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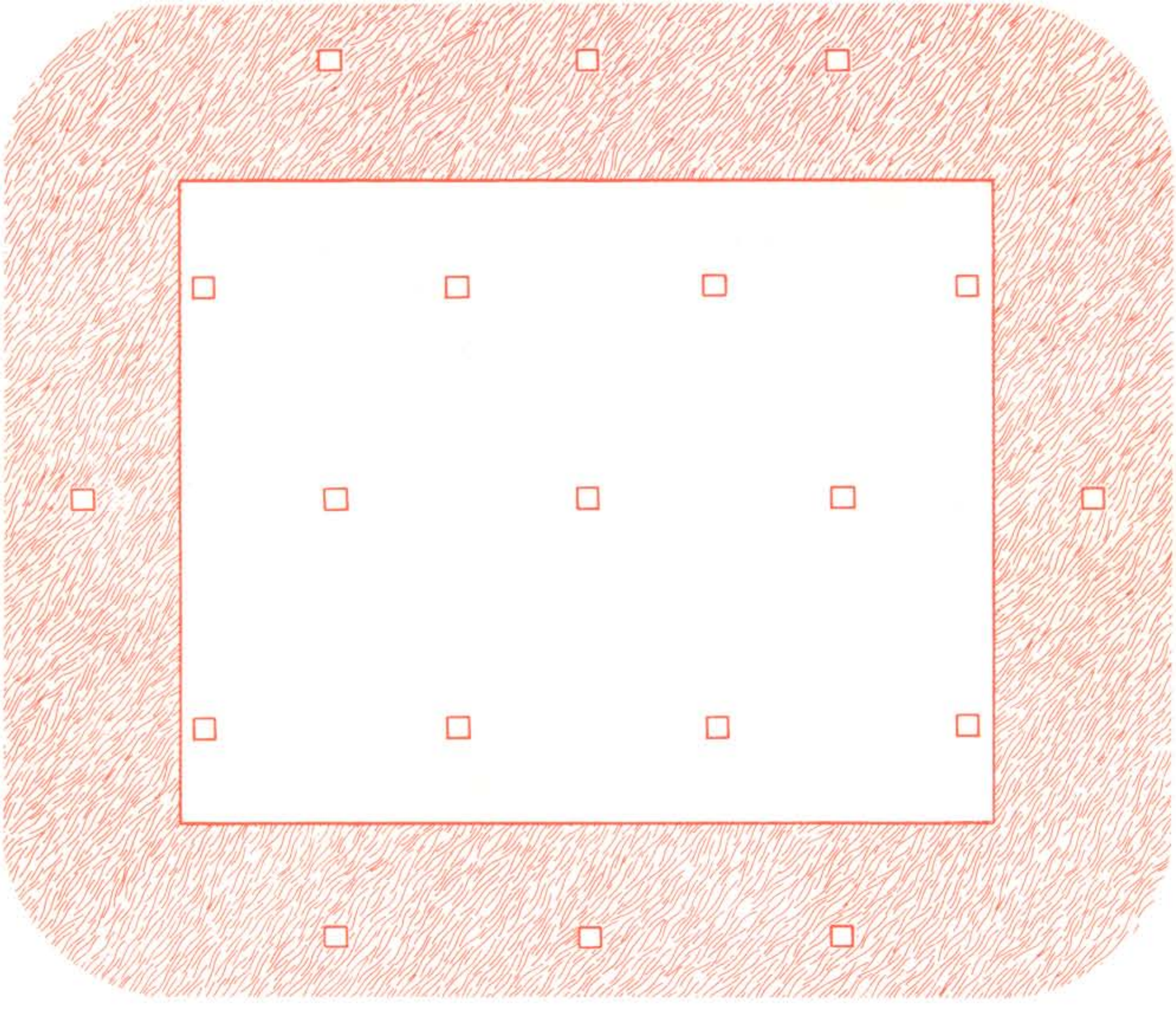
FIELD MANUAL FOR GRID SAMPLING OF PCB SPILL SITES TO VERIFY CLEANUP



FIELD MANUAL FOR GRID SAMPLING OF PCB SPILL SITES TO VERIFY CLEANUP

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DISCLAIMER

PREFACE

This Interim Report was prepared for the Environmental Protection Agency under EPA Contract No. 68-02-3938, Work Assignment 37. The work assignment was directed by Mitchell D. Erickson. This report was prepared by Gary Kelso and Dr. Erickson of Midwest Research Institute (MRI). David C. Cox of the Washington Consulting Group, 1625 I Street, N.W., Washington, D.C. 20006, contributed to the sampling design (Section 5.0) and compositing strategies (Appendix) sections under subcontract to Battelle Columbus Laboratories, Subcontract No. F4138(8149)435, EPA Contract No. 68-01-6721 with the Design and Development Branch, Exposure Evaluation Division.

This report is a revision of a previous draft report entitled "Field Manual for Verification of PCB Spill Cleanup" (Draft Interim Report No. 3, Task 37, EPA Prime Contract No. 68-02-3938, June 27, 1985). Both English and metric units are used in this document, where appropriate. EPA field inspectors will most commonly measure the site in English units; therefore these units were used for the site measurements in this report.

The EPA Work Assignment Managers, Daniel T. Heggem, Richard A. Levy, and John H. Smith, as well as Joseph J. Breen and Cindy Stroup of the Office of Toxic Substances, provided helpful guidance. Ms. Joan Westbrock and Mr. Ted Harrison of MRI and Mr. David Phillippi and Mr. Robert Jackson of EPA Region VII assisted in the field validation of this manual.

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May 1986

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1.0 SCOPE AND APPLICATION

The purpose of this manual is to provide detailed, step-by-step guidance to EPA staff for using hexagonal grid sampling at a PCB spill site. Emphasis is placed on sampling sites which have already been cleaned, although the sampling methods presented may also be used at PCB spill sites which have not been cleaned. Guidance is given for preparing the sample design; collecting, handling, and preserving the samples taken; maintaining quality assurance and quality control; and documenting and reporting the sampling procedures used. An optional strategy for compositing samples is given in the appendix.

This is a companion document to the report "Verification of PCB Spill Cleanup by Sampling and Analysis" (EPA 560/5-85-026, August 1985, Second Printing). That report provides an overview of PCB spill cleanup activities and guidelines for sampling and analysis including: sampling designs, sampling techniques, analytical techniques, selection of appropriate analytical methods, quality assurance, documentation and records, and reporting results. The previous report provided the rationale and background for the techniques selected and describes many options in greater detail.

This "how-to" report concentrates on detailed guidance for field sampling personnel and does not attempt to provide background information on the techniques presented. This manual addresses field sampling only and does not provide information on laboratory procedures, including sample analysis, data reduction and laboratory data reporting. The types of field sampling situations discussed in this manual are those typically found when a PCB spill results from a PCB article, PCB container, or PCB equipment spill. Unusual PCB spill situations, such as elongated spills on highways from a moving vehicle, large spills in waterways, and large, catastrophic spills, are not addressed.

2.0 SUMMARY

This manual is divided into the following sections:

- Safety
- Sampling Equipment and Materials
- Sample Design
- Sample Collection, Handling, and Preservation
- Quality Assurance
- Quality Control
- Documentation and Records
- Validation of the Manual

Safety aspects of field sampling include wearing proper protective equipment, practicing good hygiene, using safe work practices, and training field inspectors in safety procedures. Sampling equipment and materials include personnel equipment, sampling equipment, and documentation materials. Prior to making the field sampling trip, the EPA inspector should ensure that all sampling equipment and materials are available, and that all sampling containers and equipment have been properly precleaned.

The sample design is based on a hexagonal grid of 7, 19, or 37 sample points. A step-wise method describes how to construct a diagram of the PCB spill site on graph paper; determine the radius and center of the sampling circle; determine which grid size to use; lay out the grid on the diagram; and then lay out the sampling grid on the site.

After the sampling grid has been laid out on the site, a sample must be taken at each grid point. Methods to collect, handle, and preserve different types of samples, including surface soil samples, soil core samples, surface and subsurface water samples, wipe samples from nonporous hard surfaces, destructive samples from porous hard surfaces, and vegetation samples, are suggested. For each type of sample to be taken, methods are recommended to prevent cross-contamination between samples.

Quality assurance (QA) and quality control (QC) must be an integral part of any sampling scheme. A quality assurance plan must be developed by appropriate EPA offices according to EPA guidelines and be submitted to the regional QA officer or other appropriate QA official for approval prior to sampling PCB spill sites. Each EPA office must operate a formal QC program and all QC measures should be stipulated in the QA plan. Some of the requirements of quality control are discussed in this report, including field blanks, sampling without cross-contamination, sample custody, and documentation of the field sampling activities.

All sampling activities should be thoroughly documented and reported as a part of the verification process. Each EPA office is responsible for preparing and maintaining complete records, including an equipment preparation log book, a field log book, site description forms, chain-of-custody forms, sample analysis request forms, and field trip reports.

Section 10.0 briefly describes a field study which was conducted to test and validate the sample design given in this manual. The study showed that the sampling design is easy to follow and understood by those unfamiliar with the manual prior to reading it, and that the grid sample points can be correctly laid out in a relatively short period of time.

The appendix gives strategies that may be used to composite the samples taken at a PCB spill site when compositing is deemed to be desirable.

3.0 SAFETY

A PCB spill site which has been cleaned up should have very low levels of PCBs present. The EPA inspector(s) who sample the site to verify that the site has been properly cleaned up should, however, take some precautions to minimize any exposure to PCBs or other potential hazards at the site.

In order to ensure that the inspectors understand and practice good safety procedures, a training and education program should be established and a health and safety manual provided by the responsible EPA officer. The program should inform inspectors of the potential hazards of exposure to PCBs, and the proper safety procedures to follow when sampling PCB spill sites.

4.0 SAMPLING EQUIPMENT AND MATERIALS

The equipment and materials required to sample a PCB spill site will vary with the types of samples to be taken. The general lists of equipment and materials given below must be adjusted for the specific requirements of each spill. The lists include personnel equipment, sampling equipment and materials, and documentation materials which should be taken to the spill site by the EPA inspector. These equipment and materials must be assembled prior to making the site visit, and all sampling containers and sampling equipment must be precleaned.

4.1 Personnel Equipment

The inspector should take the following personnel equipment to the spill site:

- Disposable rubber gloves
- Plastic overshoes
- Safety glasses
- Impervious paper-like coveralls
- Hardhat
- Safety shoes
- First-aid kit
- Other safety equipment specified by safety officer

4.2 Sampling Equipment and Materials

Since the types of samples to be taken at a spill site may vary from site to site, the following sampling equipment and materials should be taken:

- Precleaned glass sample jars with Teflon-lined caps
- Aluminum foil (solvent-rinsed)
- Container of reagent-grade solvent (isooctane is recommended)
- Box of 11 cm filter paper (e.g., Whatman 40 ashless or Whatman 50 smear tabs)
- Gauze pads
- Stainless steel forceps
- Stainless steel templates (10 cm x 10 cm square)
- Stainless steel trowels, Teflon scoops, or laboratory spatulas (precleaned)
- Soil coring devices (such as King-tube samplers or piston corers)
- Hammer and chisel
- Hole saw and drill
- Pruning shears
- Stainless steel buckets
- Disposable wiping cloths
- Plastic disposable bags
- Sample bags and seals
- Survey stakes
- 100 ft tape measure
- Ice chests containing ice or ice packs and secured with padlocks
- Compass and maps
- Duct tape
- Subsurface water sampling equipment (such as pumps, siphons, glass sampling jars with attachments, etc.)
- Container of distilled water
- Stainless steel mixing bowls and spoons

4.3 Documentation Materials

The following documentation materials should be taken to the field site:

- Field log book
- Chain-of-custody forms
- Site description forms
- Sample analysis request forms
- Sample bottle labels
- Camera with film
- Yellow TSCA PCB marks

4.4 Trip Preparation

The EPA field inspector must assemble all the necessary equipment and materials prior to making the field sampling trip. Special attention should be given to assuring that all of the equipment and materials are available, and that the sample containers and sampling equipment have been properly precleaned. The equipment preparation should be documented in a log book (Section 9.1) prior to making the trip.

5.0 SAMPLE DESIGN

The methods to be used for determining the sample point locations at a PCB spill site are given in this section, and are based upon a hexagonal grid sample design which was recommended in the report "Verification of PCB Spill Cleanup by Sampling and Analysis." Although the grid design involves more samples and a more complicated layout than the usual grab sampling methods, the grid design is essential to obtaining a representative sample of the site and greatly increases the chance of detecting high levels of PCB contamination when they exist. For example, when 4% of the PCB spill site remains contaminated at 50 ppm after cleanup, analysis of samples from a 37-point grid has a 98% chance of detection of this contamination level, while analysis of six random grab samples from the site has only a 3% chance of detection (Boomer et al. 1985).

The hexagonal grid sampling design is to be laid out within a sample circle centered on the spill site, and extending just beyond its boundaries. Preparation of the design requires the following steps:

- Step 1: Diagram the Cleanup Site
- Step 2: Diagram All Cleanup Surfaces in the Same Plane
- Step 3: Find the Center and Radius of the Sampling Circle
- Step 4: Determine the Number of Grid Sample Points to Use
- Step 5: Lay Out the Sampling Points on the Diagram Constructed in Step 2
- Step 6: Lay Out the Sampling Locations on the Site
- Step 7: Consider Special Cases and Use Judgment for Sample Points

The discussion which follows gives the methods to be used in accomplishing each step of the hexagonal grid sampling design, using a three-dimensional spill surface as an example. Following this discussion, a simple example of laying out the sample design on a rectangular two-dimensional surface is given.

5.1 Step 1: Diagram the Cleanup Site

Draw a scale diagram of the cleanup site on graph paper, including vertical surfaces (walls, fences, etc.), noting important dimensions and different types of surfaces (sod, cement, asphalt, etc.). Such a diagram may sometimes be found in records of the cleanup. If not, site measurements should be taken. Great accuracy (e.g., using surveying instruments) is not necessary, however; the use of a tape measure and pacing should be adequate. An example diagram is shown in Figure 1 on a scale of 1 in. = 4 ft.

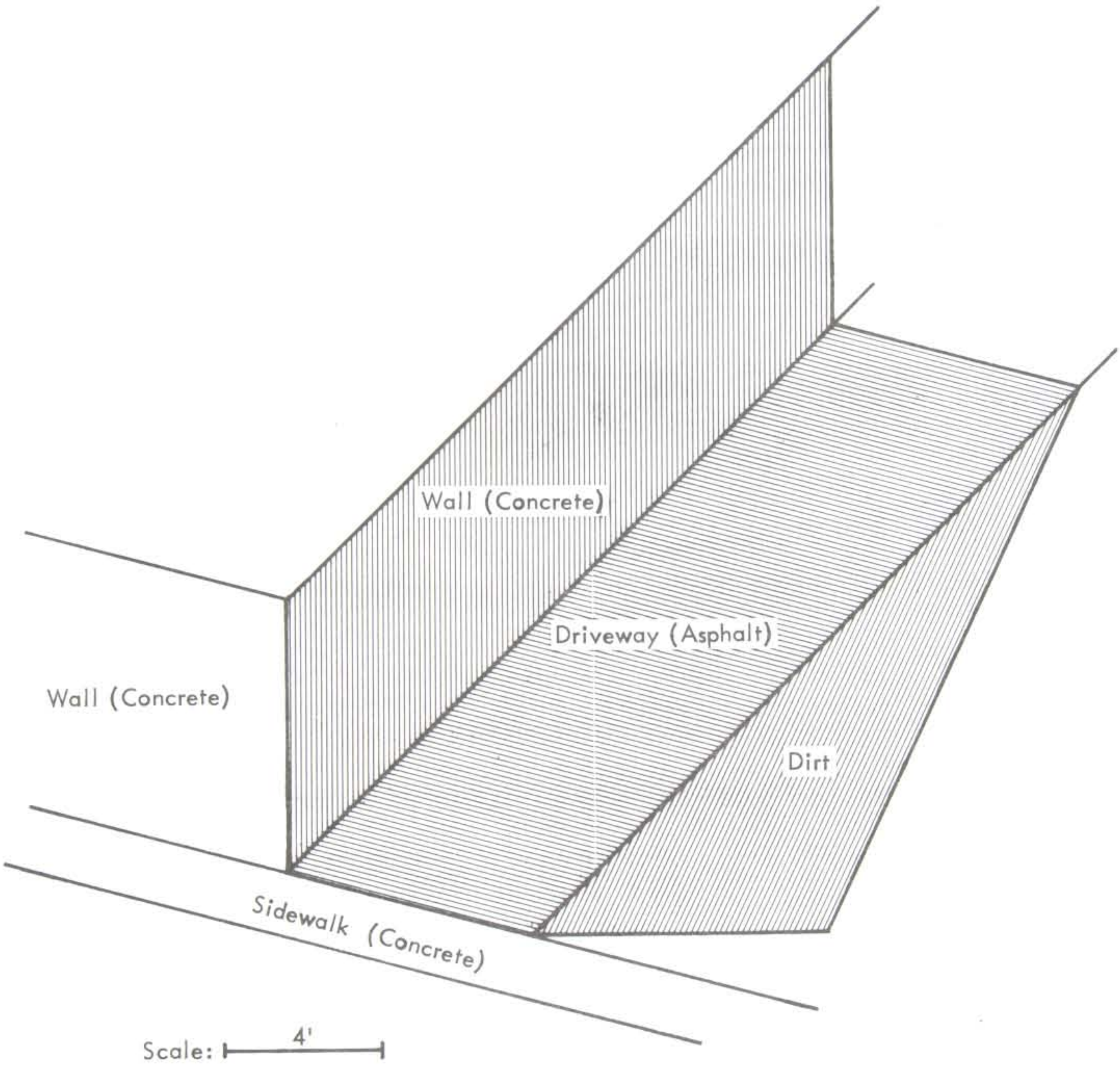


Figure 1. Example PCB spill site diagram.

The site diagram should include as many reference points as necessary to relocate the spill area in the future, if necessary. For example, a spill site in an open field should be located with respect to nearby structures such as roads, telephone poles, buildings, etc. The direction of north should be indicated on the diagram.

If available, a detailed drawing or a survey plot of the spill site should be obtained from the individual(s) that cleaned the site.

5.2 Step 2: Diagram All Cleanup Surfaces in the Same Plane

The purpose of this second diagram is to determine and show the dimensions of the total cleanup area, including vertical surfaces, so that the required sample size can be found. The diagram also facilitates the determination of sampling locations on vertical surfaces. Constructing the diagram is analogous to flattening a cardboard box. All vertical surfaces are placed in the same plane as the adjoining horizontal surfaces. Figure 2, also on a scale of 1 in. = 4 ft, shows the example spill cleanup site diagrammed in the same plane. The actual site dimensions are shown in feet.

5.3 Step 3: Find the Center and Radius of the Sampling Circle

In practice, the contaminated area from a spill will be irregular in shape. In order to standardize sample design and layout in the field, samples are collected within a circular area surrounding the contaminated area. The sampling circle is, approximately, the smallest circle containing all cleanup surfaces diagrammed in Step 2.

A recommended procedure for finding the center and radius of the sampling circle is illustrated in Figure 3 and is described below:

1. Draw the longest dimension, L_1, of the site diagram in Step 2.

2. Find the midpoint, P, of L_1.

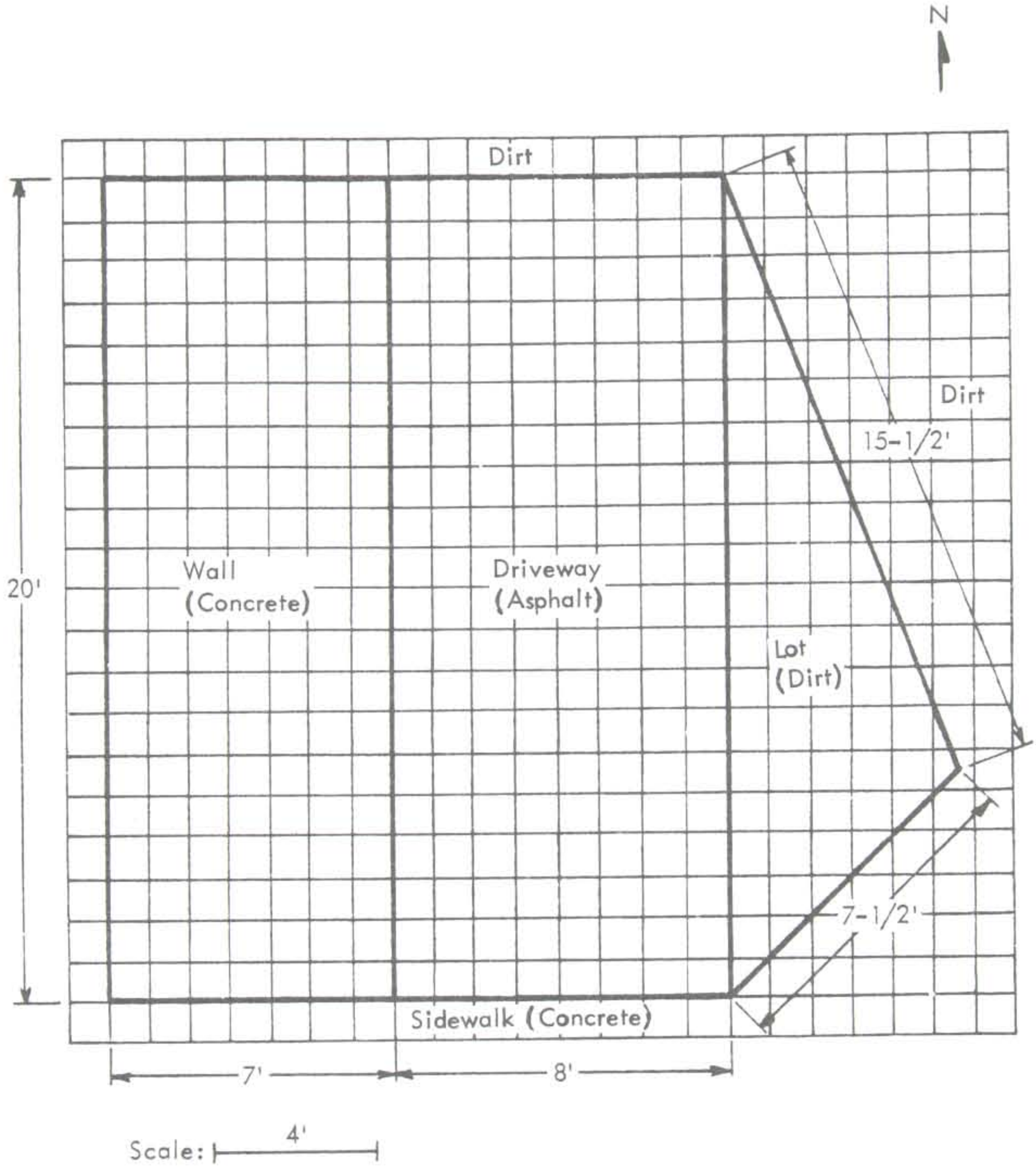


Figure 2. Example spill cleanup site diagrammed in the same plane.

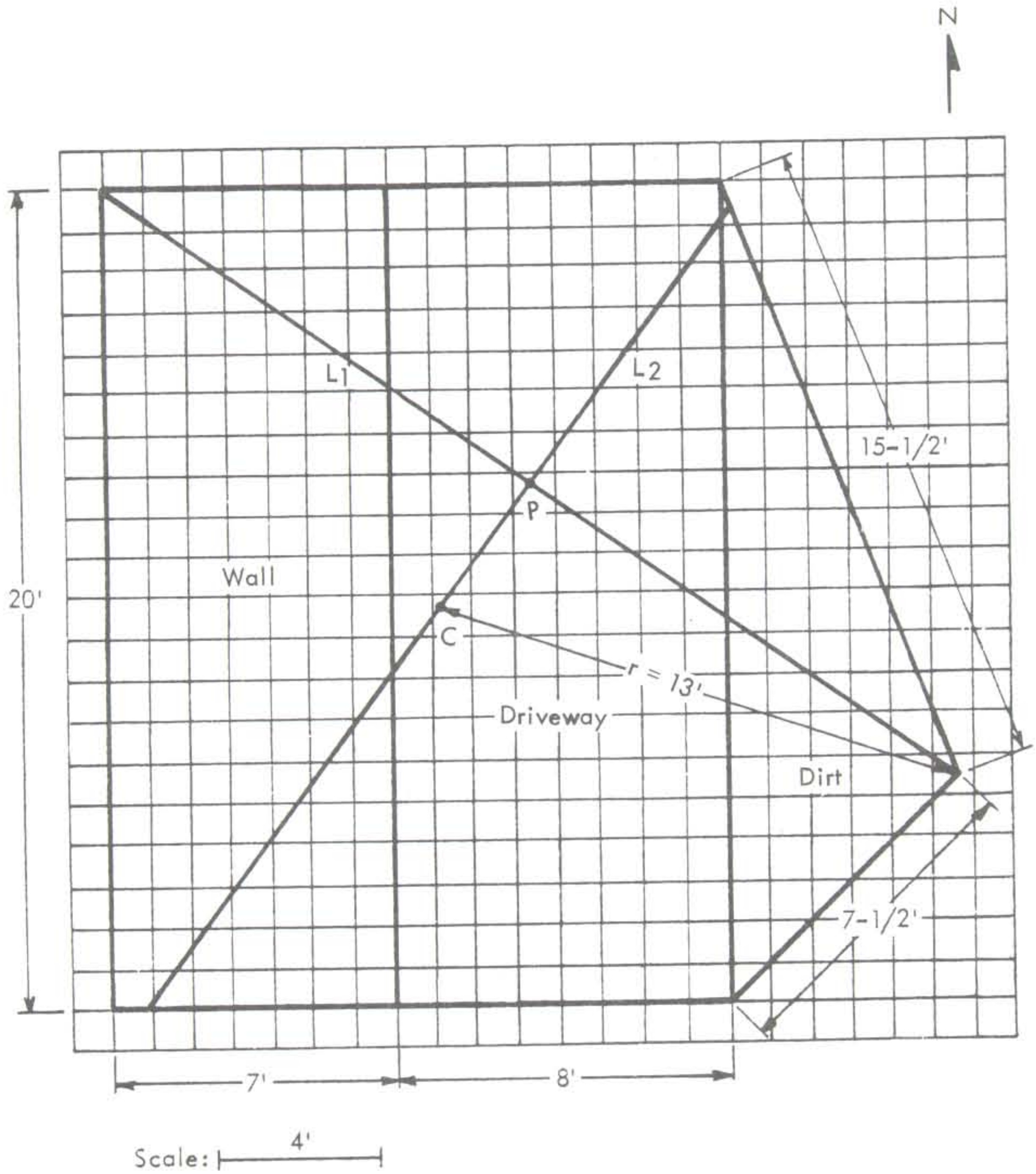


Figure 3. Locating the center and sampling radius of the example spill cleanup site.

3. Draw a second dimension, L_2, through P perpendicular to L_1. L_2 extends to the boundaries of the site diagram.

4. The midpoint, C, of L_2 is the center of the sampling circle.

5. The distance from C to either end of the longest dimension, L_1, is the sampling radius, r.

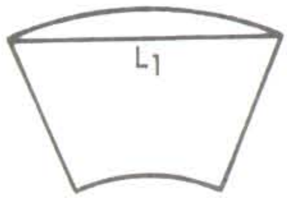
Figure 4 illustrates the application of this procedure to a site with an irregular shape, and Figure 5 shows the procedure for a variety of irregularly shaped areas. These figures show that the center and radius determined are generally reasonable.

5.4 Step 4: Determine the Number of Grid Sample Points to Use

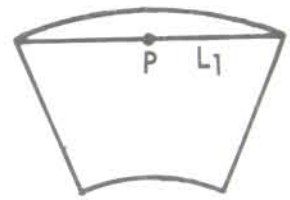
The number of grid samples to be taken at a site depends upon the radius of the sampling circle, which is determined from the scale diagram shown in Figure 3. The number of samples to be taken at a spill site should increase as the radius of the sample circle increases. The reason for this is that the probability of detecting residual PCB contamination at a given site increases as the number of grid samples increases. Table 1 shows the required number of grid samples for sampling circles with a radius of 4 ft or less (seven samples); greater than 4 ft to 11 ft (19 samples); and greater than 11 ft (37 samples).

Table 1. Required Number of Grid Samples Based on the Radius of the Sampling Circle

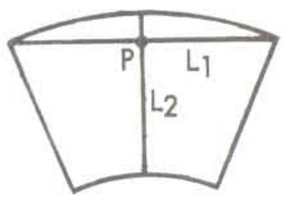
Sampling radius, r (ft)	Number of Samples
≦ 4	7
> 4 - 11	19
> 11	37



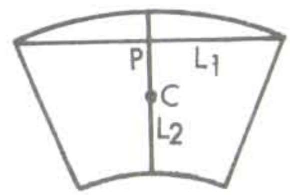
(a) Draw longest dimension, L_1, on site diagram.



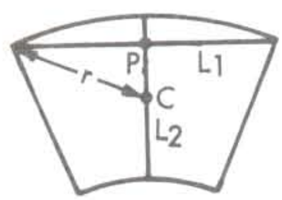
(b) Find midpoint, P, of L_1.



(c) Draw line, L_2, through P perpendicular to L_1.



(d) The midpoint, C, of L_2 is the center of the sampling circle.



(e) The distance from C to the end of L_1 is the sampling radius, r.

Figure 4. Method to find center and radius of the sampling circle.

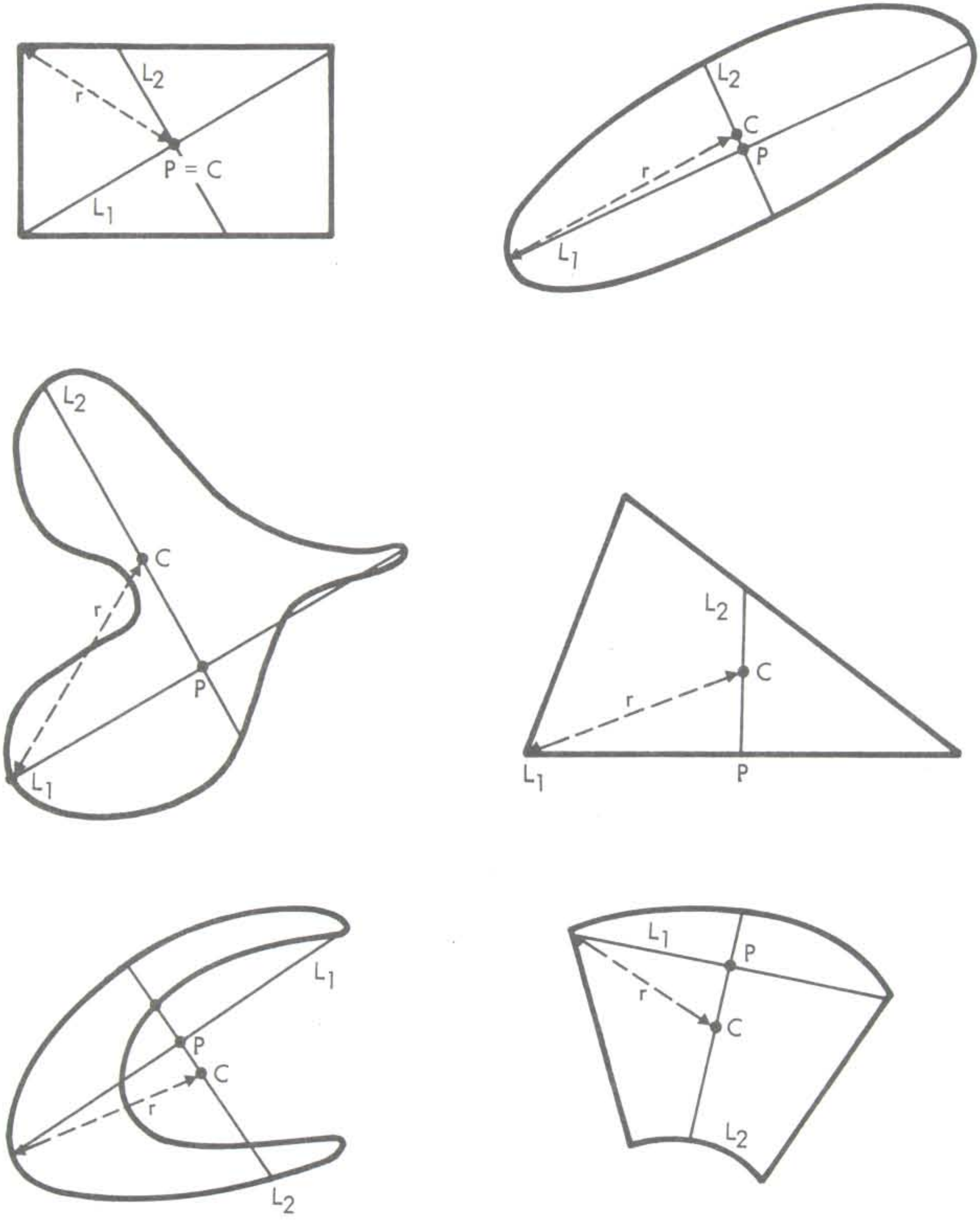


Figure 5. Locating the center and sampling circle radius of irregularly shaped spill areas.

The radius, r, for the example site is 3-1/4 in. in Figure 3. Thus, the actual site sampling radius is 13 ft (3-1/4 in. x 4 ft/in.) and the number of grid samples required is 37.

Figures 6, 7, and 8 illustrate the hexagonal grid sampling design for the three sample sizes given in Table 1, for a sampling radius of 4, 10, and 20 ft, respectively.

5.5 Step 5: Lay Out the Sampling Points on the Diagram Constructed in Step 2

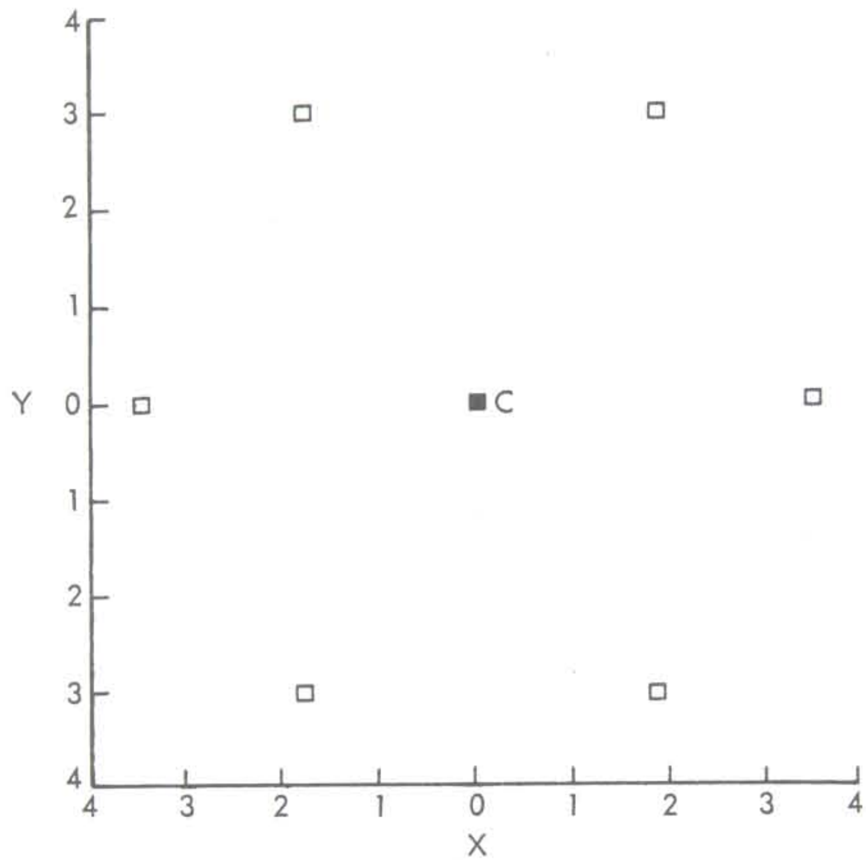
The geometric properties of the hexagonal designs can be used in many ways to lay out the sampling points. Perhaps the simplest way to proceed is as follows. Define s to be the distance between adjacent points and u to be the distance between successive rows of the design. The distances s and u are given in terms of the sampling radius, r, in Table 2 below for the given number of samples defined by the radius rule and listed in Table 1.

Table 2. Geometric Parameters of the Hexagonal Grid Designs, for Sampling Radius r

Number of samples	Distance, s, between adjacent sample points	Distance, u, between successive rows
7	0.87r	0.75r
19	0.48r	0.42r
37	0.30r	0.26r

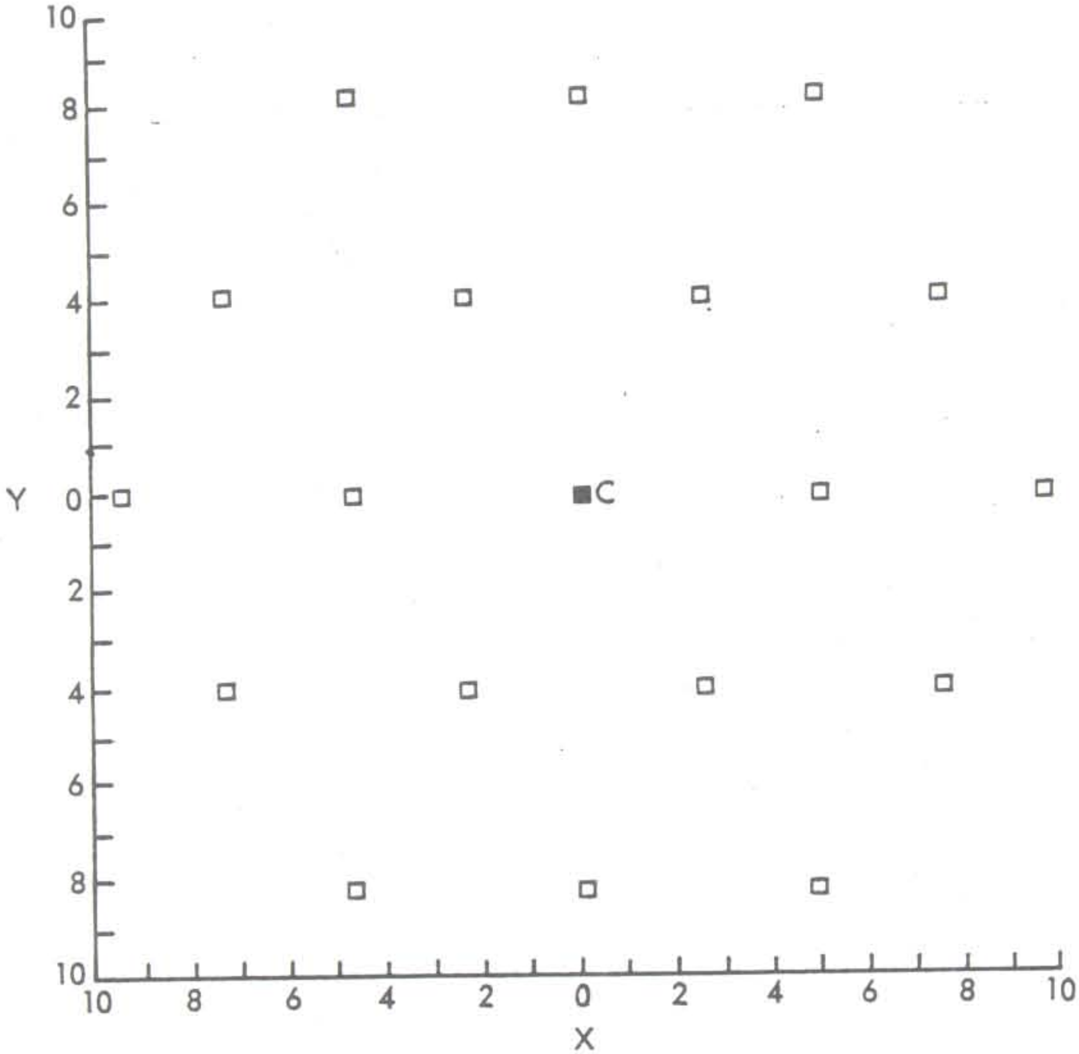
The recommended method for laying out the sample points of the hexagonal grid on the scale diagram is illustrated in Figure 9 and is described below.

1. Draw a diameter of the sampling circle on the scale diagram. The orientation of the diameter (e.g., east-west) should be chosen to maximize the number of sample points which fall within the spill area, when practical.



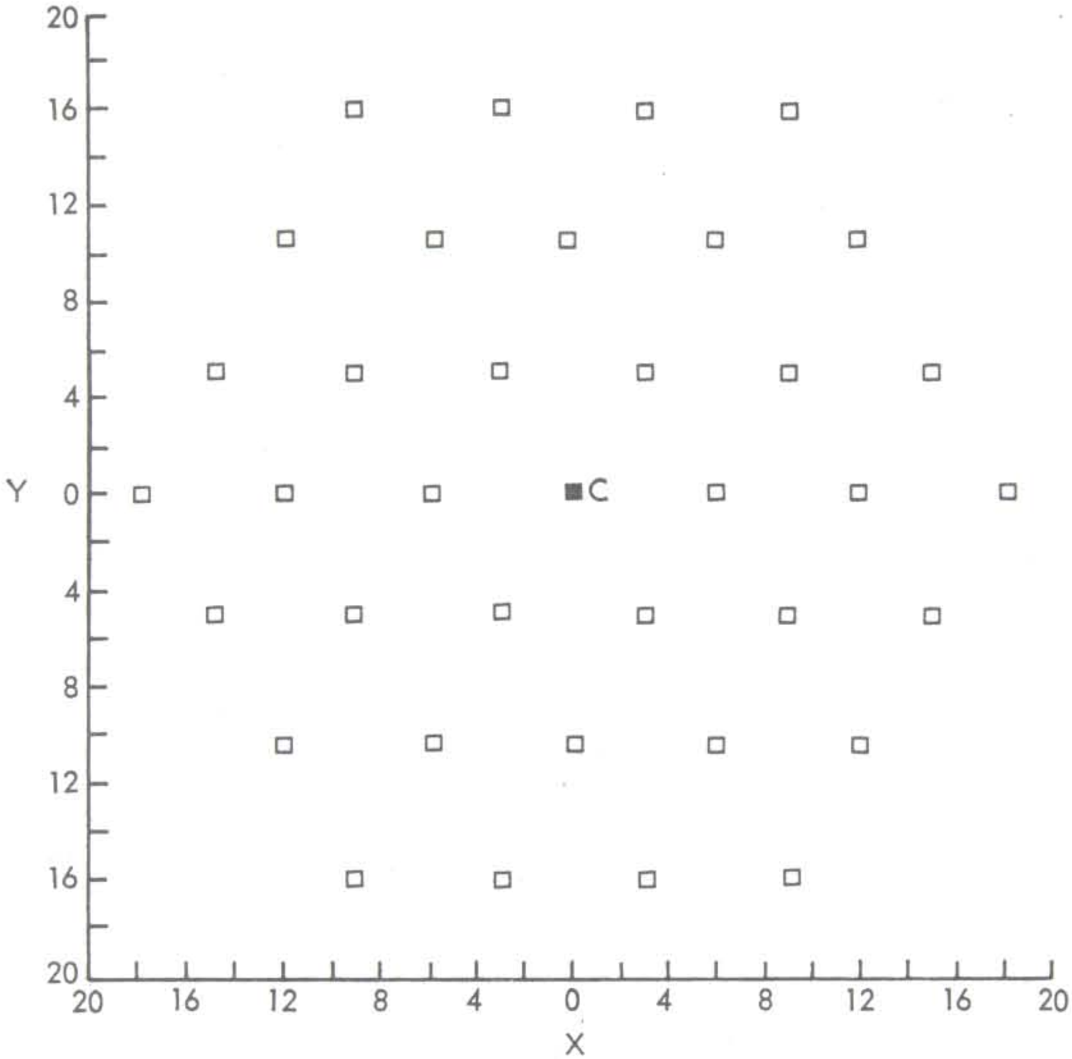
The outer boundary of the contaminated area is assumed to be 4 feet from the center (C) of the spill site.

Figure 6. Location of sampling points in a 7-point grid.



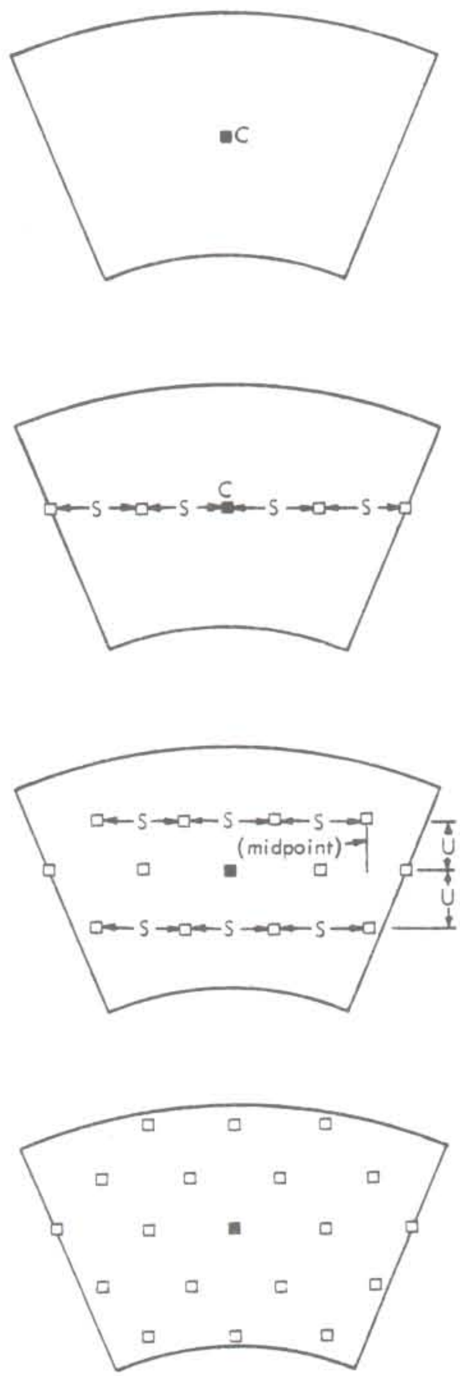
The outer boundary of the contaminated area is assumed to be 10 feet from the center (C) of the spill site.

Figure 7. Location of sampling points in a 19-point grid.



The outer boundary of the contaminated area is assumed to be 20 feet from the center (C) of the spill site.

Figure 8. Location of sampling points in a 37-point grid.



(a) Center of cleanup area, C.

(b) Middle row of grid points located distance, s, apart.

(c) Next two grid rows perpendicular distance, u, from middle row.

(d) Completed 19 sample point grid.

Figure 9. Construction of sampling grid on a site diagram.

A transparent overlay like Figures 6, 7 and 8 (using the appropriate scale) may be helpful in determining the orientation of the diameter.

2. Place the center point of the hexagonal design at the center (C) of the sampling circle. Lay out the middle row of the design along the diameter with successive points a distance, s, apart.

3. To lay out the next row, find the midpoint between the last two sample points of the middle row and move a distance, u, perpendicular to the middle row as shown in Figure 9. This is the first sample point of the next row. Now lay out the remaining points at distance s from each other. By systematically following this plan, the entire design can be laid out.

Figure 10 shows the sample point locations for the 37 grid points for the example PCB spill site diagrammed previously in Figures 1, 2, and 3. On the diagram, r = 3-1/4 in. so from Table 2 the grid spacing is s = 0.30r = 1 in. and the distance between the rows is u = 0.26r = 7/8 in.

In Figure 10, a horizontal diameter is drawn through C. Sampling locations 1 through 7 are marked 1 in. apart. To lay out the next row of the design, we first find location 8. Point D is the midpoint between locations 3 and 4. Then, as described, location 8 is a vertical distance u = 7/8 in. (3 ft 6 in. on the site) above D. Now locations 9 through 13 are laid out 1 in. apart. In the same way, locations 14 through 18 are found. Continuing so, the entire grid is marked on the diagram.

All of the sample points in Figure 10 are numbered (1 to 37). Any type of numbering system can be used, but the points must each be identified so that the location of the samples taken can be identified by reference to the diagram points.

Note that sampling locations 4, 7, 8, 13, 23, 34, 35, 36, and 37 are outside the cleanup area. Of these, locations 4, 8, 23, 34, and 35 do not correspond to a physical location--all are in "thin air," so to speak--and samples cannot be collected at these locations. Locations 36 and 37 are concrete samples; locations 7 and 13 are dirt samples (from Figure 2).

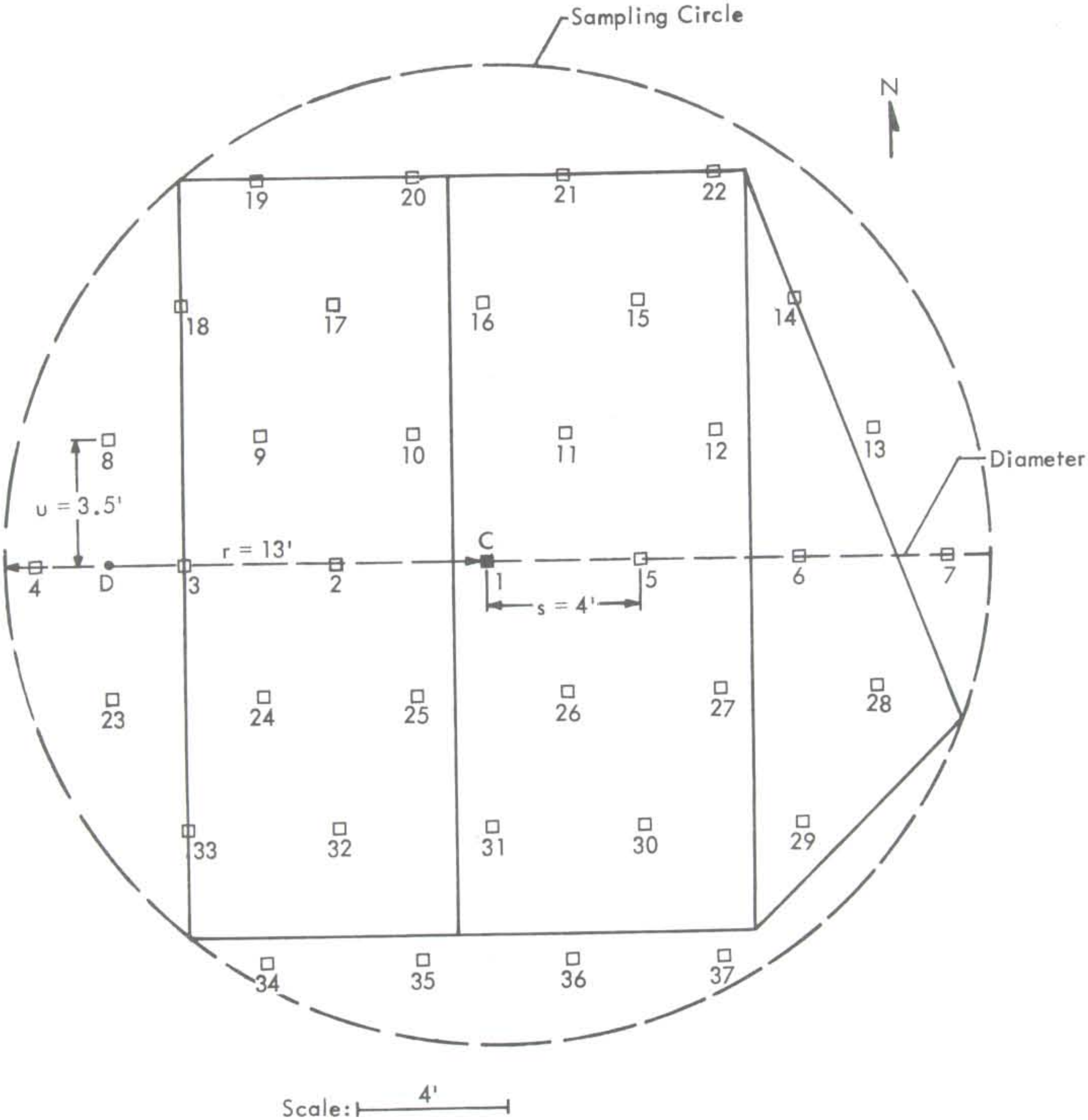


Figure 10. Sampling locations on the example PCB spill site.

The orientation of the sample circle diameter shown does not actually maximize the number of points falling within the spill area, since a 45° clockwise rotation would result in only 8 points lying outside the spill area instead of the 9 points shown. However, a 45° orientation would make the sample points very difficult to locate on the actual site with little to gain by the addition of one more sample point within the spill area.

5.6 Step 6: Lay Out the Sampling Locations on the Site

To locate the sample points on the site, use the same procedure as was used to construct the diagram of the sample points in Step 5, but use a tape measure or pacing, as appropriate, to measure distance. Since s = 1 in. in the diagram (Figure 10), then s = 4 ft on the site. Similarly, u = 3 ft 6 in. on the site. It may be helpful to show the actual distances (in ft) on the diagram before laying out the site sample points. For example, the samples on the wall are most easily found by measuring the distance on the scaled diagram from one end of the wall and the height above the driveway, and then converting these measurements to find the actual location on the wall. Consider point 32, for example. On Figure 10, it is located approximately 3/4 in. above the driveway and 5/8 in. from the left edge of the wall. On the site, then, this point is 3 ft above the driveway and 2-1/2 ft from the left edge of the wall.

The PCB spill site should be considered contaminated until laboratory analyses of the samples taken verify the site is clean. Therefore, caution should be exercised when marking the sample points on the site to prevent possible cross-contamination. The inspector should make minimum contact with the spill surfaces. One method for accomplishing this would be to cover the surfaces with plastic sheeting.

5.7 Step 7: Consideration of Special Cases

5.7.1 Sample Points Outside the Spill Cleanup Area

Samples from points outside the spill area should generally be collected, although taking these samples is at the discretion of the inspector. Collection of these samples permits the EPA to check the contamination of samples outside the spill area designated by the party responsible for the cleanup. This provides a mechanism for assessing whether the spill area was underestimated by the cleanup crew.

In cases where the contaminated area is very different from a circle (e.g., a very elongated ellipse) the sampling circle may be a poor approximation of the contaminated area, and a moderate to large percentage of the sampling points may fall outside the contaminated area. If the sampler is certain that the spill boundaries truly represent the contaminated area (i.e., there is definitely no contamination outside of this area), then it is permissible to disregard those sampling points falling outside the contaminated area. However, it is still good practice to collect such samples because the effort required to return to the site and sample again (should these samples be needed for any reason) is much greater than the effort required while on site.

5.7.2 Sample Locations Which Do Not Physically Exist

The grid can also indicate sample locations which do not physically exist on the real site. These locations are in "thin air" so to speak and cannot be sampled. The number of samples to be collected is adjusted downward for these samples; replacement locations are not needed.

5.7.3 Judgmental Samples

The inspector's best judgment should be used to collect samples where residual PCB contamination is suspected. These samples would be collected in addition to those from the sampling grid. Examples of extra sampling points include suspicious stains outside the spill area, cracks or crevices, or any area where the inspector suspects inadequate cleanup.

5.7.4 Sampling Small Areas

The grid sample design specifies that seven samples should be taken in areas which have a sample circle radius of less than 4 ft. In cases where the spill area is very small, fewer than seven samples can be taken at the discretion of the EPA inspector.

5.8 Example of Laying Out the Sample Design

This section summarizes the step-wise procedures required to determine the locations of the grid sample points at a PCB spill site. The example used is a simple 8 x 10 ft rectangular spill site.

Steps 1 and 2: Measure and Diagram the PCB Spill Cleanup Site

The PCB spill cleanup site must first be measured (usually with a tape measure). Then the site should be drawn to scale on graph paper. In this example, the site is assumed to be an 8 x 10 ft rectangle, as shown in Figure 11. A scale of 1 in. = 2 ft is used.

Step 3: Determine the Center and Radius of the Sampling Circle

The center and radius of the sampling circle is determined on a separate diagram as follows, and is illustrated in Figure 12:

1. Draw the site diagram to scale (same as Figure 11).

2. Draw a line representing the longest dimension, L_1, of the site diagram.

3. Find the midpoint, P, of L_1.

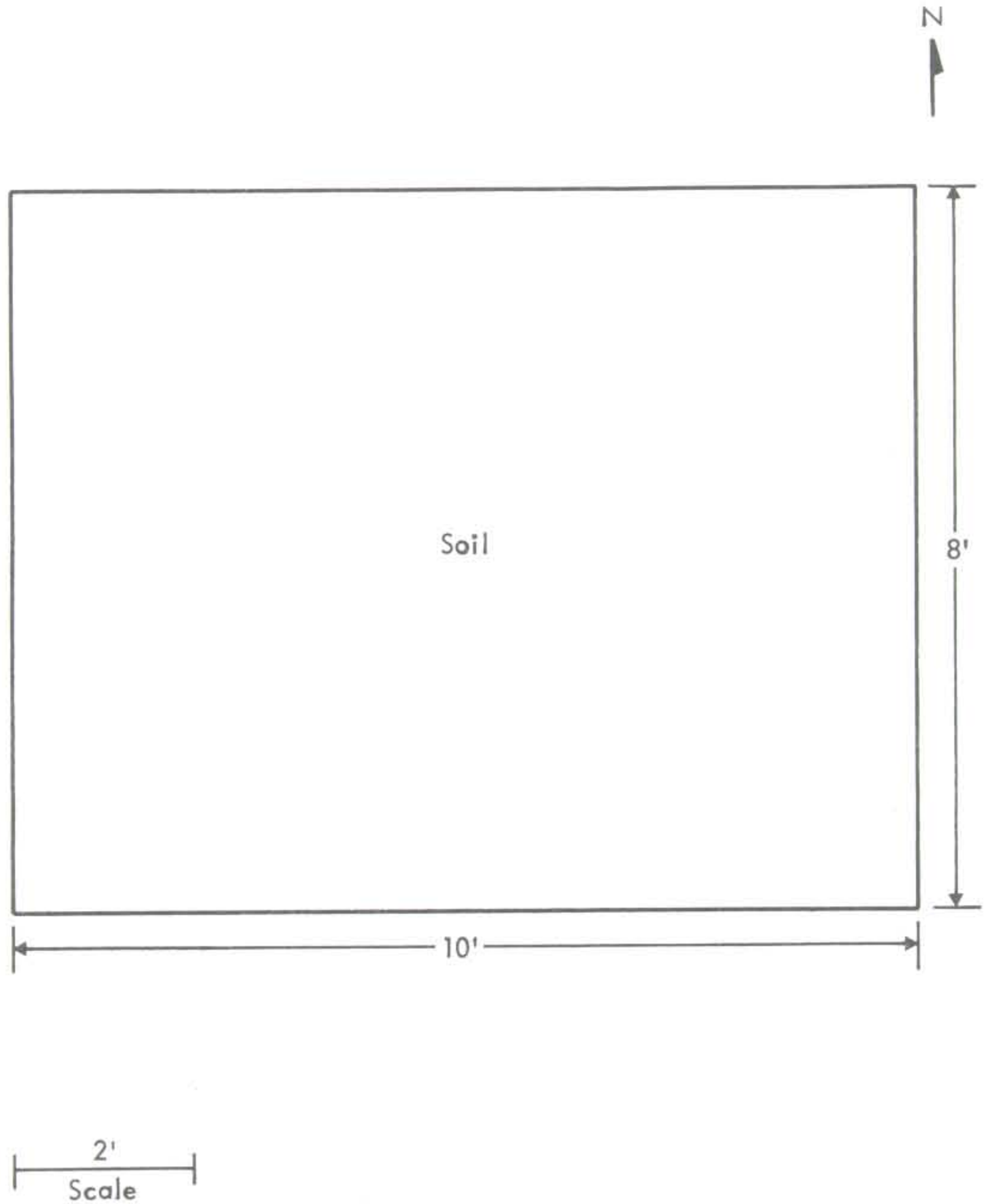


Figure 11. Scale diagram of PCB spill site.

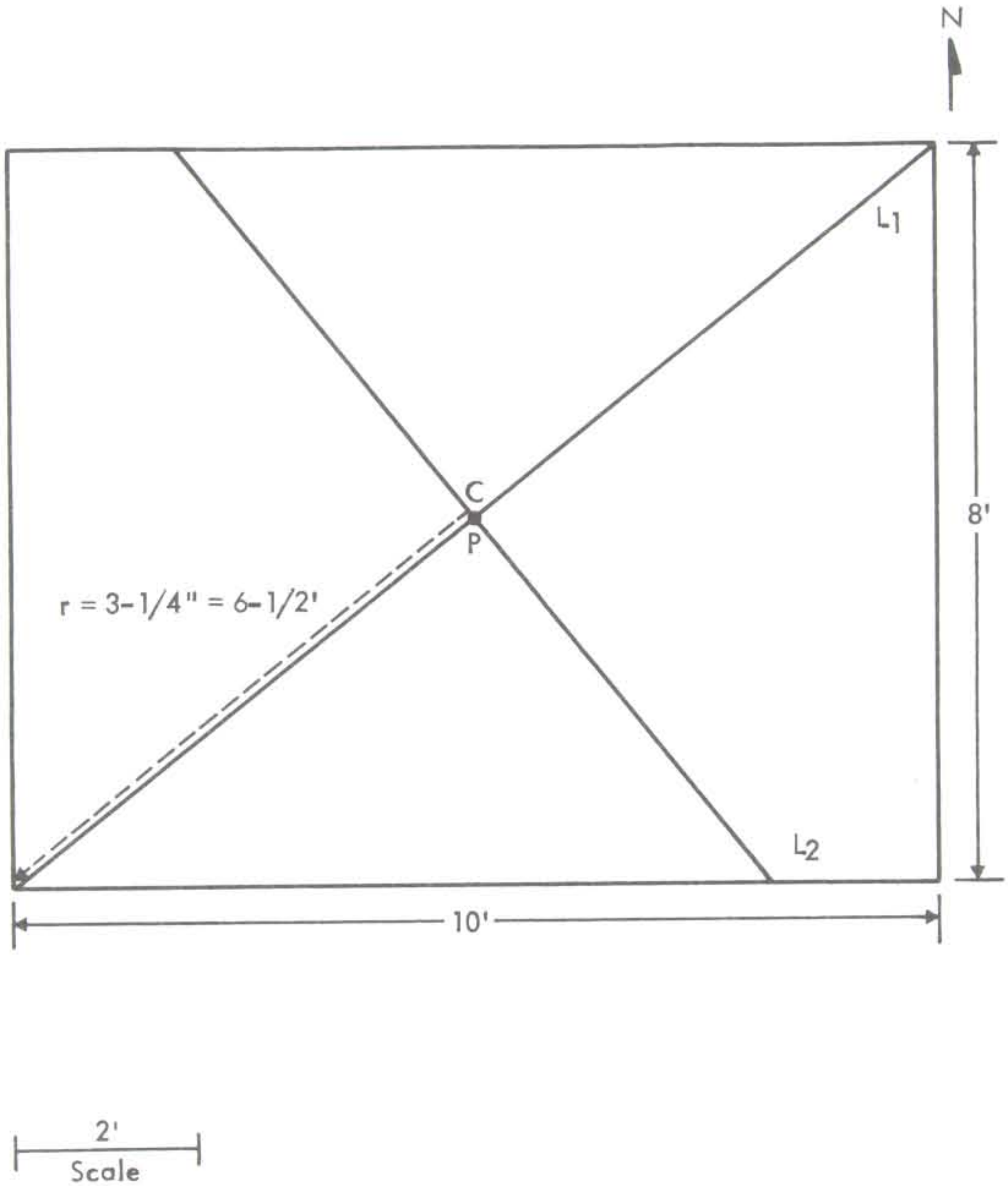


Figure 12. Determining center (C) and sampling radius (r) of sampling circle.

4. Draw a second line, L_2, perpendicular to L_1, through point P. Line L_2 must extend to the boundaries of the site.

5. Find the midpoint, C, of line L_2. Point C is the center of the sampling circle. (In this example, points P and C coincide, but will not coincide for many other types of configurations.)

6. Measure the distance from point C to either end of L_1, which is the sampling radius, r. The distance, r, should be measured to the nearest 1/16 in.

7. Scale radius, r, up to actual size. In this example, the radius, r, is 3-1/4 in. on a scale of 1 in. = 2 ft, or 6-1/2 ft (3-1/4 in. x 2 ft/in.).

Step 4: Find the Number of Grid Samples to be Used

The number of samples to be taken in a hexagonal grid depends upon the length of the sampling radius, as shown in Table 1 and repeated here.

Sampling Radius, r (ft)	Number of Samples
≤ 4	7
$> 4 - 11$	19
> 11	37

Since the radius in this example is 6-1/2 ft, the number of sampling points would be 19.

Step 5: Plot the Sampling Points on the Site Diagram

The sampling points in a grid row are a distance, s, apart; and the grid rows are a distance, u, apart. The distances s and u are determined from the following table.

Number of Samples	Distance, s, Between Adjacent Sample Points	Distance, u, Between Adjacent Rows
7	0.87 r	0.75 r
19	0.48 r	0.42 r
37	0.30 r	0.26 r

In this example, the distance, s, between the points in a row is 1-9/16 in. [(0.48) x (3.25 in.)] on the diagram, or about 3 ft 2 in. [(1-9/16 in.) x (2 ft/in.)] on the actual site. The distance, u, between rows is 1-3/8 in. [(0.42) x (3.25 in.)] on the diagram, or about 2 ft 9 in. [(1-3/8 in.) x (2 ft/in.)] on the actual site.

The center point of the grid lies on the center, C, of the sampling circle. Construct the hexagonal grid and superimpose it over the site diagram (constructed on a third piece of graph paper), as illustrated in Figure 13 for this example. The middle row of the grid (points 1 through 5) should be oriented to maximize the number of sample points which lie within the boundaries of the spill cleanup site.

It should be noted that adjacent rows are staggered, and that the sample points of one row are located midway (horizontally) between the sample points of the other row.

Step 6: Mark the Sample Points on the Site

Starting at the center, C, of the spill cleanup site, mark the middle row points a distance of 3 ft 2 in. apart. Locate the adjacent rows a distance (u) of 2 ft 9 in. from the middle row, and mark the four sample points in each of these rows a distance of 3 ft 2 in. apart. Complete the site sampling grid with the other two rows of sample points.

6.0 SAMPLE COLLECTION, HANDLING AND PRESERVATION

After the sampling grid has been diagrammed on the site description forms and laid out on the site, a sample must be taken at each grid point.

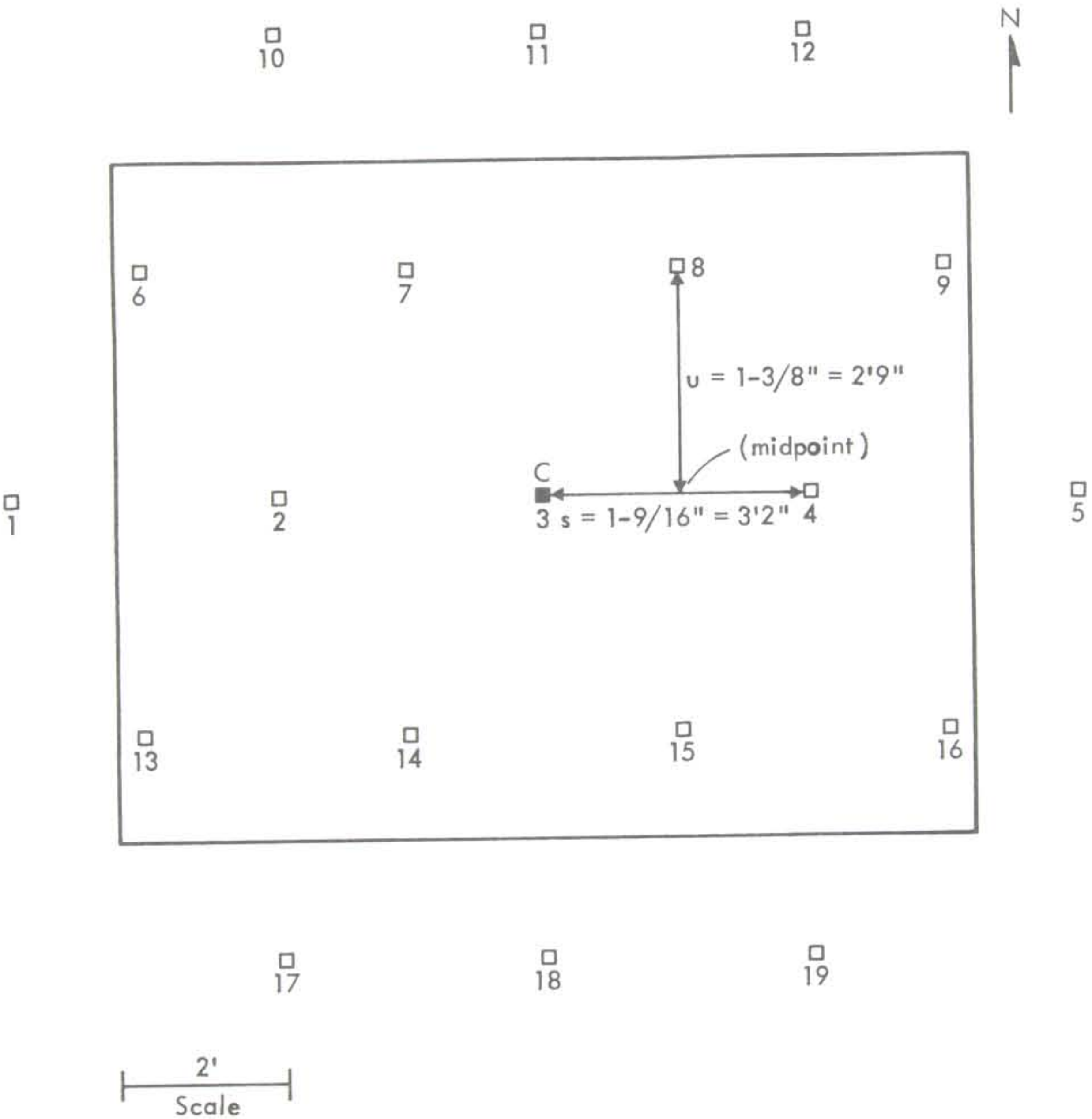


Figure 13. Diagram of 19-point grid superimposed on the PCB spill site.

Until the samples have been analyzed, the entire area must be assumed to be contaminated with residual PCBs. Therefore, appropriate measures must be taken to protect workers and the general public, prevent cross-contamination of samples, and prevent contamination of the surrounding area during sampling. Detailed contamination prevention procedures should be given in the staff training (Section 3.0 and 8.2).

PCB spill sites will vary widely in nature, and the types of media to be sampled may include soil, sod, water, hard surfaces, and vegetation. This section presents some general methods that can be used to sample these different media. These sample collection, handling and preservation techniques are provided for information; other techniques may also be used. Additional sample collection guidance documents are also available (Mason 1982; USEPA 1981).

6.1 Surface Soil Sampling

When surface soil (or sand) is to be sampled, the sample area should be marked by a 10 cm x 10 cm (100 cm^2) template. The soil should be scraped to a depth of about 1 cm with a stainless steel trowel, scoop, or spatula to yield about 100 g of soil. If more soil is required, the area should be expanded without increasing the depth of soil obtained. The soil sample should be placed in a precleaned glass bottle, the bottle capped, the sample bottle label filled out and attached, and a yellow TSCA PCB mark affixed. The bottle should be sealed in a plastic sample bag and placed in an ice chest containing ice (to keep the sample at about 4°C). If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data should be entered in the field log book and on the chain-of-custody form.

The template used to mark surface soil samples, the scoop or spatula used to take the sample, and the rubber gloves worn by the inspector are all sources of cross-contamination between samples. Ideally, a different template, scoop, and pair of rubber gloves should be used to take each sample. The template and scoop may then be placed in a plastic bag to be taken back to the laboratory to be cleaned for the next field sampling job. The rubber gloves should be discarded into a plastic bag which will be disposed of as PCB-contaminated material if any samples exhibit PCB contamination.

If a sufficient number of templates or scoops are not available to use only one item per sample, then each of these equipment items must be thoroughly cleaned between samples. The template and scoop should be thoroughly rinsed with solvent and wiped with a disposable wiping cloth (which should be discarded into the plastic bag intended for disposal of PCB-contaminated materials).

6.2 Soil Core-Sampling

When core samples of sod or soil are needed, the samples may be taken using a coring device such as a piston corer or King-tube sampler. Core samples should be taken to a depth of about 5 cm. The soil core can be pushed out into a precleaned glass bottle and capped, or the tube containing the sample can be wrapped in solvent-rinsed aluminum foil, depending upon the type of coring device used. The sample should be properly labeled, a yellow TSCA PCB mark affixed, and placed in an ice chest (to keep the sample about 4°C). If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data should be entered in the field log book and on the chain-of-custody form.

Core samples of soil or sod should be taken with individual core tubes for each sample. If this is not possible, then the coring device should be rinsed with solvent and wiped with a disposable wipe cloth to remove any visible particles before taking another sample. After each sample, rubber gloves and wipe cloth should be discarded into a plastic bag intended for disposal of PCB-contaminated materials.

6.3 Water Sampling

PCB spills on water may result in a surface film (particularly when the PCBs are dissolved in hydrocarbon oils) or sink to the bottom (particularly when the PCBs are in askarel or other heavier-than-water matrix). When a surface film is suspected (or visible), the water surface should be sampled. Otherwise, a water sample should be taken near the bottom of the body of water.

6.3.1 Surface Sampling

Surface water samples should be collected by lowering an open, precleaned glass sample bottle horizontally into the water at the designated sample collection point. As water begins to run into the bottle, slowly turn the bottle upright, keeping the lip just under the surface so that only surface water is collected. Lift the bottle out of the water, wipe the outside with a disposable wiping cloth, and cap the bottle. Label the bottle, affix a yellow TSCA PCB mark, and put the bottle in an ice chest (to keep the sample at about 4°C). If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data should be entered in the field log book and on the chain-of-custody form. The wiping cloth and rubber gloves should be discarded into a plastic bag used for disposal of PCB-contaminated materials.

6.3.2 Subsurface Sampling

Water near the bottom of the body of water should be sampled by lowering a sealed sampler bottle to the required depth, removing the bottle top, allowing the bottle to fill, and removing the bottle from the water. Transfer the subsurface sample into a precleaned glass bottle and cap. Wipe the bottle with a disposable wiping cloth, fill out and label the sample bottle, affix a yellow TSCA PCB mark, and put the sample bottle in an ice chest. If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data should be entered into the field log book and on the chain-of-custody form.

The wiping cloth and rubber gloves should be discarded into a plastic bag used for disposal of PCB-contaminated materials.

To prevent cross-contamination of samples, separate sampler bottles should be used to take the samples. Alternatively, the sampler bottle can be rinsed three times with distilled water, solvent-rinsed, and air-dried between samples.

Sometimes the above approaches to water sampling are not feasible. In these cases, other equipment such as siphons, pumps, dippers, tubes, etc., may be used to collect a water sample and transfer it to a precleaned glass sample bottle. The sampling system should be constructed of glass, stainless steel, Teflon, or other inert, impervious, and noncontaminated materials. Water samples taken with siphons, dippers, tubes, pumps, etc., may become cross-contaminated if the equipment is not cleaned between samples. Equipment cleaning may be achieved in most cases by flushing the equipment with distilled water and solvent.

6.4 Surface Sampling

Samples of hard surfaces may be taken by two methods: (a) wipe sampling and (b) destructive sampling. Wipe samples are taken of any smooth surface which is relatively nonporous (such as rain gutters, automobiles, and aluminum siding), while destructive samples are taken of hard porous surfaces (such as concrete, brick, asphalt, and wood). Both wipe and destructive samples may be taken if it is not known whether the surface is porous or not.

6.4.1 Wipe Sampling

A wipe sample is taken by first applying a suitable solvent (such as isooctane) to a piece of 11 cm filter paper (e.g., Whatman 40 ashless or Whatman 50 smear tabs) or gauze pad. The moistened filter paper or gauze pad is then held with a pair of stainless steel forceps or rubber gloves and rubbed thoroughly over a 100-cm^2 area (delineated by a template) of the sample surface to obtain the sample. The filter or pad is placed in a precleaned sample bottle, which is then capped, labeled, affixed with a yellow TSCA PCB mark, and placed in an ice chest (to keep the sample at about 4°C). If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data are entered into the field log book and on the chain-of-custody form.

The template should be thoroughly rinsed with solvent and wiped with a disposable wiping cloth. The rubber gloves worn when taking wipe samples and the wiping cloth should be discarded into a plastic bag for disposal of PCB-contaminated materials.

6.4.2 Destructive Sampling

Wipe sampling is not appropriate on some porous surfaces, such as wood, asphalt, concrete, and brick, which will absorb the PCBs. In some cases, these surfaces can be sampled by taking a discrete sample such as a piece of wood or paving brick. Otherwise, chisels, drills, hole saws, etc., can be used to remove sufficient sample for analysis. Samples less than 1 cm deep should be taken and placed in a glass sample bottle or solvent-rinsed aluminum foil. Each sample container should be labeled, affixed with a yellow TSCA PCB mark, and placed in an ice chest. If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. Sample collection data should be entered into the field log book and on the chain-of-custody form.

Equipment used to take samples of wood, asphalt, etc., should be cleaned with solvent and wiped between samples. Also, rubber gloves and wipe cloths should be discarded into a plastic disposal bag intended for PCB-contaminated materials.

6.5 Vegetation Sampling

The sample design or visual observation may indicate that samples of vegetation, such as tree leaves, bushes, and flowers, are required. In this case, the sample may be taken with pruning shears, a saw, or other suitable tool, and placed in a precleaned glass bottle, which should be capped, labeled, affixed with a yellow TSCA PCB mark, and placed in an ice chest. If samples are to be analyzed soon, the cold storage requirements may be relaxed as long as sample integrity is maintained. The sample collection data should be entered into the field log book and on the chain-of-custody form.

After each sample is taken, the pruning shears should be rinsed with solvent and wiped with a disposable wipe cloth to prevent cross-contamination between samples. Also, rubber gloves and wipe cloths should be discarded into a plastic disposal bag intended for PCB-contaminated materials.

6.6 Compositing Strategies

Compositing is the pooling of several samples to form one sample for chemical analysis. In many circumstances it may be desirable to composite samples to reduce the number of (often costly) analyses needed. The suggested strategies for compositing samples are given in the appendix.

7.0 QUALITY ASSURANCE

Quality assurance must be applied throughout the entire sampling program, including sample design and sample collection, handling, and preservation. Each EPA office must develop a quality assurance plan (QAP) according to EPA guidelines (USEPA 1980). The QAP must be submitted to the regional QA officer or other appropriate QA official for approval prior to sampling PCB spill sites.

The elements of a QAP (USEPA 1980) include:

- Title page
- Table of contents
- Project description
- Project organization and responsibility
- QA objectives for measurement data in terms of precision, accuracy, completeness, representativeness, and comparability
- Sampling procedures
- Sample tracking and traceability
- Calibration procedures and frequency
- Analytical procedures
- Data reduction, validation, and reporting
- Internal quality control checks
- Performance and system audits
- Preventive maintenace
- Specific routine procedures used to assess data precision, accuracy, and completeness
- Corrective action
- Quality assurance reports to management

Each EPA inspector who will sample PCB spill sites should understand and conform with all elements of the QAP.

8.0 QUALITY CONTROL

Each EPA office that samples PCB spill sites must operate a formal quality control (QC) program. The minimum requirements of this program consist of preparing field blanks for the laboratory; sampling without contamination of samples; maintaining a rigid chain-of-custody procedure for the samples; and fully documenting the entire sampling program and maintaining records of the documentation.

The quality control measures taken by each EPA office should be stipulated in the QA plan. The QC measures discussed below are given as examples only. EPA offices must decide which of the following measures, and additional measures, will be required for each situation.

8.1 Field Blanks

Field blanks are given to the laboratory to demonstrate that the sampling equipment has not been contaminated. A field blank may be generated by using the sampling equipment to obtain a clean sample of solids or water. For example, the scoop or soil coring device can be used to obtain a clean solids blank sample. The water sampling equipment can be used to collect a blank sample using laboratory reagent grade water. These field blanks should be obtained both before and after field sampling.

Field blanks for wipe samples should be obtained in the field by wetting a clean filter paper with the solvent and storing the wetted paper in a clean sample jar.

One empty glass sample bottle and one filled with solvent should also be given to the laboratory as field blanks.

8.2 Sampling Without Contamination

Samples collected from PCB spill sites which have been cleaned up may become contaminated in two ways: (a) dirty sample containers, and (b) cross-contamination of samples from the use of contaminated sampling equipment. The first type of contamination can be eliminated by properly precleaning all sample containers prior to making the sampling trip. All glass jars should be washed with soap and water, rinsed three times with distilled water, rinsed with solvent (isooctane is recommended), baked in an oven at 350°C for 1 h, and sealed with a Teflon-lined cap. All aluminum foil used should be rinsed with solvent.

The sampling equipment should be precleaned before the site visit by rinsing with solvent and thoroughly wiping the equipment down. Cross-contamination during sampling can be avoided by using a separate sampler (such as a scoop, spatula, corer, etc.) for each sample, or cleaning the sample equipment between samples. Methods that can be used to clean the equipment between samples are given in the sample collection, handling, and preservation discussion (Section 6.0).

8.3 Sample Custody

As part of the quality assurance plan, the chain-of-custody protocol must be described. A chain-of-custody provides defensible proof of the sample, and data integrity. The less rigorous sample traceability documentation merely provides a record of when operations were performed, and by whom. Sample traceability is not acceptable for enforcement activities.

Chain-of-custody is required for analyses which may result in legal proceedings, and when the data must be subject to legal scrutiny. Chain-of-custody provides conclusive written proof that samples are taken, transferred, prepared, and analyzed in an unbroken line as a means to maintain sample integrity. A sample is in custody if:

- It is in the possession of an authorized individual.
- It is in the field of vision of an authorized individual.
- It is in a designated secure area.
- It has been placed in a locked container by an authorized individual.

A typical chain-of-custody protocol contains the following elements:

1. Unique sample identification numbers.

2. Records of sample container preparation and integrity prior to sampling.

3. Records of the sample collection, such as:

- Specific location of sampling.
- Date of collection.
- Exact time of collection.
- Type of sample taken (e.g., water, soil).
- Initialing each entry.
- Entering pertinent information on chain-of-custody record.
- Maintaining the samples in one's possession or under lock and key.
- Transporting or shipping the samples to the analytical laboratory.
- Filling out the chain-of-custody records.
- Chain-of-custody records accompanying the samples.

4. Unbroken custody during shipping. Complete shipping records must be retained; samples must be shipped in locked or sealed (evidence tape) containers. The addressee should be notified and prepared to receive the samples from the shipper.

8.4 Documentation of Field Sampling

In order to assure that the field sampling project has been thoroughly documented, the documents described in the next section should be used to maintain the quality of the project.

9.0 DOCUMENTATION AND RECORDS

Each EPA office is responsible for preparing and maintaining complete records of the field sampling operations. A detailed documentation plan should be prepared as a part of the QAP, and should be strictly followed. The following written records should be maintained for each field sampling operation:

Equipment preparation log book
Sample codes
Field log book
Site description forms
Chain-of-custody forms
Sample analysis request forms
Field trip report

9.1 Equipment Preparation Log Book

A log book should be maintained which lists the sampling equipment taken to each spill site. A detailed description of the cleaning and preparation procedures used for the sample collection equipment (templates, scoops, glass bottle, etc.) should be recorded.

9.2 Sample Codes

Each sample should be assigned a unique sample code and labeled accordingly when collected. The sample code should contain information on the site and which sampling point the sample represents. This sample code must be used to identify all sample records.

Each sample must also be labeled with a yellow TSCA PCB mark as described in 40 CFR 761.45 until it is determined to be PCB free.

9.3 Field Log Book

The EPA inspector should maintain a field log book which contains all information pertinent to the field sampling program. The notebook should be bound and entries be made in ink by the field inspector. All entries should be signed by the inspector.

At a minimum, the log book should include the following entries:

Owner of spill site
Location of spill site
Date(s) of sample collection
Exact times of sample collection
Type of samples taken and sample identification numbers
Number of samples taken
Description of sampling methodology
Field observations
Name and address of field contact
Cross-reference of sample identification numbers to grid sample points (shown on site description forms)

Since sampling situations will vary widely, no specific guidelines can be given as to the extent of information which should be entered into the field log book. Enough information should be recorded, however, so that someone can reconstruct the sampling program in the absence of the field inspector.

The field log book should be maintained in a secure place.

9.4 Site Description Forms

Serialized site description forms should be used to record the conditions of the site, provide sketches of the site, and show the location of the grid sampling points. The grid sampling points should be shown on dimensioned drawings and numbered. These forms should be accompanied by photographs (preferably Polaroid-type photographs) of the site. Each form and photograph should be signed and dated by the EPA inspector.

9.5 Chain-of-Custody Forms

Chain-of-custody forms should be completed and accompany the samples. These forms should contain the following information:

- Project site
- Sample identification number
- Date and time of sample collection
- Location of sample site
- Type of sample (soil, water, etc.)
- Signature of sample collector
- Signatures of those who relinquish and those who receive the samples, and date and time that samples change possession
- Inclusive dates of possession

9.6 Sample and Analysis Request Forms

A sample analysis request form should accompany the samples delivered to the laboratory. The field inspector should enter the following information on the form:

- Project site
- Name of sample collector
- Sample identification numbers
- Types of samples (soil, water, etc.)
- Location of sample site for each sample
- Analysis requested [analyte (i.e., total PCBs), method, desired method detection limit, etc.]
- QC requirements (replicates, lab blanks, lab spikes, etc.)
- Special handling and storage requirements

The laboratory personnel receiving the samples should enter the following information on the form:

- Name of person receiving the samples
- Laboratory sample numbers
- Date of sample receipt
- Sample allocation
- Analyses to be performed

9.7 Field Trip Report

The EPA inspector should prepare a brief field trip report to be maintained on file. The report should provide information such as the project site, date(s) of sampling, types and number of samples collected, any problems encountered, any notable events, and specific reference to the other documents listed above.

10.0 VALIDATION OF THE MANUAL

A previous draft of this manual entitled "Field Manual for Verification of PCB Spill Cleanup" (Draft Interim Report No. 3, Task 37, EPA Prime Contract No. 68-02-3938, June 27, 1985) was used in a brief field validation study. The primary purposes of the study were to: (1) determine the degree of difficulty of understanding the grid sampling designs in the field manual; (2) determine the amount of time and degree of difficulty required to lay out the sampling grids on simulated PCB spill sites; and (3) identify any concerns or problems that may arise in implementing the field manual. To achieve these goals, simulated PCB spill sites were constructed for the exercise. Four persons (Mr. David Phillippi and Mr. Robert Jackson of the EPA Region VII Office and Ms. Joan Westbrook and Mr. Ted Harrison of MRI) were selected to lay out the sampling grids on the spill sites after they had read the field manual. These four persons had no prior association with developing the field manual. Other persons from EPA and MRI acted as observers since they were intimately familiar with the field manual.

Four simulated spill sites having the following characteristics were laid out:

- A rectangle (3 ft x 6 ft)
- A parallelogram (about 3 ft on a side)
- A circle (about 12 ft diameter)
- A square (6 ft on a side)

The first two sites required seven grid sample points, and the other two required 19 grid sample points.

Each of the four "inspectors" laid out the grid sample points on two of the four sites after constructing the designs on graph paper. In all cases the sample points were laid out correctly with little or no difficulty in 30 min or less. Each inspector commented that there was little or no difficulty in performing the exercises.

As a final exercise, a large irregular simulated PCB spill site was constructed, and all attendees participated in laying out the 37 grid sample points. The spill site was designed so that some sample points were located on the floor and two adjacent walls to make the exercise relatively difficult. The 37 grid sample points were laid out correctly with relative ease in about 45 min. Some discussions were required to decide how to treat sampling points which fell in the overlap where the two walls intersected.

It was concluded from the exercise and discussions which followed that: (1) the field manual is easy to follow and understood by people unfamiliar with the manual prior to reading it; (2) the grid sample points are never "perfectly" laid out (with the sample points precisely aligned) so that some degree of randomness is built into the sample designs; (3) the time required to lay out the grid sample points after the boundaries of the spill site have been determined is relatively short (less than 1 h); and (4) using this manual, the grid sample points can be correctly laid out by inexperienced people.

11.0 REFERENCES

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APPENDIX

STRATEGIES FOR COMPOSITING SAMPLES

APPENDIX

This appendix gives suggested strategies for compositing samples taken from PCB spill sites which are sampled using the grid sampling methods described in the text of the report. Compositing may result in a savings of analysis time and cost. Sample compositing is not required and should be used only if time or cost savings may result. The strategies for forming composites are as follows:

1. Composite only samples of the <u>same type</u> (i.e., all soil or all water). Since the composite must be thoroughly mixed to ensure homogeneity, certain types of samples such as asphalt, wipe samples, wood samples and other hard-to-mix matrices should not be composited.

2. Do not form a composite with more than 10 samples, since in some situations compositing a greater number of samples may lead to such low PCB levels in the composite that the recommended analytical method approaches its limit of detection and becomes less reliable.

3. For each type of sample, determine the number of composites to be formed using the table below.

Number of samples	Number of composites
2-10	1
11-20	2
21-30	3
31-37	4

As much as possible, try to form composites of equal size. For example, if 37 soil samples are taken, then four composites could be formed using 9, 9, 9, and 10 samples apiece.

4. To the extent possible, composite adjacent samples. If residual contamination is present, it is likely that high PCB levels will be found in some samples taken close together.

Because of the large number of situations that may be encountered in practice, it is not possible to specify compositing strategies more precisely. The laboratory and field staff should exercise judgment in all cases.