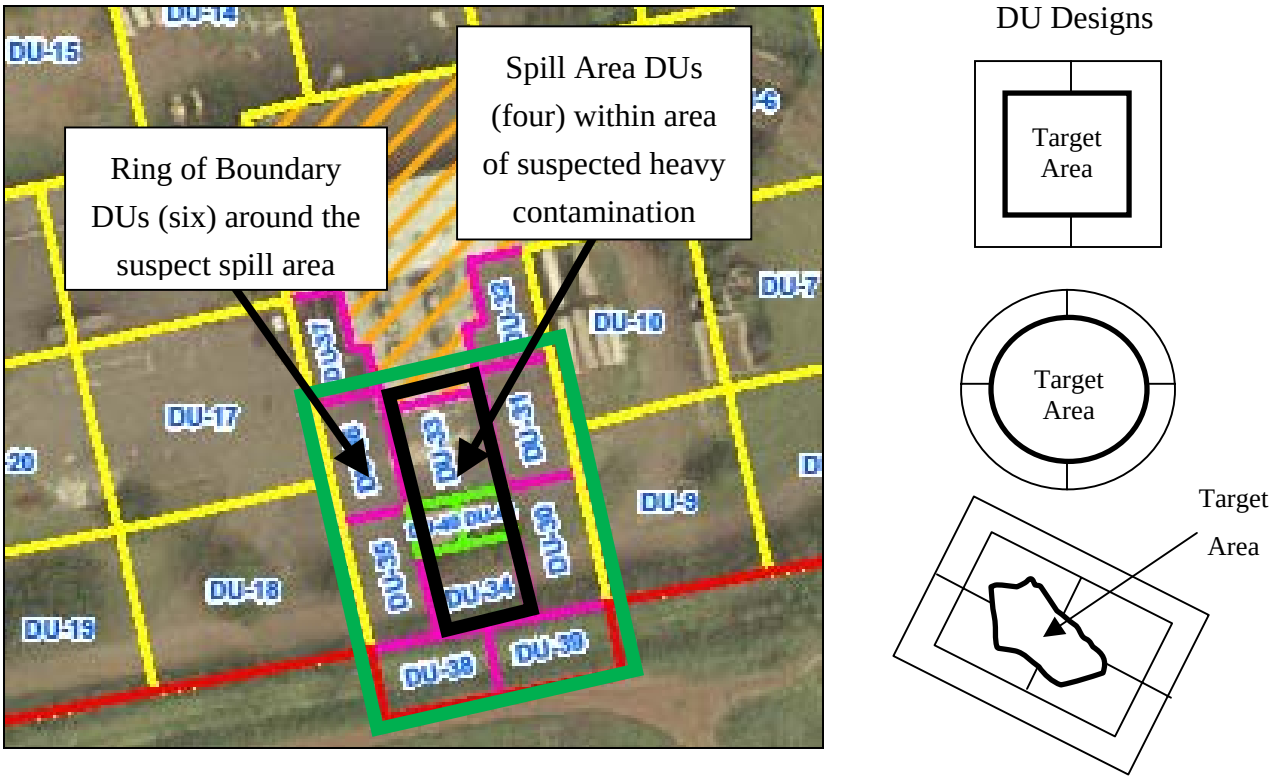


Figure 11. Investigation "Perimeter DUs" designated around a suspected ash-related spill area at a former incinerator with the objective of establishing the lateral extent of contamination (Waipahu Incinerator investigation, AMEC). Several of the outer DUs were ultimately determined to be contaminated, although the southern boundary of contamination was established (DU-38 and DU-39 clean) as well as the vertical extent of contamination (borings installed in each DU).

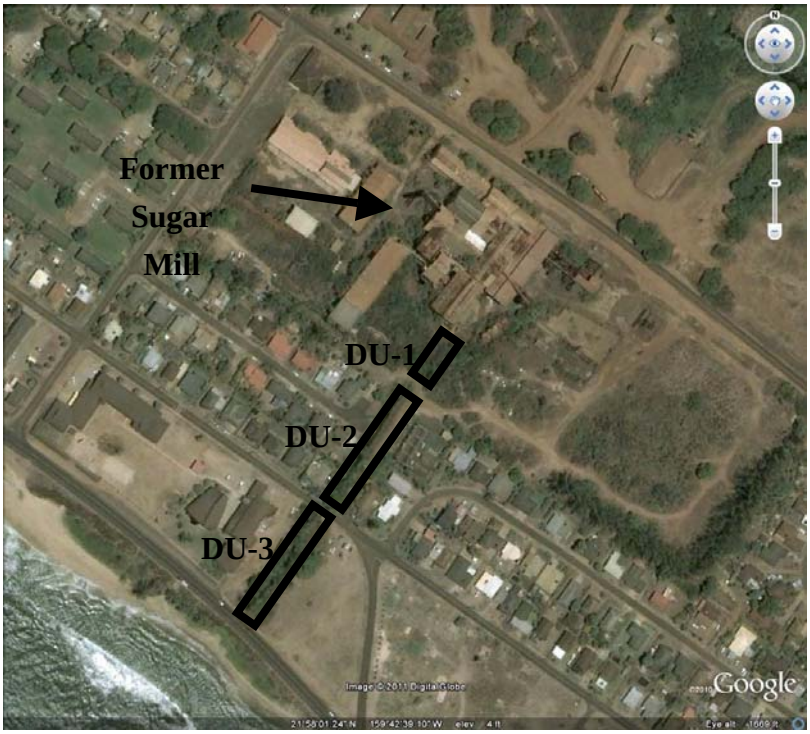


Figure 12a. DU designation for investigation of mercury contamination in a drainage ditch associated with a former sugar mill. DU-1 is 75' long and 10' wide (750ft^2); DUs 2 and 3 are 250' long and 10' wide (2,500ft^2). DU sediment volume estimated 20 yrd^3 and 50 yrd^3, respectively.

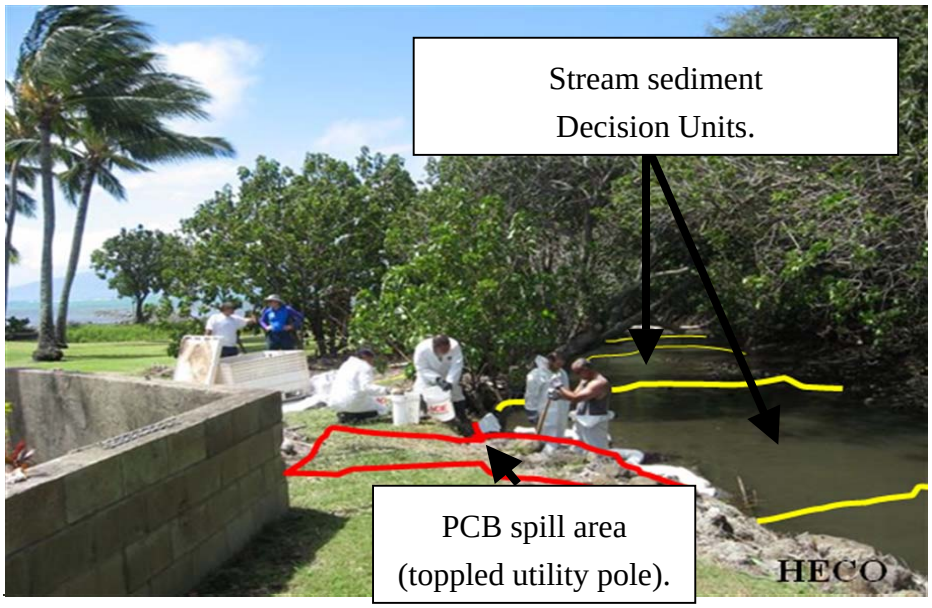


Figure 12b. DU designation for sediment investigation at a PCB-transformer spill (photo from HECO with graphics added by HDOH). Approximate 500ft^2 DUs; estimated 25 cubic yards of sediment per DU.

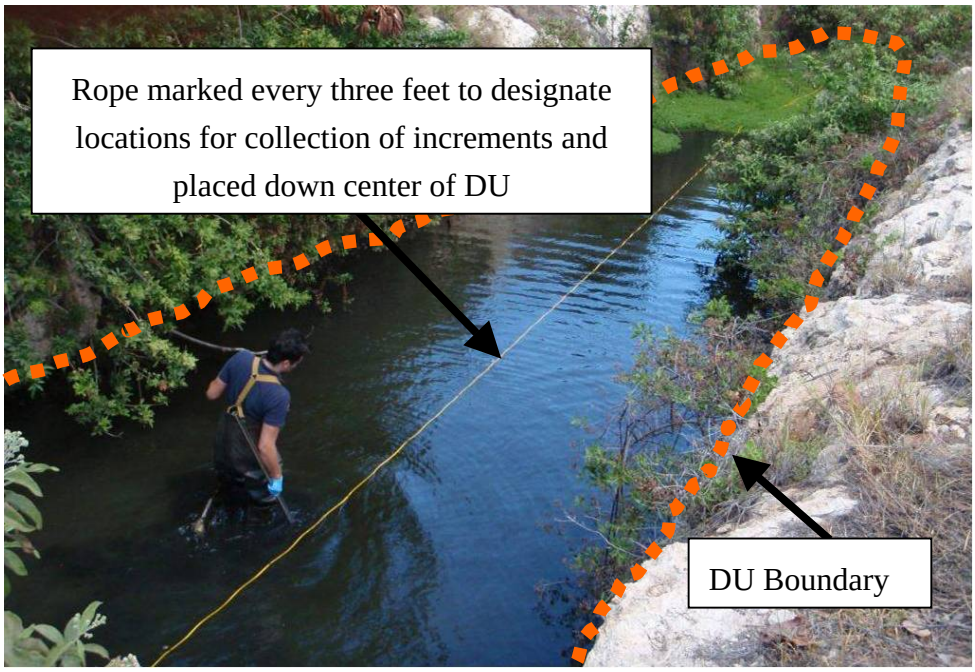


Figure 12c. Collection of MI sediment increments from a drainage canal.

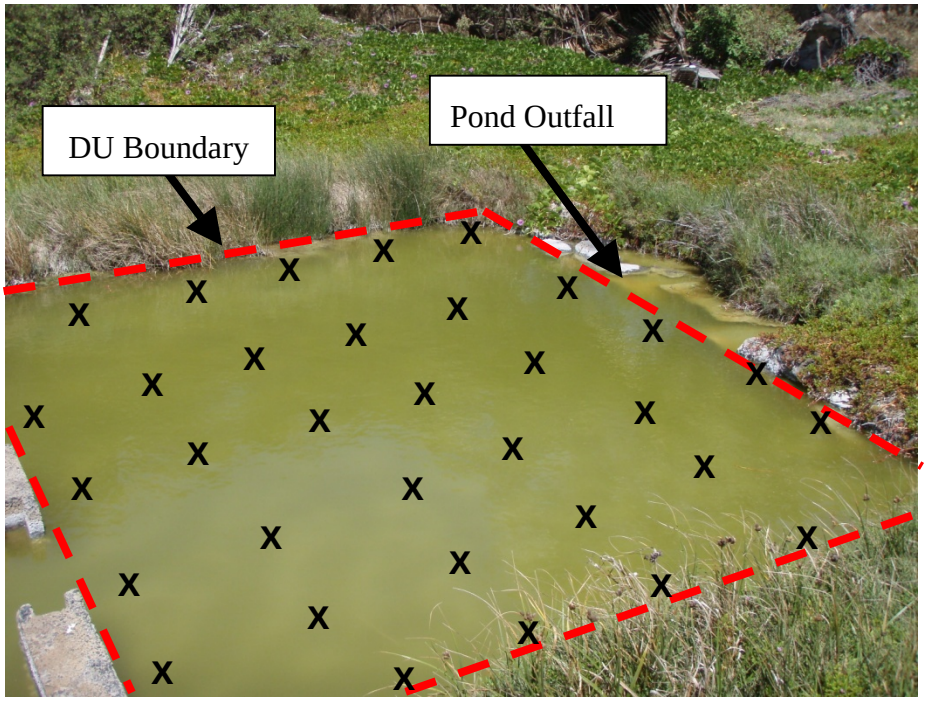


Figure 12d. DU designated for characterization of sediment at the mouth of a pond outfall.

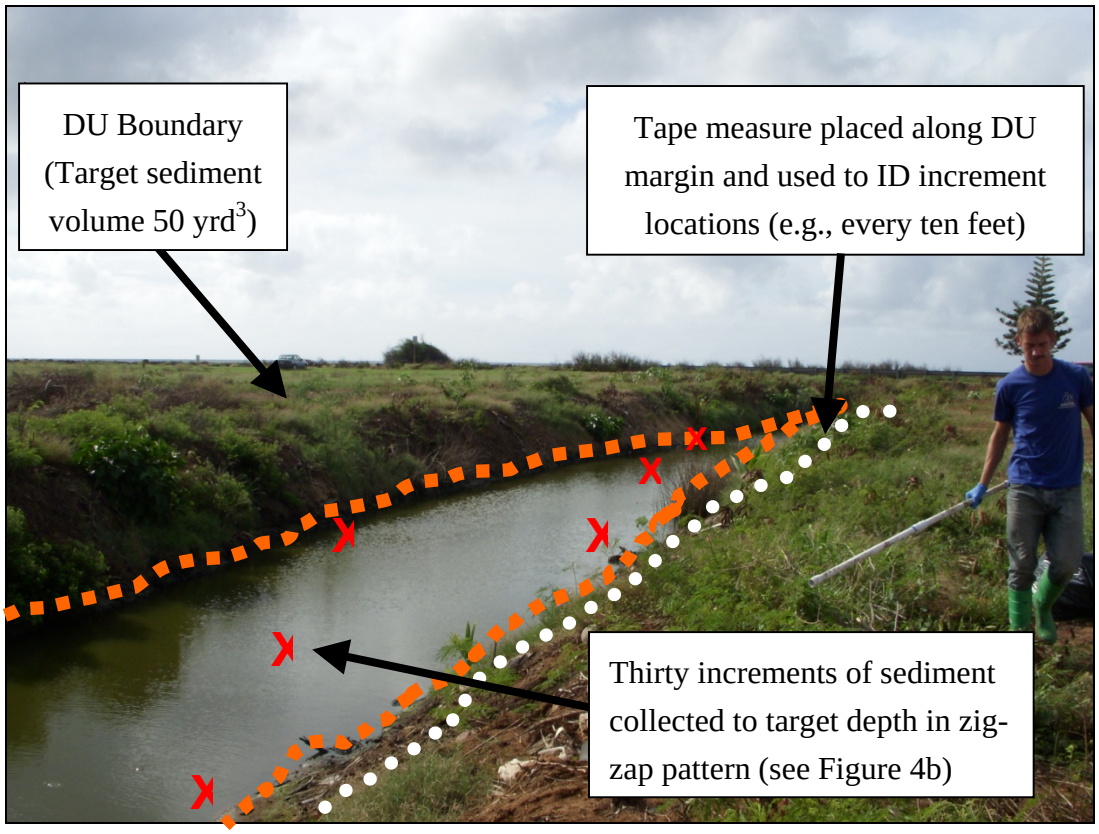
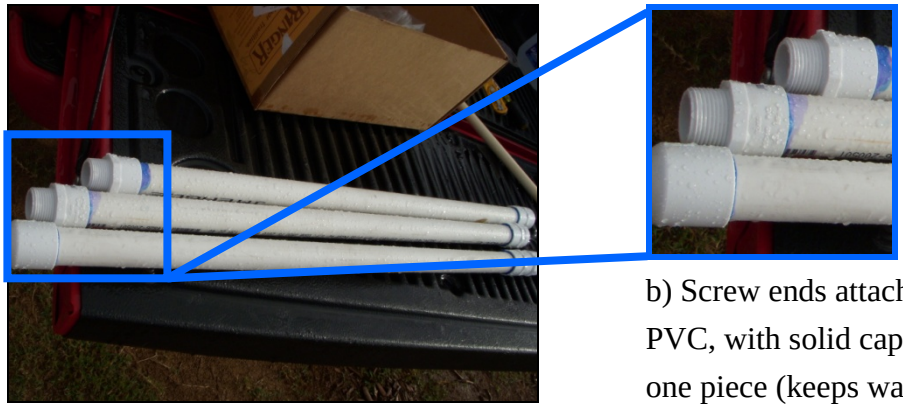
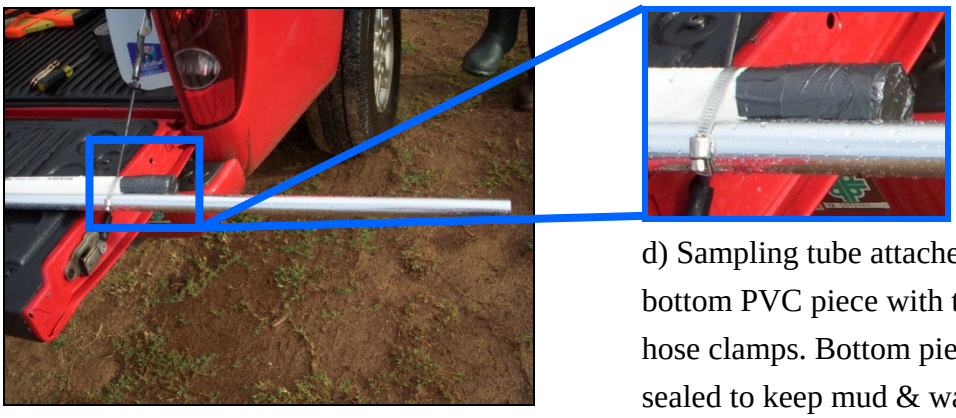


Figure 12e. DU Designation and collection of MI samples from a sugar mill drainage canal (DU-3 in Figure 12a, photo from Weston Solutions; see also Figure 14).



a) Ten-foot long PVC pipe for pole handle cut into five, 2' lengths for easy assembly in field (1" diameter Schedule 40) .

b) Screw ends attached to cut PVC, with solid cap on end of one piece (keeps water out).



c) Two-foot long, 1" aluminum sampling tube (thin-walled towel holder) attached to bottom PVC pole .

d) Sampling tube attached to bottom PVC piece with two metal hose clamps. Bottom piece of PVC sealed to keep mud & water out.

Figure 13. Sediment Sampling Tube (example shown made by Weston Solutions, not patented; see also Figure 14).

a) Increment collection point accessed.

b) Sampling tube pushed into sediment to target depth.

c) Increment core pushed out of tube using disposable 3/4” wooden dowel. Tilt tube slightly backward before pushing out sample in order to drain excess water, but be careful not to lose sediment.

d) Increment collected on disposable plate and placed into sampling container (e.g., one-gallon freezer bag carried in clean bucket). Note cylindrical shape of increment.

Figure 14. Collection of sediment increments from a drainage canal (see Figure 12).

a) Collection of increments from a canal with a thin sediment cover using a scoop sampler scoop (made by TetraTech EMI, not patented).

b) Flat-bottom scoops with upright, flat sides to help Avoid a bias toward the upper layers of sediment.

Figure 15. Alternative scoop-shaped sampler for coarser-grained sediment or other situations where a tube sampler is not practical, including collection of increments from very thin sediment. A flat-bottom scoop with upright, square sides will also help to avoid bias to the upper portion of the sediment.

a) Subsampling of dried and sieved MI sample. Subsamples prepared by using a small scoop to collect 30+ increments from flattened sample.

b) Subsampling of dried and sieved MI sample using a sectoral splitter.

Figure 16. Laboratory preparation and subsampling of MI samples (or discrete samples) for extraction and analysis. For non-volatile chemicals, samples are dried and sieved to $\leq$2mm particle. Use a flat-bottom scoop with vertical, square sides to help ensure that increments are not biased toward the upper layers of the soil. Sectoral splitter preferred but may involve increased sample preparation costs due to added, decontamination effort required between samples.