

ATTACHMENT D

RADIATION PROTECTION MANUAL FOR RECLAMATION ACTIVITIES

Responsible Authority

Radiation Safety Officer

The Radiation Safety Officer (RSO) shall meet the requirements as specified in section 2.4, Technical Qualifications of Health Physics Staff in NRC Regulatory Guide 8.31. Along with meeting the requirements outline in Regulatory Guide 8.31, the RSO must also be submitted and approved by the State of Utah as an acceptable responsible authority for reclamation activities.

The RSO will be responsible for following and complying with all rules and specifications that are outlined in the Reclamation Plan along with all standards pertaining to the health and safety of the employees and environment. The RSO must also maintain accurate documentation of all decontamination and disposal activities. The RSO will have the responsibility of overseeing all aspects of this procedure and all total releases of any materials from the facility. These records will be maintained on site for review.

1.0 RADIATION MONITORING – PERSONNEL

This section contains the following procedures for personnel radiation monitoring including: (1) airborne particulates (2) alpha surveys (3) beta/gamma surveys and (4) urinalysis surveys.

1.1 AIRBORNE PARTICULATES

Sampling for personnel exposure to airborne particulate radionuclides, other than for radon progeny, will be done utilizing two distinct sampling protocols: (1) personnel breathing zone samplers, and (2) ambient air high volume samplers. Specific standard operating procedures for these two collection methods are described in Section 1.1.2 and 1.1.3 below.

1.1.1 Frequency

For work where there is the potential to cause airborne radiation doses to site personnel, the frequency and type of air sampling to be conducted is determined from measured air concentrations:

0.01 DAC – 0.1 DAC	Quarterly or monthly area air sampling and/or bioassay measurements
> 0.1 DAC	Continuous sampling is appropriate if concentrations are likely to exceed 0.10 DAC averaged over 40 hours or longer.

The RSO will determine the exact frequency of area air sampling, breathing zone sampling and/or bioassay measurements and determine how many workers in a group of workers performing similar jobs are to be equipped with breathing zone air samplers. Higher airborne concentrations warrant more frequent use of area air samplers, bioassay measurements, and breathing zone air samplers. Area air samplers may be used where documentation exists showing the sample is equivalent to a breathing zone sample. Breathing zone samples taken within one foot of the worker's head are considered representative without further documentation. Breathing zone air samplers are preferred under work conditions of higher airborne concentrations. Table 1.1.1-1 below, from Regulatory Guide 8.25, provides additional guidance for the RSO in designing and implementing air sampling programs for specific jobs.

**Table 1.1.1-1
 Air Sampling Recommendations Based on Estimated Intakes and Airborne Concentrations**

Worker’s Estimated Annual Intake as a Fraction of ALI	Estimated Airborne Concentrations as a Fraction of DAC	Air Sampling Recommendations
< 0.1	< 0.01	Air sampling is generally not necessary. However, monthly or quarterly grab samples or some other measurement may be appropriate to confirm that airborne levels are indeed low.
	> 0.01	Some air sampling is appropriate. Intermittent or grab samples are appropriate near the lower end of the range. Continuous sampling is appropriate if concentrations are likely to exceed 0.1 DAC averaged over 40 hours or longer.
> 0.1	< 0.3	Monitoring of intake by air sampling or bioassay is required by 10 CFR 20.1502(b).
	> 0.3	A demonstration that the air samples are representative of the breathing zone is appropriate if (1) intakes of record will be based on air sampling and (2) concentrations are likely to exceed 0.3 DAC averaged over 40 hours (i.e., intake more than 12 DAC-hours in a week).
Any annual intake	> 1	Air samples should be analyzed before work resumes the next day when potential intakes may exceed 40 DAC-hours in 1 week. When work is done in shifts, results should be available before the next shift ends. (Credit may be taken for protection factors if a respiratory protection program is in place.)
	> 5	Continuous air monitoring should be provided if there is a potential for intakes to exceed 40 DAC-hours in 1 day. (Credit may be taken for protection factors if a respiratory protection program is in place.)

1.1.2 Breathing Zone Sampling

1.1.2.1 General

Breathing zone samplers (SKC pumps and accessory kits, or equivalent) are used to determine airborne exposure to uranium while individuals are performing specific jobs. The units consist of a portable low volume pump that attaches to the individuals belt, tygon tubing and filter holder that is attached to the individual's lapel or shirt collar. The unit monitors airborne uranium in a person's breathing zone. Pumps must be recharged after 6 to 8 hours of use.

1.1.2.2 Applicability

Breathing zone samples are required:

- for all calciner activities,
- at least quarterly during routine tasks on representative individuals performing these tasks,
- when radiation work permits are issued in which airborne concentrations may exceed 25% of 10 CFR Part 20 limits, or
- at the discretion of the RSO.

1.1.2.3 Procedure

The procedure for collecting a breathing zone sample is as follows:

1. Secure the breathing zone sampler, which has been charged and loaded with a filter paper from the radiation department.
2. Secure the pump to the worker's belt and the filter holder to the shirt collar or lapel. Try to secure pump tubing to minimize restriction of motion.
3. Turn pump on (record the time pump was turned on) and continue monitoring until the work being monitored is completed and the worker no longer is in the exposure area. Record the time at which the job is complete.
4. Return the pump and accessories to the RSO, who will remove the filter paper for analysis. Be sure to indicate accurately the total time taken by the work being monitored.
5. Analysis of filter samples will be performed using a sensitive alpha detector. The procedure is as follows: (a) count a background sample for ten minutes; (b) divide the background count by ten to obtain the background count rate in cpm; (c) Place the breathing zone sample in the instrument and count the sample again for ten minutes;

- (d) divide the sample count by ten to obtain the count rate in cpm; (e) subtract the background count rate from the sample count rate; and, (f) record all data on the Breathing Zone sampling analysis form (a copy of which is attached).
- Record the total hours of exposure that are being assigned to the employee on the Employee Exposure form, which is maintained in personnel folders. Be sure to consider protection factors permitted by respirator use if the employee was also wearing respiratory protection during the job.
 - The number of DAC hours assigned is calculated using the following formula:

$$\text{DAC hours of exposure} = \frac{\text{Measured air concentration}}{(\text{DAC})(\text{PF})} \times \text{Total hours of exposure}$$

where: DAC = Derived Air Concentration (for uranium; 10 CFR Part 20, Appendix B)

PF = protection factor for respirator use. If no respiratory protection was used PF =1.

The measured air concentration must be in $\mu\text{Ci/cc}$.

1.1.2.4 Calibration

Prior to use, calibration of the breathing zone samplers will be done using a calibration method as described in Section 3.2.

1.1.2.5 Equipment – Breathing Zone Sampler

The equipment used for breathing zone samples consists of:

- Personal sampling pumps
- Gelman 37 mm Delrin filter holders, or equivalent
- Gelman 37 mm type A/E glass fiber filters, or equivalent
- Kurz Model 543 air mass flow meter, or equivalent

1.1.2.6 Data Record

Data maintained on file includes:

- Time on and off for each sample pump.
- Sampling location(s).
- Individual's name, identification number, etc.
- Date and sample number.

5. Sample count rate.

1.1.2.7 Calculations

The airborne concentration in $\mu\text{Ci}/\text{cc}$ is equal to the sample count rate minus the background count rate in cpm divided by the instrument alpha efficiency, the sample flow rate in cc/minute, the sample time in minutes and a conversion factor converting dpm to μCi .

The calculation is:

Equation Number 1:

$$\text{Airborne concentration} = \frac{\text{(Count Rate)}}{\text{(Time)(eff)(Conversion factor)(Flow Rate)}}$$

$$\text{i.e. } \frac{\mu\text{Ci}}{\text{cc}} = \frac{(\text{cpm}-\text{Bkg})}{(\text{eff})(2.22 \times 10^6 \text{dpm})(\text{cc}/\text{min})(\text{min})} \frac{(1)}{(1)} \frac{(1)}{(1)}$$

where: eff = cpm/dpm for counting instruments
cpm = counts/min
dpm = disintegrations/min
Conversion factor 1 $\mu\text{Ci} = 2.22 \times 10^6$ dpm
Flow Rate = cc/min
Collection time = min

Once the airborne concentration has been calculated it is possible to calculate personnel exposure in microcuries (μCi). Personnel exposure is determined for an individual who is working in an area at a known air concentration ($\mu\text{Ci}/\text{cc}$) for a given amount of time (hours) breathing the area air at an assumed rate. The breathing rate for a standard person (Handbook of Radiological Health) is 1.20 cubic meters per hour (m^3/hr).

The calculation for personnel exposure is:

Equation Number 2:

$$\text{Exposure } \mu\text{Ci} = (\mu\text{Ci}/\text{cc})(1.20\text{m}^3/\text{hr})(\text{hours of exposure})(\text{conversion rate})$$

Where: $\mu\text{Ci}/\text{cc}$ = air concentration from Equation 1

1.20 m^3/hr = breathing rate for standard man (ICRP)
hours of exposure = hours
conversion factor = $10^6 \text{cc}/\text{m}^3$

It is also possible to determine the percent or fraction of the Derived Air Concentration (DAC) for a particular radionuclide using the information obtained from the exposure calculation and dividing this value by the regulatory limit DAC listed in 10 CFR Part 20.

$$\% \text{ DAC} = \text{Exposure in } \mu\text{Ci} / \mu\text{Ci limit 10 CFR Part 20}$$

For the natural uranium (U-Nat) the DAC limits from 10 CFR Part 20 for insoluble Class Y compounds are as follows:

- Weekly $1.0 \times 10^{-3} \mu\text{Ci /week}$
- Quarterly $1.25 \times 10^{-2} \mu\text{Ci /Qt}$
- Yearly $5.0 \times 10^{-2} \mu\text{Ci /yr}$

1.1.2.8 ALARA/Quality Control

The RSO reviews each monitored result and initiates action if levels exceed 25% of 10 CFR 20 limits. At a minimum, ten percent (10%) of the air samples collected in a given quarter will be recounted using the same instrument or using a different instrument and these results will be compared to the original sample results. Deviations exceeding 30% of the original sample results will be reviewed by the RSO and the samples will be recounted again until the sample results are determined to be consistent. Additional QA samples consisting of spiked air samples, duplicate samples and blank samples will be submitted to the radiation department for counting. This will be based on ten percent (10%) of the number of samples collected during a quarter. The sample results will be compared to the spiked values, duplicate values, or blank (background) values of the prepared sample. Deviations exceeding 30% of the determined spiked, duplicate or blank value will be recounted. If no resolution of the deviation exceeding 30% is made the QA samples preparation will be repeated. Periodic reviews by the RSO and the ALARA audit committee will be made and documented to ensure quality maintenance and ALARA control.

1.1.3 Airborne High Volume Sampling

Grab air sampling involves passing a representative sample of air through a filter paper disc via an air pump for the purpose of determining the concentration of uranium in breathing air at that location. Although the process is only measuring airborne concentrations at a specific place and at a specific time, the results can often be used to represent average concentration in a general area. A high volume sample pump will be used for this purpose. Samples will be analyzed as per standard gross alpha analysis procedures using a sensitive alpha detector.

1.1.3.1 Frequency and Locations

The following principles used for the collection of area grab samples must be considered when collecting a sample in order to obtain a representative air concentration that workers may be exposed to during their assigned work tasks.

1. The locations selected for sampling should be representative of exposures to employees working in the area.
2. For special air sampling, the sampling period should represent the conditions during the entire period of exposure. This may involve sampling during the entire exposure period.
3. For routine sampling, the sampling period must be sufficient to ensure a minimum flow rate of 40 liters per minute (lpm) for at least 60 minutes.
4. Sample filters will be analyzed for gross alpha using a sensitive alpha detector.
5. Grab sampling procedures may be supplemented by use of Breathing Zone Samples for special jobs or non-routine situations.

1.1.3.2 Sampling Equipment

Monitoring equipment will be capable of obtaining an air sample flow rate of at least 40 liters per minute for one hour or longer. Equipment utilized will be an Eberline RAS-1, or a Scientific Industries Model H25004, or equivalent. Filter media will be of appropriate micron pore diameter. Equipment is calibrated prior to each usage as per Section 3.3 of this manual.

1.1.3.3 Sampling Procedure

Steps for collection of area airborne grab samples are as follows:

1. A high volume pump will be used for sample collection.
2. Check sample pump calibration.
3. Locate sampler at designated site. Insert a clean filter, using tweezers, into the filter holder on the sampler. Do not contaminate the filter. Log start time and conditions at the site.
4. Collect a sample for a minimum of 60 minutes at a flow rate of 40 lpm.
5. After sampling is completed, carefully remove the filter, using tweezers, from the filter holder and place it in a clean envelope, or in the plastic casing furnished with the filter.

6. Log all sample data on the log sheet.
 - A. Sample location and number (also on the envelope).
 - B. Time on, time off and date.
 - C. Mill operating conditions at the site.
 - D. Sampler's initials.

7. Analyze for gross alpha

1.1.3.4 Calculations

Perform calculations as described in Section 1.1.2.7.

1.1.3.5 Records

Logs of all samples taken are filed in the RSO's files. Data are used to calculate radiation exposures as described in Section 4.0.

Whenever grab sampling results indicate that concentrations in work locations exceed 25% of the applicable value in 10 CFR Part 20, Appendix B, time weighted exposures of employees who have worked at these locations shall be computed. Calculations will reveal an individual's exposure in DAC hours. This value shall be assigned to the worker and logged onto the worker's "Employee Exposure to Airborne Radionuclides" form. This form is in Section 4. Whenever special air sampling programs (as required for cleanup, maintenance, decontamination incidents, etc.) reveal that an employee has been exposed to airborne radioactive material, the calculated value shall also be entered on the individual's exposure form.

1.1.3.6 Quality Assurance

Calibration checks on each air sampler, prior to field use, ensure accurate airflow volumes. Use of tweezers and new filter storage containers minimizes contamination potential. Field logging of data during sampling and logging of identifying data on sampled filter containers minimizes sample transposition. Quality control samples will be analyzed as described in Section 1.1.2.8

Review of data by the RSO and by the ALARA Audit committee further assures quality maintenance.

1.2 ALPHA SURVEYS

1.2.1 Restricted Area

The Restricted Area is defined as:

1. The property area within the chain link fence surrounding the mill property and the area enclosed to the north and east of the facility by the posted Restricted Area fence.
2. The active tailings and liquid waste disposal areas.

All personnel who enter the Restricted Area will monitor themselves each time they leave the Restricted Area and at the end of their shift. The Radiation Safety Department will review the monitoring information. All personnel exiting the Restricted Area must initial a record of their monitoring activity.

1.2.2 Instrumentation

The instrumentation utilized for personnel alpha scanning is listed in Appendix 1 at the end of this manual. Personnel alpha survey instruments are located at the exits from the Restricted Area.

1.2.3 Monitoring Procedures

The monitoring procedure includes the following steps:

1. The alarm rate meter is adjusted within the range of 750 to 1,000 dpm/100 cm² to ensure a margin of 250 dpm/100 cm² due to the low efficiency of this instrumentation.
2. An individual monitors himself by slowly passing the detector over their hands, clothing and shoes, including the shoe bottoms, at a distance from the surface of approximately ¼ inch. An area that is suspected of possessing any contamination (i.e. hands, boots, visible spotting/stain on clothing etc.) should be carefully monitored by placing the detector directly on the surface and note the measurement.
3. Should an alarm be set off indicating the presence of contamination, the individual should:
 - a. Resurvey themselves to verify the contamination.
 - b. If contamination is present the individual must wash the affected area and again resurvey themselves to ensure the contamination has been removed.
4. If the decontamination efforts by the individual are not successful, then the Radiation Safety personnel will be contacted to assess the situation. Further decontamination may be required.
5. If an individual's clothing cannot be successfully decontaminated, they must obtain clothing from the warehouse to use and must launder the personal clothing in the laundry room.

6. Individual surveys are to be logged and initialed.
7. Access to and from the Mill's Restricted Area by all Mill workers, contractors and delivery personnel, other than Radiation, Safety and Environmental Staff, Senior Laboratory personnel, Mill Management and Mill Supervisory personnel and others as may be designated by the RSO, will be limited to one or more access points as may be designated by the RSO from time to time.
8. A Radiation Technician will be positioned at each access point designated by the RSO under paragraph 7 above during peak transition times, such as during breaks and at the ends of shifts, to observe that each worker, contractor or delivery person is performing a proper scan.

1.2.4 Training

All employees will be trained on the proper scanning procedures and techniques.

1.2.5 Records

Log sheets will be collected daily and filed by the Radiation staff. Records will be retained at the Mill. Contamination incidents will result in a written record, which is maintained on file.

1.2.6 Limits/ALARA

Contamination limits for personnel scans are set at 1,000 dpm/100 cm². Records will be reviewed by the RSO to maintain levels noted as low as reasonable achievable.

1.2.7 Quality Assurance

A random check of an individual's scanning technique provides quality assurance of the monitoring procedures. Daily function checks using calibrated sources assures instrumentation performance. Periodic review by the RSO and the ALARA audit committee document and ensure quality control and ALARA maintenance.

1.3 PERSONNEL BETA-GAMMA MONITORING

Site employees working within the Restricted Area will be required to wear a personal monitoring device (such as a TLD, LUXEL badge or other NVLAP approved device which has been approved by the RSO and the SERP) during their work period. The personal monitoring devices are normally issued to each employee quarterly; however, during pregnancy or if the radiological potential for exposure to an individual is

anticipated to be elevated and requires quick assessment the badges may be issued monthly.

1.3.1 Monitoring Procedures

The monitoring procedures consist of:

1. Personnel issued personal monitoring devices will wear the device on the trunk (torso) of the body. The personal monitoring device records beta/gamma radiation as well as other forms of penetrating radiation such as x-rays. A personal monitoring device is an exposure record of an individual's personal exposure to radiation while on the job. Therefore, personal monitoring devices are to remain at the Mill and stored on the assigned dosimeter storage boards. All exposure records obtained by a personal monitoring device which are not consistent with the exposure rates of work tasks or work location measurements made throughout the Mill will be evaluated by the RSO. This evaluation will result in an investigation by the RSO and a written explanation of the findings. These written records will be maintained at the Mill.
2. Personal monitoring devices will be issued at a minimum quarterly and will be exchanged by the Radiation Safety Department. Missing or lost badges will be reported to management.
3. Female employees that become pregnant and continue to work during the course of their pregnancy will be placed on a monthly personal monitoring device exchange during this period. NRC Regulation Guide 8.13 provides guidelines to be followed during pregnancy and is made part of this procedure.

1.3.2 Records

The Radiation Safety Department will maintain all occupational exposure records in the departmental files:

1. Occupational exposure records are a part of an individual's health record and, as such, will be considered private information.
2. An individual may examine his/her exposure record upon request.
3. An employee terminating his/her employment with the Company may request a copy of his/her occupational exposure records.
4. The Radiation Safety Department on the signature of the employee will request prior occupational exposure records.

5. Occupational exposure records will be made available to authorized company or regulatory personnel.

1.3.3 Quality Assurance

Periodic reviews by the RSO and the ALARA audit committee document and ensure quality control and maintenance of conditions ALARA.

1.4 URINALYSIS SURVEYS

1.4.1 Frequency

Urinalyses will be performed on those employees that are a) exposed to potential airborne yellowcake or involved in maintenance tasks during which yellowcake dust may be produced, or b) routinely exposed to airborne uranium dust. Baseline urinalyses will be performed prior to initial work assignments.

Urine samples are collected on a routine basis from employees as required in Regulatory Guide 8.22. Samples will be collected from all employees monthly. Bi-weekly samples will be collected if individual exposures are expected to exceed 25% of the DAC value. Non-routine urinalyses will usually be performed on employees who have been working on assignments that require a Radiation Work Permit, and always on any individual that may have been exposed to airborne uranium or ore dust concentrations that exceed the 25% of the DAC level.

1.4.2 Specimen Collection

Clean, disposable sample cups with lids will be provided to each employee that will be required to submit a urine specimen. The containers will be picked up at the administration building before the individual enters the Restricted Area.

The container, filled with specimen, will be returned to the bioassay laboratory prior to reporting to work. The name of the employee and the date of collection will be indicated on the specimen cup.

A valid sample must be collected at least 40 hours, but not more than 96 hours, after the most recent occupancy of the employee's work area (after two days, but not more than four days off).

The specimen should be collected prior to reporting to the individual's work location. To prevent contamination, the hands should be carefully washed prior to voiding.

Under unusual circumstances where specimens cannot be collected in this manner, the worker will shower immediately prior to voiding.

1.4.3 Sample Preparation

Equipment required:

- 15 ml disposable centrifuge tubes with lids
- 10 ml pipette
- 1 mL pipette
- 200 µL pipette
- 5 µl pipette
- 10 µl pipette
- Disposable tips for the above pipettes
- 1,000 ppm uranium solution
- Spiking solution – 0.03 or 0.02 g/l of uranium in de-ionized water

After the specimens are received, they will be stored in a refrigerator until they are prepared for analysis.

Sample preparation will be done in an area decontaminated to less than 25 dpm alpha (removable) per 100 cm² prior to preparation of samples. All of the equipment that is used in sample preparation will be clean and maintained in such condition.

A log will be prepared and the following information will be kept for each urinalysis performed:

- Sample identification number
- Name of employee submitting the specimen
- Date of sample collection
- Date the sample was sent to the laboratory
- Date the results were received
- Results of the urinalysis in µg/l
- Indication of any spike used in µg/l

The centrifuge tubes will be marked with a sample identification number. 10 milliliters of urine will then be pipetted into the centrifuge tube using the pipette device. Or 1 milliliters of urine will then be pipette into the centrifuge tube using the pipette device (To prevent contamination, a new tip must be used for each specimen.) After each step of the procedure, the proper entry must be made in the logbook.

The samples that are to be spiked for quality assurance purposes will then be prepared. The spikes will be introduced into the sample with 5 µl or 10 µl pipettes. A new tip must be used with each spike. With the standard spike solution (0.03 g/l of U), a 5 µl spike will result in a 15 µg/l concentration for the 10 ml sample; the 10 µl spike will give 30 µg/l). The proper entry must be made in the logbook for each sample spiked.

After preparation has been completed, the QA samples are securely packaged as soon as practicable and sent to the contract laboratory for analysis.

The samples that are to be analyzed in-house will be placed in the chemistry laboratory's refrigerator until the analysis can be completed. A copy of the in-house analytical procedure is described in Section 1.4.7.6. Once the on-site laboratory is no longer functional, all samples will be submitted to a certified laboratory.

1.4.4 Quality Assurance

To assure reliability and reproducibility of results, at least 25% of the samples that are submitted for analysis will be used for quality assurance purposes. These samples will consist of spikes, duplicates, and blanks (samples collected from individuals known to have no lung or systemic uranium burden).

Spiked samples will be prepared as stated under sample preparation of this procedure.

Duplicates will be identical samples of the same specimen and/or spikes of identical concentrations.

To assure reliability of the in-house analytical procedure, 10% of the samples will be sent to a contractor laboratory for analysis. These samples will contain quality assurance items designed to provide intra-laboratory comparisons.

1.4.5 Analysis

After the samples are collected as outlined in Guide 8.22, they are identified to the lab by collection date and number. Urinalysis results must be completed and reported to the Radiation Safety Department within seven days of the sample collection.

1.4.5.1 Equipment List

1. Specimen collection cups with disposable lids (VWR No. 15708-711 or equivalent)
2. Screw cap, disposable, graduated 15 ml centrifuge tubes (Corning No. 25310 or equivalent)
3. Micro-pipettes 1 each 5, 5 each 10 μ L (Oxford Model 7000 or equivalent)
4. Adjustable Finnpiptette each 1,000 μ L, 200 μ L and 5 mL
5. Disposable micro-pipette tips for micro-pipettes (Oxford No. 910A or equivalent)
6. Fume Hood
7. Ultrasonic Cleaner
8. PE-SCIEX ELAN DRC II AXIAL FIELD TECHNOLOGY ICP-MS (or equivalent)
9. Polyscience Water Circulator (or equivalent)
10. Perkin-Elmer AS-10 Auto Sampler (or equivalent)

11. Thermo Scientific Vortex mixtures (or equivalent)

1.4.5.2 Reagent List

1. 1% to 2% Nitric Acid
2. Concentrated Nitric Acid
3. 1,000 µg/ml Uranium Stock Solution, certified vendor prepared
4. Dilutions of the above stock solution, replaced bi-annually. Used for QA/QC.
5. Appropriate Cleaning Solution for Ultrasonic Cleaner
6. 1,000 µg/ml Uranium Stock Solution, purchased from certified vendor to use as calibration standard at different dilutions

Ensure that all reagents used are within their expiration dates listed on each reagent package, if applicable.

1.4.5.3 Premise

A portion of urine is diluted with 2% Nitric acid solution, mixed thoroughly and analyzed.

1.4.5.4 Safety Precautions

1. Follow laboratory guidelines when working with acids.
2. Utilize all appropriate PPE.

1.4.5.5 Sample Preparation Procedure

1. Compare sample numbering with bioassay result sheet to insure order and eliminate discrepancies.
2. To 15 ml centrifuge tube add 1 mL urine sample, 200 µL internal standard of 1,000 ppb and 2% Nitric acid to make up volume to 10 mL.
3. Maintaining sample order of left to right, front to back, lowest sample number to highest sample number in the set.
4. Use vortex to mix it thoroughly.
5. Analyze using procedure on the ICP-MS described in section 1.4.5.6.

1.4.5.6 ICP-MS Procedures

Special considerations: Because of the high salt content of the samples, it is necessary to clean the skimmer and sampler cones after each use.

1. Turn the argon on at the tank and set the delivery pressure at 80 pounds per square inch (psi).
2. Turn on the exhaust fan and the water supply to the ICP-MS. The water supply has to have a delivery pressure of 70 psi. It may be necessary to change the filters on the water supply in order to achieve sufficient water supply pressure. The ICP-MS will not operate below this pressure.
3. Turn on the computer, monitor and printer.
4. On the windows desktop, double-click the ELAN icon.
5. Check the condition of the sample introduction system.
6. Check that the sample tubing and drain tubing leading from the peristaltic pump to the spray chamber are properly set up and in good working condition. It is recommended to use new tubes every day.
7. Place the capillary tubing into a container of 2% Nitric acid solution.
8. Open the instrument window, and then click the Front Panel Tab.
9. On the front panel tab click vacuum start.
10. When the instrument is ready, click Plasma Start.
11. After the plasma ignites, allow the instrument to warm up for 45 minutes.
12. To begin sample analysis, click the sample tab, build the sample analysis list and click on analyze sample.
13. After the last sample, aspirate the blank long enough to clean the lines.
14. Allow the pump to run long enough without aqueous uptake to void all lines.
15. Turn the flame off and relax lines off of pump.
16. After 5 to 10 minutes, turn off the water supply, exhaust fan and argon.

All bioassay samples need to be analyzed three (3) working days from receipt in the laboratory. Samples are extremely susceptible to contamination. Precautions should be taken to minimize traffic and fugitive dust while samples are digesting.

1.4.6 Reporting and Corrective Actions

As soon as the analytical results are received, they are entered in the logbook and the entries are checked for correctness and completeness.

The lab report is returned to the Radiation Safety Department with results reported as micrograms/liter of uranium. The information must be placed in the individual employee's exposure file and maintained as directed by the DRC.

The Radiation Safety Department is notified immediately of any sample with a concentration greater than 35 micrograms/liter of uranium. Corrective actions will be taken when the urinary uranium concentration falls within the limits listed in Table 1 (attached).

The Radiation Safety Department should compute the error on the control spiked samples and advise the lab if the results are more than $\pm 30\%$ of the known values. If any of the results obtained for the quality assurance control samples are in error by a $\pm 30\%$, the analysis must be repeated.

1.5 IN-VIVO MONITORING

In-vivo body counting for lung burdens of U-natural and U-235 will not be routinely conducted. Monitoring will be conducted at the discretion of the RSO, samples may be sent for a follow-up analysis for specific radionuclides in consultation with DUSA management should potential exposure to an individual warrant.

2.0 RADIATION MONITORING – AREA

2.1 HIGH VOLUME AIRBORNE AREA AIR SAMPLING

Area air sampling involves passing a representative sample of air through a filter paper disc via an air pump for the purpose of determining the concentration of uranium in breathing air at that location. Although the process is only measuring airborne concentrations at a specific place and at a specific time, the results can often be used to represent average concentration in a general area. A high volume sampler or similar high volume pump will be used for this purpose. Samples will be analyzed as per standard gross alpha analysis procedures using a sensitive alpha detector.

2.1.1 Equipment

Monitoring equipment will be capable of obtaining an air sample flow rate of 40 lpm or greater for one hour or longer. A variety of equipment may be used for area air sampling, however normally the equipment used is an Eberline RAS-1, Scientific Industries Model H25004, or equivalent. Equipment is calibrated prior to each usage as per Section 3.6 of this manual.

2.1.2 Frequency/Locations

Area dust monitoring frequency is monthly for the locations shown in Table 2.1.2-1.

**Table 2.1.2-1
Airborne Radiation Sample Locations**

<u>Code</u>	<u>Location/Description</u>
BA1	Ore Scalehouse
BA2	Ore Storage
BA6	Sample Plant
BA7	SAG Mill Area
BA7A	SAG Mill Control Room
BA8	Leach Tank Area
BA9	Washing Circuit CCD Thickness
BA10	Solvent Extraction Building/Stripping Section
BA11	Solvent Extraction Building/Control Room
BA12	Yellowcake Precipitation & West Storage Area
BA12A	North Yellowcake Dryer Enclosure
BA12B	South Yellowcake Dryer Enclosure
BA13	Yellowcake Drying & Packaging Area
BA13A	Yellowcake Packaging Enclosure
BA14	Packaged Yellowcake Storage Room
BA15	Metallurgical Laboratory Sample Preparation Room

<u>Code</u>	<u>Location/Description</u>
BA16	Lunch Room Area (New Training Room)
BA17	Change Room
BA18	Administrative Building
BA19	Warehouse
BA20	Maintenance Shop
BA21	Boiler
BA22	Vanadium Panel
BA22A	Vanadium Dryer
BA23	Filter Belt/Rotary Dryer
BA24	Tails
BA25	Central Control Room
BA26	Shifter's Office
BA27	Operator's Lunch Room
BA29	Filter Press
BA30	Truck Shop
BA31	Women's Locker Room
BA32	Oxidation
BA33A	AF South Pad
BA33B	AF North Pad

Areas BA-10 and BA-12 were soluble uranium exposure areas. These areas were areas where the uranium compounds that were produced are soluble in lung fluids and are comparatively quickly eliminated from the body. All the other areas are insoluble exposure areas. Insoluble uranium areas were areas where the uranium compounds are not readily soluble in lung fluids and are retained by the body to a higher degree. Temperature of drying operations has a significant impact on solubility of uranium compounds. High drying temperatures produce insoluble uranium compounds. Area uranium dust monitoring, during production periods, is weekly in the designated yellowcake production areas. Monitoring increases to weekly in other monitored areas with the observance of levels exceeding 25% of 10 CFR 20 limits and reverts to monthly upon a continued observance of levels below 25% of 10 CFR 20 limits as determined by the RSO. The RSO may also perform any additional samplings at his or her discretion.

As areas are decommission and the ability to sample those areas is removed, the RSO will document this in the files and those areas will be removed from further monitoring.

2.1.3 Sampling Procedures

1. A RAS-1 or similar high volume pump shall be used for area grab sampling. Insure the pump has been recently calibrated within the past month.
2. The locations selected for area air samples should be representative of exposures to employees working in the area.
3. For routine sampling, the sampling period should be for a minimum collection duration of 60 minutes at a flow of 40 lpm or greater.
4. Insert a clean filter into the filter holder on the sampler. Note start time of pump and record unusual mill operating conditions if they exist.
 - A. Stop sample collection and note time. Normally, an automatic timer is connected to the sampler and a 1 hour sample collection time is used.
6. Remove the filter from the sampler and place in a clean glassine envelope or the package supplied by the manufacturer for delivery to the Radiation Department.
7. Count the sample by gross alpha counting techniques and enter the result and sampling information into the record.

2.1.4 Calculations

Perform calculations as specified in Section 4.0.

2.1.5 Records

Logs of all samples taken are filed in the Radiation Safety Officer's files. Data is utilized to calculate radiation exposures as specified in Section 4.0.

2.1.6 Quality Assurance

Calibration checks on each air sampler are made at least monthly to ensure accurate airflow volumes are being collected. Usage of tweezers and new filter storage containers minimizes contamination potential. Field logging of data during sampling and logging of identifying data on sampled filter containers minimizes sample transposition. Samples may periodically be submitted for chemical analysis and a comparison of these results to the radiometric measurements will be made.

Review of data by the RSO and by the ALARA audit committee further assures quality maintenance.

2.2 RADON PROGENY

2.2.1 Definitions

Working Level:

A. The exposure to $1.3E + 05$ MEV of alpha energy or the potential alpha energy in one liter of standard air containing 100 pCi each of RaA (Polonium-218), RaB (Lead-214), RaC (Bismuth-214), and RaC prime (Polonium-214). (Exposure level, not a dose rate)

Kusnetz Method: Method of radon progeny measurement and calculation based upon a 10 liter sample and at least 40 minutes decay time before counting.

2.2.2 Equipment

The equipment utilized consists of the following, or appropriate equivalents:

- Portable personal sampler
- Gelman 25 mm filter holder with end cap, or equivalent
- Gelman Type A/E 25 mm diameter glass fiber filters, or equivalent
- Counter-Scaler – Eberline MS-3 with SPA-1 probe, or equivalent

2.2.3 Frequency/Location

Radon progeny samples are obtained monthly for only those locations occupied by personnel where exposures may have the potential of exceeding 25% of 10 CFR 20 limits.

2.2.4 Procedures

The procedures to be utilized are as follows:

1. Assemble filter trains.
2. Ensure pump batteries are fully charged.
3. Calibrate pump (see Section 3.5).
4. Attached filter trains at sample locations; disconnect end plug.
5. Collect sample in the breathing zone of the employee.
6. Collect sample for five minutes at 4.0 lpm.

7. Log sample site, time started, time stopped, and filter pump number prior to leaving each site on the field log notebook.
8. Samples are counted between 40 minutes and 90 minutes after collection using sensitive alpha detector.
9. Check the calibration and function check information to ensure the detector is calibrated and operating.
10. If the calibration check correlates, proceed with sample analysis.
11. Radon progeny samples are normally counted for three minutes; however any sample count time may be selected for counting.
12. Run background detector count prior to running sampled filters.
13. After counting, calculate working levels.

Equation:
$$\frac{(\text{CPM} - \text{Bkg})}{(\alpha \text{ eff}) (20 \text{ liters}) (\text{Time Factor})} = \text{WL}$$

Where:

- CPM - sample count per minute
- Bkg - counter-detector background count per minute
- α Efficiency - The efficiency of the counting system (See Section 3.2.3.3)
- Time Factor - Values determined from Kusnetz method (See attached Table 2.2.4-1)
- WL - Working Levels

TABLE 2.2.4-1
Time Factors

<u>Min.</u>	<u>Factor</u>	<u>Min.</u>	<u>Factor</u>
40	150	71	89
41	148	72	87
42	146	73	85
43	144	74	84
44	142	75	83
45	140	76	82
46	138	77	81
47	136	78	78
48	134	79	76
49	132	80	75
50	130	81	74
51	128	82	73
52	126	83	71
53	124	84	69
54	122	85	68
55	120	86	66
56	118	87	65
57	116	88	63
58	114	89	61
59	112	90	60
60	110		
61	108		
62	106		
63	104		
64	102		
65	100		
66	98		
67	96		
68	94		
69	92		
70	90		

2.2.5 Exposure Calculations

The personnel exposure calculations are a job-weighted average of those areas and concentrations that an individual is exposed to. The procedure is:

1. Determine areas and durations (hrs.) each individual worked during the period (month and quarter).

2. Determine monitored concentrations (WL) for each area so noted.
3. The multiplication of the hours worked in each area by the area concentration (WL) noted is added to the result for each area involved in the period.
4. The result is the Working Level Hours exposed (WLH) for the period.
5. The working level hours (WLH) divided by 173 (30 CFR 57.5-40 note); or hours per month gives the working level months (WLM) exposure. (The limit is 4 working level months exposure per year.)
6. If calculated per quarter, the working level hours summed for the quarter are divided by 519 (173 X 3) to obtain the working level quarter exposure.

See Section 4.0 for details on how to perform exposure calculations and maintain the exposure records.

2.2.6 Records

Data records, which are filed in the Radiation Safety files, include:

1. Sample location
2. Date and time of sample
3. Time on and off of sample pump
4. Counts per minute of sample
5. Elapsed time after sampling
6. Background detector count
7. Appropriate Kusnetz time factor
8. Working level
9. Sampler identification

Employee exposure records include:

1. Month monitored
2. Areas and duration worked
3. Employee identification
4. Concentrations (WL) observed
5. Calculated WLMs

2.2.7 Quality Assurance

Calibration checks each month assure proper calibration of the counting equipment. Documented semi-annual calibrations of the counting equipment using certified alpha calibration and pulse meter sources ensure proper calibration of the equipment over the

anticipated ranges. The air sampling system has documented calibration prior to each use, ensuring sampling the appropriate air volumes. Duplicate counts of select data may be counted to assure instrument precision. Field documentation is maintained for each sample during monitoring. This methodology provides assurance in data quality.

Review of data by the RSO and the ALARA audit committee further assures quality maintenance.

2.3 ALPHA SURVEYS

2.3.1 Equipment

Equipment to be utilized in area alpha surveys is shown in Appendix 1. Pre-use function checks will be performed on all radiation survey equipment as specified in Section 3.1.2.3.2.

2.3.2 Frequency/Locations

Fixed and removable alpha surveys are made at those general locations on the Table 2.3.2-1, “Alpha Area Survey Locations.” Surveys are completed weekly in those areas designated by the RSO as authorized lunchroom/break areas are monitored. Designated eating areas are listed in Table 2.3.2-2.

As areas are decommission and the ability to sample those areas is removed, the RSO will document this in the files and those areas will be removed from further monitoring.

**Table 2.3.2-1
White Mesa Mill
Alpha Area Survey Locations**

Scale House Table
Warehouse Office Desks
Maintenance Office Desks
Change Room Lunch Tables
Maintenance Lunchroom Tables
Mill Office Lunchroom Tables
Metallurgical Laboratory Desks
Chemical Laboratory Desks
Administrative Break Room Counter
Administrative Office Desks

Table 2.3.2-2
White Mesa Mill
Designated Eating Area Locations

Maintenance Supervisor Break Room
Main Lunch/Training Room
Administrative Break/Conference Rooms
Administrative Office Desks

2.3.3 Procedures

2.3.3.1 Respirators

Respirators are monitored utilizing a removable alpha smear that is read using alpha scaler meter such as a Ludlum Model 2200 or other equivalent radiological instruments. Readings exceeding 100 dpm/100 cm² result in re-cleaning or discarding of the respirator. Respirator cleaning and monitoring is a function of the Radiation Safety staff assigned to this duty. The meter's performance is checked prior to each use period.

2.3.3.2 Fixed Alpha Surveys

Alpha surveys for fixed alpha contamination are performed using a variety of alpha detecting instruments, as listed in Appendix 1. Each instrument is checked using a calibrated alpha source for proper function and operation prior to use, as described in Section 3.1.2.3.2.

Adjustments to the surface area being measured must be made to convert from the particular detector's surface area to the commonly used surface area of 100 cm². Therefore when converting a measurement to the commonly used unit of dpm/100 cm², a multiplying area factor must be applied to the measurement. For the Ludlum instrument with a 43-1 detector of 75 cm² surface, multiply the value by 1.33 (i.e. 100 cm² divided by 75 cm²).

The procedures are:

1. Turn the meter on and check the meter battery condition.
2. Check alpha detector mylar surface for pinholes, etc. Replace if necessary and repeat calibration.
3. As specified in Section 3.1.2.3.2, perform a function calibration check using calibrated alpha source.
4. If check is acceptable, proceed with monitoring.

5. At each designated site, monitor designated surfaces, table tops, etc., holding within $\frac{1}{4}$ inch of the surface.
6. Record data, location, cpm/cm² monitored on data sheet.
7. At the conclusion of the survey, transpose results to the file log, correcting to dpm/100 cm², using correction for detector's surface area and cpm/dpm conversion factor.

2.3.3.3 *Removable Alpha Surveys*

The Ludlum Model 2200 scaler with 43-17 detector, or a variety of other sensitive alpha detection instruments such as Model 2929 or equivalent, counts wipe samples collected during removable alpha surveys. Glass fiber filters, sized to fit the detector sample slot, are utilized as the wipe medium. A template having a 100 cm² surface area maybe used to standardize the surface area wiped.

The procedure is:

1. Perform function check calibration of the scaler/detector. Ensure that this measurement is within $\pm 10\%$ of the value obtained from the calibration laboratory.
2. If so proceed with the survey and counting.
3. Obtain clean filters and clean envelopes for filter storage.
4. At a location to be surveyed, remove the filter from the envelope and wipe the surface covering approximately 100 cm². This is easily accomplished by making an "S" shaped smear for approximately 10 inches using normal swipes (approximately 2.5 cm diameter).
5. Record on envelope the date and location of the sample.
6. Upon returning to counting lab, place an unused filter in the counting unit for at least 1 minute and obtain a background count rate.
7. Repeat procedure for each used filter, extracting filter from envelope, immediately prior to counting, using tweezers and placing in the detector slot with the wiped surface facing the detector, and count for at least 1 minute.
8. Convert results from cpm/filter to dpm/filter (100 cm² wiped) after subtracting the blank background count.

9. Record on the alpha survey form the following information:

- A. Sample location and conditions
- B. Sample date
- C. Sampler identification
- D. Wipe count dpm/100 cm²

10. Discard the filters and envelopes

2.3.4 Action Limits

2.3.4.1 Respirators

Levels greater than 100 dpm/100 cm² squared require re-cleaning or discarding of a respirator.

2.3.4.2 Fixed Alpha Surveys

Levels greater than 1,000 dpm/100 cm² squared require remedial action by management. ALARA criterion ensures that the RSO takes action where necessary to maintain levels as low as reasonably achievable.

2.3.4.3 2.3.4.3 Removable Alpha Surveys

Levels greater than 1,000 dpm/100 cm² squared require remedial action and decontamination. ALARA criteria ensure that the RSO takes action where necessary to maintain levels as low as reasonably achievable.

2.3.5 Records

Records of fixed and removable alpha surveys are maintained in the Radiation Safety office files. Records include:

- 1. Sample location/conditions
- 2. Sample date
- 3. Sampler identification
- 4. Fixed alpha determination – dpm/100 cm²
- 5. Removable alpha determination – dpm/100 cm²
- 6. Remedial action taken, where necessary

2.3.6 Quality Assurance

Calibration function checks of detector performance and visual observation of detector surfaces prior to each survey ensures counting reliability and consistency. Usage of clean

containers and tweezers minimizes contamination of wipe samples. A Field log of sample I.D.'s on sample containers minimizes transposition of samples. Data review by the RSO and by the Audit Committee further assures quality maintenance.

2.4 BETA-GAMMA SURVEYS

2.4.1 Equipment

Beta/Gamma surveying instruments used for beta-gamma surveys are listed in Appendix 1 and the sources used are listed in Appendix 2.

Some instruments read directly in mrem/hour while others read in cpm (with a conversion to mrem/hour). The model 44-6 detector has a removable beta shield allowing discrimination between beta and gamma contributions. Each instrument has a manufactures user's manual which describes the function, use and capability of each instrument. These manuals must be understood before surveying proceeds. Calibration of Beta/Gamma and functional checks are performed using calibrated Cs-137 or SrY 90 sources

2.4.2 Frequency/Locations

The sites noted on Table 2.4.2-1 may be monitored on a monthly basis by of the Radiation Safety staff. During reclamation periods, only areas routinely occupied by personnel are monitored as designated by the RSO. As areas are decommission and the ability to sample those areas is removed, the RSO will document this in the files and those areas will be removed from further monitoring.

**Table 2.4.2-1
 Beta-gamma Survey Locations**

<u>Identification Number</u>	<u>Description of Possible Source of Area of Exposure</u>	<u>Distance from Source in cm</u>
WM-1	Mill Feed Hopper & Transfer Chute	1
WM-2	SAG Mill Intake-Feed Chute	1
WM-3	Screens-Area Floor Between Screen	1
WM-4	Leach Operator's Desk	1
WM-5	Leach Tank Vent #3	1
WM-6	Leach Tank #3 – Wall	1
WM-7	CCD Thickeners	1
WM-8	Pumphouse Tailings Discharge	1
WM-9	Oxidant Makeup Room-Sump Pump	1
WM-10	Shift Foreman's Office-Work Desk	1
WM-11	SX Operator's Area	1
WM-12	Precipitation Tanks #1 Tank; Wall	1
WM-13	Precipitation Section "Lab Bench"	1

<u>Identification Number</u>	<u>Description of Possible Source of Area of Exposure</u>	<u>Distance from Source in cm</u>
WM-14	Precipitation Vent	1
WM-15	Yellowcake Thickener #1; Wall	1
WM-16	Centrifuge Discharge-Chute Wall	1
WM-17	Yellowcake Thickener #2; Wall	1
WM-18	Yellowcake Packaging Room	1
WM-19	Yellowcake Dryer	1
WM-20	Yellowcake Dust Collector	1
WM-21	SX Uranium Mixer #1 Extractor	1
WM-22	SX Uranium Mixer #1 Stripping	1
WM-23	SX Vanadium Mixer #1 Stripping	1
WM-24	Vanadium Dryer	1
WM-25	Mill Laboratory Fume Hood	1
WM-26	Chemical Laboratory Work Area	1
WM-27	Metallurgical Laboratory Work Area	1
WM-28	Lunchroom Eating Area	1
WM-29	Lunchroom Wash Area	1
WM-30	Maintenance Shop – Work Area	1
WM-31	Maintenance Shop – Rubber Coating	1
WM-32	Tailings Impoundment Discharge	1
WM-33	Tailings Impoundment Dike 1	1
WM-34	Tailings Impoundment Dike 2	1
WM-35	Tailings Impoundment Dike 3	1
WM-36	Scalehouse	1
WM-37	Tailings Impoundment Dike 4	1

2.4.3 Procedures

The monitoring procedures are:

1. Check meter battery condition.
2. Check detector using a check source.
3. If the calibration function check indicates that the instrument is operating within calibration specifications, proceed with monitoring.
4. Survey each designated location on Table 2.4.2-1 and record in the field log:
 - A. Site location/condition
 - B. Date
 - C. Instrument used
 - D. Sampler's initials
 - E. Meter reading (beta + gamma)
 - F. Meter reading (gamma)

5. Upon returning to the office, record the mrem/hr reading into a permanent file which is maintained for beta-gamma exposure evaluation.

2.4.4 Action Levels

The ALARA concept is utilized in action levels. Responses include operative cleaning of the area or isolation of the source. The Radiation Safety Department will ensure levels ALARA.

2.4.5 Records

Records maintained in the Radiation Safety office files include:

1. Date monitored
2. Site location/condition
3. Instrument used
4. Sampler's initials
5. Beta/Gamma level, mrem/hr
6. Remedial action taken, if necessary

2.4.6 Quality Assurance

Quality of data is maintained with routine calibration and individual function checks of meter performance. Personnel utilizing equipment are trained in its usage. Records of the operational checks and calibrations are maintained in the files. The RSO routinely reviews the data and the ALARA audit committee periodically analyzes the performance of the management of the monitoring and administrative programs.

2.5 EXTERNAL GAMMA MONITORING

External gamma area monitoring is conducted at various locations around the Mill site in order to provide Radiation Safety Staff with area-specific gamma measurements. The procedures applicable to such monitoring are set out in Section 4.3 of the Mill's Environmental Protection Manual.

2.5.1 Locations and Frequency of Monitoring

External gamma measurements are taken over a quarterly interval for the twelve months of the year at all BHV locations and selected areas around the mill site (see Attachment #1 for those locations).

2.5.2 Quality Assurance

Quality assurance for external gamma measurements consists of:

- 2.5.2.1.1 Monitoring the container locations to ensure the TLDs have not been lost;
- 2.5.2.1.2 Ensuring that all containers are present when receiving or shipping to Landauer; and
- 2.5.2.1.3 Reviewing Landauer data for consistency and data transportation.

2.5.3 Analytical Requirements

Values reported are in millirems per week average for the monitor period (supplied by Landauer) along with a counting error term. The counting error term is calculated by:

$$[(\text{sample } 2 \text{ sigma}) - (\text{control mrem/week})] / (\text{\#weeks})$$

2.5.4 STANDARD OPERATING PROCEDURES

2.5.4.1 Equipment

External gamma is monitored at the ambient air sampling sites and other selected areas around the mill site, using the OSL badges from Landauer, Inc., or the equivalent.

2.5.4.2 Monitoring Methodology

- 2.5.4.2.1 The containers, each containing five TLD chips, are mounted approximately one meter above ground plane at each site with one container per site.
- 2.5.4.2.2 The containers loaded with TLDs are received the first of each quarter from Landauer and exchanged with those in the field.
- 2.5.4.2.3 A background TLD is stored in the Administration Vault as a transportation control.
- 2.5.4.2.4 The TLDs are returned to Landauer for processing.

2.5.4.3 Record Keeping

Data maintained in record form for external gamma is:

- 2.5.4.3.1 Sample period;

2.5.4.3.2 Sample location; and

External gamma levels for total radiation.

2.6 EQUIPMENT RELEASE SURVEYS

2.6.1 Policy

Materials leaving a Restricted Area going to unrestricted areas for usage must meet requirements of NRC guidance for “Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use” (dated April 1993).

All material originating within the restricted area will be considered contaminated until checked by the Radiation Safety Department. All managers who desire to ship or release material from the facility will inform the RSO of their desires. The RSO has the authority to deny release of materials exceeding NRC guidance for “Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use” (dated April 1993). No equipment or materials will be released without documented release by the RSO or his designee.

2.6.2 Limits

The release limits for unrestricted use of equipment and materials is contained in the NRC guidance listed above in Section 2.6.1 and are summarized as follows:

Limits for Alpha emissions for U-Nat and its daughter products are:

Average	5,000 dpm/100 cm ²
Maximum	15,000 dpm/100 cm ²
Removable	1,000 dpm/100 cm ²

Limits for Beta-gamma emissions (measured at a distance of one centimeter) for Beta/Gamma emitting radioisotopes are:

Average	0.2 mrem/hr or 5,000 dpm/100 cm ²
Maximum	1.0 mrem/hr or 15,000 dpm/100 cm ²

2.6.3 Equipment

Radiological survey instruments are listed in Appendix 1.

2.6.4 Procedures

Upon notification that materials are requested for release, the Radiation Safety Department shall inspect and survey the material. Surveys include fixed and removable alpha surveys and beta-gamma surveys. See sections 2.3 Alpha Surveys and 2.4 Beta-Gamma Surveys for a detailed breakdown on the surveying aspects and equipment used for each survey. An equipment inspection and release form, see attached, is to be prepared and signed by the RSO or his designee. Any material released from the mill will be accompanied with the appropriate release form. If contamination exceeds levels found in NRC guidance “Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use”, (dated April 1993), then decontamination must proceed at the direction of the RSO. If the material cannot be decontaminated, then it will not be released.

2.6.5 Records

Documented records for each released item are filed in the Radiation Safety Department files. These files shall include a completed Release Form, see attached, and a photograph of the material that is being released.

2.6.6 Quality Assurance

The RSO and the ALARA Audit Committee periodically review the policy and documented release forms to ensure policy and regulatory compliance.

2.7 Field Gamma Surveys

The field gamma surveys will be conducted in accordance with the currently approved Reclamation Plan, Section 6 of the Technical Specifications.

3.0 EQUIPMENT/CALIBRATION

All radiation detection instruments used at the Mill are sent to a qualified independent laboratory for calibration every six months. If necessary, Radiation Safety Staff can use the procedures outlined below to verify calibration.

3.1 Counters/Detectors

3.1.1 General

All radiation detectors require determination of detector optimal voltage performance or plateau operating point. The graph of voltage applied to a detector versus detector response is referred to as a plateau curve. The plateau curve typically has two rapidly sloping sections and a stable, flat region. The optimal operating point is typically located at the beginning of the flat, or flatter, section of the graph. The plateau curve is specific for a particular detector and its accompanying readout, or measuring meter, and may vary over time depending upon electronic component condition.

The equipment used to determine detector plateau curves includes:

1. Appropriate radiation sources
2. Electrostatic voltmeter
3. Radiation detecting instrument
4. Graph paper
5. Manufacturer's technical manual

The procedure is:

1. Ensure instrument batteries are fresh or fully charged, if applicable.
2. Turn the instrument on.
3. Adjust the instrument voltage control starting at voltage of 600 using electrostatic voltmeter to monitor voltage setting.
4. Expose detector to a radiation source applicable to the type of detector and in the appropriate setting.
5. Record voltage and instrument response for each adjustment of voltage applied; increments of 50 volts are adequate.
6. Repeat steps 4 and 5 until instrument response rapidly increases versus voltage level. At this point, the detector is approaching potential differentials across the electrode that may damage the detector.

7. Graph instrument response versus voltage applied.
8. Set equipment high voltage control to the optimum operating point. Record on graph voltage selected.
9. Retain graph with calibration records.

3.1.2 Function Checks

Calibration function checks are required prior to use of radiation detection instruments used at the Mill for the purpose of verifying that the instruments are operating at the same efficiency as when they were calibrated by the calibration laboratory (i.e., within +/-10%). Function checks are also used for verifying repeatability, reliability, and comparability of an instrument's measurements from one period to another. By performing function checks for extended time periods, or on a larger sample size, these goals are met.

Function checks involve two basic elements:

- (1) The calibration laboratory efficiency is compared to the instrument's efficiency on the date of the function check; and
- (2) The function check is verified with a check source having similar isotopic composition as the one that was used by the calibration laboratory to calibrate the instrument.

Function checks are made for all types of radiation survey instruments. The basic principle in performing a function check is measuring the radiation field using a survey instrument against a known amount of radiation from a calibrated source. These measurements are made for the specific type of radiation occurring. For example, when performing a beta/gamma survey, the instrument function check is performed using a beta/gamma check source, such as a (SrY)-90. When performing an alpha survey, use an alpha check source, such as Th-230 or Pu-239 for performing the function check.

Function checks are documented on the Calibration Check Forms (see Attachment A for copies of forms to be used) for each specific instrument. They will be maintained in the instrument's' calibration and maintenance file.

A number of radiation detection instruments are used at the Mill. An Instrument Users Manual for each instrument is maintained in the calibration files, together with calibration documentation. The Users Manuals are to be considered the primary reference for operating a particular instrument. This Standard Operating Procedure (SOP) is not intended to replace the Users Manual, but rather to supplement the Manual by providing steps to be performed for function checks. Before operating an instrument, personnel should read the Users Manual and become familiar with the instrument's operation,

capabilities, and special features. Personnel will also receive on the job training on each instrument.

3.1.3 Alpha Monitors

Alpha particles travel very short distances in the air due to their high ionization ability – typically ¼ to ½ inch. Due to this limitation, alpha monitoring must be done at a distance of ¼ inch or less between the detector face and the source. Alpha monitoring, to be consistent, requires ensuring a consistent distance be utilized between the detector face and the source. Alpha detectors read out in counts per minute (cpm). A correlation relationship, known as the efficiency factor, between the meter response and the actual disintegration rate of the source is used to determine actual calibration of the meter.

Radioactivity is measured in curies (Ci), which, by definition, is 3.7×10^{10} disintegrations per second (dps), or 2.2×10^{12} disintegrations per minute (dpm). Another measurement unit is the Becquerel, or one dps. Alpha radiation is usually monitored as dpm, per surface area measured.

Radiation survey equipment used at the Mill for alpha surveys is listed in Appendices 1 and 2.

3.1.3.1 Calibration and Function Check Frequency

The frequency of calibration is specified in individual instrument user manuals and manufacturer's specifications.

The following frequencies are observed for calibration and function checks of radiation detection instruments:

	<u>Type</u>	<u>Calibration Frequency</u>	<u>Function Checks</u>
1.	Employee scans	6 months	7 days/week
2.	Radon progeny	6 months	each use
3.	Respirator checks	6 months	each use
4.	Area fixed scans	6 months	Daily or each use
5.	Area wipe scans	6 months	Daily or each use

3.1.3.2 Function Check Procedures – Alpha Counters and Scaler Instruments

The following steps will be used for function checks for alpha counters and alpha scaler instruments.

1. Turn the instrument on and place a calibrated alpha check source in the detector holder on or the face of the detector.
2. Count the source for 1 minute and record this value in cpm.
3. Repeat step 2 four more times.
4. Average the five readings and divide the average in cpm by the known activity on the alpha source. This is the efficiency of the instrument and detector.
5. Compare this efficiency with the efficiency obtained from the calibration lab. If the efficiency comparison is within $\pm 10\%$ deviation the instrument needs is calibrated if not the instrument needs to be recalibrated.
6. If this efficiency comparison is within $\pm 10\%$ deviation the instrument is in calibration.
7. Proceed with monitoring activities.

3.1.3.4 Calibration Procedures

All radiation detection instruments used at the Mill are sent to a qualified offsite laboratory every six months for calibration. However, if additional onsite calibration is required the calibration procedures are:

1. Set the detector high voltage at the prior determined operating point using an electrostatic voltmeter.
2. For counter/scalers (radon progeny/wipes), close the detector, without source present, obtain a reading for a set time. This is a background reading.
3. Place a calibrated source for the type of radiation being measured in the source holder and obtain reading.
4. Observe the cpm for both the background and the source.
5. Subtract the cpm value of background from the cpm value of the source to obtain the net cpm.
6. Divide the net cpm value by the known dpm of the source. This is the percentage efficiency of the instrument system for this energy source.
7. By dividing 100 by this efficiency, an efficiency factor is obtained.

8. Dpm equals the cpm divided by the efficiency of the instrument detector system;

Note:

$$1 \text{ curie} = 2.22 \text{ E} + 12 \text{ dpm}$$
$$1 \text{ microcurie} = 2.22 \text{ E} + 6 \text{ dpm}$$
$$1 \text{ picocurie} = 2.22 \text{ dpm}$$

3.1.4 Beta-gamma Monitors

Equipment utilized for beta-gamma monitoring is listed in Appendices 1 and 2.

3.1.4.1 Function Check Procedure

The following steps will be used for function checks on beta/gamma instruments:

1. Turn the instrument on and place the calibrated beta/gamma (SrY-90) check source on the face of the detector.
2. Let the reading stabilize to a constant value.
3. Record this value in cpm.
4. Divide this value by the known activity on the check source. This is the efficiency of the instrument and detector.
5. Compare this efficiency to the efficiency obtained from the calibration laboratory. If the efficiency comparison is within $\pm 10\%$ deviation the instrument needs is calibrated if not the instrument needs to be recalibrated.
6. If this efficiency comparison is within $\pm 10\%$ deviation the instrument is in calibration.
7. Proceed with monitoring activities.

3.1.4.2 Calibration

All beta-gamma survey instruments are sent out every six months for calibration. Additional calibration, if necessary, may be performed on site using techniques described in Reg. Guide 8.30, Appendix C – Beta Calibration of Survey Instruments for calibration performed by a qualified calibration laboratory using the indicated source as listed in Appendix 2.

3.1.5 Gamma Monitors

Instruments for gamma measurements are listed in Appendix 1.

3.1.5.1 Calibration

Independent calibration service laboratories shall perform calibrations every six months. Meters are calibrated to Cs-137 or other radioisotopes as suggested by the calibration laboratory or manufacturer. Most calibration service laboratories calibrate Beta/Gamma instruments electronically in accordance with their standard calibration procedures. However, electronic calibration basically consists of the steps described below:

1. Connect survey instrument to be calibrated to the Model 500.
2. Turn both instruments on.
3. Record high voltage reading on Model 500.
4. Set cpm and the range multiplier on the Model 500 to the desired meter deflection. The model 500 frequency controls consist of the three-digit readout, range selector, coarse tuning knob, and the fine tuning knob. The three-digit readout is in cpm times the frequency multiplier.
5. Calibrating survey instruments in cpm:
 - A. Set Model 500 frequency to value that will provide a $\frac{3}{4}$ meter deflection on the survey instrument's highest count scale. Set pulse height/amplitude to twice instrument input sensitivity.
 - B. Adjust the range calibration potentiometer on the survey meter to provide correct reading record.
 - C. De-code Model 500 frequency to next lower value; then do the same for the survey instrument.
 - D. Adjust the range calibration potentiometer for correct reading on survey instrument. Record readings.
 - E. Repeat process until all ranges have been calibrated at $\frac{3}{4}$ meter deflection. Record readings.
 - F. Return to highest count scale on survey meter.
 - G. Set Model 500 for $\frac{1}{4}$ scale deflection readings.
 - H. Survey instrument should read within $\pm 10\%$ of Model 500 frequency. Record readings.

- 1) If readings are outside of the tolerance, re-calibrate for $\frac{3}{4}$ meter deflection.
 - 2) Tap instrument meter lightly to check for sticky meter. Meter tolerance is $\pm 3\%$ from the initial readings to the final reading.
- I. Decode Model 500 to next lower scale. Check survey instruments for $\frac{1}{4}$ scale reading. Record.
6. Record input sensitivity.
 - A. Select the most sensitive amplitude range 0-5 mv on the Model 500.
 - B. Observe meter on survey instrument.
 - C. Increase pulse amplitude, switching to next higher range, if necessary, until the rate meter indicates a stable reading (i.e., further increase of pulse amplitude does not cause an increase in meter reading). Now, decrease pulse height until the survey instrument meter reading drops $15 \pm 5\%$. Record this pulse height as the instrument sensitivity.
 - D. If your instrument has a gain or threshold control to set instrument sensitivity, set pulse height on the Model 500 to desired sensitivity level. Now adjust your instrument threshold or gain control until the rate meter reading is within $85 \pm 5\%$ of its stable reading value (see step C). Record the pulse height as instrument sensitivity.
 7. Calibrating survey instrument to cps.
 - A. Set frequency in Model 500. Divide the Model 500 readings by 60 to convert to counts per second.
 - B. Repeat calibration steps as in item 5 above.

3.1.5.2 *Frequency of Calibration*

If electronic calibration is performed using the above method by the Radiation Safety Department, the Model 500 pulse generator will be sent out for calibration on an annual basis.

3.2 PERSONNEL AIR SAMPLERS

The calibration procedure for personnel air samplers involves one of three calibration procedures. Samplers will be calibrated prior to each use by one of the three

methodologies: bubble tube, electronic or mass flow determinations. Air samplers may be calibrated to standard air conditions.

3.2.1 Bubble Tube Calibration Method

The Bubble Tube Calibration Method is a calibration method and does not require corrections to or from standard conditions for temperature and pressure. Personal air samplers are calibrated for the flow rate for the sampling being performed, typically 2-4 lpm.

The equipment utilized is as follows:

1. Burette – 1,000 ml capacity, 10 ml divisions
2. Support, iron, rectangular base, with rod
3. Burette clamps – 2
4. Soap solution, dish
5. Tubing, Gelman filter holder, filter media (0.8 micron glass fiber Gelman type A/E)
6. Stopwatch
7. Small screwdriver
8. Sample pump

The procedures utilized are:

1. Assemble a filter train – place a filter in an in-line filter. Attach two lengths of tubing to each connector of the in-line filter holder.
2. Make sure the Burette is clean. Clamp the 1,000 ml Burette upside down on the ring stand with the Burette clamps.
3. Attach the pump to be calibrated to one end of the filter train, connect the other end of the filter train to the small end of the 1,000 ml Burette, as per Figure 1.
4. Check all tubing connections for air tightness.
5. Pour approximately ½ inch (12 mm) of soap solution into the dish.
6. Start the pump.
7. Raise the dish up under the Burette opening, and then immediately lower the dish. This should cause a film of soap to form over the Burette opening (i.e., a bubble). Repeat this procedure until the film (bubble) will travel up the inverted Burette the length of the graduation marks on the Burette without breaking.

8. When the film (bubble) has wetted the Burette inside and will travel the entire length of the graduated area of the Burette, proceed with the actual calibration run.
9. Quickly form three bubbles and start the stopwatch when the middle bubble is at the bottom graduation line (actually the 1,000 ml mark, but for purposes here, it will be called the “zero” line).
10. Time the travel of the bubble from the zero line to the top line of the graduated distance (0 ml). Since the capacity of the Burette is 1,000 ml (1.0 liter), then the volume of air that is displaced above the bubble (i.e., needed to raise the bubble) is 1.0 liter. Stopping the stopwatch at the top mark is the time elapsed for the pump to accomplish this. The rate of rise of the bubble through the apparatus is the flow rate of air being pulled by the pump.
11. Increase or decrease the pump collection rate by adjusting the appropriate screw or knob designed for this purpose.
12. Set the pump flow collection rate to the desired valued usually between 2 and 4 liters per minute for low volume collection pumps and between 30 and 80 liters per minute for high volume collection pumps.

3.2.2 Mass Flow Method

Mass flow meters are manufactured equipment designed to measure air collection flow rates for a variety of purposes. Mass flow meters may be subject to temperature and pressure corrections of air movement depending on whether they are calibrated/manufactured for standard conditions.

Utilizing an air mass flow meter, traceable to NBS, the airflow rate of pumps can be quickly adjusted to correct standard flow rate conditions. However, the mass flow meter must be calibrated annually using a primary calibration method.

The equipment consists of the following:

1. Kurz air mass flow model 543 or equivalent
2. Suitable filter head adapter connections
3. Filter heads with filter media
4. Pump to be calibrated

Note: The meter is calibrated directly in standard air conditions – 25° C., 29.82” Hg.

The procedures utilized are:

1. Ensure pump batteries are fully charged.

2. Ensure flow meter batteries are fully charged.
3. Assemble filter train.
4. Connect (with a suitable adapter) the Kurz probe onto the filter train. Ensure an airtight seal with tape, if necessary.
5. Set the meter function switch to the highest range: 40 std liters per minute.
6. Turn the pump on.
7. Select appropriate range on the meter. (Do not allow meter needle to be forcibly pegged.)
8. Adjust the pump flow rate as necessary to desired flow rate. Allow the meter to stabilize before adjustment of the pump.
9. Meter reads directly in standard air conditions, correcting for temperature and barometric pressure.

Pump is now calibrated. Low volume pumps are set 4 lpm.

3.2.3 Electronic Calibration Method

The electronic calibration is the calibration method and does not require corrections to or from standards conditions for temperature and pressure. Personal air samplers are calibrated for the flow rate for the sampling being performed typically 2 – 4 lpm. Area Airborne high volume air samplers should be calibrated to a minimum of 40 lpm.

The equipment utilized is as follows:

1. UltraFlo Primary Gas Flow Calibrator, or equivalent
2. Soap solution
3. Tubing
4. Small screwdriver
5. Sample pump

The procedure proceeds as follows:

1. Remove the two nipples on the back of the UltraFlo Primary Gas Flow Calibrator.
2. Attach the connection tubing from the top nipple to the sample pump.
3. Turn calibrator on.
4. Turn sample pump on.

5. Press the plunger style button on top of the soap dispensing portion of the device.
6. Write down the digital reading from the calibrator device.
7. Repeat steps 5 and 6 three times.
8. Take an average of the three readings.
9. If the sample pump requires adjustment, take the screwdriver and adjust the set screw on the face of the sample pump and then repeat steps 5 through 7.
10. After the sample pump is calibrated, document the calibration on the Breathing Zone/Radon or the High Volume Calibration Sheet depending on which device is being calibrated, in the Radiation department.
11. Replace nipple caps on the back of the calibrator.

3.3 AREA AIR SAMPLERS

The calibration procedure for area air samplers involves one of the following procedures; Kurz Mass Flow, Wet Test Gas Meter, Electronic or Bubble Tube Method.

3.3.1 Kurz Mass Flow Method

Repeat procedures discussed in 3.2.2 – except – airflow rate is adjusted to 40 slpm and samplers utilized are:

1. Eberline RAS-1
2. Scientific Industries Model H25004
3. Equivalent

3.3.2 Wet Test Gas Meter Method

The wet test gas meter method utilizes a Precision Scientific wet test meter rated at one cubic foot per revolution of the main dial. This method is used to calibrate the Kurz air mass flow meter in addition to direct calibration of the area air samplers.

The procedures are:

1. Attached coupling to sampler filter assembly; secure it with tape.
2. Connect wet test meter hose to coupling.
3. Check water level of wet test meter. The needle should be on slightly above the water level.
4. Check the thermometer temperature of the wet test meter. Record this on the calibration sheet. Assume that the wet and dry bulb temperatures are the same.

5. Turn on the sampler. Check the wet test meter's manometer reading. This reading is obtained by adding the left and right column values. (A typical reading might be .3). Log these values for each ball height on the "Static pressure ... H₂O" column.
6. For the following sampler approximate settings, pull one cubic foot of air through the wet test meter and record the time (in seconds) for each: 20, 30, 40, and 50 lpm.

Sampler Calibration Procedures – Calculations and Equations

1. To convert the static pressure (of the manometer attached to the wet test meter) from inches of water to inches of mercury, divide the number of inches to water by 13.6.
Example: $0.4/13.6=0.02941176$ " Hg
2. To compute the actual flow rate ("Q rate act. lpm"), first divide the number of cubic feet by the number of seconds. Example: $1 \text{ ft.}^3/90 \text{ sec} = .01111 \text{ ft.}^3/\text{awx}$. Convert the cubic feet to liters. The conversion factor is 28.317. Example: $.01111 \text{ ft.}^3/\text{sec} \times 28.317 \text{ L ft.}^3 = .3146 \text{ L/sec}$. Multiply this by 60 to convert from seconds to minutes. Example: $.3146 \text{ L/sec} \times 60 \text{ sec} = 1888 \text{ L/m}$ or 18.88 lpm.
3. Using the "Vapor Pressures of Water" chart, find the vapor pressure inside the wet test meter by matching the wet bulb temperature with the corresponding vapor pressure. This number is the vapor pressure at the standard wet bulb (Pvpstw).
4. Find the vapor pressure at dewpoint using this formula: $P_v \text{ dewpoint} = P_{vpstw} = 0.0003613 (td-tw) B_p$ (Where +d = dry bulb temp; tw = wet bulb temp; bp = barometric pressure in inches of mercury.) Assume that the dry bulb temperature and the wet bulb temperature are the same, so the difference between them will always be zero. Thus, P_v dewpoint will equal Pvpstw.
5. Determine the actual air density (D act) with this formula:

$$D \text{ act} = \frac{1.327}{td + 459.67 [(P_g - Sp) - 0.378 (P_v \text{ dewpoint})]}$$

(Where td - dry bulb temp in degrees F.; B_p = barometric pressure in inches of mercury; Sp = static pressure of wet test meter in inches of mercury.)

Example:

$$\begin{aligned} D_{act} &= 1.327 \\ & \frac{70.5 + 459.67}{530.17} \quad [(24,8031 - 0.02941176) - 0.378 (.875)] \\ &= 1.327 \\ & \frac{70.5 + 459.67}{530.17} \quad (24,773688 - 0.33075) \\ &= (0.00250297) (24.442938) \end{aligned}$$

$$D_{act} = 0.06117996$$

Log this in “Air Density lbs/ft³” column of log sheet.

6. Find the flow rate of the sampler at standard conditions (Q std) using this formula:

$$Q_{std} = Q_{act} \frac{D_{act}}{D_{std}}$$

(Where D std = .075 lbs/ft³)

$$\begin{aligned} \text{(i.e., } Q_{std} &= 18.88 \frac{(0.06117996)}{0.075} \\ &= 18.88 (0.8157328) \\ &= 15.40 \end{aligned}$$

Q std = 15.40 (write this down for each position in the Q 0.075 column)

3.3.3 Bubble Tube Method

Refer to Section 3.2.1 to perform this method.

3.3.4 Electronic Calibration

Refer to Section 3.2.3 to perform this method.

4. EXPOSURE CALCULATIONS AND RECORD MAINTENANCE

4.1 PERSONNEL EXPOSURE CALCULATIONS

4.1.1 DACs for Conventional Ores

4.1.1.1 Solubility Classes

The solubility class, chemical form and abundance of conventional ores at the Mill, and the resulting DACs to be used are as set out in the following table:

**Table 4.1.1.1-1
 Solubility Class, Chemical Form and Abundance of Conventional Ores**

Location	DAC	U nat	Th-230	Ra-226	Pb-210
Ore-Grind	6.00E-11	DAC is specified in 10 CFR Part 20			
Leach	2.8E-10	½ Ore, ½ Precipitation	½ Ore, ½ Precipitation	½ Ore, ½ Precipitation	½ Ore, ½ Precipitation
CCD	1.2E-11	Class D Sulfate 25%	Class W ¹ Sulfate 25%	Class W ¹ Sulfate 25%	Class D ¹ Sulfate 25%
SX	1.2E-11	Class D Sulfate 25%	Class W ¹ Sulfate 25%	Class W ¹ Sulfate 25%	Class D ¹ Sulfate 25%
Precipitation	5.00E-10	Class D ² Diuranate 100%	NA	NA	NA
Yellowcake Packaging	2.20E-11	Class Y: 90 % and Class W: 10 % Oxide 100%	NA	NA	NA
Tailings	1.70E-11	Class Y Oxide 4%	Class Y ² Oxide 32%	Class W ¹ Oxide 32%	Class W ¹ Oxide 32%

¹ 10 CFR Part 20, Appendix B

² NUREG/CR-0530, PNL-2870, D.R. Kalkwarf, 1979, "Solubility Classifications of Airborne Products from Uranium Ores and Tailings Piles"

4.1.1.2 Application of Conventional Ore DACs to Workplace Locations

The Conventional Ore DACs will be applied as follows to the various locations in the Mill site:

**Table 4.1.1.2-1
 Application of Conventional Ore DACs to Workplace Locations**

Type of DAC	DAC ($\mu\text{Ci/ml}$)	Individual Location
Ore/Grind	6.00E-11	Ore Scalehouse Ore Storage Maintenance Shop Warehouse Lunch Room Change Room Administration Bldg
Ore/Grind	6.00E-11	Dump Station
Ore/Grind	6.00E-11	SAG Mill SAG Mill Control Shifter's Office Operations Lunch Room Filter Press
Leach	2.80E-10	Leach Tank Area
CCD	1.20E-11	CCD Circuit Thickeners
SX	1.20E-11	SX Building South Boiler
Ore/Grind	6.00E-11	Control Room
Yellowcake Precipitation	5.00E-10	YC Precipitation & Wet Storage
Yellowcake Packaging	2.20E-11	North YC Dryer Encl. South YC Dryer Encl. YC Pkg Enclosure YC Drying & Packaging Area Packaged YC Staging Area
Tailings	1.70E-11	Truck Shop Tailings
Yellowcake Precipitation	5.00E-10	Vanadium Circuit

4.1.2 Sampling Time

Calculate the sampling time required to detect 10% of the DAC by solving for sampling time in the following equation:

$$\frac{\text{LLD}}{(\text{Sampling Time}) (\text{Flow Rate of Sampler})} = 0.1 \text{ DAC}$$

For example:

To detect 10% of the DAC for U-Nat, a 40 lpm air sampler would have to operate 57 minutes, assuming the sample counter has a lower level of detection of 10 dpm above background, i.e.:

$$\frac{(10 \text{ DPM}) \left(\frac{\text{pCi}}{2.22 \text{ DPM}} \right) \left(\frac{\text{E-6 } \mu\text{Ci}}{\text{pCi}} \right)}{(X \text{ min.}) \left(\frac{40 \text{ lit}}{\text{min.}} \right) \left(\frac{10^3 \text{ ml}}{\text{lit}} \right)} = \frac{2\text{E-}12 \text{ } \mu\text{Ci}}{\text{ml}}$$

$$X = 56.8 \text{ minutes}$$

4.1.3 Dose Calculations (10 CFR 20.1201-20.1202)

1. Analytical results of airborne particulate samples may be obtained in several different units that need to be converted into mg soluble natural uranium to determine the weekly exposures and into uCi-hr/ml or WL-hr to determine annual exposures. The following table presents a summary of the conversions that may be necessary. The first row of the table presents the operations to be performed in the conversions. Enter the measured weight or activity, the sampler flow rate, the sampling time, and the exposure time into the first four columns. Divide the values in column 1 by the values in column 2 and column 3, and then multiply by the values in columns 4 and 5 to obtain the units in column 6, or:

$$\frac{(\text{Column 1}) (\text{Column 4}) (\text{Column 5})}{(\text{Column 2}) (\text{Column 3})} = \text{Column 6}$$

UNIT CONVERSION TABLE

1	2	3	4	5	6
OPERATION	DIVIDE	DIVIDE	MULTIPLY	MULTIPLY	ANSWER
MEASURED VALUE	SAMPLER FLOW RATE	SAMPLING TIME	EXPOSURE TIME	CONSTANT	ANSWER
µg soluble U-Nat	L/min	min	hrs	1.2	mg soluble U-Nat
pCi soluble U-Nat	L/min	min	hrs	1.77	mg soluble U-Nat
pCi gross alpha	L/min	min	hrs	E-9	µCi-hrs ML
µg U-Nat	L/min	min	hrs	6.77E-10	µCi-hrs ML
µCi mL Radon	---	---	hrs	E7	WL-hrs

For example:

$$\frac{(10 \mu\text{g Soluble U-Nat})}{(2 \text{ L/min})} \frac{(10 \text{ hrs})}{(30 \text{ min})} (1.2) = 2 \text{ mg Soluble U-Nat}$$

See notes for a description of the unit conversions.

- The table on the following page is divided into four quadrants. Different quadrants are for soluble uranium, insoluble uranium, tailings dust, and radon. Select the proper quadrant for the type of airborne particulate being sampled. Enter the area, particulate concentration, and hours of exposure in the labeled columns of the selected quadrant.
- The protection factors are whole numbers, e.g., 10, 50, 1,000. Divide 1 by the protection factor and enter the quotient in the fourth column of each quadrant, e.g., for a protection factor of 1,000, enter 1/1,000 or 0.001 in the column. The 1/PF values are unit-less.
- Enter the product of the airborne concentration, the hours of exposure, the time, and 1/PF in the fifth column of each quadrant. Add these values and enter the total at the bottom of the column.
- On the dose calculations form which follows, enter the total for Soluble Uranium in the equation and calculate the corresponding mg. If a value exceeds 10 mg, an over-exposure may have occurred. If verified by a high uranium in urine results, an over-exposure has probably occurred and needs to be reported to the NRC.
- Enter the totals for Soluble Uranium, Insoluble Uranium, Tailings Dust, and Radon in their respective equations. Perform the indicated calculations, add the fractions

TOTAL	---	---	---		TOTAL	---	---	---	

DOSE CALCULATIONS (10 CFR 20.1201 + 20.1202)

Name	Soc. Sec. No.	Co. I.D. No.	Week	Year
Weekly Soluble Uranium	$\frac{(\mu\text{Ci-hr}) (1.77\text{E}9)}{(\text{mL})}$		=	_____ mg
		Limit		10 mg

Annual Soluble Uranium $\left(\frac{(\mu\text{Ci-hr})}{\text{mL}} \right) =$ _____
 (2000 hr) (5E-10)

Annual Insoluble Uranium $\left(\frac{(\mu\text{Ci-hr})}{\text{mL}} \right) =$ _____
 (2000 hr) (2E-11)

Annual Tailings Dust $\left(\frac{(\mu\text{Ci-hr})}{\text{mL}} \right) =$ _____
 (2000 hr) (*)

* = DAC for Th-230 = 6E-12;
 or = DAC for tailings dust.

Annual Radon with Daughters Present $\left(\frac{(\text{WL-hr})}{(2000 \text{ hr}) (0.33 \text{ WL})} \right) =$ _____

Subtotal _____

Limit 1

Deep Dose Equivalent = TLD Whole Body Dose in rem = _____ rem

Limit 5 rem

If the Deep Dose Equivalent is > 0.5 rem
 and
 the Subtotal is > 0.1, then

Total Effective Dose Equivalent = Deep Dose Equivalent + Committed Effective Dose Equivalent

= (_____ rem) + (5 rem) (_____ Subtotal) = _____ rem

Limit 5 rem

DOSE CALCULATIONS (10 CFR 20.1201 + 20.1202)

Notes:μ

1. PF = Respiratory Protection Factor.
2. The 10 mg soluble uranium per week limit in 10 CFR Part 20.1201 is more restrictive than the (40 hour) (DAC) limit for natural uranium, thus compliance is based on 10 mg per week.
3. The conversion of uCi-hr/mL to mg natural uranium is the product of:
 (air concentration) (hours of exposure) (breathing rate for light work)
 (conversion of minutes to hours) (specific activity of natural uranium)
 (conversion of ug to mg) which is:

$$\frac{(\mu\text{Ci-hr})}{\text{mL}} \frac{(2\text{E}4 \text{ mL})}{\text{min}} \frac{(60 \text{ min})}{\text{hr}} \left(\frac{\mu\text{g}}{6.77\text{E-}7 \mu\text{Ci}} \right) \frac{(E-3 \text{ mg})}{\mu\text{g}} =$$

$$\frac{(\mu\text{Ci-hr})}{\text{mL}} (1.77\text{E}9) = \text{mg U-Nat}$$

Thus to obtain mg natural uranium, multiply the μCi-hr/mL by 1.77E9.

- | | | | |
|----|--|---|-----------------------|
| 4. | Soluble Uranium DAC (Class D) | = | 5E-10 μCi/mL |
| | Insoluble Uranium DAC (Class Y) | = | 2E-11 μCi/mL |
| | Thorium-230 DAC (Class Y) | = | 6E-12 μCi/mL |
| | Radon with Daughters DAC | = | 3E-8 μCi/mL = 0.33 WL |
| | Tailings Dust DAC is a Site Specific Value | = | μ5. Description of |

unit conversions:

- a. ug soluble U-Nat → mg soluble U-Nat

$$\frac{\left(\frac{\mu\text{g}}{\text{L/min}} \right) (\text{min sampler}) (E3 \text{ mL})}{\text{L}} \frac{(\text{E-}3 \text{ mg})}{\mu\text{g}} \frac{(60 \text{ min})}{\text{hr}} (\text{hr exposure}) =$$

$$\frac{\left(\frac{\mu\text{g}}{\text{L/min}} \right) (\text{hr exposure}) (1.2)}{(\text{L/min}) (\text{min sampler})} = \text{mg soluble U-Nat}$$

- b. pCi soluble U-Nat → mg soluble U-Nat

$$\frac{(\text{pCi})}{(\text{L/min}) (\text{min sampler})} \frac{(\text{E-9 mCi})}{(\text{E3 mL})} \frac{(\text{mg})}{\text{L}} \frac{(2\text{E4 mL})}{6.77\text{E-7 mCi min}} \rightarrow$$

$$\frac{(60 \text{ min})}{\text{hr}} (\text{hr exposure}) =$$

$$\frac{(\text{pCi})}{(\text{L/min}) (\text{min sampler})} (\text{hr exposure}) (1.77) = \text{mg soluble U-Nat}$$

c. pCi gross alpha → μCi-hr

$$\frac{(\text{pCi})}{(\text{L}) (\text{min sampler})} \frac{(\text{E-6 μCi})}{(\text{E-3 mL})} (\text{hr exposure}) =$$

$$\frac{(\text{pCi})}{(\text{L}) (\text{min sampler})} (\text{hr exposure}) (\text{E-9}) = \frac{\text{μCi-hr}}{\text{mL}}$$

d. μg U-Nat → μCi-hr
mL

$$\frac{(\text{μg})}{(\text{L}) (\text{min sampler})} \frac{(\text{6.77E-7 μCi})}{(\text{E3 mL})} (\text{hr exposure}) =$$

$$\frac{(\text{μCi})}{(\text{L}) (\text{min sampler})} (\text{hr exposure}) (\text{6.77E-10}) = \frac{\text{μCi-hr}}{\text{mL}}$$

e. μCi of Radon-222 → WL
mL

$$\frac{(\text{μCi})}{\text{mL}} \frac{(\text{E6 pCi})}{\text{μCi}} \frac{(\text{E3 mL})}{\text{L}} \frac{(\text{L-WL})}{\text{E2 pCi}} =$$

$$\frac{(\text{μCi})}{\text{mL}} (\text{E7}) = \text{WL}$$

4.2 Personnel Exposure Files

The Company will generate and maintain individual exposure records for each employee that works at the White Mesa Mill. The record system will be designed to meet the specifications of the Federal Code of Regulations 10 CFR Part 20.

When an employee is hired, a file will be generated specifically for that individual. All records that are to be in the radiation exposure file will be maintained during the term of employment. When the employee terminates, all records will be preserved until the NRC authorizes their disposition.

Personnel exposure records will be maintained at the mill site and will be accessible only to the employee and the Radiation Safety staff. No copy of the exposure history will be furnished to anyone outside of the Radiation Safety Department without a signed consent form from the employee.

Contents of the exposure file:

Each personnel exposure file will contain the following records:

1. Information Sheet – Each information sheet will include the following information:
 - A. Employee's full name
 - B. Birth date
 - C. Social Security number
 - D. Date of hire
 - E. Date of termination

2. Record of Urinalyses – A multiple entry log of all urinalyses conducted at this work site will include the following information:
 - A. Employee's full name
 - B. Sample dates
 - C. Sample identification number
 - D. Concentration of uranium in $\mu\text{g/l}$
 - E. An entry for any quality assurance "spikes" entered in $\mu\text{g/l}$

3. Internal personnel Exposure Records – These will be calculated and prepared using the forms above or by the computer and the printout will be used as the permanent record in the exposure file. The internal exposure records will contain the following information:
 - A. Employee's full name
 - B. Social Security number

- C. Birth date
 - D. Exposure to airborne uranium expressed in both μCi and percent MPC
 - E. Any breathing zone samples collected for airborne uranium to be expressed in μCi
 - F. Radon daughters expressed in working levels (WL) and period of exposure (date)
4. External Exposure Record (OSL, Dosimeter) – The date received from the Dosimeter contractor will be posted to the Dosimeter record in the exposure file. The following information will be included on the Dosimeter record:
- A. Employee's full name
 - B. Birth date
 - C. Social Security number
 - D. Period of exposure (dates)
 - E. Exposure in millirems (mrem) for a given period
 - F. Total accumulated exposure while at the White Mesa Mill
 - G. Identification number of the Dosimeter badge
5. Record of Exposure from Previous Employment (NRC form 4 or similar) – A record of occupational exposures that occurred prior to employment at the mill must be obtained for each employee. If no such exposure record is available, the employee must sign a statement to that affect. If previous exposure records were kept, a copy must be secured and placed in the individual's file.
6. Reports of Over-exposure – If an individual has been found to be over-exposed, the RSO will draft a letter of explanation. The report will explain the circumstances and/or reasons for the over-exposure. It will also state any actions taken to correct the problem or to prevent future over-exposures. The report must be placed in the individual's exposure file.

5. RADIATION WORK PERMITS

5.1 General

A Radiation Work Permit (“RWP”) system has been established for non-routine activities where there is a potential for a significant radiation exposure, or for certain routine activities where there is a potential to spread radioactive materials.

Specifically, an RWP is required for:

- a) All non-routine maintenance work, or work for which there is no effective procedure, which may, by the determination of the RSO, exceed 25% of the R313-15 limits;
- b) All routine work, not covered by an procedure, that could involve the spread of radioactive materials; and
- c) The receipt, handling or processing of any alternate feed material or other radioactive material, which has been determined by the RSO, not to fall within an existing operating procedure.

An RWP may also be used on a temporary basis for routine activities in lieu of an procedure, while a procedure is being developed for the activity.

5.2 All Non-Routine Activities Require RSO Review

All non-routine activities require review by the RSO. The RSO will advise the Mill Manager on a regular basis of any activities that require an RWP.

5.3 Radiation Work Permit

The RWP is a form that describes the work to be performed, the location, duration and personnel involved, and the radiological controls needed, such as respirator, urine samples, breathing zone monitoring, time limitations for the activity, etc. The form must also have an area for the RSO, or his designee’s, signature. A copy of a form of RWP is attached.

5.4 Procedure for Obtaining a Radiation Work Permit

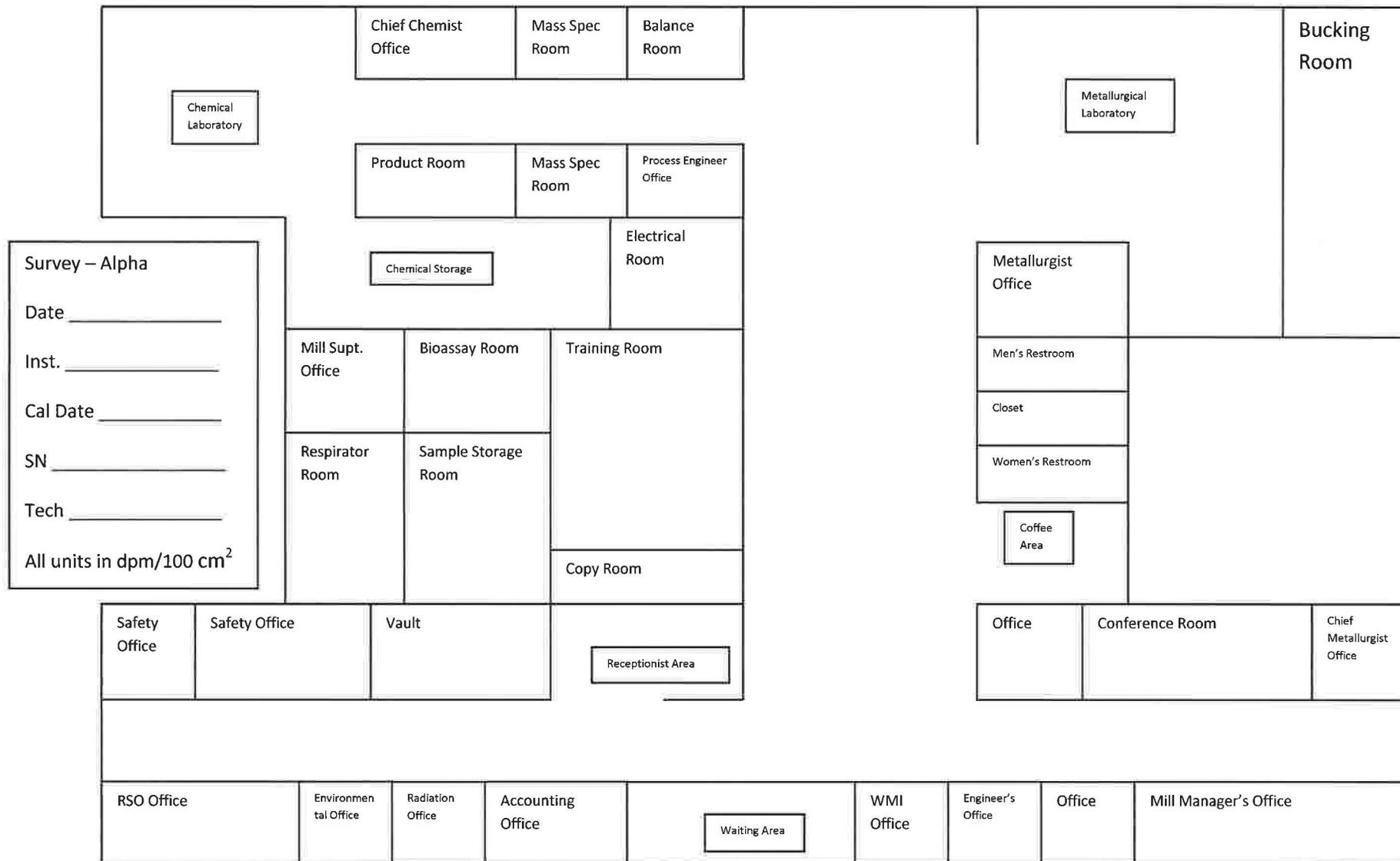
The procedure for obtaining an RWP is:

- a) When RWP-type work is to be performed, the Shift Foreman, Maintenance Superintendent or other supervisory personnel shall complete the top portion of the RWP, which will provide information on the specific work locations,

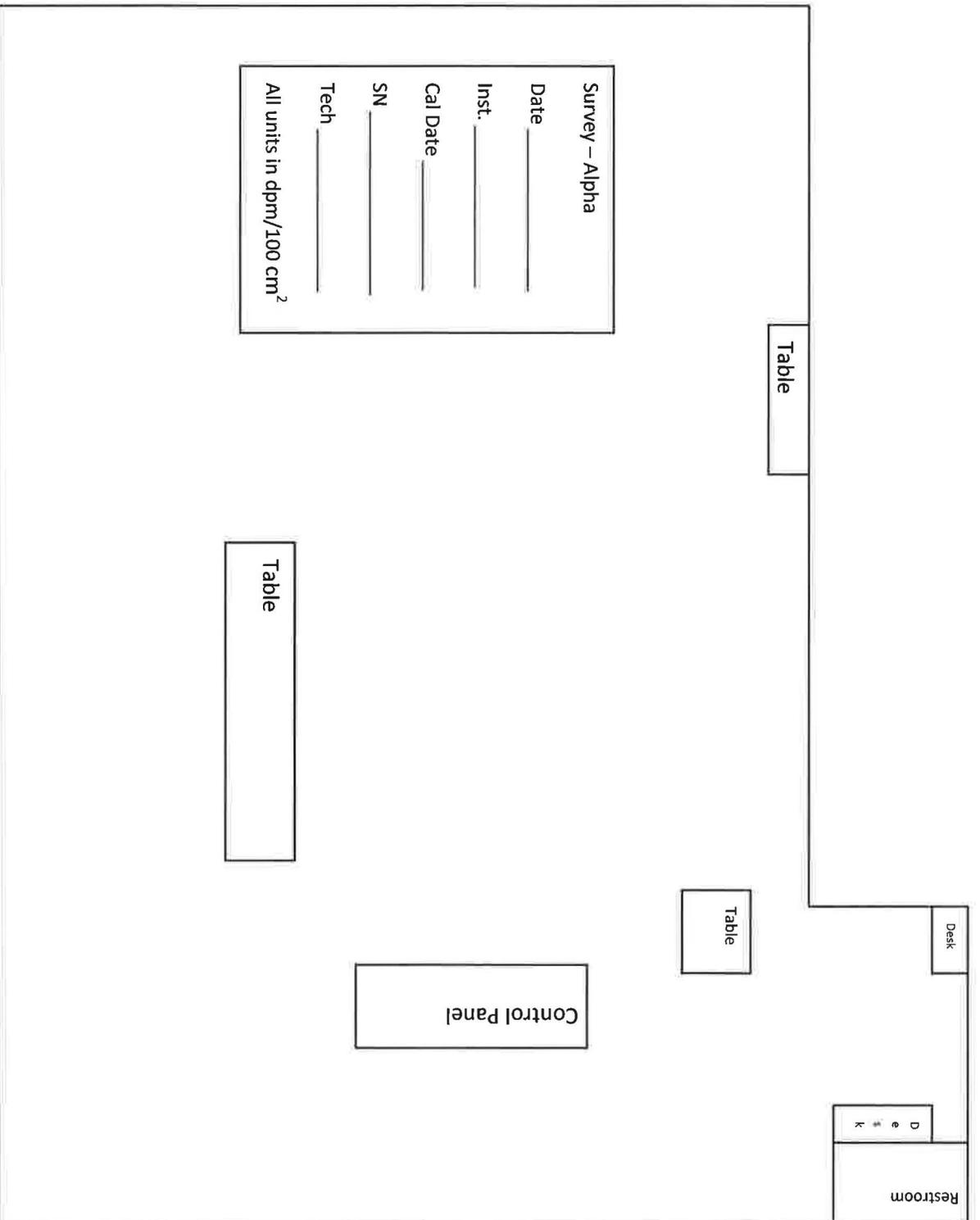
estimated work duration, type of work to be performed, and personnel utilized, and present it to the RSO;

- b) The RSO will indicate the radiological controls needed based on the information given and the safety of personnel. The RSO or his designee will provide the necessary surveillance and respiratory protection equipment;
- c) No work can be performed until the RSO or his designee has approved the RWP;
- d) Any maintenance or RWP jobs done in the yellowcake dryer or packaging enclosures will require a member of the Radiation Staff to be present for the duration of the job;
- e) All supervisors will be given training in and copies of the requirements for using RWPs, with the permits remaining on file for five years; and
- f) Any supervisor found to be knowingly and willfully violating these procedures will be issued a written warning, and the situation will be reviewed by appropriate management for remedial action.

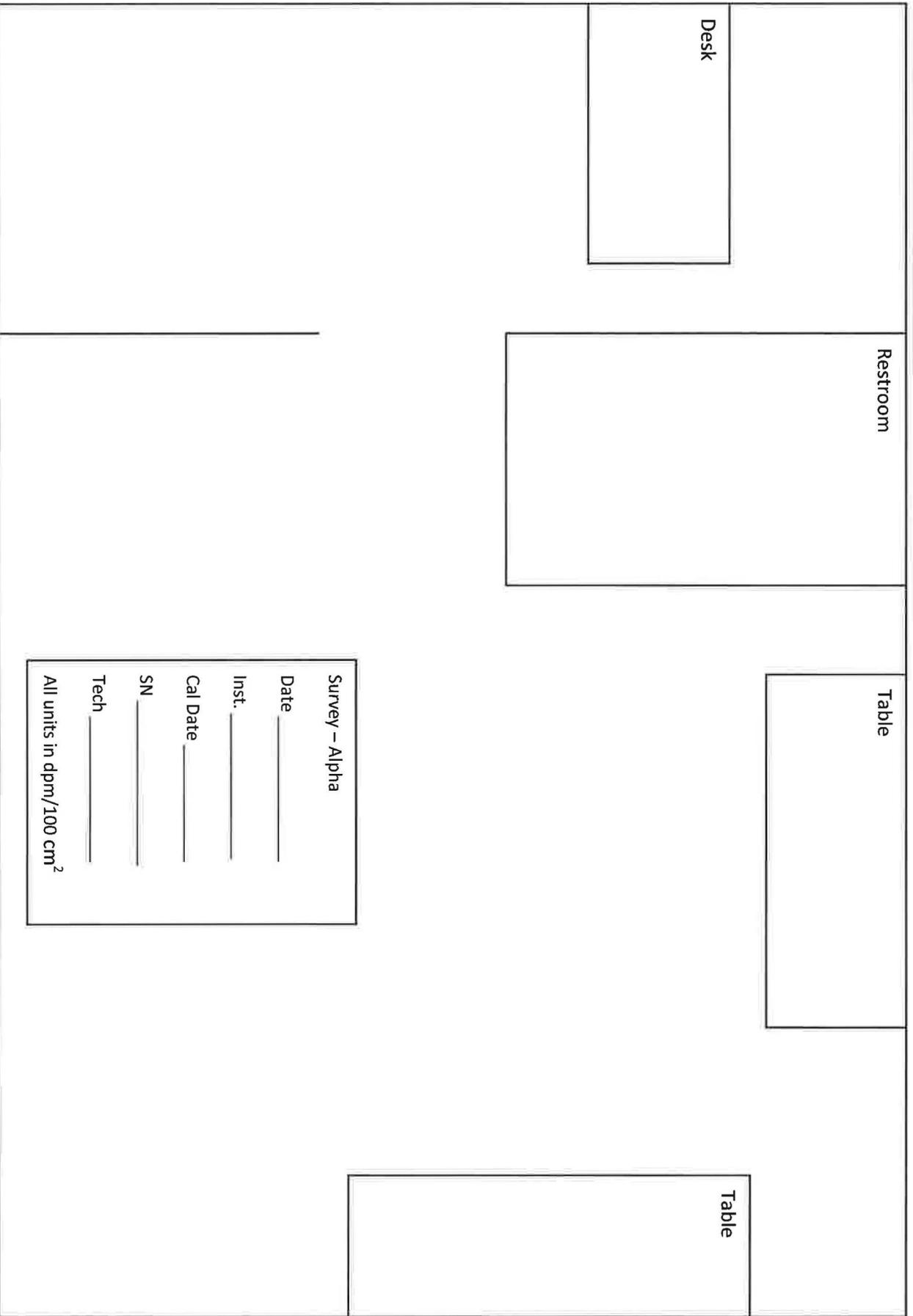
Administration Building



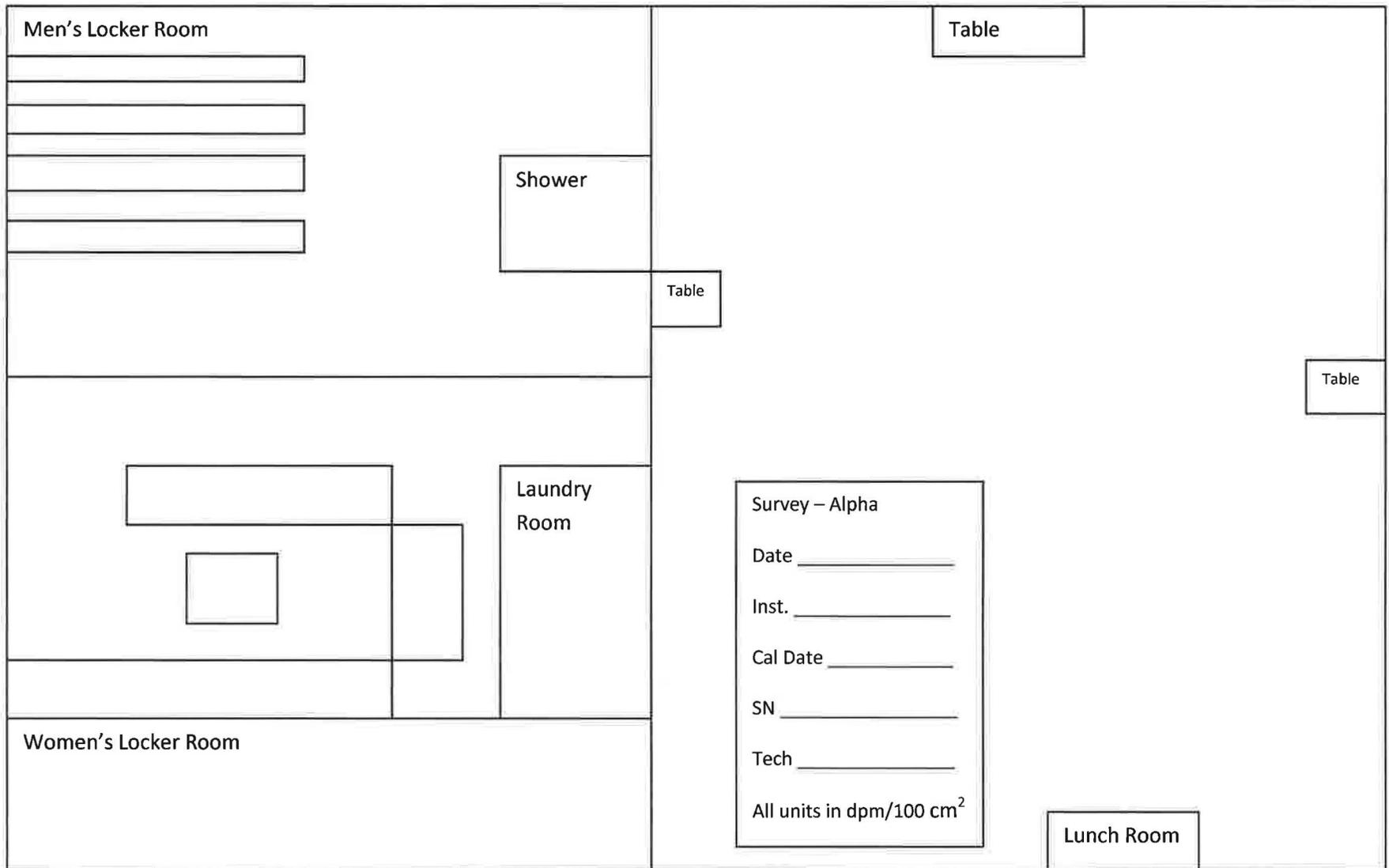
Central Control Room



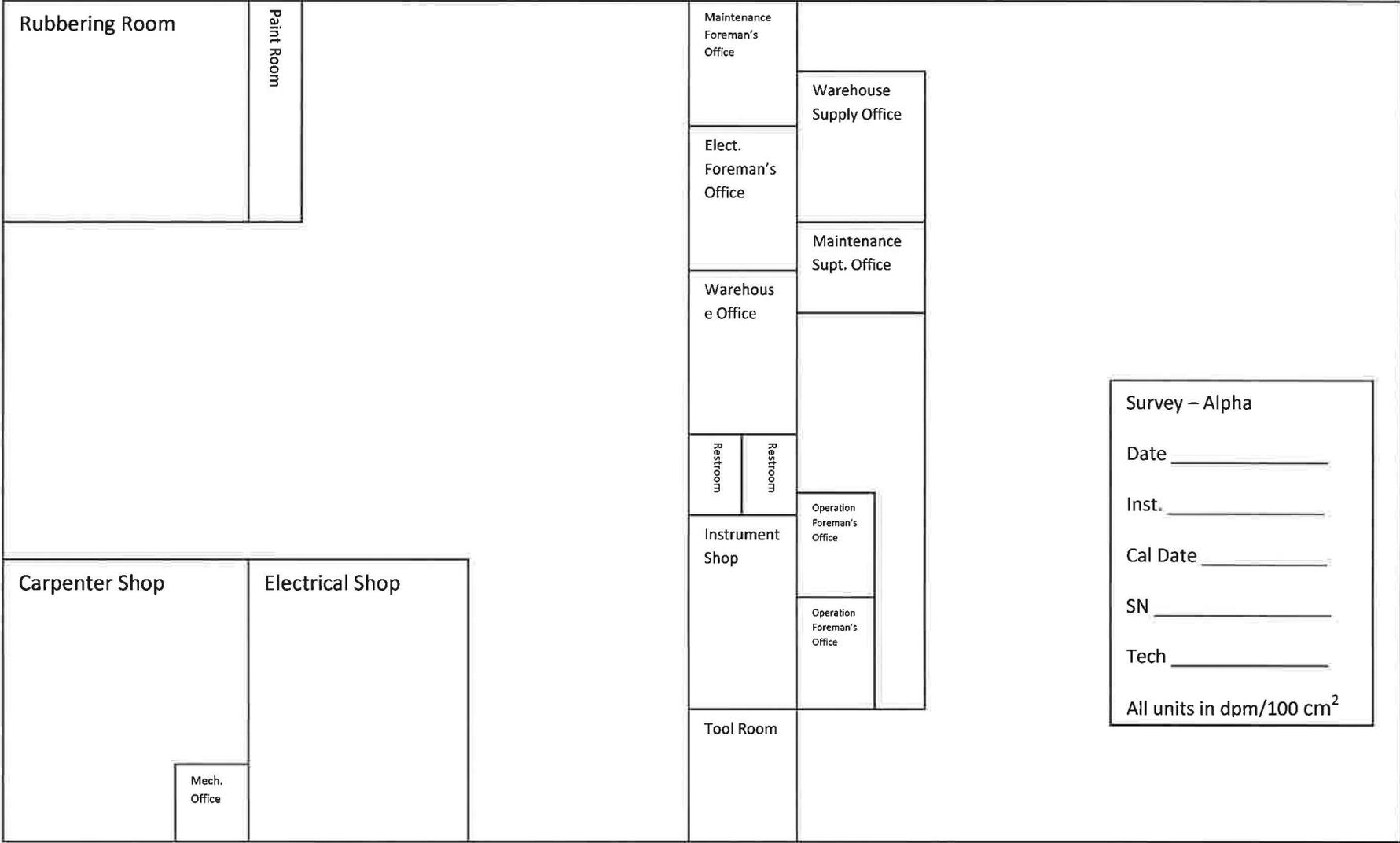
Scalehouse



Change/Lunch Room



Maintenance and Warehouse Areas



Survey – Alpha

Date _____

Inst. _____

Cal Date _____

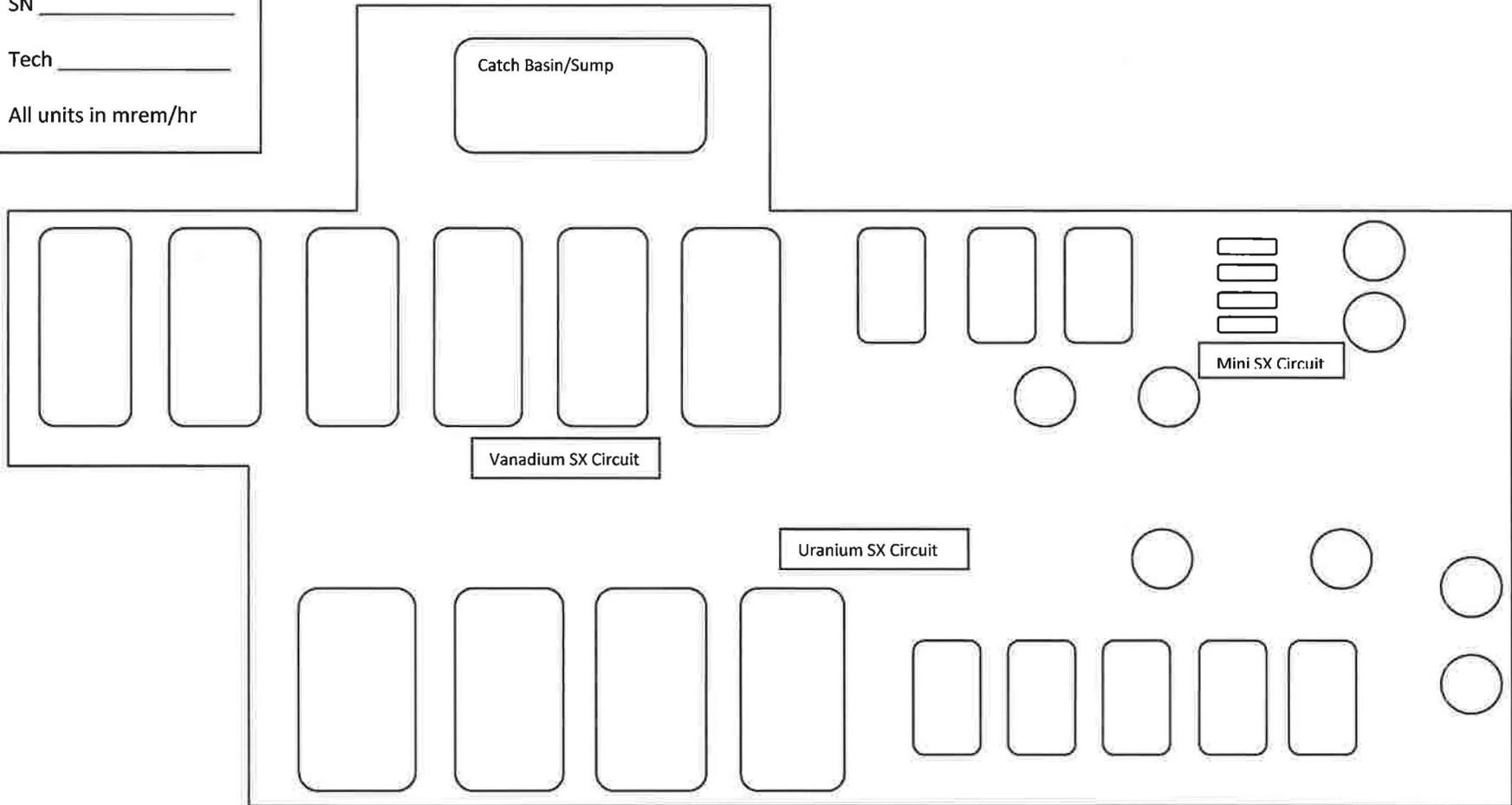
SN _____

Tech _____

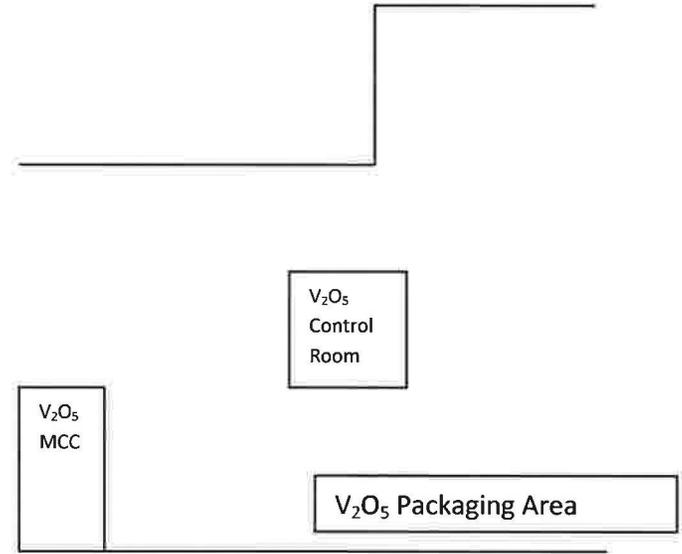
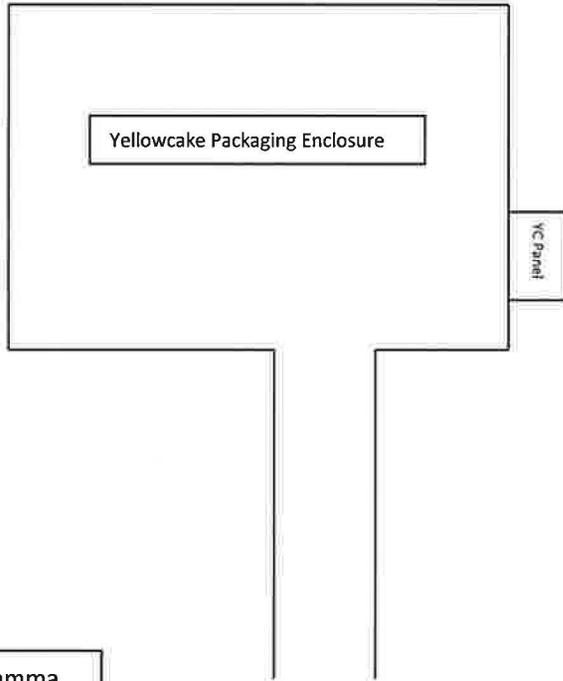
All units in dpm/100 cm²

SX Building

Survey – Beta/Gamma
Date _____
Inst. _____
Cal Date _____
SN _____
Tech _____
All units in mrem/hr



Product Packaging Areas



Survey – Beta/Gamma

Date _____

Inst. _____

Cal Date _____

SN _____

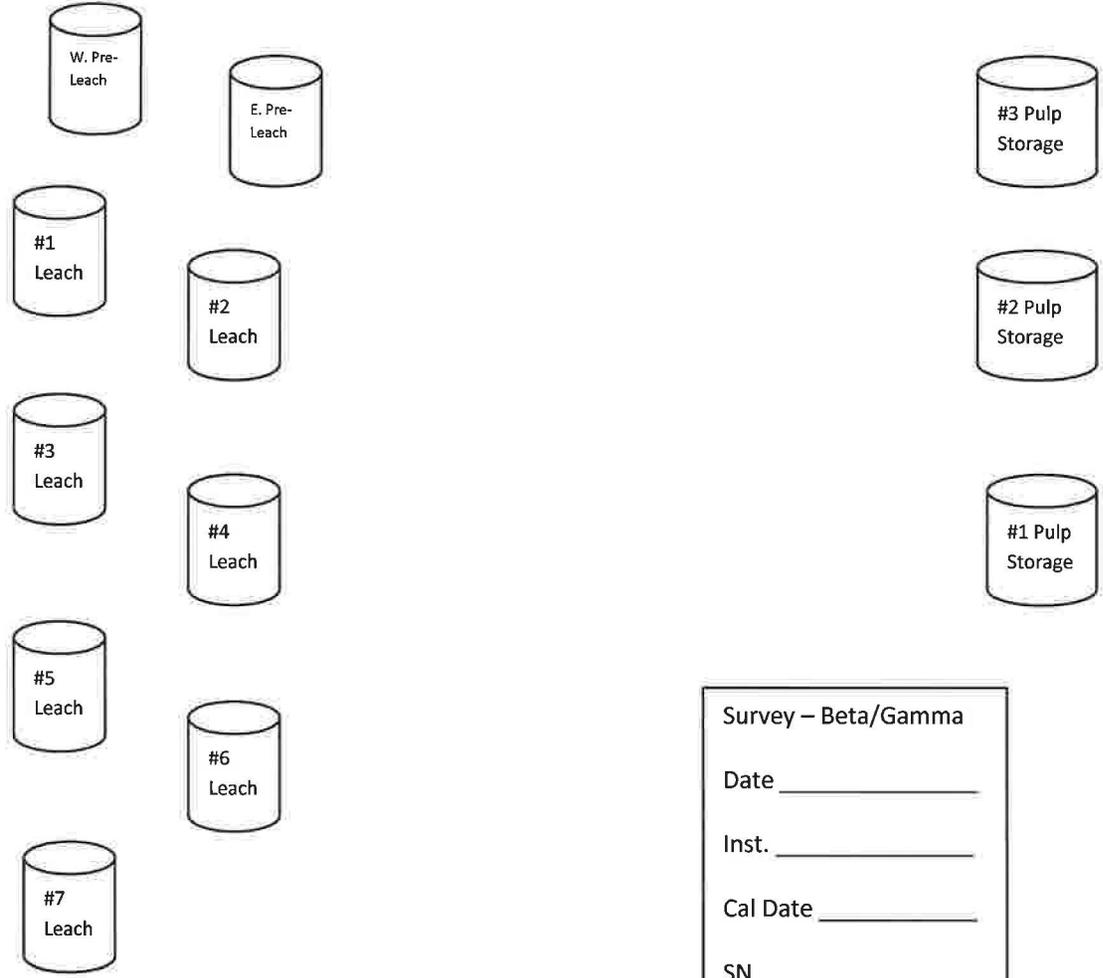
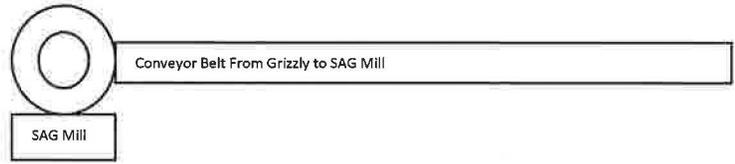
Tech _____

All units in mrem/hr

SAG Mill/Leach Areas

Old Shifter's Office

Old Operator's Lunch Room



Survey – Beta/Gamma

Date _____

Inst. _____

Cal Date _____

SN _____

Tech _____

All units in mrem/hr

Emergency Generator Building

Survey – Beta/Gamma

Date _____

Inst. _____

Cal Date _____

SN _____

Tech _____

All units in mrem/hr

Emergency Generator

CCD/Precipitation Circuits

Survey – Beta/Gamma

Date _____

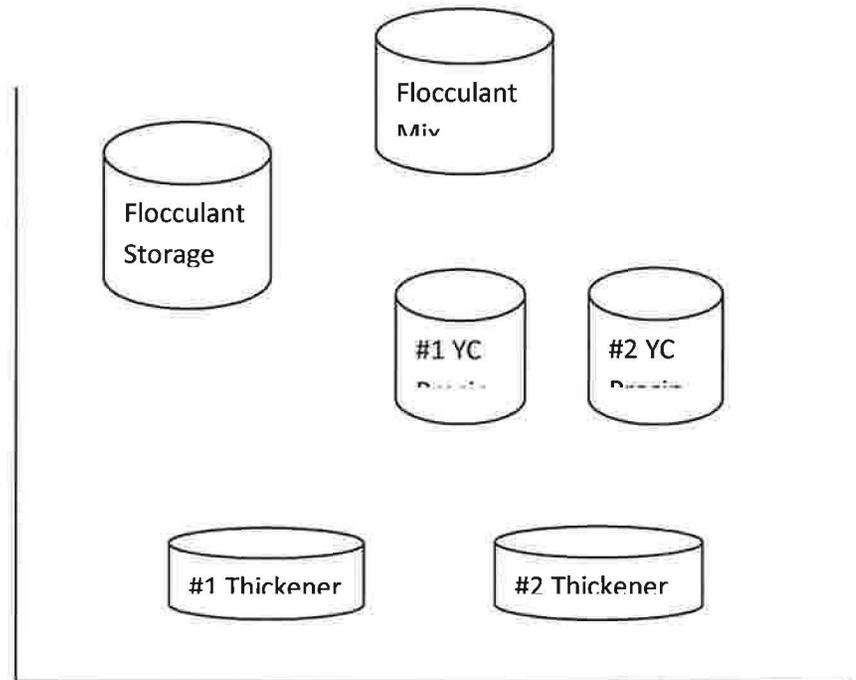
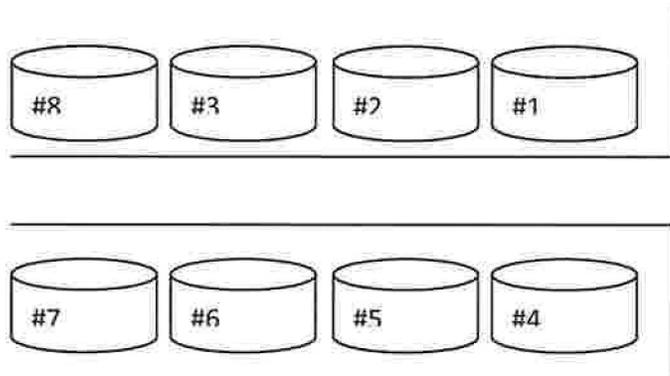
Inst. _____

Cal Date _____

SN _____

Tech _____

All units in mrem/hr



Uranium Packaging Circuit Upper Levels

Survey – Beta/Gamma

Date _____

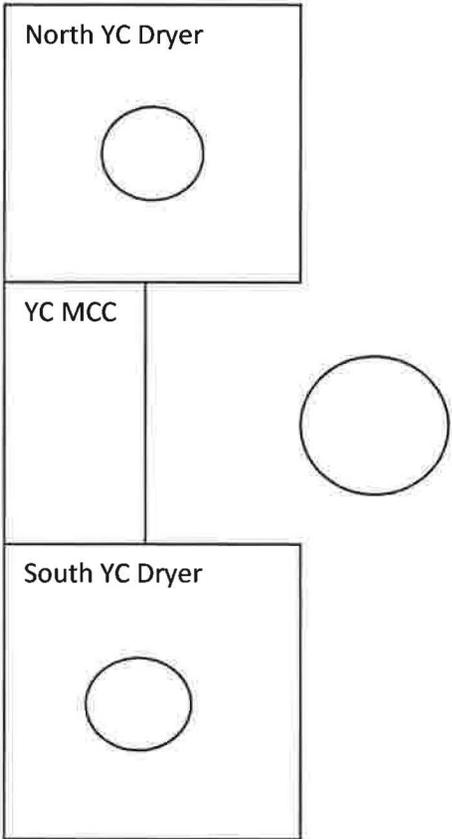
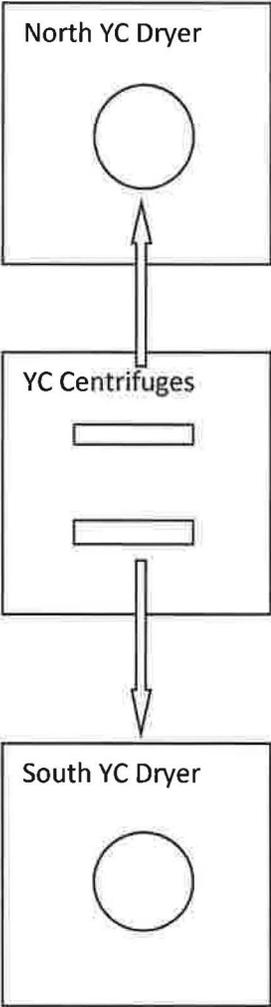
Inst. _____

Cal Date _____

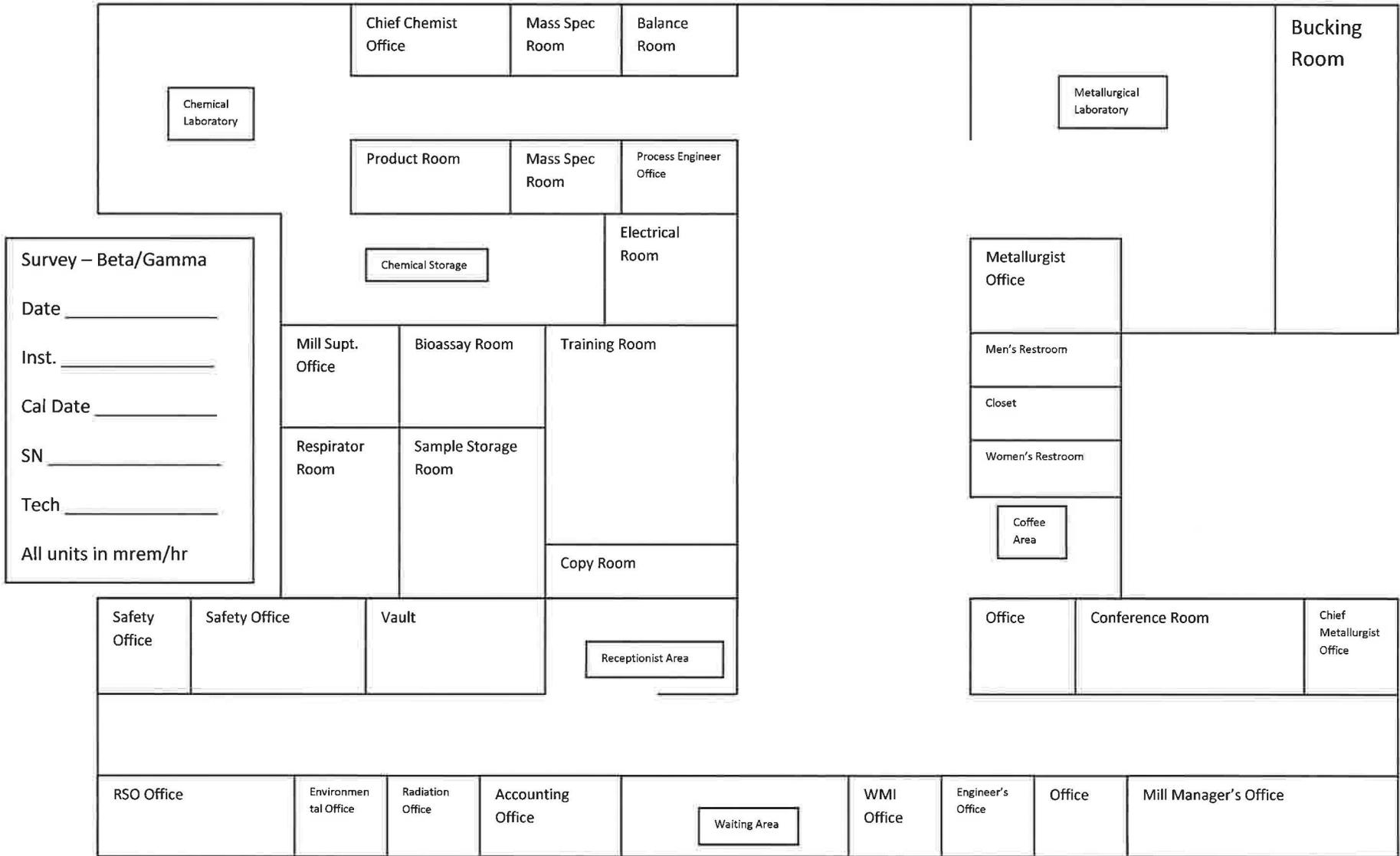
SN _____

Tech _____

All units in mrem/hr



Administration Building



Survey – Beta/Gamma

Date _____

Inst. _____

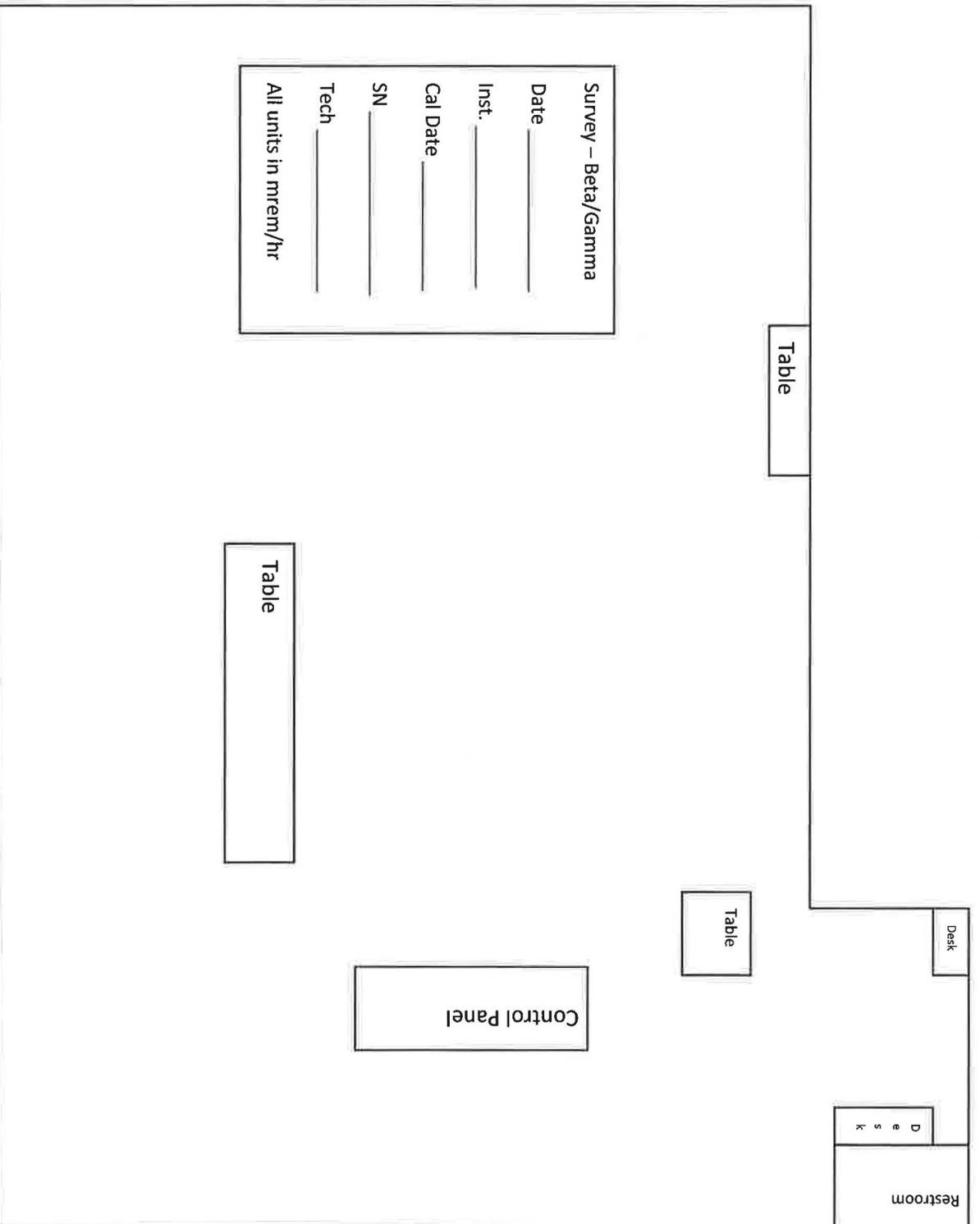
Cal Date _____

SN _____

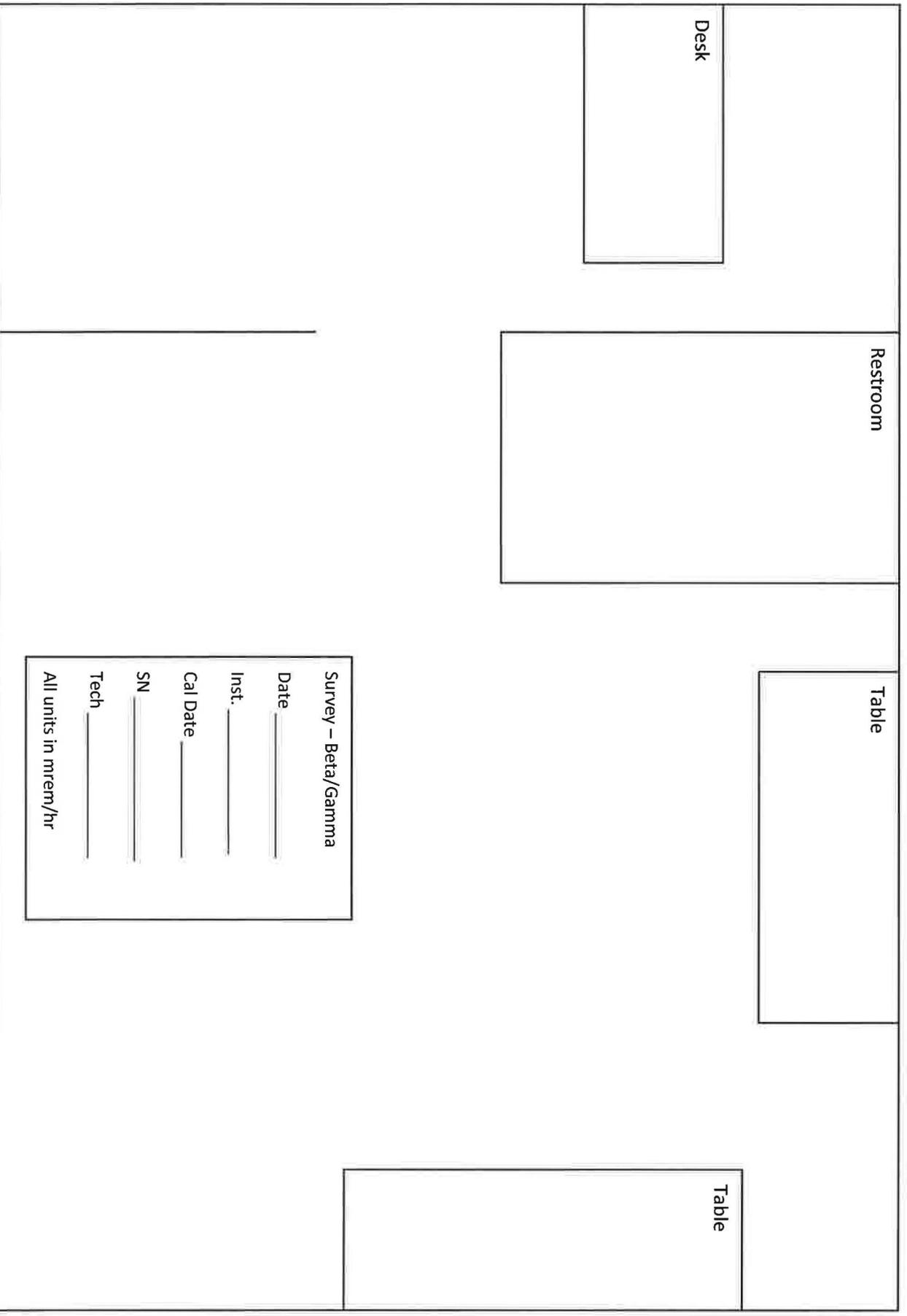
Tech _____

All units in mrem/hr

Central Control Room



Scalehouse



Survey – Beta/Gamma

Date _____

Inst. _____

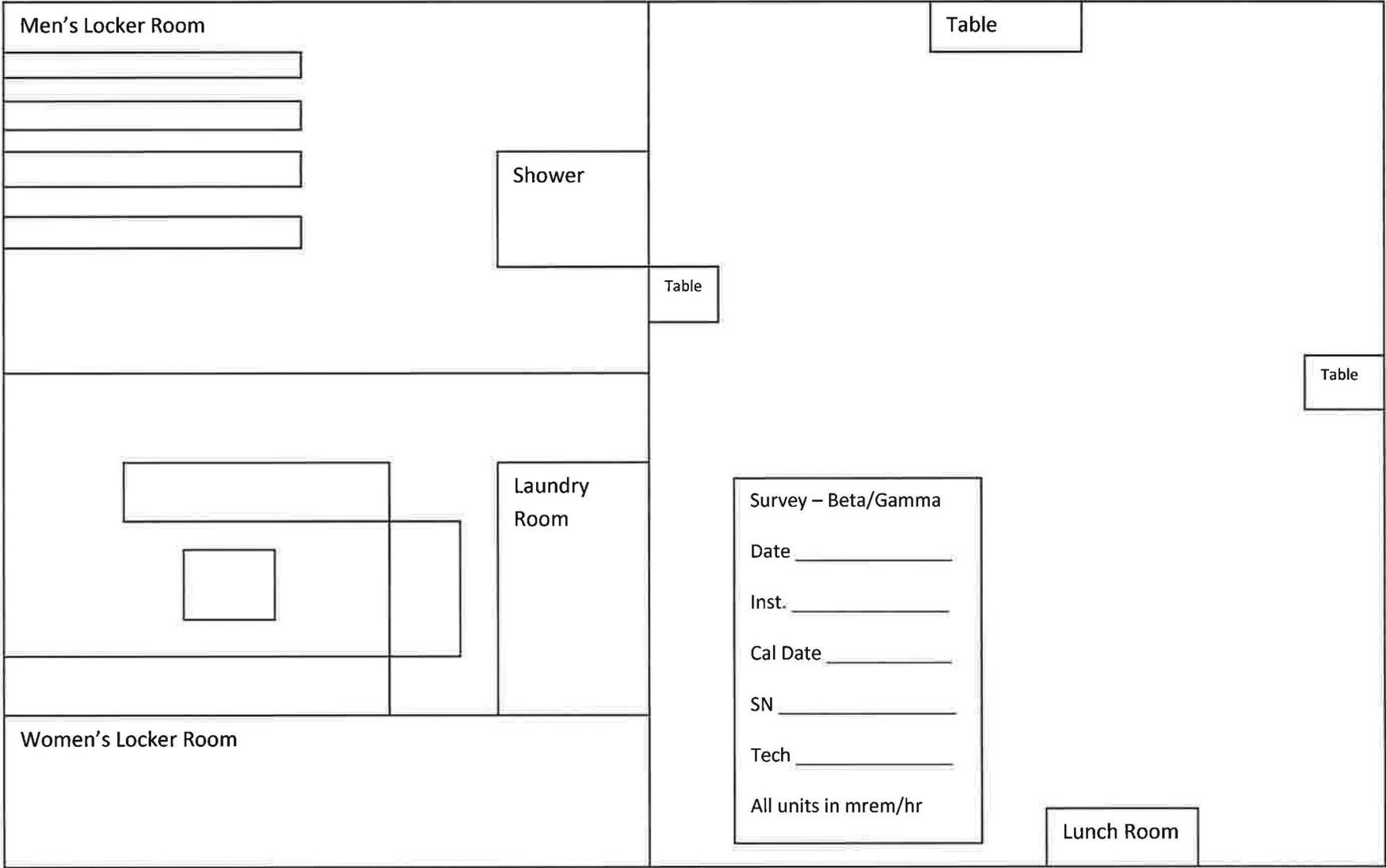
Cal Date _____

SN _____

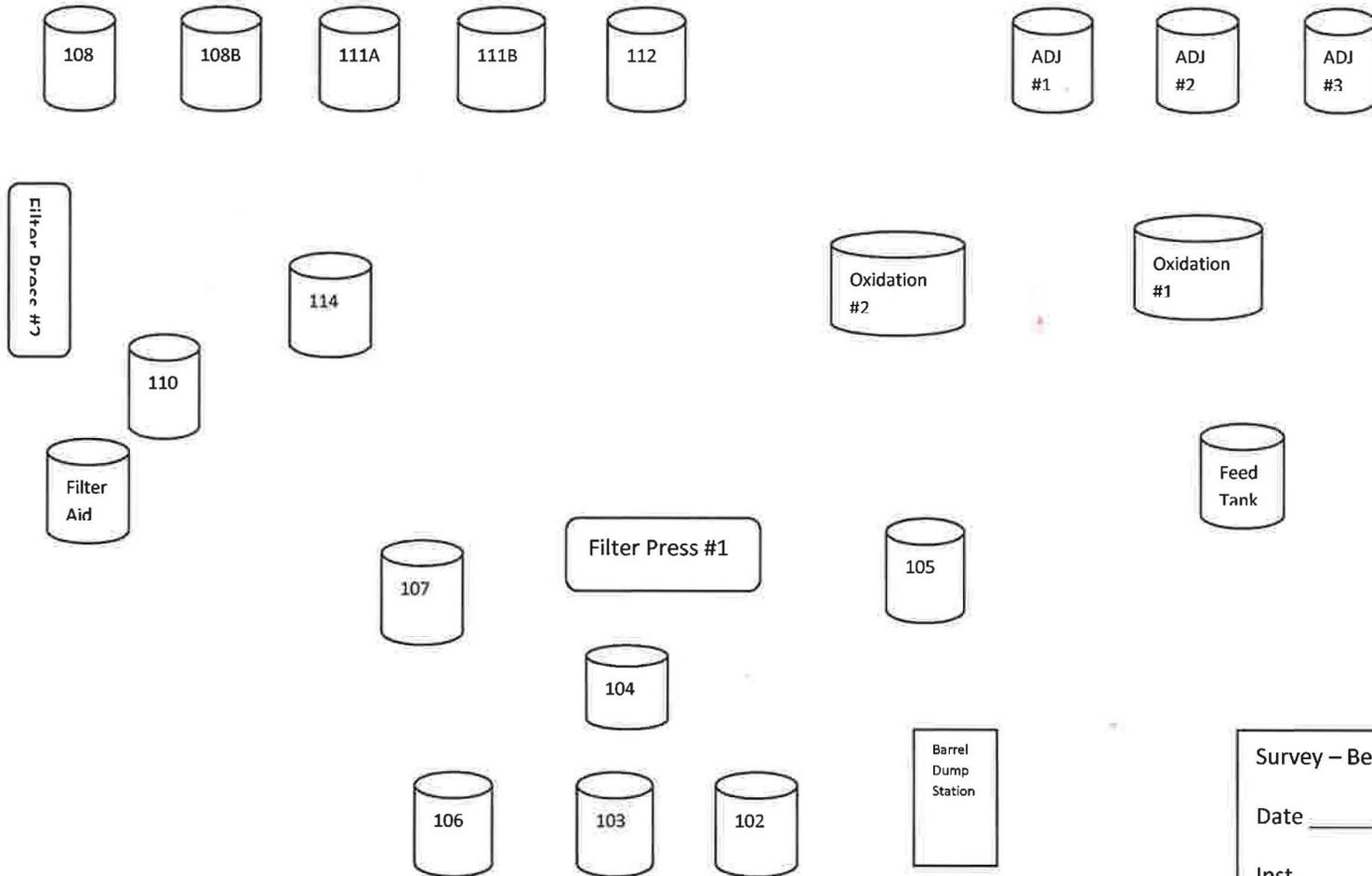
Tech _____

All units in mrem/hr

Change/Lunch Room

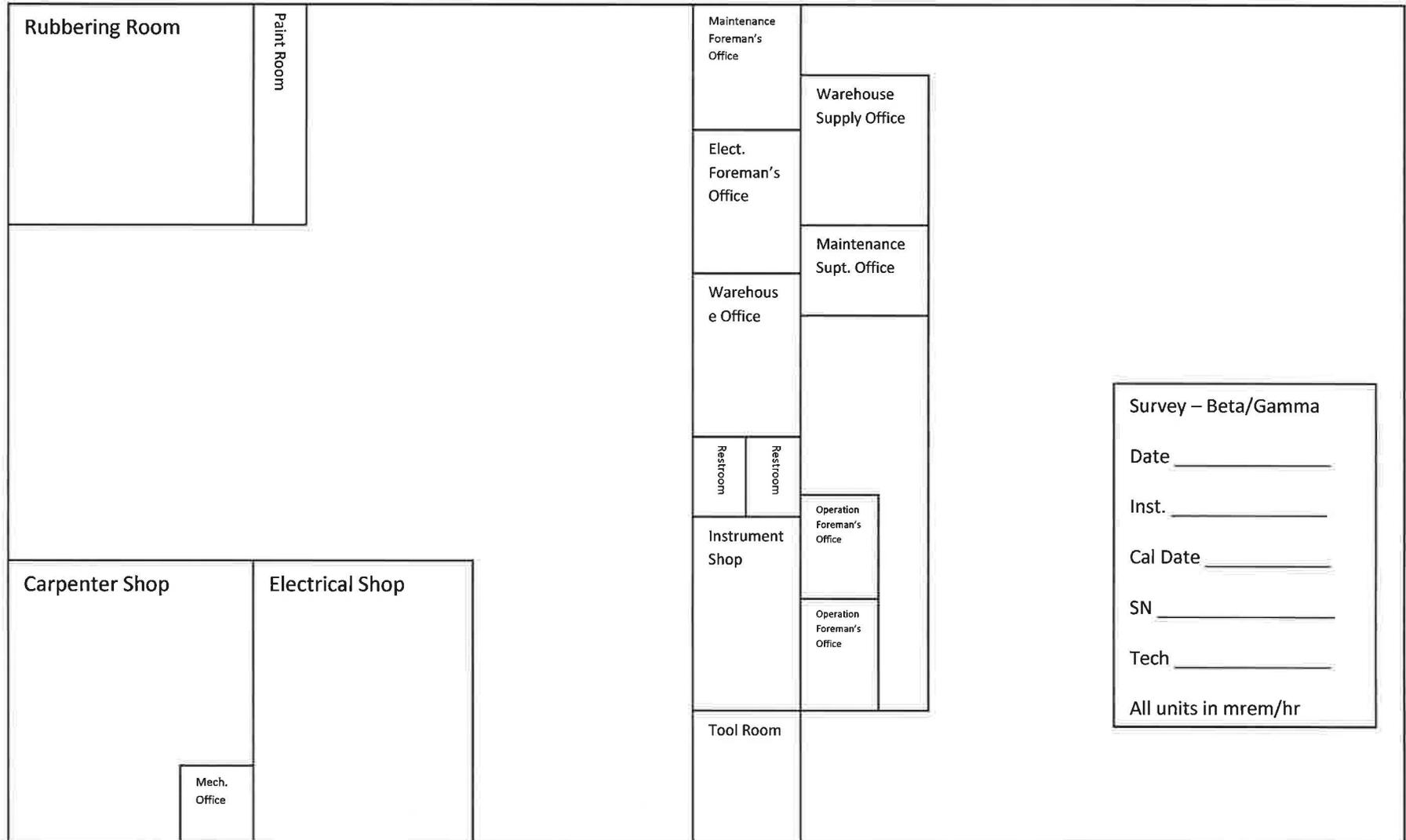


Alternate Feed Circuit



Survey – Beta/Gamma
Date _____
Inst. _____
Cal Date _____
SN _____
Tech _____
All units in mrem/hr

Maintenance and Warehouse Areas



Survey – Beta/Gamma

Date _____

Inst. _____

Cal Date _____

SN _____

Tech _____

All units in mrem/hr

Monthly Beta-Gamma Survey

Date: _____

Technician: _____

Function Check of Survey Instrument

Model #: _____

Serial #: _____

Calibration: _____

Source: _____

Source #: _____

Reading mrem/hr: _____

All units are in mrem/hr.

RSO Reviewed: _____

RSO Comments: _____

Tails Area

Survey – Beta/Gamma

Date _____

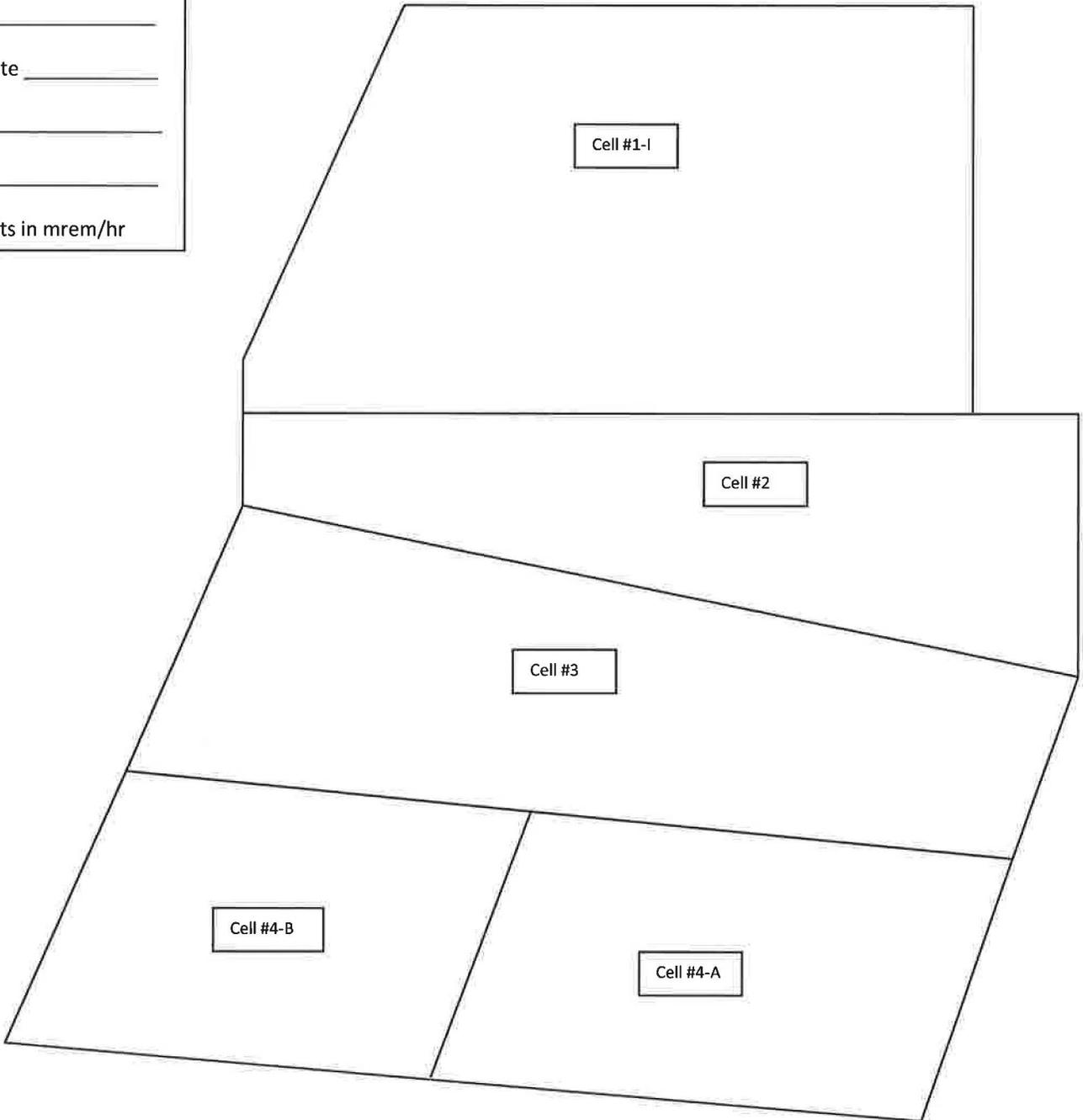
Inst. _____

Cal Date _____

SN _____

Tech _____

All units in mrem/hr



White Mesa Mill Weekly Alpha Survey

Date: _____

Technician: _____

Alpha Survey Instruments

Fixed

Model #: _____

Serial #: _____

Calibration: _____

Efficiency: _____

Factor: _____

Background: _____

MDA: _____

Removable

Model #: _____

Serial #: _____

Calibration: _____

Efficiency: _____

Factor: _____

Background: _____

MDA: _____

Notes:

All fixed readings are in dpm/100 cm²

T or t = Total or Fixed Alpha Reading in dpm/100 cm²

R or r = Removable Alpha Reading per swipe or filter (approximately 100 cm²)

RSO Reviewed: _____

RSO Comments: _____

Energy Fuels Resources (USA) Inc.
 White Mesa Mill
Radiation Survey of Equipment Released for Unrestricted Use

All equipment or material released from the White Mesa Mill to an unrestricted area must be surveyed for release in accordance with the following procedure.

1. Monitor for Gross alpha contamination with the appropriate survey meter.
2. If calculated assay exceeds 1,000 dpm/100cm², then perform swipe analysis at applicable points.
3. Decontaminate if a removable alpha exceeds 1,000 dpm/100cm² or fixed alpha exceeds 5,000 dpm/100cm².
4. Release equipment or material if alpha contamination and Beta-Gamma levels are below the following limit:

Removable alpha – 1,000 dpm/100cm²
 Fixed alpha- 5,000 dpm/100cm² average
 15,000 dpm/100cm² maximum

Beta-Gamma- 0.2 mr/hr @ 1cm average
 1.0 mr/hr @ 1cm maximum

Released from White Mesa Mill to: _____

Released by (print name): _____

Signature: _____

Date: _____

List of Equipment	Total Alpha dpm/100cm ²	Removable Alpha dpm/100cm ²	Beta/Gamma mr/hr
1.			
2.			
3.			
4.			
5.			

Instrument Function checks

Alpha Meter:
 Inst. Model _____ SN _____
 Th-230 Source SN _____
 dpm _____ cpm _____ eff _____
 Efficiency Factor _____
 Cal. Date: _____
 Bkg _____
 MDA _____

Beta-Gamma Meter:
 Inst. Model _____ SN _____
 Cs-137 Source SN _____
 Inst. Response _____
 Cal. Date: _____

Removable Alpha:
 Inst. Model _____ SN _____
 Th-230 Source SN _____
 dpm _____ cpm _____ eff _____
 Efficiency Factor _____
 Cal. Date: _____

Was a copy of this document offered to the recipient? Yes or No Signature of recipient _____

Comments: _____
