PNL-5344

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# BTD Building Uranium Mass Balance Study

S. L. Sutter
J. W. Johnston
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January 1985

Prepared for
the U.S. Army
under a Related Services Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Insitute

Battelle

PNL-5344

PACIFIC NORTHWEST LABORATORY
*operated by*
BATTELLE
*for the*
UNITED STATES DEPARTMENT OF ENERGY
*under Contract DE-AC06-76RLO 1830*

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

| Pages | Price Codes |
|---|---|
| 001-025 | A02 |
| 026-050 | A03 |
| 051-075 | A04 |
| 076-100 | A05 |
| 101-125 | A06 |
| 126-150 | A07 |
| 151-175 | A08 |
| 176-200 | A09 |
| 201-225 | A010 |
| 226-250 | A011 |
| 251-275 | A012 |
| 276-300 | A013 |

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# BTD BUILDING URANIUM MASS BALANCE STUDY

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## SUMMARY

Fifteen test firings of depleted uranium (DU) munitions were made during the qualification study of the new target building at the BTD Range operated by the U.S. Army Combat Systems Test Activity (CSTA) at Aberdeen Proving Ground, Maryland. Following these test firings, Pacific Northwest Laboratory determined the total mass and mass distribution of DU inside the BTD facility to define decontamination requirements for the new target building.

The 15 rounds fired were grouped into 5 runs of 3 rounds each for this mass balance investigation. Three forms of DU were sampled after the runs: nonaerosol particles, aerosol particles depositing onto interior surfaces, and aerosol particles depositing in the filters.

Most of the results could logically be anticipated:

1. Depleted uranium tray samples from the floor represented the largest portion of the uranium collected.
2. The target backstop samples accounted for about twice as much DU as the equipment surfaces.
3. The weighted average of the building surface deposition was greatest for the back wall and lowest for the ceiling.
4. Aerosols showed a tendency for increased deposition from the building front to back.
5. The amount of DU collected by the filters declined progressively with each successive filter stage.

The estimated random error standard deviation (precision) for the DU quantity in an area was 6% to 15% relative; systematic error (accuracy) was 5% to 12% relative.

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<u>TABLES</u>

# 1.0 INTRODUCTION

The U.S. Army Combat Systems Test Activity (CSTA) constructed a new target building at its BTD range in the Aberdeen Proving Ground, Maryland, for the test firing of depleted uranium (DU) munitions. The objective of this study, which was conducted by Pacific Northwest Laboratory (PNL), was to determine the total mass and mass distribution of uranium inside the target building following test firings of DU penetrators. This information will be useful in defining the BTD range decontamination requirements.

Fifteen test firings (rounds) of DU munitions were made in the building during a qualification study. To determine the uranium mass, these rounds were grouped into 5 runs of 3 rounds each and samples collected after each run. A background run was made before the rounds were fired to determine whether significant levels of material that would interfere with the uranium analysis were present. This report details this sampling (Sections 2 and 3) and presents the results of the data analysis (Section 4). Basic data for the analysis are in Appendix A. Results for standard solutions and yield standards submitted for quality control of leaching and analytical methods are in Appendix B.

# 2.0 SAMPLING PROCEDURES

Appropriate sampling methods were developed to sample DU in various areas of the BTD facility. A schematic view of this building is shown in Figure 2.1. It has three major components: the target bay or building interior, the baffled plenum, and the filter house. The front of the building is the end where the projectile enters the building through the tunnel; the back is the end where air is exhausted from the target bay.

This section describes the sample collection methods and then defines the stratification of the facility into areas (locations) for sampling. This is followed by a description of the runs, shots within the runs, and quality control samples and standards.

## 2.1 SAMPLE COLLECTION

Three DU forms must be accounted for after each run:

- nonaerosol particles, consisting of pieces of projectiles and piles of oxidized DU
- aerosol particles depositing onto interior surfaces
- aerosol particles depositing in the filters

Different sampling techniques were used for each form. Nonaerosol particles were recovered by picking up DU chunks, scooping up piles of oxidized DU, or sweeping up large quantities of oxidized DU dust. Visible piles of DU were swept or scooped from equipment surfaces. Aerosol particles depositing on floor, ceiling, wall, and equipment surfaces were sampled by devices that simulated those surfaces and covered a limited portion of the total surface area. These devices were gravel-filled trays implanted in the gravel floor and steel coupons fastened to steel surfaces. The ventilation system air filters were sampled by cutting representative portions of the filter media from the filters for analysis.

### 2.1.1 Floor Tray and Scoop and Sweep Samples

Plastic trays containing gravel were embedded in the gravel floor at random locations. These samplers had dimensions of 4.75 in. by 3.75 in. by

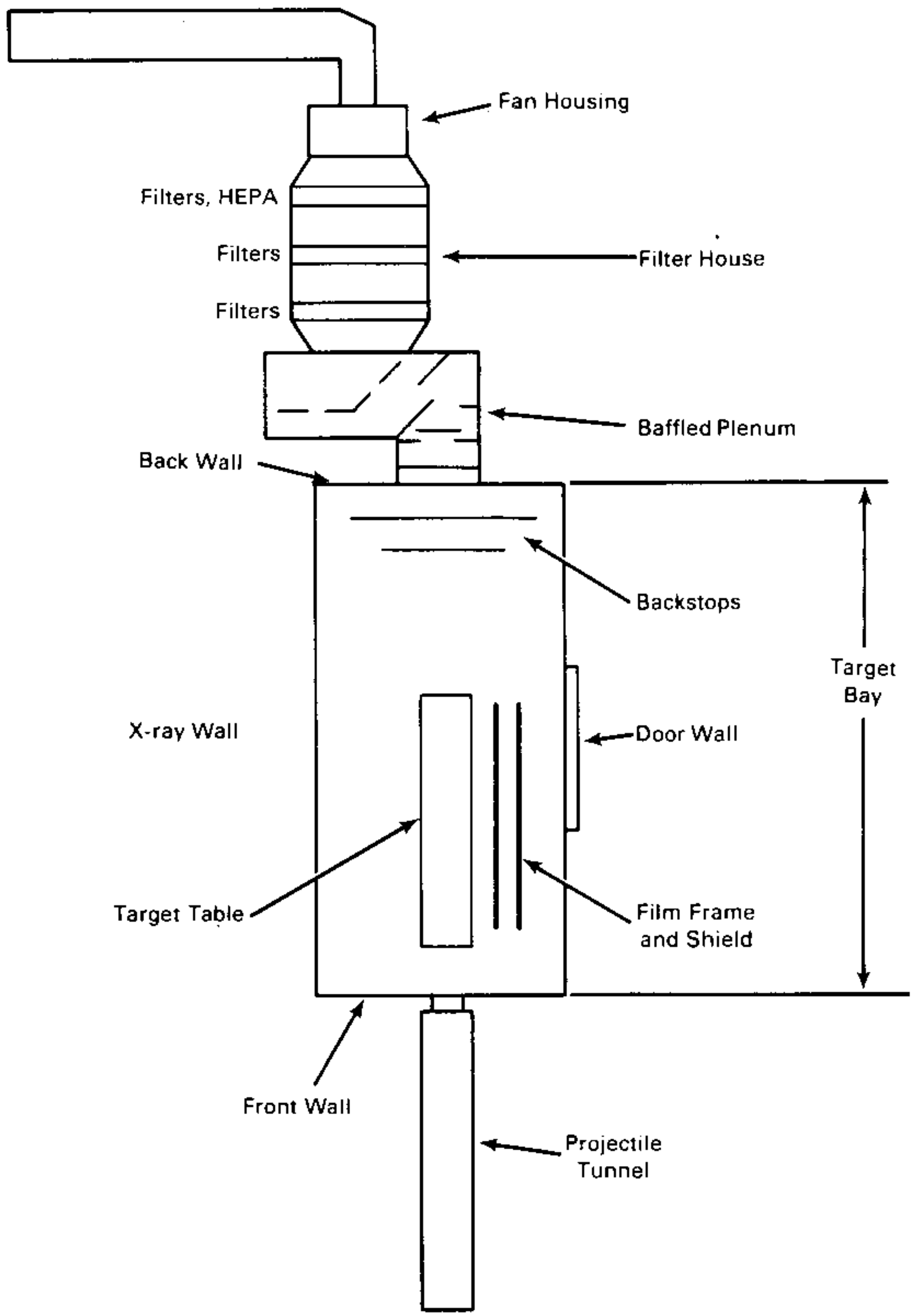



FIGURE 2.1. Generalized View of BTD Building

2.5 in. deep and held about 950 g of gravel. The top surface of the gravel in the tray is the calculated deposition surface and is 17.8125 $in^2$. The gravel in the trays was identical to that covering the floor, having been taken from the floor before the tests.

Nonaerosol DU was scooped or swept up for sampling. After each shot (3 shots per run) a visual survey of the target bay interior was made and large pieces of the penetrator and piles of DU ash were collected. Depleted uranium depositing in large amounts on equipment surfaces was swept up. Materials depositing on the plenum floor, in the filter house, and at the baffle entrance were also swept up for samples after selected runs.

### 2.1.2 Coupon Samples

Stainless steel coupons for collecting DU particles depositing on steel surfaces were attached to the various surfaces with screws, adhesive tape, or magnetic tape. Coupon dimensions were 1 in. by 5 in. For those coupons attached with magnetic tape, the tape covered one side of the coupon entirely for a total thickness of 0.11 in. Without tape backing, the coupons were 0.045 in. thick.

### 2.1.3 Filter Samples

Three banks of filters are located in the filter house as shown in Figure 2.1. Eighteen individual filters compose one entire bank. The original design configuration used for runs 0 and 1 consisted of the Farr 30/30®, Riga-Flo 200®, and HEPA (high-efficiency particulate air) filter banks in series. After run 1, the pressure drop on the Riga-Flo 200® was excessive, indicating the first prefilter was not efficient enough. For subsequent runs (2 through 5) a Dust Trap® filter bank was added between the Farr 30/30® and Riga-Flo 200® banks. Table 2.1 gives information on the filter types and also indicates the runs for which they were sampled. The HEPA sample represented DU collected from all of the runs.

® Farr 30/30 and Riga-Flo 200 are registered trademarks of the Farr Company, Los Angeles, California.

® Dust Trap is a registered trademark of the TRI-DIM Filter Corp., Hawthorne, New Jersey.

TABLE 2.1. Filter Sample Information

| Filter Type | Approximate Efficiency, % | Depth, in. | Folds per Filter | Sampled After Run |
|---|---|---|---|---|
| HEPA | 99.97[a] | 12 | 58 | 5 |
| Riga-Flo 200® | 95[b] | 12 | 16 | 1,5 |
| Dust Trap® | 60[b] | 2 | 21 | 2-5 |
| Farr 30/30® | 25[b] | 4 | 21 | 0-5 |

(a) From Burchsted, Fuller and Kahn (1976)
(b) From ASHRAE 52-76 (1976).

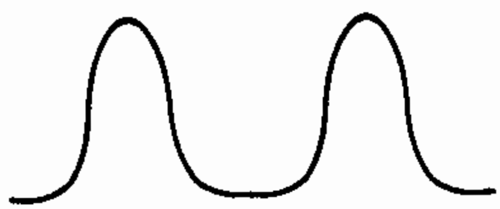


FIGURE 2.2. Typical Filter Sample, Two Folds

Each air filter contains a sheet of filtration media that has been pleated, folded, or corrugated to maximize the available surface area contained therein. A typical filter sample consisted of two folds or pleats as shown in Figure 2.2. Two sets were extracted from selected filters. The identification of filters and folds is detailed in Section 2.2.

## 2.2 SAMPLE LOCATIONS

Tray, coupon, and filter samples represented various areas of the BTD facility. The location where samples were taken was determined by using random coordinates generated by a statistical program (MINITAB) to ensure that the experiment would provide valid data for the statistical analysis. This design allows an unbiased comparison of the total DU mass collected in different runs. Figure 2.3 is an expanded view of the enclosure, and Figure 2.4 is a view of the filter housing, showing the location designation of the areas sampled. Both letter and numerical designations are given. The letter designations are for the convenience of the reader; however, numerical designations were more convenient to use for the computerized data reduction.

Table 2.2 lists the coupon and tray samples, the corresponding areas they represent, and decodes the notations used in the figures and text to designate samples and sampling locations. The size of some sampled areas changed from run to run as noted in the table. The areas listed are described in the following section, which also details the selection of filter and scoop and sweep sample locations.

### 2.2.1 Floor Tray and Scoop and Sweep Samples

#### Floor (FL) Tray

The floor was divided into three sections: front, middle, and rear, as shown in Figure 2.5, with the exclusion areas identified (i.e., areas covered by equipment). Each third was sampled using two randomly located trays that were left in place for the three rounds in a run. A specific set of tray coordinates was used for each run.

#### Scoop and Sweep Samples

Nonaerosol DU collected after each round was identified by a visual survey of the target bay interior. Any large pieces of the penetrator and any piles of DU ash were collected. Separate containers were used for each type of material. Depleted uranium in the plenum was swept up after runs 2 through 5. After the first three runs, we noticed material collecting in the baffle entrance, so sweepings from that area were also collected. They (the baffle entrance sweeps) represent runs 1, 2, and 3 (a composite) and runs 4 and 5. The filter house was swept after runs 4 and 5.

### 2.2.2 Coupon Samples

Coupons were held in place using magnetic tape where possible. Some of the surfaces were nonmagnetic or dynamic and therefore the coupons were fastened onto these areas with adhesive tape or screws. Coupons were screwed

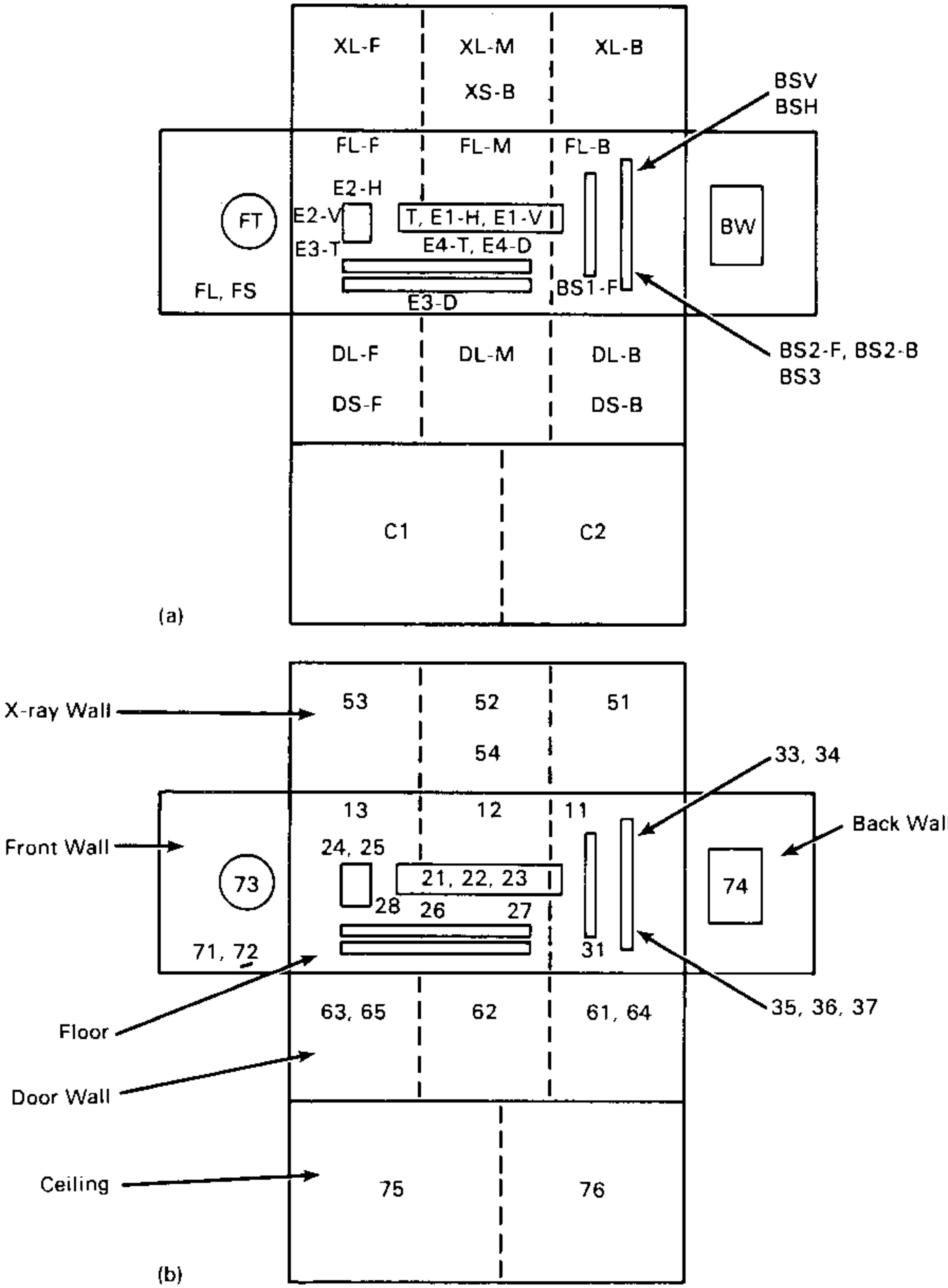



FIGURE 2.3. Exploded View of Enclosure Sampling Areas
(a) Sample Run Identification
(b) Numerical Designation in Sampling Runs

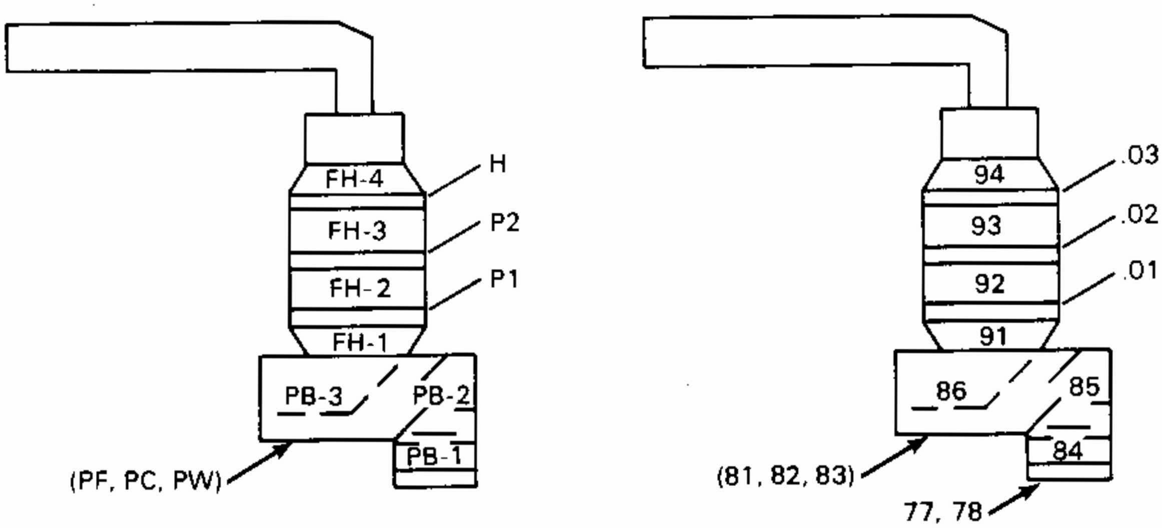



FIGURE 2.4. Filter House Sampling Areas
(a) Sample Area Identification
(b) Numerical Designation of Sampling

to the target, target side of the film shield, and exposed frontal areas of the first two backstop plates. Adhesive tape was used to tape some coupons to the x-ray table and part of the film frame. Some of the screwed coupons were blown from the surfaces by the force of the shot and were lost. Others were bent outward away from the surfaces they were screwed to, thus making both sides collection surfaces. The same coupon area of 0.044 $ft^2$ was used for all coupons collected.

Equipment (E)

Target, target table, x-ray table, film frame shield, film frame, and film frame support surfaces were represented by coupon samples. The tables were divided into two areas, the horizontal and vertical surfaces. Inner surfaces of the film frame and shield were inaccessible for sampling. The areas of some of the target table and target equipment surfaces varied from run to run as shown in Table 2.2.

The tables were divided into horizontal and vertical surfaces for sampling. Figure 2.6 shows the horizontal and vertical surfaces of the target table;

## TABLE 2.2. Enclosure Areas Represented by Tray and Coupon Samples

| Area | LOC Code | LOC ID | Description | Area Represented by Sample, $ft^2$ | Run 1, 3 | Run 2, 4 | Run 5 | Run 0, 1 |
|---|---|---|---|---|---|---|---|---|
| Floor | 11 | FL-B | Floor - Back Section | 272.6 | | | | |
| | 12 | FL-M | Floor - Middle Section | 303.6 | | | | |
| | 13 | FL-F | Floor - Front Section | 353.6 | | | | |
| Equipment | 21 | T | Target | 0[a] | 21.8 | 52.3 | 13.4 | |
| | 22 | E1-H | Target Table - Horizontal Surfaces | 82.4 | 82.4 | 82.4 | 85.9 | |
| | | | Target Table - Bottom Surface | 60.5 | 60.5 | 60.5 | 60.5 | |
| | 23 | E1-V | Target Table - Vertical Surface | 101.9 | 101.9 | 101.9 | 101.9 | |
| | | | Weldment | 77.5 | 77.3 | 77.3 | 15 | |
| | 24 | E2-H | X-ray Table Horizontal Surfaces - Bottom | 10.2 | | | | |
| | 25 | E2-V | X-ray Table - Vertical Surfaces | 12.2 | | | | |
| | 26 | E4-T | Film Shield - Target Side | 96.6 | | | | |
| | | | Film Shield Supports | 11.6 | | | | |
| | 27 | E4-D | Film Frame Support Structure | 65.4 | | | | |
| | 28 | E3-T | X-ray Table - Horizontal Surfaces - Top | 10.2 | | | | |
| | 29 | E3-D | Film Frame - Door Side | 96.6 | | | | |
| Backstop | 31 | BS1-F | Primary Plate - Front | 162 | | | | |
| | 33 | BS2-F | Secondary Plate - Front | 294 | | | | |
| | 34 | BS2-B | Secondary Plate - Back | 294 | | | | |
| | 35 | BSV | Vertical Surfaces | 94.7 | | | | |
| | 36 | BSH | Horizontal Surfaces | 66.8 | | | | |
| | 37 | BS3 | Additional Backup Plates | 818.6 | | | | |
| X-ray Wall | 51 | XL-B | Liner Plate - Back | 380.8 | | | | |
| | 52 | XL-M | Liner Plate - Middle | 380.8 | | | | |
| | 53 | XL-F | Liner Plate - Front | 380.8 | | | | |
| | 54 | XS-B | Space Around X-ray Opening | 256.9 | | | | |
| Door Wall | 61 | DL-B | Liner Plate - Back | 406.7 | | | | |
| | 62 | DL-M | Door | 378 | | | | |
| | 63 | DL-F | Liner Plate - Front | 406.7 | | | | |
| | 64 | DS-B | Space - Back | 813.4 | | | | |
| | 65 | DS-F | Space - Front | 813.4 | | | | |
| End Walls/ Ceiling | 71 | FL | Front Wall - Liner Plate | 514.4 | | | | |
| | 72 | FS | Front Wall - Space Around Tunnel Penetration | 45.9 | | | | |
| | 73 | FT | Tunnel | 1265 | | | | |
| | 74 | BW | Back Wall | 472.8 | | | | |
| | 75 | C1 | Ceiling - Front Half | 643.4 | | | | |
| | 76 | C2 | Ceiling - Rear Half | 643.4 | | | | |
| | 77 | BA | Baffles | 155.3 | | | | |
| | 78 | BE | Baffle entrance | 82.2 | | | | |
| Plenum | 81 | PF | Floor | 202 | | | | |
| | 82 | PC | Ceiling | 202 | | | | |
| | 83 | PW | Walls | 357.1 | | | | |
| | 84 | PB-1 | Baffles - Set 1 | 200.3 | | | | |
| | 85 | PB-2 | Baffles - Set 2 | 121.7 | | | | |
| | 86 | PB-3 | Baffles - Set 3 | 134 | | | | |
| Filter House | 91 | FH-1 | Plenum Transition Area | 278.9[b] | | | | 255.1 |
| | 92 | FH-2 | Area Between Primary and Secondary Filters | 483.7 | | | | |
| | 93 | FH-3 | Area Between Secondary and HEPA Filters | 486.5 | | | | |
| | 94 | FH-4 | Area Between HEPA Filters and Fan House | 304.0 | | | | |

(a) No target in Run 0. Values for other runs as indicated.
(b) Area sampled during all runs except 0 and 1.

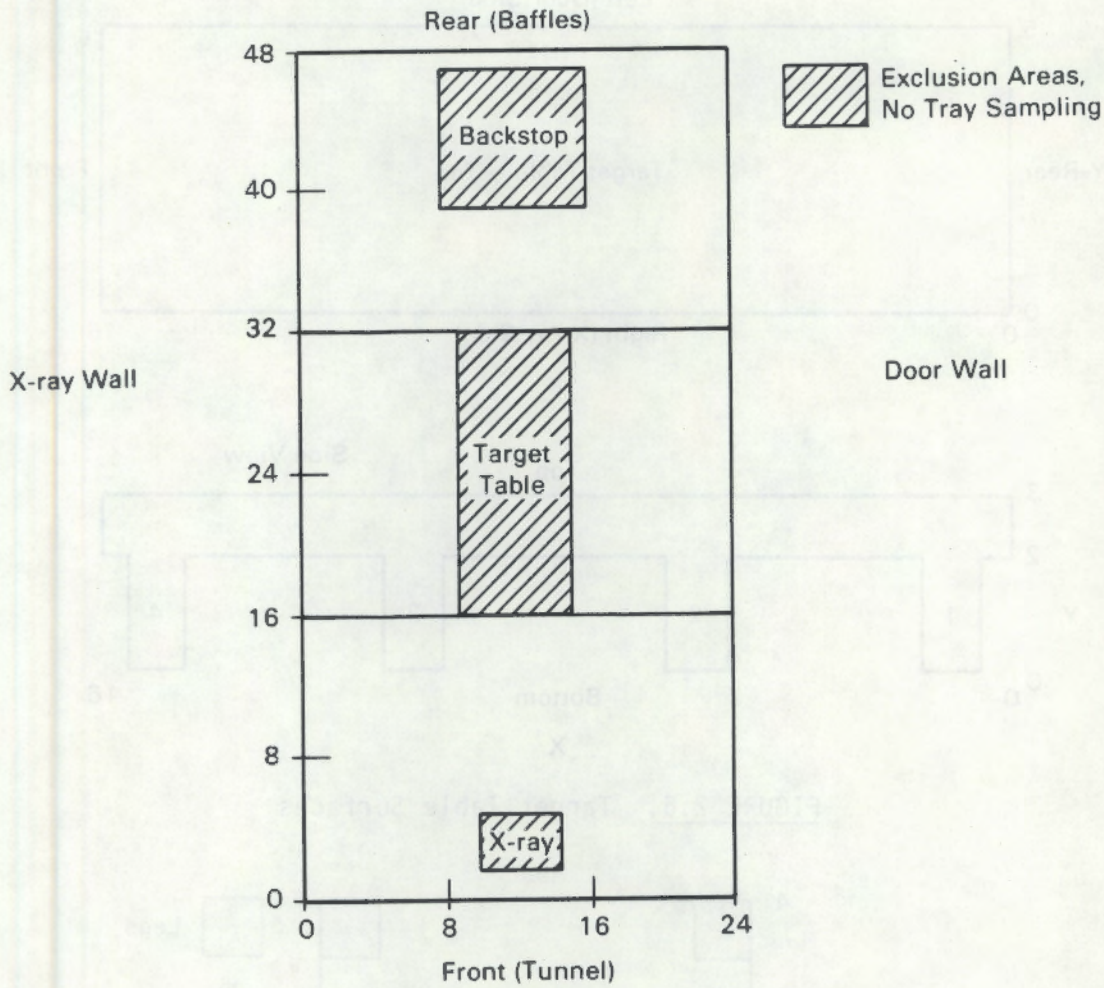



FIGURE 2.5. BTD Floor Sampling Areas

Figure 2.7 shows the overhead x-ray table. Sampler positions on the horizontal surfaces are described by the coordinates and vertical surfaces by positions on the support legs.

The shield and frame are divided into two sides: those facing the target and those facing the door wall of the building. Figure 2.8 shows the film frame and shield and the coordinates used in sampler placement.

Backstop (B)

Several backstop plates were located at the rear of the target bay. Figure 2.9 shows the plate positions and coordinates for sampler placement. The plates were divided into the following subareas for sampling: front of the

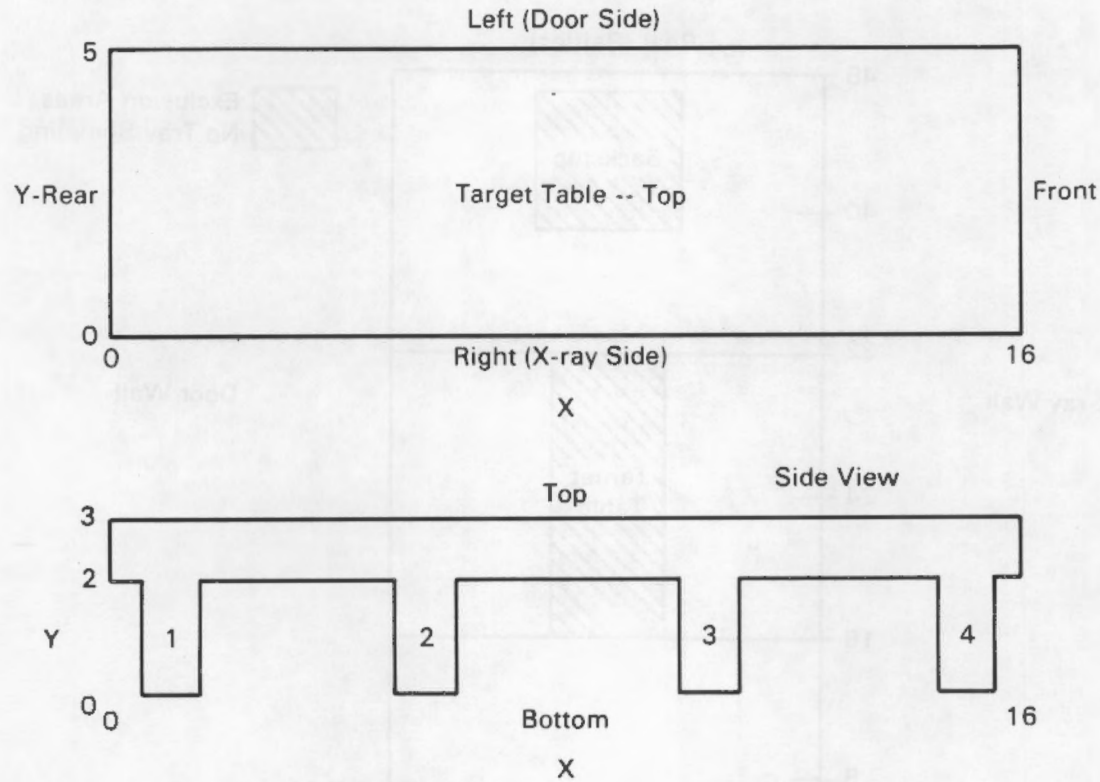



FIGURE 2.6. Target Table Surfaces

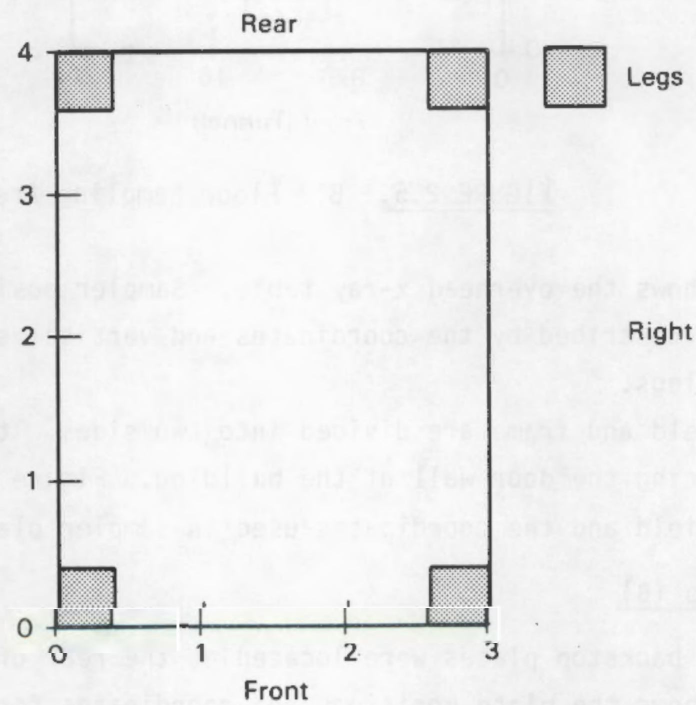



FIGURE 2.7. Overhead X-ray Table Surfaces

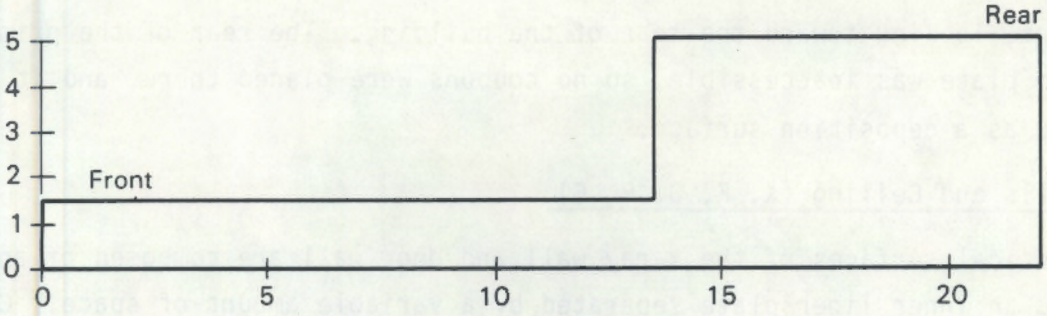



FIGURE 2.8. Coordinates for the Film Frame and Film Frame Shield From Door Side of Building

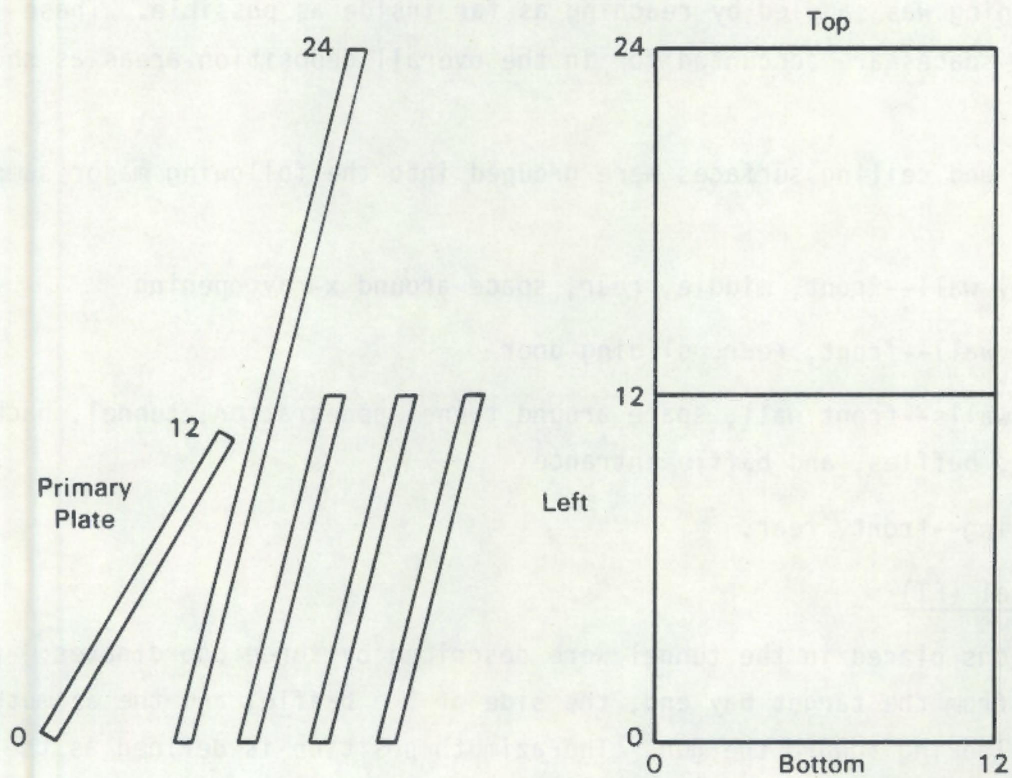



FIGURE 2.9. Side and Front View of Backstop Primary and Secondary Plates

primary plate, front and rear of the second plate, and vertical and horizontal components of the support structure, and the remaining backstop plates. All coupon positions were described as if the observer were facing the plates from the front, looking toward the rear of the building. The rear of the primary backstop plate was inaccessible, so no coupons were placed there, and it is not included as a deposition surface.

Walls and Ceiling (X, F, D, B, C)

Vertical surfaces of the x-ray wall and door wall are composed of an outer wall and an inner liner plate separated by a variable amount of space. Coupon samplers were concentrated on the exposed wall surfaces with additional coupons in accessible spaces. Inaccessible areas between the outer wall and the liner plates were either not sampled or sampled with difficulty; the space around the x-ray opening was sampled by reaching as far inside as possible. These indicated spaces are accounted for in the overall deposition areas as shown in Table 2.2.

Wall and ceiling surfaces were grouped into the following major sampling areas:

- x-ray wall--front, middle, rear, space around x-ray opening
- door wall--front, rear, sliding door
- end walls--front wall, space around tunnel penetration, tunnel, back wall, baffles, and baffle entrance
- ceiling--front, rear.

Tunnel (FT)

Coupons placed in the tunnel were described by three coordinates: the distance from the target bay end, the side of the baffle, and the azimuth position looking toward the gun. The azimuth position is defined as the angle of deviation, measured clockwise from the top of the tunnel designated 0. These tunnel coordinates are shown in Figure 2.10.

Plenum (P)

The plenum connects the target bay to the filter housing (Figure 2.1) and contains baffles to reduce the shock impact on the filter system. It was divided into six sampling areas: floor, walls, ceiling, and three groups of baffles. A general view of the plenum showing the internal baffles is shown in

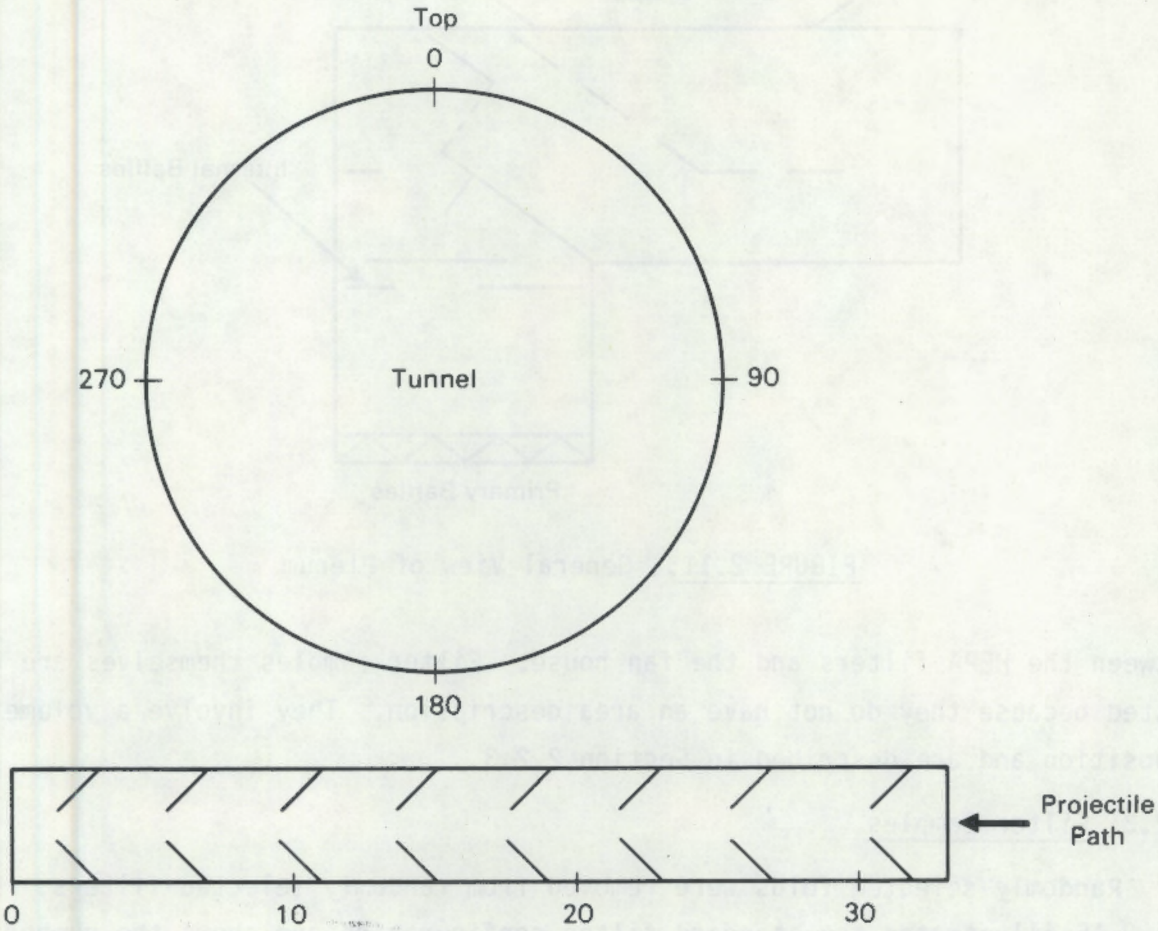



FIGURE 2.10. Tunnel Sampling Coordinates

Figure 2.11. Figure 2.12 shows the coordinates used in sampling the plenum floor, ceiling, and walls. Sampler coordinates for the three baffle groups are shown in Figure 2.13.

Filter House (FH)

The filter house has an exhaust fan house at one end and the plenum at the other. Sample areas listed in Table 2.2 represent deposition surfaces between the filter banks, and coordinates for coupon placement are shown in Figure 2.14. They are the plenum transition area, area between the primary and secondary filters, area between secondary and HEPA filters, and the area

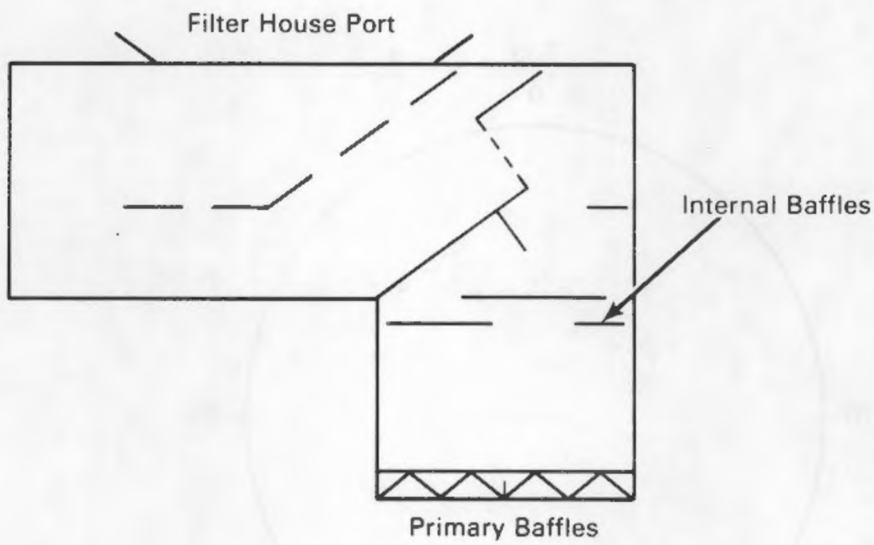



FIGURE 2.11. General View of Plenum

between the HEPA filters and the fan house. Filter samples themselves are not listed because they do not have an area description. They involve a volumetric deposition and are described in Section 2.2.3.

### 2.2.3 Filter Samples

Randomly selected folds were removed from randomly selected filters. Figure 2.15 illustrates the standard filter configuration and shows the numbering scheme for their location. All sample locations were identified while facing the direction of the airflow; fold locations were identified by counting left to right in the direction of airflow. The illustrated filter is 2,2 with sample folds 3 and 6 identified as the blacked out area. The first sample from filter 2,2 would consist of folds 3 and 4 and the second of folds 6 and 7. The sample is related to the entire filter by the ratio of the total folds/sampled folds.

## 2.3 DESCRIPTION OF RUNS

Information on the shots, targets, and penetrators for each run are summarized in the data analysis section in Table 4.5 showing the coded

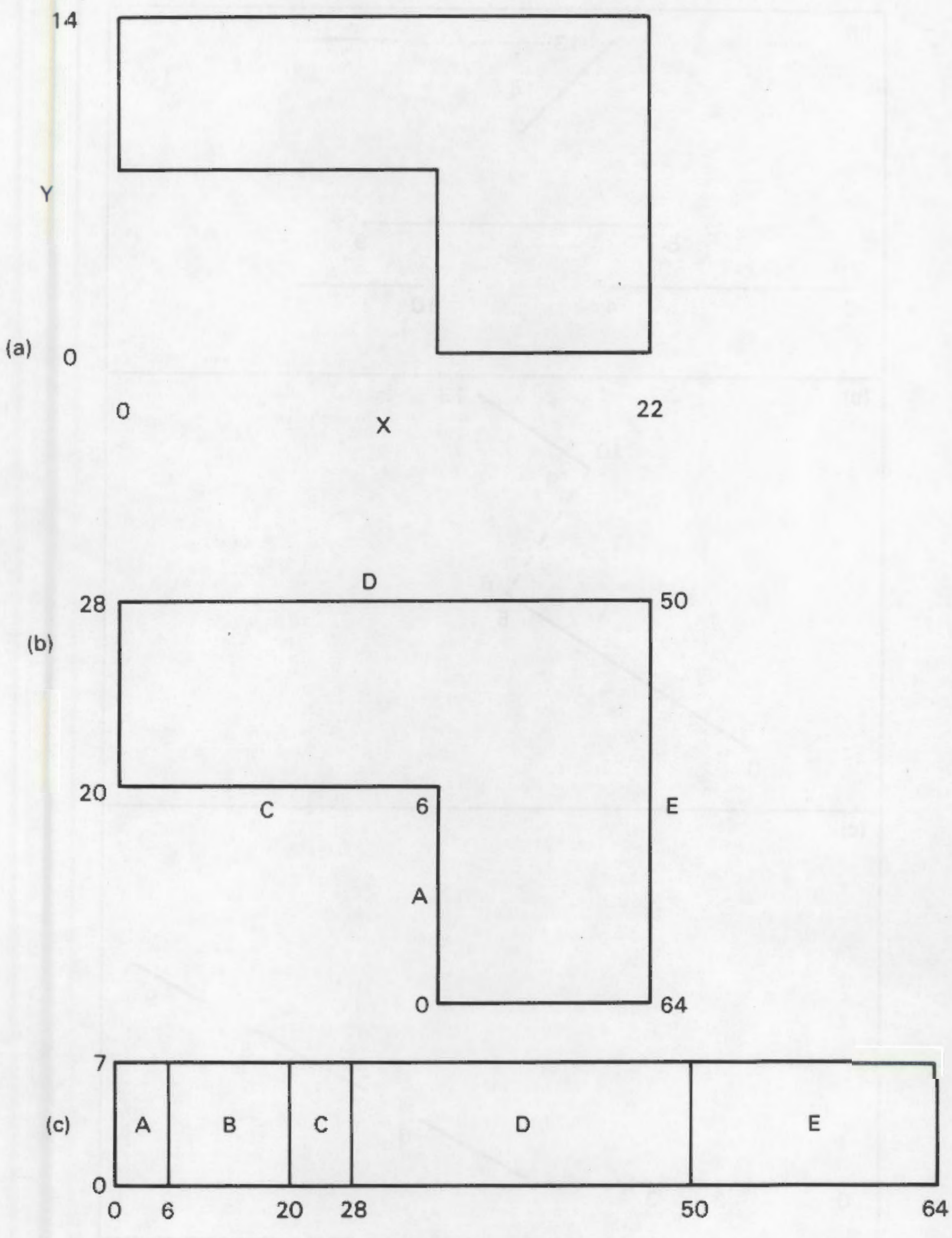



FIGURE 2.12. Sampling Coordinates for Plenum Floor, Ceiling, and Walls
(a) Plenum floor and ceiling
(b) Plenum wall top view showing x coordinate
(c) Flattened view of plenum walls.

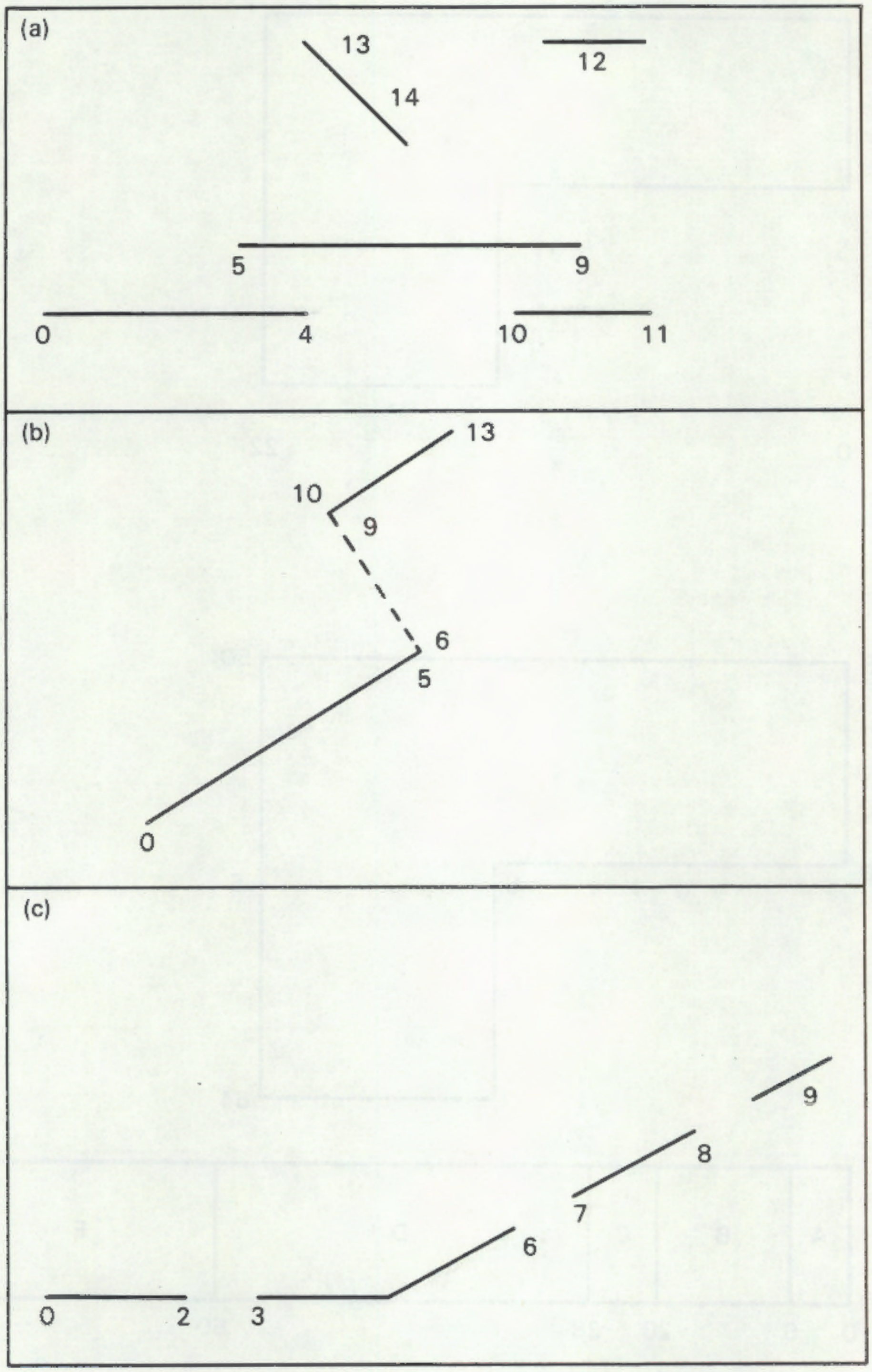



FIGURE 2.13. Plenum Baffle Sampling Coordinates
(a) PB-1
(b) PB-2
(c) PB-3

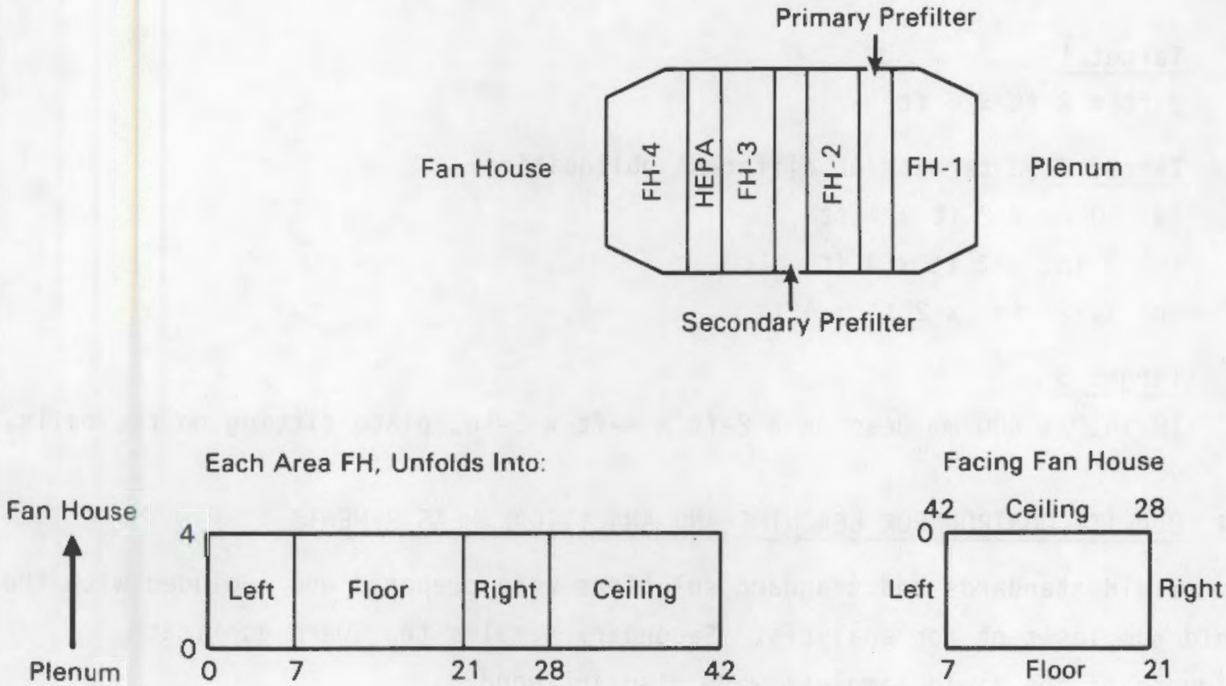



FIGURE 2.14. Filter House Sampling Coordinates

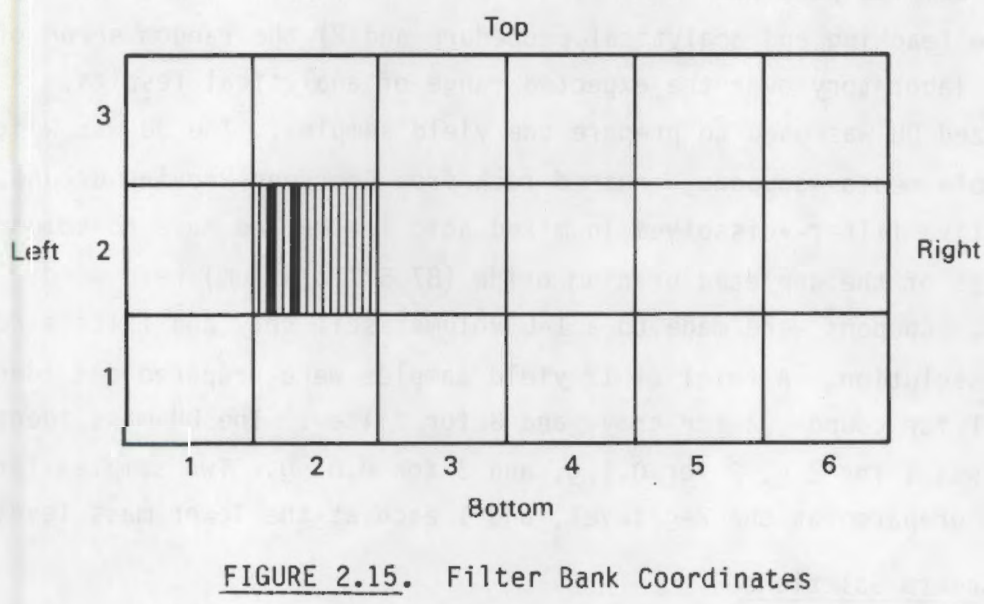



FIGURE 2.15. Filter Bank Coordinates

conditions for each shot. Each run consisted of three shots, for a total of 15 shots and 5 runs and a background run to investigate interferences. Three targets and two penetrator masses were used:

Target 1

2 ft x 2 ft x 6 ft

Target 2 (3 targets at different obliquities)

(a) 10 mm x 2 ft x 4 ft

(b) 1 in. x 2 ft x 4 ft

(c) 3.125 in. x 2 ft x 4 ft

Target 3

18 in.$^2$ x 600 mm deep on a 2-ft x 4-ft x 3-in. plate sitting on the rails.

## 2.4 QUALITY CONTROL FOR LEACHING AND ANALYTICAL MEASUREMENTS

Yield standards and standard solutions were prepared and included with the field samples sent for analysis. Secondary samples that were duplicate aliquots of the field samples, were also included.

### 2.4.1 Yield Standards

Yield samples were submitted with the field samples to estimate 1) the bias in the leaching and analytical procedure and 2) the random error of the analytical laboratory over the expected range of analytical results. A well-characterized DU was used to prepare the yield samples. The DU was weighed onto a sample media--coupons, crushed rock from Aberdeen Proving Ground, or a representative filter--dissolved in mixed acid leach, and made to volume. Three masses of the depleted uranium oxide (87.57% uranium) were used: 2, 0.1, and 0.01 g. Coupons were made to a 1-L volume; soil tray and filters required 2 L for dissolution. A total of 12 yield samples were prepared and identified by code: 1 for coupon, 2 for tray, and 3 for filter. The DU mass identification code was 1 for 2 g, 2 for 0.1 g, and 3 for 0.01 g. Two samples for each media were prepared at the 2-g level, and 1 each at the lower mass levels.

### 2.4.2 Standard Solutions

The goals for the standard solution analysis were to estimate the bias of the analytical laboratory results and the random error of the analytical method. A stock uranyl nitrate hexahydrate (UNH) solution was used to prepare standard solutions to send with the field samples. The standard solutions were prepared using the successive dilution method. A nominal 100 g/L stock solution was used to make the standard solutions, 3 batches at 3 concentration levels, 1 g/L, 0.1 g/L, and 0.001 g/L uranium. Chemical analysis of the stock solution showed it had an actual concentration of 101.85 g/L.

### 2.4.3 Secondary Samples

Secondary aliquots from leachates of the field samples were sent for analysis to estimate the sampling variability.

## 2.5 SAMPLE SUMMARY

A total of 468 field (including background), yield, standard, and secondary samples were analyzed. The quality control samples were distributed randomly through the field samples. A majority of the yield samples submitted were coupon yield because they constituted the bulk of the field samples. The number of field samples are listed by sampler type in Table 4.1 in the data analysis section.

# 3.0 CHEMICAL ANALYSIS

The following sections discuss the preparation of the samples for chemical analysis and some observations made during the work. This is followed by a description of the methods used for sample analysis.

## 3.1 SAMPLE PREPARATION

The field samples were leached in an acid mixture of 5 N nitric and 0.05 N hydrofluoric acids to dissolve the uranium. The leachate bearing the uranium was separated from the sample media by filtering, and then made to a known volume for the chemical analysis.

The various sample media required different amounts of leach solution to cover them for the uranium dissolution. Volumes prepared for the chemical analysis for each media were

| | |
|---|---|
| Coupons | 1 L |
| Tray soil, field, and yield | 2 L |
| Scoop and sweep | 1 or 2 L |
| Filter yield | 2 L |
| Filters | 4 to 8 L |

Coupons composited to form samples representing a single area were leached together. A single leaching could contain as many as eight coupons. Large DU fragments in tray soil were dissolved and analyzed separately for the first two runs. Later, fragments and soil were processed together in one leach.

The filter field samples proved difficult to work with because they were fairly large, and the uranium aerosol was embedded through the entire matrix. Early leaches indicated that only about 85% of the DU was leached from the filters in a single treatment. Recovery was based on two leaches, the second giving an additional 15%. It was assumed that two leaches would be adequate because the filter yield samples should estimate the leaching procedure. Therefore, two leaches were used for all of these samples. Leachate aliquots from both treatments were combined to send for analysis.

In most treatments, only the DU dissolved. The stainless steel coupons did not dissolve. For the filter samples, metal portions (wires or aluminum) dissolved and the filter disintegrated but did not dissolve. Cardboard portions of the filter did not dissolve or disintegrate. Soil did not dissolve, but the fine particles formed a colloidal suspension that was difficult to filter. These samples were centrifuged to separate the leachate from the soil.

Filter and tray soil yield samples were leached in the same manner as the field samples. The UNH standard solutions were already dissolved, so they needed no special treatment before analysis.

## 3.2 SAMPLE ANALYSIS

Three analytical methods were used: kinetic laser fluorometry for the samples, ferrous sulfate-potassium dichromate titrimetry to determine the uranium concentration for the UNH standard stock solution, and a gross alpha scintillation and alpha energy count to determine the specific activity of the collected uranium. Some of the identifiable large pieces of DU were weighed to determine their mass.

### 3.2.1 Kinetic Laser Fluorometry

Kinetic laser fluorometry of time-resolved emission of the uranyl ion was selected and used for the entire range of sample solutions. Kinetic laser fluorometry has been developed at PNL (Bushaw 1984) and is suitable for use when there are a large number of samples. In this method, pulsed-dye laser-excitation with multichannel scaler photon counting is used to obtain time-resolved emission spectra of uranyl ions in aqueous solution. Kinetic analysis of these data corrects for matrix quenching and temperature effects, which can reduce the quantum yield of the uranyl ion luminescence. A standard uranium stock solution, prepared from New Brunswick Laboratory standard reference $U_3O_8$, was used to calibrate the instrument. Detection limits can be as low as 1 part per trillion (pptr), and in samples with concentrations greater than 100 pptr, relative standard deviations of less than 3% are achieved routinely.

### 3.2.2 Ferrous Sulfate-Potassium Dichromate Titrimetry

An aliquot of an approximately 510 g/L uranium stock solution was used to make a 100 g/L solution for preparation of the more dilute standard solutions. Uranium in this second UNH stock solution was measured using ferrous sulfate-potassium dichromate titrimetry (ASTM 1983). In this technique, an excess of ferrous sulfate is used to reduce uranium in concentrated phosphoric acid solution containing sulfamic acid. Excess iron is oxidized by nitric acid, and then the sample is titrated with potassium dichromate (prepared using a National Bureau of Standards potassium dichromate) to a potentiometric end point. The stated limit of error at the 95% confidence level is ±0.1%.

### 3.2.3 Alpha Counting

Total alpha content was determined on a dissolved uranium fragment by counts on a gross alpha scintillation system. The ratio of $^{238}U$ to $^{234}U$ was determined by counting on an alpha energy spectrometer. The efficiencies of both counting systems were determined using a calibrated plutonium standard source. The sample standard deviation was 5%, computed using error propagation on counting errors and the variation of replicate samples.

The $^{235}U$ content was essentially negative, so for calculation, the sample was assumed to consist of only $^{238}U$ and $^{234}U$ in the determined ratio of 8 to 1. The calculated total specific activity including both nuclides was $3.08 \times 10^{-7}$ Ci/g.

# 4.0 DATA ANALYSES

## 4.1 DATA BASE

A listing of the basic data is given in Appendix A, which also includes the coding form that defines the contents of the listing. This listing has the 356 gravimetric and laser fluorometry results for the samples from the five experimental runs. The background (run zero) results are not included in the listing because they did not reveal significant interferences. Analysis of the data showed that the coupons for run zero had a median concentration of 0.004 mg/L, only 0.015% of the median for run 1 and 2 coupons. Table 4.1 gives the total number of samples of each type and the total number of analyses.

As discussed in Section 2, coupons were used to sample deposition to surfaces in the BTD building, including deposition in the projectile entry tunnel, plenum, and filter house. Scoops were used to pick piles of ash and nonaerosol uranium from the floor after each round. Large uranium pieces were separated from the ash and soil; the pieces were weighed and the ash leached. All other samples were leached, and the leachate was analyzed to determine milligrams of uranium per liter.

A total of 316 exposed, composited samples were collected and shipped to PNL. After leaching, 30 additional aliquots were made up from the leachate and sent for analysis to serve as replicates to check on the repeatability of the leachate sampling and analysis. In addition, one ash sample was subjected to two leachings, and nine of the tray samples (for runs 1 and 2) were leached twice and analyzed separately. After run 2, the tray samples were leached once, and filter samples were leached twice. The leachates were sampled and composited for analysis. Two of the composited coupon samples had no sampling location associated with them, and were removed from the analysis leaving 314 samples. Results for the two analyses for samples with replicates were averaged to provide the sample result.

TABLE 4.1. Number of Samples and Analyses

| Sample Type | Code | Samples | Replicates | 2nd Leach | Total Analyses |
|---|---|---|---|---|---|
| Coupon | 2 | 207 | 18 | | 225 |
| Scoop | | | | | |
| Ash | 3 | 15 | 2 | 1 | 33 |
| Particles | 3 | 15 | | | |
| Tray | 4 | 30 | 6 | 9 | 45 |
| Filter | 5 | 38 | 3 | (a) | 41 |
| Sweep | 6 | 11 | 1 | — | 12 |
| Total | | 316 | 30 | 10 | 356 |

(a) Both leaches combined for filter sample analyses

## 4.2 CALCULATIONS

Two calculations were made to summarize the uranium collected: first, the grams of uranium for each location, then the grams of uranium/ft$^2$/run and round.

### 4.2.1 Total Uranium

The grams of uranium for each location sampled were calculated using expansion factors based on the ratio of the area sampled to the area of the sampler used. The basic equation used was

$$GTA = \left(\frac{SQ.\ FT}{K}\right)\left(\frac{LEACH}{NCMP}\right)(0.001 \times DU) \qquad (1)$$

where

GTA = the total grams uranium for a sampled location

SQ. FT = the surface area for a location

K = the surface area of the sampler

LEACH = the liters of leachant used to dissolve the composited sample

NCMP = the number of samples composited in a leached sample

DU = the laser fluorometry result in milligrams of uranium per liter. Multiplying by 0.001 converts milligrams to grams.

The names assigned to the variables in Equation (1) are those used in the computer files.

In Equation (1), the ratio SQ. FT/K is the expansion factor, named SEXP in the computer files. For coupons, K was 0.043889 $ft^2$ and for trays 0.123698 $ft^2$. For filters, SEXP was the total number of folds in a filter bank, 18 filters times the number of folds per filter (as in Table 2.1). This gave SEXP of 378 for the prefilters (Farr 30/30® and Dust Trap®), 288 for the 90%, and 1044 for the HEPA filters. The scoop and sweep samples had no area directly associated with them and were usually collected after each round (the other samplers were usually left in place for three rounds at least). The scoop and sweep samples were treated as special collections of nonaerosol material, and SEXP was set to unity for them.

### 4.2.2 Uranium Per Square Foot

The second quantity of interest is the grams of uranium per square foot for the run and round. The value per round was calculated using the run collection for trays, coupons and filters:

$$G/U/R = GTA/(UNITS \times ROUNDS) \qquad (2)$$

where

G/U/R = the grams per unit per round,

UNITS = the $ft^2$ area for the location for trays and coupons or number of filters per bank (18), for filters,

ROUNDS = the number of rounds represented by the sample.

The quantity (UNITS x ROUNDS) was called WT, and used to calculate weighted averages for summaries that aggregated sampling locations into larger areas and over runs for the experiment total. In the summaries, an area of (23 in. x 23 in.)/144, or 3.6736 $ft^2$ was used to put the filter results on a square foot basis.

The locations were aggregated using the location codes as shown in Table 4.2. The 51 basic locations were aggregated to 20 first-level summary areas (SLID), then to ten second-level areas (SMRY), then to six third-level areas (PLOT).

TABLE 4.2. Aggregation of Sampling Locations for Summaries

| Sampler | Area | Location Codes | First-Level Summary | Second-Level Summary | Third-Level Summary |
|---|---|---|---|---|---|
| Tray | Floor | 11,12,13 | 1 | 1 | T |
| Scoops | Ash | 41 | 2 | 2 | S |
| | Particles | 41 | 3 | 2 | S |
| Coupons | Target | 21,22,23 | 4 | 3 | E |
| | X-ray table | 24,25,28 | 5 | 3 | E |
| | Film frame | 26,27,29 | 6 | 3 | E |
| | Backstop | 31-37 | 7 | 4 | E |
| | Baffles | 77,78 | 13 | 5 | W |
| | X-ray wall | 51-54 | 8 | 6 | W |
| | Door wall | 61-65 | 9 | 6 | W |
| | Front wall | 71-72 | 10 | 6 | W |
| | Back wall | 74 | 12 | 6 | W |
| | Ceiling | 75,76 | 14 | 6 | W |
| | Tunnel | 73 | 11 | 7 | W |
| | Plenum | 81-86 | 15 | 8 | P |
| | Filter house | 91-94 | 16 | 8 | P |
| Filters | Prefilter | 00,01,02 | 18 | 9 | F |
| | 90% | 03 | 19 | 9 | F |
| | HEPA | 04 | 20 | 9 | F |
| Sweeps | Plenum<br>Filter house | 81-94 | 17 | 10 | P |

## 4.3 SUMMARY OF RESULTS

An overall summary of results is given in Figure 4.1, which shows how the total grams of DU were apportioned into the third-level summary areas as a percentage of the total projectile weight for each RUN (3 rounds) and the total experiment. Table 4.3 has the data used in the plot listed by summary areas. Table 4.4 lists the amount accounted for as percent of the projectile weight. Overall, 81.3% of the total 63-kg weight of the 15 projectiles was recovered. The percent recovery ranged from a high of 97.7% in run 1 to a low of 65.2% in

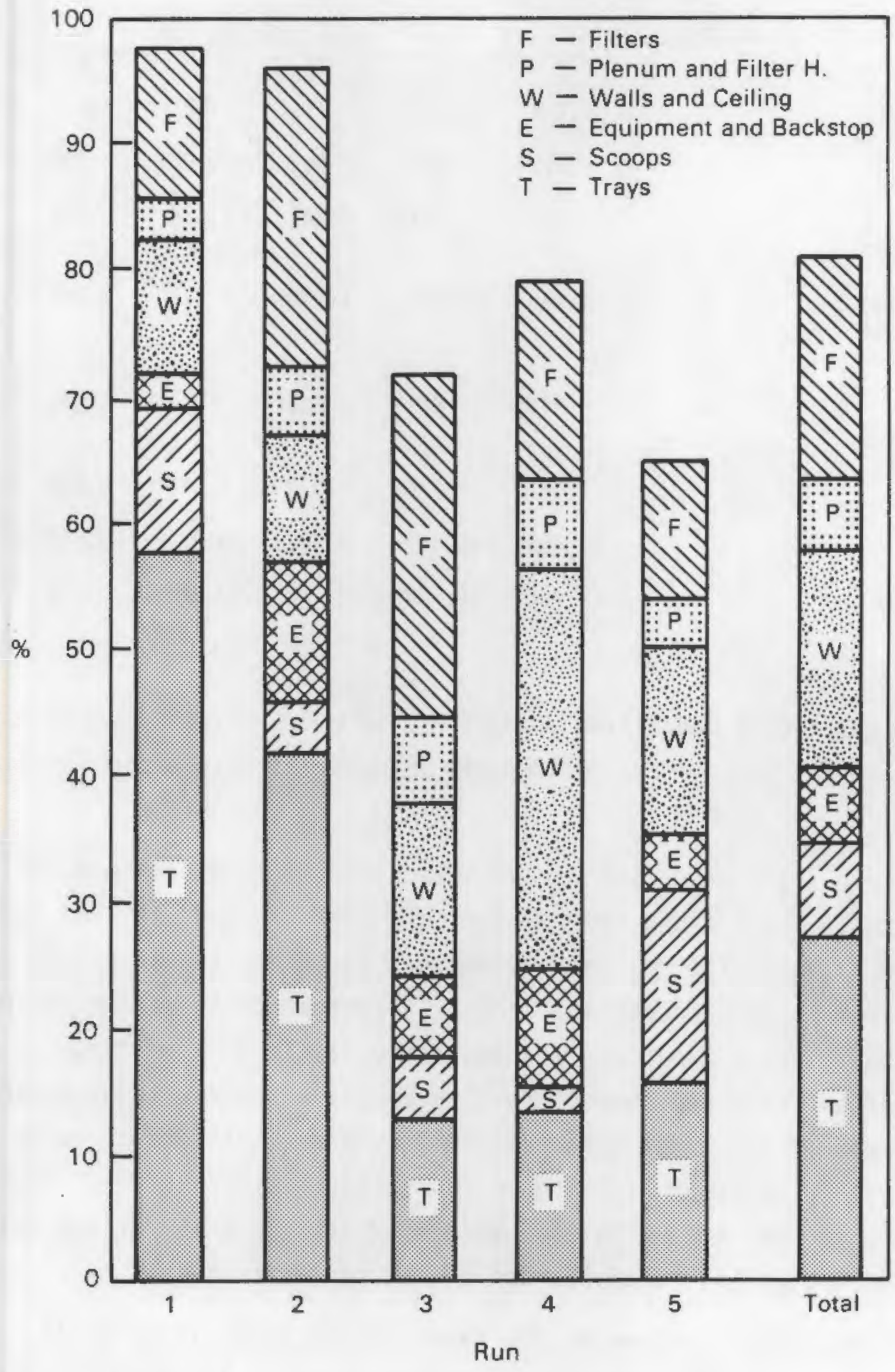



FIGURE 4.1. Percentage of DU Accounted For

TABLE 4.3. Total Depleted Uranium Accounted For

| Third-Level Area | Letter Designation | Grams Per Run 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| Floor, trays | T | 6,798 | 4,929 | 1,711 | 1,822 | 2,091 | 17,351 |
| Floor, scoops | S | 1,312 | 463 | 662 | 198 | 2,049 | 4,684 |
| Equipment and backstop | E | 333 | 721 | 841 | 1,289 | 582 | 3,766 |
| Walls, ceiling baffles, and tunnel | W | 1,236 | 1,746 | 1,805 | 4,173 | 1,945 | 10,904 |
| Plenum and filter house | P | 379 | 611 | 914 | 941 | 509 | 3,353 |
| Filters | F | 1,377 | 2,777 | 3,539 | 2,049 | 1,436 | 11,174 |
| Total | | 11,435 | 11,247 | 9,472 | 10,471 | 8,612 | 51,232 |
| Projectile weight | | 11,700 | 11,700 | 13,200 | 13,200 | 13,200 | 63,000 |

run 5. The coded test conditions listed in Table 4.5 may help explain the differences in the patterns of percentage accounted for to those familiar with the codes.

The tray (T) and scoop (S) percentages both represent amounts collected from the floor. The trays accounted for relatively more DU in runs 1 and 2 than in runs 3 to 5. The smaller percentages for trays and scoops in run 2, compared to run 1, were compensated for by larger percentages for equipment and filters. Runs 1 and 2 used the "E" projectile, and run 2 had target 2. The three low percent recovery runs (3 to 5) used the R projectile with targets 1, 2, and 3, respectively. For these six summary areas, filters accounted for the most DU in run 3, walls and ceiling in run 4, and trays in run 5. However, for run 5, trays, scoops, and walls each accounted for about 15% of the total projectile weight at 15.8%, 15.5%, and 14.7%, respectively.

A more detailed breakdown of the experimental total is given in Table 4.6. (Rounding differences may lead to slightly different totals from

TABLE 4.4. Percentage of Projectile Weight Accounted For

| Summary Area | Letter Designation | Grams Per Run 1 | 2 | 3 | 4 | 5 | Average |
|---|---|---|---|---|---|---|---|
| Trays | T | 58.1 | 42.1 | 13.0 | 13.8 | 15.8 | 27.5 |
| Scoops | S | 11.2 | 4.0 | 5.0 | 1.5 | 15.5 | 7.4 |
| Equipment and backstop | E | 2.8 | 6.2 | 6.4 | 9.8 | 4.4 | 6.0 |
| Walls, ceiling, baffles, tunnel | W | 10.6 | 14.9 | 13.7 | 31.6 | 14.7 | 17.3 |
| Plenum and filter house | P | 3.2 | 5.2 | 6.9 | 7.1 | 3.9 | 5.3 |
| Filters | F | 11.8 | 23.7 | 26.8 | 15.5 | 10.9 | 17.7 |
| Total | | 97.7 | 96.1 | 71.8 | 79.3 | 65.2 | 81.3 |

TABLE 4.5. Test Conditions

| Run | Shot | Target | Gun | Projectile | Velocity |
|---|---|---|---|---|---|
| 1 | 1 | 1 | L | E | V |
| | 2 | 1 | L | E | S |
| | 3 | 1 | L | E | U |
| 2 | 4 | 2 | L | E | V |
| | 5 | 2 | L | E | S |
| | 6 | 2 | L | E | U |
| 3 | 7 | 1 | H | R | S |
| | 8 | 1 | H | R | U |
| | 9 | 1 | H | R | M |
| 4 | 10 | 2 | H | R | S |
| | 11 | 2 | H | R | U |
| | 12 | 2 | H | R | M |
| 5 | 13 | 3 | H | R | U |
| | 14 | 3 | H | R | M |
| | 15 | 3 | H | R | B |

TABLE 4.6. Summary for Areas and Subareas

| Second-Level Area | First-Level Area | Total DU, g Subarea | Total DU, g Area | % Accounted For | Grams/ft$^2$/Round Subarea | Grams/ft$^2$/Round Area |
|---|---|---|---|---|---|---|
| 1. Floor | 1. Trays | 17,351 | 17,351 | 27.5 | 1.244 | 1.244 |
| 2. Scoops | 2. Ash | 712 | 4,685 | 7.4 | 0.051 | 0.336 |
| | 3. Particles | 3,973 | | | 0.285 | |
| 3. Equipment | 4. Target | 822 | 1,246 | 2.0 | 0.166 | 0.139 |
| | 5. X-ray Table | 39 | | | 0.092 | |
| | 6. Film Frame | 384 | | | 0.108 | |
| 4. Backstop | 7. Backstop | 2,520 | 2,520 | 4.0 | 0.100 | 0.100 |
| 5. Baffles | 13. Baffles | 981 | 981 | .6 | 0.275 | 0.275 |
| 6. Walls & Ceiling | 8. X-ray Wall | 2,738 | 9,163 | 14.5 | 0.130 | 0.093 |
| | 9. Door Wall | 3,511 | | | 0.083 | |
| | 10. Front Wall | 474 | | | 0.056 | |
| | 12. Back Wall | 1,704 | | | 0.240 | |
| | 14. Ceiling | 736 | | | 0.038 | |
| 7. Tunnel | 11. Tunnel | 760 | 760 | 1.2 | 0.040 | 0.040 |
| 8. Plenum & F.H. | 15. Plenum | 2,303 | 2,699 | 4.3 | 0.126 | 0.065 |
| | 16. Filter House | 396 | | | 0.017 | |
| 9. Filters | 18. Prefilter | 7,785 | 11,174 | 17.7 | 4.905 | 3.129 |
| | 19. 90% | 3,111 | | | 3.136 | |
| | 20. HEPA | 278 | | | 0.281 | |
| 10. Sweeps | 17. Sweeps | 654 | 654 | 1.0 | 0.016 | 0.016 |
| Total | | | 51,233 | 81.3 | | |
| Projectile Total | | | 63,000 | | | |
| Difference | | | -11,767 | 18.7 | | |

table to table.) Both the total grams and gram per square foot per round are tabulated. From Table 4.6 the following points are noted:

- DU tray samples from the floor represented the largest collection
- The weighed particles accounted for most of the grams DU for the scoop samples.
- The backstop accounted for about twice as much DU as the equipment.
- The baffles were added to the back wall and the tunnel to the front wall, and the results for the walls and the total weighted average are shown in Table 4.7.

TABLE 4.7. Total and Weighted-Average DU Wall Deposition and Ranking

| Surface | Total DU g | Rank | Unit Deposition $gram/ft^2/Round$ | Rank |
|---|---|---|---|---|
| Door wall | 3,511 | 5 | 0.083 | 3 |
| X-ray wall | 2,738 | 4 | 0.130 | 4 |
| Back wall | 2,685 | 3 | 0.252 | 5 |
| Front wall | 1,234 | 2 | 0.045 | 2 |
| Ceiling | 736 | 1 | 0.038 | 1 |
| Total | 10,904 | | 0.086 | |

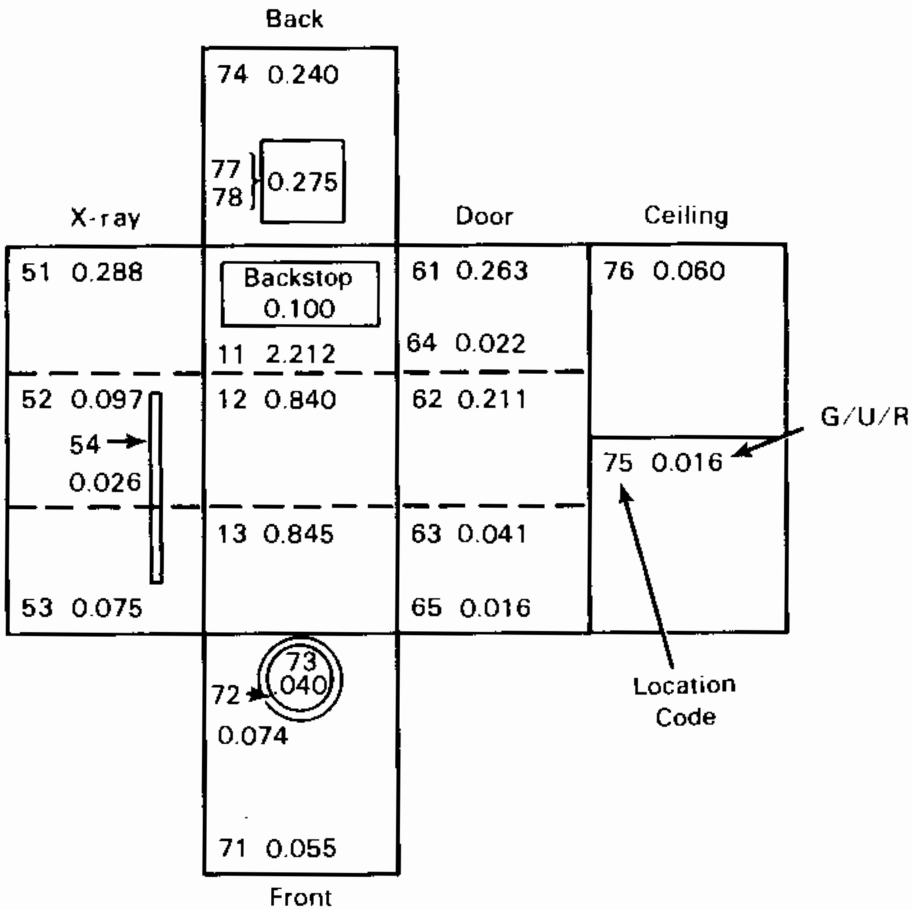
- This wall summary points out the need for considering the weighted average $gram/ft^2/round$ in determining the areas of highest deposition. Ranking, (with 5 indicating the highest deposition) based on these two variables is also shown in Table 4.7.
- The ranking based on $gram/ft^2/round$ appears more reasonable given that the projectile and air stream forces are towards the back wall.
- The amount collected by the filters declined progressively with each successive filter stage.

The $gram/ft^2/round$ results for scoops in Table 4.6 were obtained by dividing the total grams DU by 13,947, the floor area (272.6 + 303.6 + 353.6) times 15 rounds. For the plenum sweeps, the total square feet for the plenum and filter house (2765.44 x 15) was the divisor.

The most detailed breakdown of the experimental total is in Table 4.8, which contains the total grams DU [Equation (1)] and the grams/unit/round for each location. The scoop and sweep collection totals are simply divided by 15 in this table to put them on a round basis. The grams/unit/round results from Table 4.8, with scoop and sweep results from Table 4.6, were used in Figure 4.2 to illustrate the deposition distribution. The tendency for deposition to increase from front to back is obvious in the exploded plan view. The fact that most locations follow logical expectations for deposition lends credence to the results.

TABLE 4.8. Total Grams DU and Grams/ft$^2$/Round for Each Location

| Sampler | Location | Total DU, g | Grams/ft$^2$/Round |
|---|---|---|---|
| Tray | 11 Floor-back | 9,043 | 2.212 |
| | 12 Floor-mid | 3,824 | 0.840 |
| | 13 Floor-front | 4,483 | 0.845 |
| Scoop | 41 Ash | 712 | 47.477 |
| (15) | 41 Particle | 3,973 | 264.867 |
| Coupon | 21 Target | 129 | 0.429 |
| | 22 T. table-H | 540 | 0.251 |
| | 23 T. table-V | 153 | 0.061 |
| | 24 X-ray table-B | 2 | 0.014 |
| | 25 X-ray table-V | 6 | 0.043 |
| | 28 X-ray table-T | 31 | 0.202 |
| | 26 Film shield-T | 185 | 0.014 |
| | 27 Film frame | 105 | 0.134 |
| | 29 Film shield-O | 94 | 0.081 |
| | 31 Bkst.-PPF | 437 | 0.180 |
| | 33 Bkst.-SPF | 351 | 0.080 |
| | 34 Bkst.-SPB | 41 | 0.012 |
| | 35 Bkst.-V | 75 | 0.050 |
| | 36 Bkst.-H | 524 | 0.523 |
| | 37 Bkst.-Other | 1,095 | 0.089 |
| | 77 Baffles | 688 | 0.295 |
| | 78 Baffle entry | 293 | 0.237 |
| | 51 X-ray wall-back | 1,644 | 0.288 |
| | 52 Middle | 565 | 0.099 |
| | 53 Front | 429 | 0.075 |
| | 54 Opening | 100 | 0.026 |
| | 61 Door wall-back | 1,607 | 0.263 |
| | 62 Door | 1,197 | 0.211 |
| | 63 Front | 249 | 0.041 |
| | 64 Space-back | 264 | 0.022 |
| | 65 Space-front | 194 | 0.016 |
| | 71 Front | 423 | 0.055 |
| | 72 Space | 51 | 0.074 |
| | 74 Back wall | 1,704 | 0.240 |
| | 75 Ceiling-front | 158 | 0.016 |
| | 76 Ceiling-back | 578 | 0.060 |
| | 73 Tunnel | 760 | 0.040 |
| | 81 Plenum-floor | 535 | 0.177 |
| | 82 Plenum-ceiling | 378 | 0.125 |
| | 83 Plenum-walls | 433 | 0.081 |
| | 84 Plenum-baffles-1 | 479 | 0.159 |
| | 85 Plenum-baffles-2 | 217 | 0.119 |
| | 86 Plenum-baffles-3 | 216 | 0.130 |
| | 91 Filter-house-TA | 275 | 0.066 |
| | 92 Between 1st, 2nd | 100 | 0.014 |
| | 93 Between 2nd, HEPA | 19 | 0.003 |
| | 94 HEPA to fan | 3 | 0.001 |
| Sweeps | 81 Plenum-floor | 534 | 35.623 |
| (15) | 84 Plenum baffles | 35 | 2.367 |
| | 91 Filter house-TA | 61 | 4.067 |
| | 92 Between 1st, 2nd | 23 | 1.520 |
| Filters | 102 Prefilters | 7,785 | 4.905 |
| | 3 90% | 3,111 | 3.136 |
| | 4 HEPA | 278 | 0.281 |




## Plenum and Filter House

| | |
|---|---|
| 81-86 Plenum | 0.126 |
| 91-94 Filter House | 0.017 |
| Sweeps | 0.016 |

## Filters

| | | |
|---|---|---|
| 1 + 2 Pre-F | 4.905 | 3.129 |
| 3 90% | 3.136 | |
| 4 HEPA | 0.281 | |

## Scoops From Floor

| | | |
|---|---|---|
| 41A Ash | 0.051 | 0.336 |
| 41P Particles | 0.285 | |
| | | 0.139 |

## Equipment

| | | |
|---|---|---|
| 21. Target | 0.429 | 0.166 |
| 22. T. Table-H | 0.251 | |
| 23. T. Table-V | 0.061 | |
| 24. X-ray Table-B | 0.014 | 0.092 |
| 25. X-ray Table-V | 0.043 | |
| 28. X-ray Table-T | 0.202 | |
| 26. Film Shield-T Side | 0.114 | 0.108 |
| 27. Film Frame | 0.134 | |
| 29. Film Shield-D Side | 0.081 | |

FIGURE 4.2. Aggregation of Sampling Locations for Summaries, Grams/$ft^2$/Round

## 4.4 PRECISION AND ACCURACY

The uncertainty associated with an estimated grams DU for an area (GTA) depends on the uncertainty associated with the variables used in its calculation. These variables were defined for Equation (1), except that DU masks the fact that the mg/L analytical result is calculated from a more basic analytical result, µg/L, times an analytical dilution, in mL. Then GTA was calculated as

$$GTA_g = \left(\frac{SQ.\ FT}{K}\right) \left(\frac{LEACH}{NCMP}\right) \left[(0.001)\quad U_{\mu} \times DILU\right] \tag{3}$$

where, in addition to the variables for Equation (1), $U_{\mu}$ is the µg/L result from the lifetime fit of analyzed solutions, and DILU is the predilution in mL of the aliquot taken from the leachate for a (composited) sample.

The standard deviation associated with GTA can be estimated using error propagation procedures. Calculation uses variances, V, which are squared standard deviations. The equation for random errors is

$$V_R(GTA_g) = \frac{(GTA)}{(NCMP)^2} \left[\frac{V(SQ.\ FT/K)}{(SQ.\ FT)^2} + \frac{V(LEACH)}{(LEACH)^2} + \frac{V(U_{\mu})}{U_{\mu}^2} + \frac{V(DILU)}{(DILU)^2}\right] \tag{4}$$

$$= \left(\frac{GTA}{NCMP}\right)^2 \left[P_X^2 + P_L^2 + P_{\mu}^2 + P_D^2\right]$$

where the $P^2$ are relative variances defined implicitly by the terms in the brackets. This approach makes the calculation easier because relative standard deviations can be used (the Ps). The price paid for the easier calculation is an approximate result.

The measurement uncertainties involved are listed in Table 4.9. The upper part of this table lists the preliminary uncertainties for calculating $V_R(GTA_g)$. The lower part lists the uncertainties from the quality control data to be used for checking the reported uncertainties and calculating the variance associated with sampling leachates, bias estimation, and the assignment of

## TABLE 4.9. Measurement Uncertainties

| Measurement or Calculation | Units | sd | Relative sd, % Typical | | Source of Estimate |
|---|---|---|---|---|---|
| Laser fluorometry | μg/L | "σ" | $P_{\mu}$ | 3 | Bushaw (1984) |
| Analytical dilution | mL | sd(D) | $P_D$ | 5 | B. A. Bushaw, 1984[a] |
| Leach volume | L | sd(L) | $P_L$ | 0.5 | Assumed sd of 5 mL and 1 L |
| Area $ft^2$ | $ft^2$ | sd(A) | $P_A$ | 2 | Assumed |
| Sampler area | $ft^2$ | sd(S) | $P_S$ | 2 | Assumed |
| SEXP = Area/Sampler | - | sd(X) | $P_X$ | 2.8 | $100(0.02^2 + 0.02^2)^{1/2}$ |
| DU.MG/L (basic data) | mg/L | $sd(U_m)$ | $P_M$ | 5.8 | $100(P_L^2 + P_X^2 + P_M^2)$ |
| Leachant sampling | mg/L | (1) | $(s_R^2 - s_A^2)^{1/2}$ | 10.4 | Yield standards |
| Leaching bias | mg/L | (1) | % Bias = -4.4<br>$sd(B_L)$ = 2.45 | | Yield standards (for 2 g STND) |
| Analytical bias | mg/L | (1) | % Bias = -5.6<br>sd(BA) = 1.53 | | Solution standards (for 1 g STND) |
| Analytical reproducibility | mg/L | (1) | $s_R$<br>$s_A$ | 12.3<br>6.5 | Field replicates<br>Solution standards |
| Assigned values | | | | | |
| Yield standards | g/g | (1) | $S_{gs}$ | 0.39 | For base solution only<br>(base powder only) |
| Solution standards | g/L | (1) | $s_{SS}$ | 0.13 | C. M. Matsuzaki, 1983[b] |
| Calibration standard (25.3 mg/L) | μg/L | (1) | Rel. Bias 1.5 | | B. A. Bushaw, 1984[a] |

(1) Indicates that these values need refinement.
(a) Analytical report by B. A. Bushaw, Pacific Northwest Laboratory.
(b) Analytical report by C. M. Matsuzaki, Pacific Northwest Laboratory.

standard values (sometimes called 'systematic error' to distinguish it from random error). The values listed are based on a preliminary analysis of the quality control data and need further refinement (i.e., more data on the DU oxide powder used in preparation of the yield standards). An equation similar to Equation (4), with systematic error relative variances, can be used to approximate the systematic error variance $V_S(GTA_g)$.

Based on this preliminary look at the precision and accuracy of the measurements, it appears that the random error standard deviation (precision) for GTA will be 6% to 15% relative and the systematic error (accuracy) 5% to 12% relative. Further work would be needed to refine these estimates.

# 5.0 REFERENCES

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# APPENDIX A

## LISTING OF BASIC DATA

TABLE A.1. Coding for BTD Mass Balance Data Files

| Field | Name | Code | Information/Comments |
|---|---|---|---|
| - | Case | 1-356 | Sequence number of record on file |
| 1 | RUN | 1-5 | A series of 3 rounds; end of run defined by changeout of primary prefilters. |
| 2 | ROUNDS | 1-15 | Total number of rounds fired during sampler's exposure. |
| 3 | FIRST[(a)] | 1-15 | The round number of first shot for the run. |
| 4 | STYPE | 2-6 | Type of Sampler<br>2 Coupon<br>3 Scoop (Ash and Particles)<br>4 Tray<br>5 Filter<br>6 Sweep (Plenum and Filter House) |
| 5 | LOC | 0-99 | Building location represented by sample. See Table 2.2 for definition of locations. |
| 6 | NCNP | 1-8 | Numbers of samplers composited for analysis. |
| 7 | CID | XXXXXXX | Unique ID number for each composite container. An initial digit of 9 implies a replicate analysis of leached composite was done. |
| 8 | DU/MG/L | XXXXXX.XXX | The laser/fluorometry analytical result in milligrams per liter |
| 9 | DILU | XXXXXX | The total dilution factor used to dilute the leachate for analysis. A "-1" indicates a weighed DU particle sample. |
| 10 | LEACH | 1-8 | The liters of leachant used to leach the sample. Except 3 means the DU particles from the scoop samples were weighed (i.e., not leached). |
| 11 | REP | 0-2 | Indicator for samples with replicate analysis<br>0 No replicate<br>1 First replicate<br>2 Second replicate |

(a) Not included in listing

# TABLE A.2. Listing of Basic Data

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2. | 21. | 1. | 3. | 3. | 52. | 171.872 | 2626.0 | 1. | 1. |
| 2 | 2. | 21. | 1. | 3. | 3. | 90052. | 185.073 | 1501.0 | 1. | 2. |
| 3 | 2. | 21. | 2. | 3. | 2. | 211. | 137.720 | 601.0 | 1. | 0. |
| 4 | 2. | 21. | 3. | 3. | 3. | 194. | 95.260 | 503.0 | 1. | 1. |
| 5 | 2. | 21. | 3. | 3. | 1. | 90194. | 90.130 | 503.0 | 1. | 2. |
| 6 | 2. | 21. | 5. | 1. | 3. | 165. | 41.550 | 503.0 | 1. | 0. |
| 7 | 2. | 21. | 5. | 1. | 1. | 296. | 1.720 | 263.5 | 1. | 1. |
| 8 | 2. | 21. | 5. | 1. | 1. | 90296. | 0.740 | 263.5 | 1. | 2. |
| 9 | 2. | 22. | 1. | 3. | 5. | 54. | 30.332 | 401.0 | 1. | 0. |
| 10 | 2. | 22. | 2. | 3. | 4. | 154. | 269.680 | 401.0 | 1. | 0. |
| 11 | 2. | 22. | 3. | 3. | 2. | 197. | 12.190 | 503.0 | 1. | 0. |
| 12 | 2. | 22. | 4. | 3. | 5. | 254. | 351.700 | 25653.0 | 1. | 0. |
| 13 | 2. | 22. | 5. | 3. | 6. | 299. | 116.140 | 503.0 | 1. | 0. |
| 14 | 2. | 23. | 1. | 3. | 3. | 136. | 9.373 | 101.0 | 1. | 1. |
| 15 | 2. | 23. | 1. | 3. | 3. | 90136. | 11.356 | 501.0 | 1. | 2. |
| 16 | 2. | 23. | 2. | 3. | 2. | 123. | 15.350 | 201.0 | 1. | 0. |
| 17 | 2. | 23. | 3. | 3. | 2. | 237. | 9.480 | 503.0 | 1. | 0. |
| 18 | 2. | 23. | 4. | 3. | 1. | 251. | 16.620 | 503.0 | 1. | 0. |
| 19 | 2. | 23. | 5. | 3. | 3. | 295. | 26.850 | 503.0 | 1. | 0. |
| 20 | 2. | 24. | 1. | 3. | 2. | 55. | 1.537 | 101.0 | 1. | 0. |
| 21 | 2. | 24. | 2. | 3. | 1. | 144. | 0.870 | 2.5 | 1. | 0. |
| 22 | 2. | 24. | 3. | 3. | 1. | 190. | 1.460 | 503.0 | 1. | 0. |
| 23 | 2. | 24. | 4. | 3. | 1. | 248. | 4.130 | 503.0 | 1. | 0. |
| 24 | 2. | 25. | 1. | 3. | 2. | 58. | 4.164 | 101.0 | 1. | 0. |
| 25 | 2. | 25. | 2. | 3. | 2. | 150. | 10.410 | 201.0 | 1. | 0. |
| 26 | 2. | 25. | 3. | 3. | 2. | 191. | 6.190 | 503.0 | 1. | 0. |
| 27 | 2. | 25. | 4. | 3. | 1. | 250. | 12.210 | 503.0 | 1. | 0. |
| 28 | 2. | 26. | 1. | 3. | 6. | 64. | 51.272 | 401.0 | 1. | 0. |
| 29 | 2. | 26. | 2. | 3. | 5. | 130. | 59.940 | 201.0 | 1. | 0. |
| 30 | 2. | 26. | 3. | 3. | 3. | 186. | 28.290 | 503.0 | 1. | 0. |
| 31 | 2. | 26. | 4. | 3. | 6. | 252. | 203.860 | 25653.0 | 1. | 1. |
| 32 | 2. | 26. | 4. | 3. | 5. | 90252. | 262.840 | 25653.0 | 1. | 2. |
| 33 | 2. | 26. | 5. | 3. | 4. | 293. | 25.080 | 503.0 | 1. | 0. |
| 34 | 2. | 27. | 1. | 3. | 4. | 93. | 39.064 | 1001.0 | 1. | 0. |
| 35 | 2. | 27. | 2. | 3. | 4. | 111. | 32.330 | 401.0 | 1. | 0. |
| 36 | 2. | 27. | 4. | 3. | 3. | 246. | 133.780 | 25653.0 | 1. | 0. |
| 37 | 2. | 27. | 5. | 3. | 4. | 235. | 32.980 | 503.0 | 1. | 0. |
| 38 | 2. | 28. | 1. | 3. | 2. | 51. | 31.639 | 401.0 | 1. | 0. |
| 39 | 2. | 28. | 2. | 3. | 2. | 119. | 64.070 | 201.0 | 1. | 0. |
| 40 | 2. | 28. | 3. | 3. | 2. | 188. | 53.810 | 503.0 | 1. | 0. |
| 41 | 2. | 28. | 4. | 3. | 2. | 249. | 89.130 | 503.0 | 1. | 0. |
| 42 | 2. | 28. | 5. | 3. | 1. | 288. | 13.800 | 503.0 | 1. | 0. |
| 43 | 2. | 29. | 1. | 3. | 5. | 56. | 37.918 | 1001.0 | 1. | 0. |
| 44 | 2. | 29. | 2. | 3. | 4. | 116. | 16.310 | 201.0 | 1. | 1. |
| 45 | 2. | 29. | 2. | 3. | 4. | 90116. | 16.700 | 201.0 | 1. | 2. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | OU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 2. | 29. | 3. | 3. | 5. | 199. | 9.440 | 503.0 | 1. | 0. |
| 47 | 2. | 29. | 4. | 3. | 6. | 247. | 181.570 | 25653.0 | 1. | 0. |
| 48 | 2. | 31. | 1. | 3. | 4. | 100. | 17.930 | 1001.0 | 1. | 0. |
| 49 | 2. | 31. | 2. | 3. | 4. | 152. | 156.050 | 201.0 | 1. | 0. |
| 50 | 2. | 31. | 3. | 3. | 2. | 215. | 21.190 | 503.0 | 1. | 0. |
| 51 | 2. | 31. | 4. | 3. | 4. | 254. | 158.180 | 503.0 | 1. | 0. |
| 52 | 2. | 31. | 5. | 3. | 4. | 292. | 97.460 | 503.0 | 1. | 0. |
| 53 | 2. | 33. | 1. | 3. | 4. | 91. | 30.170 | 501.0 | 1. | 0. |
| 54 | 2. | 33. | 2. | 3. | 4. | 113. | 26.630 | 201.0 | 1. | 0. |
| 55 | 2. | 33. | 3. | 3. | 4. | 206. | 31.870 | 503.0 | 1. | 0. |
| 56 | 2. | 33. | 4. | 3. | 4. | 265. | 95.510 | 25653.0 | 1. | 0. |
| 57 | 2. | 33. | 5. | 3. | 4. | 310. | 25.690 | 503.0 | 1. | 0. |
| 58 | 2. | 34. | 1. | 3. | 4. | 102. | 1.719 | 101.0 | 1. | 0. |
| 59 | 2. | 34. | 2. | 3. | 4. | 129. | 2.620 | 201.0 | 1. | 0. |
| 60 | 2. | 34. | 4. | 3. | 4. | 255. | 17.960 | 503.0 | 1. | 0. |
| 61 | 2. | 34. | 5. | 3. | 4. | 305. | 2.310 | 503.0 | 1. | 0. |
| 62 | 2. | 35. | 1. | 3. | 4. | 51. | 7.090 | 401.0 | 1. | 0. |
| 63 | 2. | 35. | 2. | 3. | 4. | 132. | 22.420 | 201.0 | 1. | 0. |
| 64 | 2. | 35. | 3. | 3. | 2. | 195. | 25.400 | 503.0 | 1. | 0. |
| 65 | 2. | 35. | 4. | 3. | 4. | 253. | 38.990 | 503.0 | 1. | 0. |
| 66 | 2. | 35. | 5. | 3. | 3. | 303. | 9.470 | 503.0 | 1. | 0. |
| 67 | 2. | 36. | 1. | 3. | 3. | 53. | 30.569 | 2010.0 | 1. | 0. |
| 68 | 2. | 36. | 2. | 3. | 2. | 121. | 59.790 | 201.0 | 1. | 0. |
| 69 | 2. | 36. | 3. | 3. | 2. | 193. | 170.420 | 503.0 | 1. | 0. |
| 70 | 2. | 36. | 4. | 3. | 2. | 259. | 166.950 | 25653.0 | 1. | 0. |
| 71 | 2. | 36. | 5. | 3. | 4. | 301. | 482.410 | 5533.0 | 1. | 1. |
| 72 | 2. | 36. | 5. | 3. | 4. | 90301. | 469.610 | 5533.0 | 1. | 2. |
| 73 | 2. | 37. | 1. | 3. | 6. | 105. | 36.563 | 1001.0 | 1. | 0. |
| 74 | 2. | 37. | 2. | 3. | 5. | 115. | 24.870 | 201.0 | 1. | 0. |
| 75 | 2. | 37. | 3. | 3. | 5. | 196. | 134.670 | 503.0 | 1. | 0. |
| 76 | 2. | 37. | 4. | 3. | 8. | 252. | 113.430 | 503.0 | 1. | 0. |
| 77 | 2. | 37. | 5. | 3. | 8. | 298. | 58.760 | 503.0 | 1. | 0. |
| 78 | 2. | 51. | 1. | 3. | 4. | 88. | 97.507 | 1001.0 | 1. | 0. |
| 79 | 2. | 51. | 2. | 3. | 4. | 133. | 97.130 | 401.0 | 1. | 0. |
| 80 | 2. | 51. | 3. | 3. | 4. | 214. | 92.770 | 503.0 | 1. | 0. |
| 81 | 2. | 51. | 4. | 3. | 4. | 258. | 251.150 | 2563.0 | 1. | 0. |
| 82 | 2. | 51. | 5. | 3. | 4. | 307. | 209.280 | 10563.0 | 1. | 0. |
| 83 | 2. | 52. | 1. | 3. | 4. | 92. | 56.397 | 401.0 | 1. | 0. |
| 84 | 2. | 52. | 2. | 3. | 4. | 122. | 48.910 | 201.0 | 1. | 0. |
| 85 | 2. | 52. | 3. | 3. | 4. | 204. | 33.120 | 503.0 | 1. | 0. |
| 86 | 2. | 52. | 4. | 3. | 5. | 260. | 100.120 | 25653.0 | 1. | 0. |
| 87 | 2. | 52. | 5. | 3. | 4. | 309. | 42.030 | 503.0 | 1. | 0. |
| 88 | 2. | 53. | 1. | 3. | 4. | 96. | 14.141 | 251.0 | 1. | 0. |
| 89 | 2. | 53. | 2. | 3. | 4. | 147. | 39.050 | 401.0 | 1. | 0. |
| 90 | 2. | 53. | 3. | 3. | 4. | 203. | 34.470 | 503.0 | 1. | 0. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 91 | 2. | 53. | 4. | 3. | 4. | 257. | 95.530 | 25653.0 | 1. | 0. |
| 92 | 2. | 53. | 5. | 3. | 4. | 306. | 14.500 | 503.0 | 1. | 0. |
| 93 | 2. | 54. | 1. | 3. | 2. | 39. | 1.305 | 101.0 | 1. | 0. |
| 94 | 2. | 54. | 2. | 3. | 2. | 134. | 6.020 | 201.0 | 1. | 1. |
| 95 | 2. | 54. | 2. | 3. | 2. | 90134. | 5.290 | 201.0 | 1. | 2. |
| 96 | 2. | 54. | 3. | 3. | 1. | 198. | 5.430 | 503.0 | 1. | 1. |
| 97 | 2. | 54. | 3. | 3. | 1. | 90198. | 5.460 | 503.0 | 1. | 2. |
| 98 | 2. | 54. | 4. | 3. | 2. | 243. | 15.280 | 503.0 | 1. | 0. |
| 99 | 2. | 54. | 5. | 3. | 2. | 291. | 0.060 | 120.0 | 1. | 0. |
| 100 | 2. | 61. | 1. | 3. | 4. | 98. | 108.407 | 2510.0 | 1. | 0. |
| 101 | 2. | 61. | 2. | 3. | 4. | 125. | 105.480 | 201.0 | 1. | 0. |
| 102 | 2. | 61. | 3. | 3. | 4. | 213. | 125.670 | 503.0 | 1. | 1. |
| 103 | 2. | 61. | 3. | 3. | 4. | 90213. | 106.050 | 10563.0 | 1. | 2. |
| 104 | 2. | 61. | 4. | 3. | 4. | 271. | 303.310 | 503.0 | 1. | 0. |
| 105 | 2. | 61. | 5. | 3. | 2. | 297. | 30.370 | 503.0 | 1. | 0. |
| 106 | 2. | 62. | 1. | 3. | 4. | 97. | 16.272 | 251.0 | 1. | 0. |
| 107 | 2. | 62. | 2. | 3. | 4. | 126. | 202.260 | 501.0 | 1. | 0. |
| 108 | 2. | 62. | 3. | 3. | 4. | 189. | 62.290 | 503.0 | 1. | 0. |
| 109 | 2. | 62. | 4. | 3. | 4. | 253. | 131.890 | 503.0 | 1. | 0. |
| 110 | 2. | 62. | 5. | 3. | 4. | 302. | 143.400 | 503.0 | 1. | 0. |
| 111 | 2. | 63. | 1. | 3. | 4. | 95. | 6.888 | 101.0 | 1. | 0. |
| 112 | 2. | 63. | 2. | 3. | 4. | 114. | 21.290 | 201.0 | 1. | 0. |
| 113 | 2. | 63. | 3. | 3. | 4. | 208. | 33.960 | 503.0 | 1. | 1. |
| 114 | 2. | 63. | 3. | 3. | 4. | 90208. | 35.030 | 503.0 | 1. | 2. |
| 115 | 2. | 63. | 4. | 3. | 4. | 270. | 28.300 | 503.0 | 1. | 0. |
| 116 | 2. | 63. | 5. | 3. | 4. | 300. | 16.700 | 503.0 | 1. | 0. |
| 117 | 2. | 64. | 1. | 3. | 2. | 37. | 2.868 | 101.0 | 1. | 0. |
| 118 | 2. | 64. | 2. | 3. | 2. | 120. | 5.600 | 201.0 | 1. | 0. |
| 119 | 2. | 64. | 3. | 3. | 2. | 209. | 3.890 | 503.0 | 1. | 0. |
| 120 | 2. | 64. | 4. | 3. | 2. | 242. | 11.240 | 503.0 | 1. | 0. |
| 121 | 2. | 64. | 5. | 3. | 2. | 290. | 4.820 | 503.0 | 1. | 0. |
| 122 | 2. | 65. | 1. | 3. | 2. | 99. | 0.709 | 26.0 | 1. | 0. |
| 123 | 2. | 65. | 2. | 3. | 2. | 128. | 1.900 | 2.5 | 1. | 0. |
| 124 | 2. | 65. | 3. | 3. | 2. | 210. | 2.460 | 503.0 | 1. | 0. |
| 125 | 2. | 65. | 4. | 3. | 2. | 241. | 13.910 | 503.0 | 1. | 0. |
| 126 | 2. | 65. | 5. | 3. | 2. | 286. | 1.910 | 120.0 | 1. | 0. |
| 127 | 2. | 71. | 1. | 3. | 6. | 90. | 33.737 | 501.0 | 1. | 0. |
| 128 | 2. | 71. | 2. | 3. | 5. | 127. | 43.710 | 401.0 | 1. | 0. |
| 129 | 2. | 71. | 3. | 3. | 6. | 201. | 54.400 | 503.0 | 1. | 0. |
| 130 | 2. | 71. | 4. | 3. | 6. | 269. | 51.320 | 503.0 | 1. | 0. |
| 131 | 2. | 71. | 5. | 3. | 6. | 308. | 23.620 | 503.0 | 1. | 1. |
| 132 | 2. | 71. | 5. | 3. | 6. | 90308. | 25.470 | 503.0 | 1. | 2. |
| 133 | 2. | 72. | 1. | 3. | 2. | 94. | 6.015 | 101.0 | 1. | 0. |
| 134 | 2. | 72. | 2. | 3. | 2. | 140. | 23.810 | 401.0 | 1. | 0. |
| 135 | 2. | 72. | 3. | 3. | 2. | 216. | 21.590 | 503.0 | 1. | 0. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 136 | 2. | 72. | 4. | 3. | 2. | 244. | 23.420 | 503.0 | 1. | 0. |
| 137 | 2. | 72. | 5. | 3. | 2. | 239. | 22.280 | 503.0 | 1. | 0. |
| 138 | 2. | 73. | 1. | 3. | 6. | 65. | 2.859 | 101.0 | 1. | 0. |
| 139 | 2. | 73. | 2. | 3. | 5. | 135. | 8.570 | 201.0 | 1. | 0. |
| 140 | 2. | 73. | 3. | 3. | 5. | 212. | 3.010 | 120.0 | 1. | 0. |
| 141 | 2. | 73. | 4. | 3. | 6. | 245. | 91.190 | 503.0 | 1. | 0. |
| 142 | 2. | 73. | 5. | 3. | 5. | 287. | 43.400 | 503.0 | 1. | 0. |
| 143 | 2. | 74. | 1. | 3. | 2. | 131. | 24.872 | 1001.0 | 1. | 0. |
| 144 | 2. | 74. | 2. | 3. | 2. | 151. | 35.160 | 201.0 | 1. | 0. |
| 145 | 2. | 74. | 3. | 3. | 2. | 205. | 57.730 | 503.0 | 1. | 0. |
| 146 | 2. | 74. | 4. | 3. | 2. | 251. | 148.440 | 503.0 | 1. | 1. |
| 147 | 2. | 74. | 4. | 3. | 2. | 90251. | 148.330 | 503.0 | 1. | 2. |
| 148 | 2. | 74. | 5. | 3. | 2. | 294. | 50.290 | 503.0 | 1. | 0. |
| 149 | 2. | 75. | 1. | 3. | 4. | 109. | 24.533 | 627.5 | 1. | 0. |
| 150 | 2. | 75. | 2. | 3. | 4. | 118. | 5.180 | 201.0 | 1. | 0. |
| 151 | 2. | 75. | 3. | 3. | 3. | 202. | 2.850 | 503.0 | 1. | 0. |
| 152 | 2. | 75. | 4. | 3. | 4. | 266. | 8.020 | 503.0 | 1. | 0. |
| 153 | 2. | 75. | 5. | 3. | 4. | 312. | 1.580 | 120.0 | 1. | 0. |
| 154 | 2. | 76. | 1. | 3. | 4. | 107. | 37.996 | 1010.0 | 1. | 0. |
| 155 | 2. | 76. | 2. | 3. | 3. | 191. | 28.020 | 201.0 | 1. | 0. |
| 156 | 2. | 76. | 3. | 3. | 2. | 200. | 21.290 | 503.0 | 1. | 0. |
| 157 | 2. | 76. | 4. | 3. | 3. | 272. | 16.760 | 503.0 | 1. | 0. |
| 158 | 2. | 76. | 5. | 3. | 4. | 311. | 14.470 | 503.0 | 1. | 1. |
| 159 | 2. | 76. | 5. | 3. | 4. | 90311. | 15.160 | 503.0 | 1. | 2. |
| 160 | 2. | 77. | 1. | 3. | 2. | 66. | 30.573 | 501.0 | 1. | 0. |
| 161 | 2. | 77. | 2. | 3. | 2. | 133. | 13.590 | 401.0 | 1. | 0. |
| 162 | 2. | 77. | 3. | 3. | 2. | 238. | 87.000 | 503.0 | 1. | 0. |
| 163 | 2. | 77. | 4. | 3. | 2. | 258. | 208.070 | 13078.0 | 1. | 1. |
| 164 | 2. | 77. | 4. | 3. | 2. | 90258. | 217.810 | 13078.0 | 1. | 2. |
| 165 | 2. | 77. | 5. | 3. | 2. | 274. | 44.600 | 503.0 | 1. | 0. |
| 166 | 2. | 78. | 1. | 3. | 2. | 57. | 34.378 | 401.0 | 1. | 0. |
| 167 | 2. | 78. | 2. | 3. | 2. | 112. | 3.970 | 401.0 | 1. | 0. |
| 168 | 2. | 78. | 3. | 3. | 2. | 239. | 118.510 | 503.0 | 1. | 0. |
| 169 | 2. | 78. | 4. | 3. | 2. | 257. | 61.260 | 503.0 | 1. | 0. |
| 170 | 2. | 78. | 5. | 3. | 2. | 273. | 94.580 | 503.0 | 1. | 0. |
| 171 | 2. | 81. | 1. | 3. | 4. | 59. | 32.352 | 1001.0 | 1. | 0. |
| 172 | 2. | 81. | 2. | 3. | 4. | 145. | 91.910 | 401.0 | 1. | 0. |
| 173 | 2. | 81. | 3. | 3. | 4. | 236. | 97.770 | 503.0 | 1. | 0. |
| 174 | 2. | 81. | 4. | 3. | 4. | 225. | 173.600 | 503.0 | 1. | 0. |
| 175 | 2. | 81. | 5. | 3. | 4. | 275. | 69.690 | 503.0 | 1. | 0. |
| 176 | 2. | 82. | 1. | 3. | 2. | 60. | 11.307 | 101.0 | 1. | 0. |
| 177 | 2. | 82. | 2. | 3. | 2. | 138. | 35.800 | 201.0 | 1. | 1. |
| 178 | 2. | 82. | 2. | 3. | 2. | 90138. | 33.990 | 201.0 | 1. | 2. |
| 179 | 2. | 82. | 3. | 3. | 2. | 235. | 58.400 | 503.0 | 1. | 0. |
| 180 | 2. | 82. | 4. | 3. | 2. | 224. | 31.080 | 503.0 | 1. | 0. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 181 | 2. | 82. | 5. | 3. | 2. | 276. | 28.530 | 503.0 | 1. | 0. |
| 182 | 2. | 83. | 1. | 3. | 6. | 53. | 40.561 | 1001.0 | 1. | 1. |
| 183 | 2. | 83. | 1. | 3. | 6. | 90053. | 90.837 | 6275.0 | 1. | 2. |
| 184 | 2. | 83. | 2. | 3. | 7. | 136. | 66.720 | 201.0 | 1. | 1. |
| 185 | 2. | 83. | 2. | 3. | 7. | 90136. | 70.210 | 401.0 | 1. | 2. |
| 186 | 2. | 83. | 3. | 3. | 6. | 240. | 97.180 | 503.0 | 1. | 0. |
| 187 | 2. | 83. | 4. | 3. | 6. | 230. | 69.550 | 503.0 | 1. | 0. |
| 188 | 2. | 83. | 5. | 3. | 6. | 277. | 31.300 | 503.0 | 1. | 0. |
| 189 | 2. | 84. | 1. | 3. | 4. | 47. | 23.682 | 501.0 | 1. | 0. |
| 190 | 2. | 84. | 2. | 3. | 4. | 142. | 58.820 | 201.0 | 1. | 0. |
| 191 | 2. | 84. | 3. | 3. | 4. | 237. | 117.060 | 503.0 | 1. | 0. |
| 192 | 2. | 84. | 4. | 3. | 4. | 231. | 105.590 | 503.0 | 1. | 0. |
| 193 | 2. | 84. | 5. | 3. | 4. | 278. | 114.740 | 503.0 | 1. | 0. |
| 194 | 2. | 85. | 1. | 3. | 4. | 49. | 47.937 | 2211.0 | 1. | 0. |
| 195 | 2. | 85. | 2. | 3. | 4. | 151. | 59.100 | 201.0 | 1. | 0. |
| 196 | 2. | 85. | 3. | 3. | 4. | 220. | 104.690 | 503.0 | 1. | 0. |
| 197 | 2. | 85. | 4. | 3. | 5. | 229. | 85.230 | 2515.0 | 1. | 0. |
| 198 | 2. | 85. | 5. | 3. | 4. | 279. | 32.560 | 503.0 | 1. | 0. |
| 199 | 2. | 86. | 1. | 3. | 4. | 43. | 18.982 | 201.0 | 1. | 0. |
| 200 | 2. | 86. | 2. | 3. | 4. | 137. | 69.720 | 201.0 | 1. | 0. |
| 201 | 2. | 86. | 3. | 3. | 4. | 219. | 105.640 | 503.0 | 1. | 0. |
| 202 | 2. | 86. | 4. | 3. | 4. | 227. | 131.810 | 503.0 | 1. | 0. |
| 203 | 2. | 86. | 5. | 3. | 4. | 230. | 16.230 | 503.0 | 1. | 0. |
| 204 | 2. | 91. | 1. | 3. | 4. | 44. | 19.722 | 201.0 | 1. | 0. |
| 205 | 2. | 91. | 2. | 3. | 4. | 153. | 34.480 | 401.0 | 1. | 0. |
| 206 | 2. | 91. | 3. | 3. | 4. | 218. | 43.840 | 503.0 | 1. | 0. |
| 207 | 2. | 91. | 4. | 3. | 4. | 232. | 49.570 | 503.0 | 1. | 0. |
| 208 | 2. | 91. | 5. | 3. | 4. | 231. | 27.370 | 503.0 | 1. | 0. |
| 209 | 2. | 92. | 1. | 3. | 4. | 50. | 1.308 | 41.0 | 1. | 0. |
| 210 | 2. | 92. | 2. | 3. | 4. | 141. | 3.700 | 401.0 | 1. | 0. |
| 211 | 2. | 92. | 3. | 3. | 4. | 217. | 4.860 | 503.0 | 1. | 0. |
| 212 | 2. | 92. | 4. | 3. | 4. | 226. | 20.270 | 2515.0 | 1. | 0. |
| 213 | 2. | 92. | 5. | 3. | 4. | 282. | 6.000 | 503.0 | 1. | 0. |
| 214 | 2. | 93. | 1. | 3. | 4. | 45. | 0.034 | 2.5 | 1. | 0. |
| 215 | 2. | 93. | 2. | 3. | 4. | 156. | 1.520 | 51.0 | 1. | 0. |
| 216 | 2. | 93. | 3. | 3. | 4. | 221. | 2.030 | 503.0 | 1. | 0. |
| 217 | 2. | 93. | 4. | 3. | 4. | 234. | 1.540 | 2515.0 | 1. | 0. |
| 218 | 2. | 93. | 5. | 3. | 4. | 234. | 1.630 | 120.0 | 1. | 0. |
| 219 | 2. | 94. | 1. | 3. | 4. | 46. | 0.007 | 1.0 | 1. | 0. |
| 220 | 2. | 94. | 2. | 3. | 4. | 143. | 0.080 | 2.5 | 1. | 0. |
| 221 | 2. | 94. | 3. | 3. | 4. | 228. | 0.030 | 1.0 | 1. | 0. |
| 222 | 2. | 94. | 4. | 3. | 4. | 222. | 1.420 | 503.0 | 1. | 0. |
| 223 | 2. | 94. | 5. | 3. | 4. | 233. | 0.130 | 120.0 | 1. | 0. |
| 224 | 2. | 99. | 3. | 3. | 1. | 187. | 29.850 | 503.0 | 1. | 0. |
| 225 | 2. | 99. | 4. | 7. | 1. | 256. | 92.480 | 2515.0 | 1. | 0. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 226 | 3. | 41. | 1. | 1. | 1. | 1. | 15828.590 | 101606.0 | 2. | 0. |
| 227 | 3. | 41. | 1. | 1. | 1. | 1. | 981.100 | -1.0 | 3. | 0. |
| 228 | 3. | 41. | 1. | 1. | 1. | 2. | 204.900 | -1.0 | 3. | 0. |
| 229 | 3. | 41. | 1. | 1. | 1. | 2. | 7780.480 | 50803.0 | 2. | 0. |
| 230 | 3. | 41. | 1. | 1. | 1. | 3. | 7544.750 | 50803.0 | 2. | 0. |
| 231 | 3. | 41. | 1. | 1. | 1. | 3. | 64.100 | -1.0 | 3. | 0. |
| 232 | 3. | 41. | 2. | 1. | 1. | 4. | 1003.360 | 50803.0 | 2. | 0. |
| 233 | 3. | 41. | 2. | 1. | 1. | 4. | 182.000 | -1.0 | 3. | 0. |
| 234 | 3. | 41. | 2. | 1. | 1. | 5. | 238.500 | -1.0 | 3. | 0. |
| 235 | 3. | 41. | 2. | 1. | 1. | 5. | 3062.400 | 50803.0 | 2. | 0. |
| 236 | 3. | 41. | 2. | 1. | 1. | 6. | 777.080 | 101103.0 | 2. | 0. |
| 237 | 3. | 41. | 2. | 1. | 1. | 6. | 32.900 | -1.0 | 3. | 0. |
| 238 | 3. | 41. | 3. | 1. | 1. | 7. | 251.000 | -1.0 | 3. | 0. |
| 239 | 3. | 41. | 3. | 1. | 1. | 7. | 2767.690 | 101103.0 | 2. | 0. |
| 240 | 3. | 41. | 3. | 1. | 1. | 8. | 18605.990 | 101103.0 | 2. | 0. |
| 241 | 3. | 41. | 3. | 1. | 1. | 8. | 188.900 | -1.0 | 3. | 0. |
| 242 | 3. | 41. | 3. | 1. | 1. | 9. | 5201.750 | 101103.0 | 2. | 0. |
| 243 | 3. | 41. | 3. | 1. | 1. | 9. | 169.200 | -1.0 | 3. | 0. |
| 244 | 3. | 41. | 4. | 1. | 1. | 10. | 4608.580 | 101103.0 | 2. | 1. |
| 245 | 3. | 41. | 4. | 1. | 1. | 10. | 103.100 | -1.0 | 3. | 0. |
| 246 | 3. | 41. | 4. | 1. | 1. | 11. | 30.000 | -1.0 | 3. | 0. |
| 247 | 3. | 41. | 4. | 1. | 1. | 11. | 5197.190 | 101103.0 | 2. | 0. |
| 248 | 3. | 41. | 4. | 1. | 1. | 12. | 265.380 | 302303.0 | 2. | 0. |
| 249 | 3. | 41. | 4. | 1. | 1. | 12. | 45.400 | -1.0 | 3. | 0. |
| 250 | 3. | 41. | 4. | 1. | 1. | 90010. | 4191.430 | 101103.0 | 2. | 2. |
| 251 | 3. | 41. | 5. | 1. | 1. | 13. | 558.000 | -1.0 | 3. | 0. |
| 252 | 3. | 41. | 5. | 1. | 1. | 13. | 64619.078 | 302303.0 | 2. | 0. |
| 253 | 3. | 41. | 5. | 1. | 1. | 14. | 181994.266 | 302303.0 | 2. | 0. |
| 254 | 3. | 41. | 5. | 1. | 1. | 14. | 4978.920 | 302303.0 | 2. | 0. |
| 255 | 3. | 41. | 5. | 1. | 1. | 14. | 698.100 | -1.0 | 3. | 0. |
| 256 | 3. | 41. | 5. | 1. | 1. | 15. | 216.100 | -1.0 | 3. | 0. |
| 257 | 3. | 41. | 5. | 1. | 1. | 15. | 30653.520 | 302303.0 | 2. | 1. |
| 258 | 3. | 41. | 5. | 1. | 1. | 90015. | 32948.250 | 126253.0 | 2. | 2. |
| 259 | 4. | 11. | 1. | 3. | 1. | 542. | 753.920 | 1053.0 | 2. | 0. |
| 260 | 4. | 11. | 1. | 3. | 1. | 542. | 1028.730 | 13078.0 | 1. | 0. |
| 261 | 4. | 11. | 1. | 3. | 1. | 546. | 138.320 | 2315.0 | 1. | 0. |
| 262 | 4. | 11. | 1. | 3. | 1. | 546. | 122.700 | 5533.0 | 2. | 0. |
| 263 | 4. | 11. | 2. | 3. | 1. | 552. | 304.540 | 5533.0 | 2. | 0. |
| 264 | 4. | 11. | 2. | 3. | 1. | 552. | 39.460 | 503.0 | 2. | 0. |
| 265 | 4. | 11. | 2. | 3. | 1. | 555. | 223.720 | 3018.0 | 2. | 0. |
| 266 | 4. | 11. | 2. | 3. | 1. | 557. | 1538.500 | 10563.0 | 2. | 1. |
| 267 | 4. | 11. | 2. | 3. | 1. | 90557. | 1465.440 | 10563.0 | 2. | 2. |
| 268 | 4. | 11. | 3. | 3. | 1. | 560. | 233.640 | 5533.0 | 2. | 0. |
| 269 | 4. | 11. | 3. | 3. | 1. | 571. | 239.740 | 5533.0 | 2. | 0. |
| 270 | 4. | 11. | 4. | 3. | 1. | 529. | 59.440 | 503.0 | 2. | 0. |

TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 271 | 4. | 11. | 4. | 3. | 1. | 534. | 136.050 | 25653.0 | 2. | 1. |
| 272 | 4. | 11. | 4. | 3. | 1. | 90534. | 98.920 | 25653.0 | 2. | 2. |
| 273 | 4. | 11. | 5. | 3. | 1. | 528. | 425.630 | 3018.0 | 2. | 1. |
| 274 | 4. | 11. | 5. | 3. | 1. | 549. | 187.510 | 503.0 | 2. | 0. |
| 275 | 4. | 11. | 5. | 3. | 1. | 90528. | 488.980 | 3018.0 | 2. | 2. |
| 276 | 4. | 12. | 1. | 3. | 1. | 537. | 40.840 | 503.0 | 2. | 0. |
| 277 | 4. | 12. | 1. | 3. | 1. | 537. | 14.980 | 503.0 | 1. | 0. |
| 278 | 4. | 12. | 1. | 3. | 1. | 543. | 736.040 | 10563.0 | 1. | 0. |
| 279 | 4. | 12. | 1. | 3. | 1. | 543. | 242.120 | 5533.0 | 2. | 0. |
| 280 | 4. | 12. | 2. | 3. | 1. | 561. | 23.630 | 503.0 | 2. | 0. |
| 281 | 4. | 12. | 2. | 3. | 1. | 561. | 99.060 | 5533.0 | 2. | 0. |
| 282 | 4. | 12. | 2. | 3. | 1. | 564. | 27.990 | 3018.0 | 2. | 0. |
| 283 | 4. | 12. | 3. | 3. | 1. | 568. | 120.290 | 5533.0 | 2. | 0. |
| 284 | 4. | 12. | 3. | 3. | 1. | 570. | 31.390 | 503.0 | 2. | 0. |
| 285 | 4. | 12. | 4. | 3. | 1. | 527. | 114.410 | 25653.0 | 2. | 0. |
| 286 | 4. | 12. | 4. | 3. | 1. | 532. | 367.760 | 25653.0 | 2. | 0. |
| 287 | 4. | 12. | 5. | 3. | 1. | 526. | 76.600 | 503.0 | 2. | 0. |
| 288 | 4. | 12. | 5. | 3. | 1. | 535. | 53.400 | 503.0 | 2. | 0. |
| 289 | 4. | 13. | 1. | 3. | 1. | 536. | 48.700 | 503.0 | 2. | 0. |
| 290 | 4. | 13. | 1. | 3. | 1. | 536. | 392.060 | 10563.0 | 1. | 1. |
| 291 | 4. | 13. | 1. | 3. | 1. | 544. | 60.530 | 5533.0 | 2. | 0. |
| 292 | 4. | 13. | 1. | 3. | 1. | 544. | 776.590 | 10563.0 | 1. | 0. |
| 293 | 4. | 13. | 1. | 3. | 1. | 90536. | 47.550 | 503.0 | 2. | 2. |
| 294 | 4. | 13. | 2. | 3. | 1. | 563. | 466.310 | 10563.0 | 2. | 0. |
| 295 | 4. | 13. | 2. | 3. | 1. | 563. | 46.630 | 503.0 | 2. | 0. |
| 296 | 4. | 13. | 2. | 3. | 1. | 569. | 38.510 | 5533.0 | 2. | 0. |
| 297 | 4. | 13. | 3. | 3. | 1. | 533. | 41.010 | 3018.0 | 2. | 1. |
| 298 | 4. | 13. | 3. | 3. | 1. | 566. | 51.430 | 10563.0 | 2. | 1. |
| 299 | 4. | 13. | 3. | 3. | 1. | 90533. | 42.320 | 3018.0 | 2. | 2. |
| 300 | 4. | 13. | 3. | 3. | 1. | 90566. | 62.150 | 3018.0 | 2. | 2. |
| 301 | 4. | 13. | 4. | 3. | 1. | 524. | 93.900 | 13078.0 | 2. | 0. |
| 302 | 4. | 13. | 4. | 3. | 1. | 530. | 4.620 | 503.0 | 2. | 0. |
| 303 | 4. | 13. | 5. | 3. | 1. | 531. | 61.390 | 503.0 | 2. | 0. |
| 304 | 5. | 0. | 5. | 3. | 3. | 54131. | 1936.530 | 25653.0 | 5. | 0. |
| 305 | 5. | 0. | 5. | 3. | 3. | 54279. | 1957.320 | 256535.0 | 5. | 0. |
| 306 | 5. | 0. | 5. | 3. | 3. | 522617. | 2040.950 | 25653.0 | 5. | 0. |
| 307 | 5. | 1. | 1. | 3. | 2. | 113300. | 666.640 | 50803.0 | 5. | 0. |
| 308 | 5. | 1. | 1. | 3. | 2. | 113304. | 1151.650 | 50803.0 | 5. | 0. |
| 309 | 5. | 1. | 1. | 3. | 2. | 116104. | 779.170 | 50803.0 | 5. | 0. |
| 310 | 5. | 1. | 1. | 3. | 2. | 116116. | 1028.050 | 50803.0 | 5. | 0. |
| 311 | 5. | 1. | 1. | 3. | 2. | 116209. | 1199.410 | 50803.0 | 5. | 0. |
| 312 | 5. | 1. | 1. | 3. | 2. | 116214. | 1161.410 | 50803.0 | 5. | 0. |
| 313 | 5. | 1. | 2. | 3. | 2. | 211311. | 1967.590 | 25653.0 | 5. | 0. |
| 314 | 5. | 1. | 2. | 3. | 2. | 211315. | 1930.010 | 50803.0 | 5. | 0. |
| 315 | 5. | 1. | 2. | 3. | 2. | 216134. | 1990.870 | 50803.0 | 5. | 0. |

## TABLE A.2. (contd)

| Case | Stype | Loc | Run | Rounds | NCMP | CID | DU.MG/L | DILU | LEACH | Rep |
|---|---|---|---|---|---|---|---|---|---|---|
| 316 | 5. | 1. | 2. | 3. | 2. | 216110. | 2124.940 | 50803.0 | 5. | 0. |
| 317 | 5. | 1. | 2. | 3. | 2. | 216212. | 274.380 | 553.0 | 5. | 1. |
| 318 | 5. | 1. | 2. | 3. | 2. | 216212. | 1852.890 | 50803.0 | 5. | 0. |
| 319 | 5. | 1. | 2. | 3. | 2. | 216215. | 3637.080 | 25653.0 | 5. | 0. |
| 320 | 5. | 1. | 3. | 3. | 4. | 121802. | 4562.640 | 25653.0 | 5. | 0. |
| 321 | 5. | 1. | 3. | 3. | 4. | 141119. | 3762.380 | 26563.0 | 5. | 0. |
| 322 | 5. | 1. | 4. | 7. | 4. | 46335. | 2002.470 | 2563.0 | 5. | 0. |
| 323 | 5. | 1. | 4. | 7. | 4. | 462613. | 1520.200 | 25653.0 | 5. | 1. |
| 324 | 5. | 1. | 4. | 7. | 4. | 9462613. | 1971.690 | 25653.0 | 5. | 2. |
| 325 | 5. | 2. | 2. | 3. | 1. | 216215. | 734.920 | 50803.0 | 5. | 0. |
| 326 | 5. | 2. | 2. | 3. | 2. | 9216212. | 287.440 | 5533.0 | 5. | 2. |
| 327 | 5. | 2. | 3. | 3. | 4. | 1411915. | 3364.450 | 13078.0 | 5. | 0. |
| 328 | 5. | 2. | 4. | 7. | 4. | 42613. | 2449.860 | 25653.0 | 5. | 0. |
| 329 | 5. | 2. | 4. | 7. | 4. | 46335. | 1745.170 | 25653.0 | 5. | 0. |
| 330 | 5. | 2. | 4. | 7. | 4. | 452164. | 959.330 | 10563.0 | 5. | 1. |
| 331 | 5. | 2. | 4. | 7. | 4. | 452164. | 2493.290 | 10563.0 | 5. | 0. |
| 332 | 5. | 2. | 4. | 7. | 4. | 9452164. | 1224.230 | 13078.0 | 5. | 2. |
| 333 | 5. | 2. | 5. | 12. | 4. | 253322. | 6218.800 | 25653.0 | 8. | 0. |
| 334 | 5. | 3. | 1. | 3. | 2. | 121307. | 782.110 | 50803.0 | 5. | 0. |
| 335 | 5. | 3. | 1. | 3. | 2. | 121313. | 809.950 | 50803.0 | 5. | 0. |
| 336 | 5. | 3. | 1. | 3. | 2. | 122301. | 1107.350 | 50803.0 | 5. | 0. |
| 337 | 5. | 3. | 1. | 3. | 2. | 123100. | 1150.380 | 50803.0 | 5. | 0. |
| 338 | 5. | 3. | 1. | 3. | 2. | 124207. | 914.100 | 50803.0 | 5. | 0. |
| 339 | 5. | 3. | 1. | 3. | 2. | 124209. | 1141.900 | 50803.0 | 5. | 0. |
| 340 | 5. | 3. | 5. | 12. | 4. | 253153. | 3913.110 | 25653.0 | 8. | 0. |
| 341 | 5. | 3. | 5. | 12. | 4. | 254121. | 3117.320 | 50803.0 | 8. | 0. |
| 342 | 5. | 4. | 5. | 15. | 4. | 53321. | 250.570 | 5533.0 | 5. | 0. |
| 343 | 5. | 4. | 5. | 15. | 4. | 54112. | 273.440 | 5533.0 | 5. | 0. |
| 344 | 5. | 4. | 5. | 15. | 4. | 54232. | 275.880 | 5533.0 | 5. | 0. |
| 345 | 6. | 81. | 2. | 6. | 1. | 1. | 166052.906 | 604606.0 | 1. | 0. |
| 346 | 6. | 81. | 2. | 6. | 1. | 2. | 72325.930 | 322423.0 | 1. | 0. |
| 347 | 6. | 81. | 3. | 3. | 1. | 3. | 91923.094 | 302303.0 | 1. | 0. |
| 348 | 6. | 81. | 3. | 3. | 1. | 233. | 15501.520 | 50803.0 | 1. | 0. |
| 349 | 6. | 81. | 4. | 3. | 1. | 4. | 120931.477 | 604606.0 | 1. | 0. |
| 350 | 6. | 81. | 5. | 3. | 1. | 5. | 62109.801 | 606618.0 | 1. | 1. |
| 351 | 6. | 81. | 5. | 3. | 1. | 90005. | 73121.727 | 606618.0 | 1. | 2. |
| 352 | 6. | 84. | 4. | 3. | 1. | 1. | 35485.680 | 126253.0 | 1. | 0. |
| 353 | 6. | 91. | 3. | 3. | 1. | 1. | 52615.840 | 302303.0 | 1. | 0. |
| 354 | 6. | 91. | 5. | 3. | 1. | 2. | 8730.210 | 302303.0 | 1. | 0. |
| 355 | 6. | 92. | 4. | 3. | 1. | 1. | 9524.910 | 101103.0 | 1. | 0. |
| 356 | 6. | 92. | 5. | 3. | 1. | 2. | 13260.670 | 101103.0 | 1. | 0. |

# APPENDIX B

## LISTING OF STANDARD SOLUTION AND YIELD STANDARD RESULTS

TABLE B.1. Standard Solution Sample Results

| Uranium Standard g/L | Uranium Recovered g/L | Percent Recovered | Average Percent Recovered |
|---|---|---|---|
| 0.0010 | 0.00093 | 93.0 | |
| | 0.00102 | 102.0 | |
| | 0.001105 | 110.5 | |
| | 0.000955 | 95.5 | |
| | 0.00102 | 102.0 | |
| | 0.00097 | 97.0 | |
| | 0.00097 | 97.0 | |
| | 0.00101 | 101.0 | |
| | 0.001150 | 115.0 | 101.4±7 |
| 0.10185 | 0.09739 | 95.6 | |
| | 0.10461 | 102.7 | |
| | 0.10649 | 104.6 | |
| | 0.1065 | 104.6 | |
| | 0.090818 | 89.2 | |
| | 0.097582 | 95.8 | |
| | 0.088434 | 86.8 | |
| | 0.096982 | 95.2 | |
| | 0.09695 | 95.2 | |
| | 0.09449 | 92.8 | |
| | 0.09663 | 94.9 | |
| | 0.10407 | 102.2 | |
| | 0.10443 | 102.5 | |
| | 0.1008 | 99.0 | |
| | 0.10679 | 104.9 | 97.7±5.7 |
| 1.0185 | 1.0387 | 102.0 | |
| | 0.97389 | 95.6 | |
| | 1.03137 | 101.3 | |
| | 1.00355 | 98.5 | |
| | 1.06345 | 104.9 | |
| | 0.9171 | 90.0 | |
| | 1.0125 | 99.4 | |
| | 0.9585 | 94.1 | |
| | 1.032 | 101.3 | |
| | 0.90966 | 89.3 | 97.6±5.2 |

TABLE B.2. Coupon Yield Standard Sample Results

| Sample DUO, g | Sample U, g/L | Uranium Recovered g/L | Average Percent Recovered | Average Percent Recovered |
|---|---|---|---|---|
| 0.0107 | 0.00937 | 0.00927 | 98.9 | |
| | | 0.01354 | 145.0 (1) | |
| | | 0.00875 | 93.4 | |
| | | 0.008719 | 93.1 | |
| | | 0.011147 | 119.0 | |
| | | 0.009246 | 98.7 | |
| | | 0.00955 | 101.9 | 100.8±9.5 |
| 0.1002 | 0.0877 | 0.08597 | 98.0 | |
| | | 0.08625 | 98.3 | |
| | | 0.317898 | 362.5 (1) | |
| | | 0.082509 | 94.1 | |
| | | 0.036432 | 41.5 (2) | |
| | | 0.08453 | 96.4 | |
| | | 0.08082 | 92.2 | |
| | | 0.10041 | 114.5 | |
| | | 0.1036 | 118.1 | |
| | | 0.0987 | 112.5 | 103.0±10.3 |
| 2.0 | 1.7514 | 2.10098 | 120.0 | |
| | | 1.4874 | 84.9 | |
| | | 1.6208 | 92.5 | |
| | | 1.7150 | 97.9 | |
| | | 1.3786 | 78.7 | 94.8±15.9 |

(1) Excluded from average because result is anomalously high.
(2) Excluded from average because result is anomalously low.

TABLE B.3. Filter Yield Standard Sample Recovery

| Sample DUO, g | Sample U, g | Uranium Recovered g/L | Uranium Recovered g | Percent Recovered | Average Percent Recovered |
|---|---|---|---|---|---|
| 0.20217 | 0.1770 | 0.09041 | 0.1808 | 102.1 | |
| | | 0.08377 | 0.1675 | 94.7 | 98.4±5 |
| 2.0 | 1.7514 | 0.99711 | 1.9942 | 113.9 | |
| | | 0.84882 | 1.6976 | 97.0 | |
| | | 0.95301 | 1.9060 | 108.8 | |
| | | 0.87425 | 1.7485 | 99.8 | |
| | | 1.06934 | 2.1387 | 122.1 | 108.3±10.3 |

TABLE B.4. Soil Yield Standard Sample Results

| Sample DUD, g | Sample U, g | Uranium Recovered g/L | Uranium Recovered g | Percent Recovered | Average Percent Recovered |
|---|---|---|---|---|---|
| 0.1020 | 0.08932 | 0.03828 | 0.0766 | 85.7 | 85.7 |
| 2.0 | 1.7514 | 0.74325 | 1.4865 | 84.9 | |
| | | 0.72643 | 1.4529 | 83.0 | |
| | | 0.82317 | 1.6463 | 94.0 | |
| | | 0.80294 | 1.6059 | 91.7 | |
| | | 0.74070 | 1.4814 | 84.6 | |
| | | 0.77192 | 1.5438 | 88.1 | 87.7±4.4 |

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