6.0 Bioassay Services

After a bioassay monitoring need has been identified and the appropriate types of measurements have been determined, the measurements need to be scheduled and performed. This chapter describes the normal bioassay services provided through the IDP, the scheduling of bioassay samples, and the generation, reporting, and follow-up of data. Special services not included here may be obtainable by contacting Internal Dosimetry.

Frequently used telephone numbers and mail stops for bioassay services are:

- Internal Dosimetry Office, 376-7245, P7-01
- IVRRF, 376-6102, B1-60
- Dosimetry Records, 376-7247, P7-01
- Severn Trent Laboratories, Richland, 375-3131.

6.1 Indirect Bioassay Measurement Services

The indirect bioassay analyses are performed by the Analytical Services Laboratory (Lab). Terms applicable to Lab services are provided in the Glossary. The Lab is responsible for the following activities:

- Providing sample kits, including kit delivery and pickup at designated locations (usually worker residences) within a 75-mile radius of Richland. (Field Dosimetry is responsible for kit delivery and pickup outside this range unless a mailer kit is used.) Delivery and pickup of routine and priority samples are usually available on business days only.
- Attempting a second pickup of a “container not out” sample on a day specified by Field Dosimetry, within 10 days after the originally scheduled pickup.
- Analyzing urine and fecal samples in four processing categories: routine, priority, expedite, and emergency.
- Analyzing miscellaneous samples, such as air filters, smears, blood, tissue specimens, or cloth, by emergency or priority processing

Provisions have been made for obtaining bioassay samples from workers outside the 75-mile service area through the use of mail and private carrier. Internal Dosimetry should be contacted if this method of bioassay sampling is to be done.

Kit Codes

The sample type and collection method are identified by the sample kit code. Kit codes that are available are described in Appendix B, Table B.4. Instructions for kit use are provided in Appendix D.

Lab Capability

The analytical and reporting requirements for the four processing categories as of FY 2003 are detailed in Tables 6.1 through 6.6. Changes in these requirements may occur from year to year. Therefore, Internal Dosimetry should be contacted if the most current information is needed.

Note that the contract detection levels (CL) listed are extracted from the contract statement of work (SOW) for the Lab and are considered the upper limit for acceptable performance. The detection levels calculated for comparison with the CLs, are based on the equations developed in the American National Standard HPS N13.30-1996, (HPS 1996) with 5% alpha and beta errors. These detection levels may not be the same as the detection levels calculated for the minimum detectable dose.

Minimum Sample Size

Minimum volumes for valid samples are specified in the Lab's statement of work. They generally depend on the same kit code and processing category. Unless otherwise noted, the numeric kit code represents both sample delivery and pick-up and the letter kit code designation represents sample pick-up only. Values are shown below:

Kit Code	Application	Routine Processing	Other Processing
1,P	Approximate 24 hr	500 mL	20 mL
2,Q	12-hr Termination	20 mL	20 mL
3,R	Total 24-hr	500 mL	20 mL
4,S	Single Void Urine	20 mL	20 mL
5,T	Feces	not applicable	20 g
6,U	Approximate 12-hr.	250 mL	20 mL
7,V	12-hr weekend	250 mL	20 mL
8,W	Single Void Fecal	20 g	not applicable
9,X	Mailer Kit	20 mL	20 mL
A,Y	Approximate 48-hr	1000 mL	not applicable
B,Not Applicable	12-hr Term Sample "Delivery Only"	20 mL	20 mL

Tritium is an exception to these values. The minimum volume for tritium analysis is 20 mL, regardless of kit code. For other analyses, samples with less than the listed volumes shall be reported as insufficient volume (IS) and shall not be processed unless specifically directed otherwise by the Battelle Technical Administrator.

TABLE 6.1 Analytical and Reporting Requirements for Routine Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level(a) (dpm/sample) Urine	Contractual Detection Level(a) (dpm/sample) Fecal	Determination Time (business days following sample receipt)	Reporting Time Oral[g]	Reporting Time Electronic[a]	Reporting Time Written[a]	Ora; Reporting Level; (dpm/sample) Urine	Ora; Reporting Level; (dpm/sample) Fecal
Pu(∝) Isotopic (IPU)	Pu-238, Pu-239, 240	0.02	0.2	20	By close of business on day of determination	Within five business days of determination	Within 10 business days of determination	Eq. 5	Eq. 5
Pu(∝) Isotopic (IPUL)	Pu-238, Pu-239, 240	0.005		30				Eq. 5	
Am-241 (AM241)	Am-241	0.02	0.8	20				Eq. 5	Eq. 5
Am-243 (AM243)	Am-243	0.02	0.8	20				Eq. 5	Eq. 5
Cm(∝) Isotopic (ICM)	Cm-242, Cm-243, + others(b)	0.02		20				Eq. 5	
U(∝) Isotopic (IU)	U-233, 234, U-235, U-238	0.02		20				(f)	
Th(∝) Isotopic (ITH)	Th-228, Th-229, Th-230, Th-232	0.1	1	20				Eq. 5	Eq. 5
Tritium (H3)	H-3	20 dpm/ml		5				10dpm/ml	
Sr-90 (SR90)[c]	Sr-90	10		30				5	
Gamma Spectroscopy (ISPEC)	K-40, Cs-137 + Others(d)	See Table B-5		20					
Gamma Spectroscopy (LEPD)	Am-241	5		20					
U-nat (U)	Elemental U	0.06 µg/sample	0.3 µg/sample	20				0.2	0.2
Sequential Analyses:									
Pu(∝) Iso and Sr-90 (IPS)[c]	As for individual analyses	As for individual analyses		35		As for individual analyses			
Pu(∝) Iso, Am-241 (IPA)				25					
Pu(∝) Iso, U-nat (IUPU)				25					
Actinide(∝) Isotopic (ITPAC)[e]				25					
Pu(∝) Iso and U ISO (IPIU)				25					
Pu(∝) Iso, Am-241, Sr-90 (IPSA)[c]				35					

(a) Time allowed following determination of results to reciept of results by Battelle.
(b) Reprt Cm-245, Cm-246, and Cm-248 if the measured activity exceeds the oral reporting level.
(c) If total Strontium is less than 15 dpm, Y ingrowth is not required.
(d) Report all isotopes present at levels exceeding Equation 5. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table B-5 specified in the processing instruction, regardless of the activity measured in the processing instructions, regardless of the activity measured.
(e) Pu(µ) Isotopic, Am-241, and Cm(µ) Isotopic.
(f) 0.16 dpm for U-234, 0.15 dpm for U-238, and the greater of 0.007dpm and Equation 5 for U-235.
(g) Oral report required only when analytical results exceed level specified.

Eq. 5 L_c=2(total propagated uncertainty)

TABLE 6.2 Analytical and Reporting Requirements for Priority Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level(a) (dpm/sample) Urine	Fecal	Determination Time (business days following sample receipt)	Reporting Time Oral(i)	Electronic(b)	Written(b)
Pu(∝) Isotopic (IPU)	Pu-238, Pu-239, 240	0.02	0.2	8	By close of business on day of determination	Within five business days	Within 10 business days
Cm(∝) Isotopic (ICM)	Cm-242, Cm-243, + others(c)	0.02	0.8	8			
U(∝) Isotopic (IU)	U-233/234, U-235, U-238	0.02	0.3	8			
Ra(∝) Isotopic (IRA)	Ra-224, Ra-226	0.3	1.5	8			
Np-237 (NP237)	Np-237	0.02	0.1	8			
Am-241 (AM241)	Am-241	0.02	0.8	8			
Am-243 (AM243)	AM-243	0.02	0.8	8			
Th(∝) Isotopic (ITH)	Th-228, Th-229, Th-230, Th-232	0.1	1	8			
U-nat (U)	Elemental U	0.06 µg/sample	0.3 µg/sample	8			
Tritium (H3)	H-3	20 dpm/ml		3			
C-14 (C14)	C-14	10 dpm/ml	200	3			
Sr-total (SR)	Sr-89, + 90	10	30	7			
Sr-Isotopic (ISR)	Sr-89, Sr-90	30, 30 respectively	45, 30 respectively	15(e)			
Sr-90 (SR90)	Sr-90	10	30	15(e)			
Pu-241 (PU241)	Pu-241	10	10	9			
Gamma Spectroscopy (ISPEC)	K-40, Cs-137 + Others(d)	See Table 6.5	See Table 6.5	3			
Gamma Spectroscopy (LEPD)	Am-241	5	5	8			
Sequential Analyses:							
Pu(∝) Iso and Sr-90 (IPS)	As for individual analyses	As for individual analyses		9(f)			
Pu(∝) Iso, Am-241 (IPA)				9			
Pu(∝) Iso, Am-241, Sr-90 (IPSA)				9(f)			
Pu(∝) Iso, Pu-241 (IPUB)				9(g)			
Pu(∝) Iso, Pu-241, Am-241 (IPUBA)				9(g)			
Pu(∝) Iso, U-nat (IUPU)				9(h)			
Pu(∝) Iso and UISO (IPIU)				9			

(a) CL is stated in terms of dpm/sample for fecal samples of 20 to 500 g.
(b) Time allowed following determination of results to reciept of results by Battelle.
(c) In addition, report Cm-245, Cm-246, and Cm-248 if the measured activity exceeds the oral reporting level.
(d) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table 6.5 specified in the processing instructions, regardless of the activity measured.
(e) Sr-90 to be determined within 15 business days. Total Strontium to be determined within 7 business days and reported orally upon determination. If total Strontium is less than 15 dpm, Y ingrowth is not required.
(f) Sr-90 to be determined within 16 business days. Total Strontium to be determined within 9 business days and reported upon determination. If total Strontium is less than 15 dpm, Y ingrowth is not required.
(g) Pu-241 to be determined within 16 business days.
(h) U-nat to be determined within 12 business days.
(i) Oral reports required for all analytical results.

TABLE 6.3 Analytical and Reporting Requirements for Expedite Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detections Level(a) (dpm/sample) Urine	Feces	Reporting Time Oral(e)	Electronic(b)	Written(b)
Pu(∝) Isotopic (IPU)	Pu-238, Pu-239, 240	0.08	3	By 9:00 a.m. on 2nd business day following sample receipt	Within five business days	Within 10 business days
Cm(∝) Isotopic (ICM)	Cm-242, Cm-243, 244, + Others(c)	1.2	70			
U(∝) Isotopic (IU)	U-233, 234, U-235, U-238	0.12	4			
Ra(∝) Isotopic (IRA)	Ra-224, Ra-226	0.3	3			
Am-241 (AM241)	Am-241	0.08	6			
Am-243 (AM243)	Am-243	0.08	6			
Np-237 (NP237)	Np-237	0.12	3			
Th(∝) Isotopic (ITH)	Th-228, Th-229, Th-230, Th-232	0.1	1			
U-nat (U)	Elemental U	0.5 µg/sample	5 µg/sample			
Tritium (H3)	H-3	100 dpm/ml				
C-14 (C14)	C-14	20 dpm/ml	2000			
Sr-total (SR)	Sr-89, 90	50	150			
Gamma Spectroscopy (ISPEC)	K-40, Cs-137 + Others(d)	See Table 6.5	See Table 6.5			
Gamma Spectroscopy (LEPD)	Am-241	5	5			
Sequential Analyses:						
Pu(∝) Iso, Am-241 (IPA)	As for individual analyses	As for individual analyses		As for individual analyses		
Pu(∝) Iso, Sr-tot (IPSR)						
Pu(∝) Iso, Sr-tot, Am-241 (IPSA)						
Pu(∝) Iso, U-nat (IUPU)						

(a) Detection level in terms of dpm/300 ml for urine samples in excess of 300 ml. CL is stated in terms of dpm/sample for fecal samples of 20 to 500 g.
(b) Time allowed following oral report to delivery of results to the Battelle Technical Administrator.
(c) Report Cm-245, Cm-246, and Cm-248 if their measured activity exceeds the oral reporting level.
(d) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table 6.5 specified in the processing instructions, regardless of the activity measured.
(e) Oral report required for all analytical results.

TABLE 6.4 Analytical and Reporting Requirements for Emergency Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detections Level(a) (dpm/sample) Urine	Feces	Reporting Time Oral (hours following sample receipt) Urine/Feces (b)	Electronic(c)	Written(c)
Pu(∝) Isotopic (IPU)	Pu-238, Pu-239/240	0.5	9	7/8	Within five business days	Within ten business days
Cm(∝) Isotopic (ICM)	Cm-242, Cm-243, 244, + Others(d)	10	240	6/8		
U(∝) Isotopic (IU)	U-233/234, U-235, U-238	1	12	7/8		
Ra(∝) Isotopic (IRA)	Ra-224, Ra-226	2	10	6/8		
Am-241 (AM241)	Am-241	1	20	7/8		
Am-243 (AM243)	Am-243	1	20	7/8		
Np-237 (NP237)	Np-237	1	10	7/8		
Th(∝) Isotopic (ITH)	Th-228, Th-229/230, Th-232	0.5	2	7/8		
U-nat (U)	Elemental U	7 µg/sample	8 µg/sample	3/8		
Tritium (H3)	H-3	100 dpm/ml		3/-		
C-14 (C14)	C-14	100 dpm/ml	10,000	3/8		
Sr-total (SR)	Sr-89, 90	80	450	4/8		
Gamma Spectroscopy (ISPEC)	K-40, Cs-137 + Others(e)	See Table 6.6	See Table 6.6	3/3		
Gamma Spectroscopy (LEPD)	Am-241,Am-243	20	20	3/3		
Sequential Analyses:						
Pu(∝) Iso, Am-241 (IPA)	As for individual analyses	As for individual analyses	As for individual analyses	7/8		
Pu(∝) Iso, Sr-tot (IPSR)				7/8		
Pu(∝) Iso, Sr-tot, Am-241 (IPSA)				7/8		
Pu(∝) Iso, U-nat (IUPU)				7/8		

(a) Detection level in terms of dpm/300 ml for urine samples in excess of 300 ml. CL is stated in terms of dpm/sample for fecal samples of 20 to 500 g.
(b) Oral report required for all anlytical results. These time requirements apply for up to six samples submitted at any one time except for gamma spectroscopy analysis for which the requirements apply for up to 5 samples submitted at one time and gamma spectoscopy for Am-241 and Am-243 (LEPD) for which the requirements apply to two samples submitted at one time. However, additional samples up to 25 (20 for LEPD) at one time must be competed within 24 hours.
(c) Time allowed following oral report to delivery of results to the Battelle Technical Administrator.
(d) Report Cm-245, Cm-246, and Cm-248 if their measured activity exceeds the oral reporting level.
(e) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.6. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table 6.6 specified in the processing instructions, regardless of the activity measured.

. **Table 6.5** Contractual Detection Levels for Routine, Priority, and Expedite Processing of Gamma Spectroscopy Analysis[a]

Isotope	CL, Urine (dpm/sample)[b]	CL, Feces (dpm/sample)
^{60}Co	15	15
^{59}Fe	15	15
^{54}Mn	10	10
^{106}Ru	60	75
^{141}Ce	15	20
^{144}Ce	40	50
^{134}Cs	10	10
^{137}Cs	15	15
^{95}Zr	15	20
^{140}Ba	35	35
^{131}I	10	20
^{24}Na	15	15
^{22}Na	15	15
^{65}Zn	20	20
^{239}Np	25	30
^{241}Am	70	65

(a) The Contractor shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and CLs listed shall be interpreted as a minimum requirement; the Contractor shall detect and quantify all other gamma emitters present at a nominal detection level of 20 dpm for each unspecified nuclide with E_τ >100 keV as relative to the energy and photon abundance ^{137}Cs.

(b) CL is in units of dpm/L, for samples greater than or equal to 1 L.

Table 6.6. Contractual Detection Levels for Emergency Processing of Gamma Spectroscopy Analyses[a]

Isotope	CL, Urine (dpm/sample)[b]	CL, Feces (dpm/sample)
^{60}Co	35	35
^{59}Fe	35	55
^{54}Mn	20	35
^{106}Ru	115	220
^{141}Ce	20	35
^{144}Ce	75	145
^{134}Cs	20	30
^{137}Cs	20	35
^{95}Zr	30	50
^{140}Ba	60	115
^{131}I	15	25
^{24}Na	25	25
^{22}Na	25	25
^{65}Zn	40	65
^{239}Np	40	70
^{241}Am	100	180

(a) The Contractor shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and CLs listed shall be interpreted as minimum requirements; the Contractor shall detect and quantify all other gamma emitters detectable using the same conditions as for the CLs listed.

(b) CL is in units of dpm/L, for samples greater than or equal to 10 mL.

6.2 In Vivo Measurement Services

Routine in vivo measurements are performed at the 747-A Building. In vivo measurement services are summarized below and details are provided in the *In-Vivo Monitoring Program Manual* (PNL-MA-574). The type of measurement performed depends on the radionuclide(s) being tested for and the expected location of the radionuclide(s) in the body.

6.2.1 Whole Body Counts

Most gamma-emitting radionuclides can be easily detected by a standard whole body count. This measurement is normally scheduled as a periodic routine measurement or when an employee is newly hired, terminated, or beginning or ending a special project. Whole body counts are scheduled by Field Dosimetry through the REX System. A limited number of walk-ins can also be accommodated.

Routine whole body measurements are performed using two systems, the NaI or the HPGe (Coax Counter). A screening count is performed on the Preview Counter, using five NaI detectors. If the Preview Counter indicates the presence of an occupationally related radionuclide, or if there are interferences that limit the usefulness of NaI spectrometry, the Coax Counter is also used. The Coax Counter uses seven coaxial germanium detectors to better resolve and quantify radionuclides, especially in the presence of interfering radionuclides, such as radon progeny. Routine 10-minute coax counts are performed on workers for whom more sensitive measurements are required because of radionuclide mixture or potential interferences on the NaI system. A 20-minute recount is performed if a result exceeds the decision level.

A mobile whole body count is available which has technology and sensitivities comparable to the Preview Counter. This system is contained in a trailer and requires substantial lead-time for assembly and relocation.

Table 6.7 lists the detection capabilities for radionuclides routinely quantified by the preview counter. The Coax Counter provides sensitivity equal to or better than that of the preview counter for all listed radionuclides. A peak search analysis is performed on each spectrum to look for peaks from nuclides that are not normally expected to be present. The peak search is less sensitive than the library directed analysis.

Table 6.7. Nominal Minimum Detectable Amount (MDA) Values for Whole Body Exams

Nuclide	Preview Counter MDA (nCi)[(a)]	Coax Counter MDA (nCi)[(b)]
^{40}K	10	12
^{60}Co	1.3	0.6
^{137}Cs	1.3	0.8
^{154}Eu	3.7	1.7

(a) The MDA values are for routine 200-s measurements with the Preview Counter (five cylindrical sodium-iodide detectors in a vertical array). The corresponding values for 200-s measurements with the mobile counter are comparable.

(b) The MDA values are for 600-s variable velocity scans with the coaxial germanium detector system positioned posteriorly to the supine subject. The corresponding values for 1200-s measurements will be decreased by a factor of approximately 1.4.

6.2.2 Chest Counts

Chest counting is also performed when there is concern about the presence in the lung of radionuclides that emit photons with energies of less than 200 keV. A chest count must be scheduled in advance with the IVRRF staff. When possible, annual chest counts are scheduled to coincide with a worker's whole body measurement and physical examination. There are two sensitivities of chest counts: a normal count (code C) and an extra-sensitive count (code C2). They differ only in the length of the count. Detection capabilities for chest counts are listed in Table 6.8. In addition chest counts may be scheduled to provide only americium-241 results (code CA), only uranium-235 and thorium-234 results (code CU), or the combination of all three results (code CC).

Table 6.8. Nominal Minimum Detectable Activity (MDA) Values for Planar Germanium Detector In Vivo Measurements

Measurement and Radionuclide	MDA (nCi)
Normal Chest Count[(a)]	
^{241}Am	0.16
^{235}U	0.09
^{234}Th	1.50
Skeleton Burden by Head Count[(b)]	
^{241}Am	0.5
Liver Count[(c)]	
^{241}Am	0.17
Thyroid Count[(d)]	
^{125}I	0.80
^{131}I	0.10
Transuranic Wound Count (600-s count time)	
^{241}Am (59.5 keV x-ray)	Determined as needed
^{239}Pu (17.0 and 20.4 keV x-rays)	Determined as needed

(a) Values are for 3000-s measurements with four detectors.
(b) Value is based on 3000-s measurement with two detectors positioned on the forehead.
(c) Value is based on 3000-s measurement with three detectors positioned over the liver.
(d) Values are based on 600-s measurements with one 38 cm^2 detector positioned 10cm above the thyroid.

If activity is detected in a chest count, a measurement of chest wall thickness, a liver count, and a head count may also be needed to make appropriate corrections to the chest count data. These measurements may be performed on the same day or rescheduled for a later date. Ultrasound measurements are routinely scheduled on a two-year interval for workers with long-term detectable chest count activity.

6.2.3 Special Counts

Other counts performed by special request include liver counts (for low-energy photons), head counts (to determine skeletal content of low-energy photons), thyroid counts (for radioiodines), wound counts, and selected lymph node counts. These counts are normally performed as part of special investigations or as a long-term follow-up of known depositions. These counts are arranged through Internal Dosimetry.

Table 6.8 lists the detection capabilities for radionuclides emitting low-energy photons, which are analyzed using germanium detectors, assuming normal count times. Slightly lower MDAs can be achieved if longer count times can be arranged. The MDA values for wound counts or other tissues (e.g., lymph nodes) are highly variable depending on the circumstances of the measurement. Contact Internal Dosimetry if additional information is required.

6.3 Scheduling and Recordkeeping

This section discusses scheduling of bioassay measurements, reporting of routine results to Field Dosimetry, and record keeping. Follow-up of detected activity is discussed in Section 6.4. Assessment of confirmed intakes is covered in Chapter 3.0, and response to incidents is described in Chapter 7.0.

6.3.1 Contacting the Worker

Contacts with the worker concerning the scheduling and results of bioassay measurements are usually conducted by Field Dosimetry. (During a response to an incident, both Field Dosimetry and Internal Dosimetry usually work directly with the worker.) Internal Dosimetry also consults with a worker at other times at the request of Field Dosimetry.

6.3.2 Scheduling Indirect Bioassay Measurements

Summary

Internal Dosimetry coordinates all bioassay measurement requests to the Lab, either through the IDP or the HRRP, using the REX database.

The details of scheduling depend on the reason the sample is needed. Currently used sample-reason codes are described in Table 6.9, and scheduling details categorized by reason type are discussed below.

Baseline, Termination, End of Assignment

To schedule a worker for a baseline, termination, or end-of-assignment sample, Field Dosimetry must

1. Complete a Dosimetry Change Request form (Exhibit 6.1) and enter the information into the REX database. This deletes the old schedule (if there is one) and establishes the new schedule. The completed form is submitted to the HRRP for inclusion in the worker's radiation exposure file. (A Dosimetry Change Request form is not needed for beginning and end-of-assignment samples for planned offsite exposures.)

2. Internal Dosimetry staff are responsible for reviewing special requests and the transmittal to the Lab.

Table 6.9 Bioassay Measurement Reason Codes for the REX System

Code	Name	Description
BL	Baseline	Measurement is performed to establish a reference level against which subsequent measurements will be compared. This may be for new or established employees prior to commencing work with radioactive materials, beginning a specific type of radiation zone work, or making an offsite trip where potential internal exposure could occur.
PR	Periodic	Measurement is performed at a regularly scheduled interval.
EA	End of Assignment	Measurement is performed following completion of a specific work assignment, but not end of employment.
SP	Special	Measurement is performed as part of a specific investigation of potential internal dose. May include response to off-normal work conditions, or follow-up of abnormal periodic measurements.
CR	Contractor Request	Measurement is requested by employer for reasons other than periodic, baseline, end-of-assignment, or special investigation.
RA	Reanalysis A	First reanalysis of sample, by taking another aliquot and repeating the same radiochemical or chemical analysis.
RB	Reanalysis B	Second reanalysis of sample, by taking another aliquot and repeating the same radiochemical or chemical analysis.
R1	Recount 1	First recount of original excreta sample or repeat in vivo exam.
R2	Recount 2	Second recount of original excreta sample or repeat in vivo exam.
QR	Quality and Research	Measurement is performed as part of quality control, quality assurance, or research work.
TM	Termination	Final bioassay at termination of employment.
12	Contract Work	In vivo measurement performed under contract to customers rather than Hanford employees.
20	Source Count	In vivo source count is made for system calibration or as a function check, usually using a known check source.
30	Background Count	In vivo system background measurement is performed for system calibration or as a functional check.

Periodic

Field Dosimetry initiates the request for a periodic bioassay measurement schedule by completing the Dosimetry Change Request form (Exhibit 6.1), and entering the information into the REX database. The completed form is sent to the HRRP for verification and filing in the worker's radiation exposure file.

Approximately one month before the scheduled sample time, a list of scheduled periodic samples is sent to Field Dosimetry for review. The reviewed list is then electronically transmitted to the Lab one week before the scheduled sample month. This pattern is repeated until another Dosimetry Change Request form is received.

If the periodic sample is not collected, is of insufficient volume, or is a failed analysis, the Lab notifies Internal Dosimetry, who then notifies Field Dosimetry. Field Dosimetry reschedules the sample request through the REX System. Internal Dosimetry transmits the request electronically to the Lab.

Contractor Request Contractor-requested measurements are made by Field Dosimetry or the Internal Dosimetrist. An Explanation for Supplemental "Contractor Request" Bioassay Form (Exhibit 6.2) should be completed to explain the reason for the measurement and sent to HRRP.

Special, Reanalysis, Special measurement requests, reanalysis, and recount requests are made by an Internal Dosimetrist after consultation with Field Dosimetry. During incident response, the Internal Dosimetrist often gives sample kits directly to the worker. The "special" measurement code is used while data are being collected for an evaluation. After a final evaluation has been made, samples collected for long-term surveillance of the intake are usually scheduled as periodic samples.

6.3.3 Reporting Results from Indirect Measurements

Valid Results A result from a routinely processed sample is verbally reported or faxed to Internal Dosimetry by the Lab if the result exceeds the reporting level. Contractual reporting requirements for indirect bioassay measurements are included in Tables 6.1 through 6.6 All sample results are transferred electronically from the Lab to the REX database, as specified contractually. The analytical and reporting requirements are listed in Tables 6.1 through 6.6. Results below the reporting level for samples other than reason code Special are sent a REX-generated letter (Exhibit 6.3)

Invalid or No Results There are a number of reasons that a sample may not be obtained or a result not be provided. When such circumstances occur, the Lab notifies Internal Dosimetry to take appropriate follow-up action. These circumstances and appropriate actions are as follows:

Failed Analyses (FA) An FA code indicates that a valid sample was provided by the worker; however, due to analytical problems, a valid analytical result could not be obtained. Examples of these problems include spillage, cross-contamination, analytical procedure errors, inadequate yield, or out-of-specification quality control samples. For FA results, the Lab notifies Internal Dosimetry by fax or by email and writes a nonconforming data report to the contract administrator, with a copy to Internal Dosimetry. Generally, a worker whose result is a failed analysis should be rescheduled for the lost analysis.

Insufficient Volume Sample (IS) If a urine sample does not meet the minimum volume requirement specified for the sample type (see Section 6.1), the sample is not analyzed and the IS code is noted in the REX database. A worker who provides an insufficient volume sample should be contacted to ensure that the sample kit instructions will be followed, and then the sample and analysis should be rescheduled.

Container-Not-Out (CN) If the kit was not out at the time of the scheduled pickup, a CN interim status code is assigned. The Lab will advise Internal Dosimetry of the attempted pickup and will make one more attempt to retrieve the container when notified of a revised pickup date. Samples not retrieved or scheduled for later retrieval within 10 days of the scheduled pickup are assigned a "lost container" designation and should be rescheduled.

Lost Container (LC) The LC code means that the Lab delivered a sample kit but was unsuccessful in retrieving it. The sample should be rescheduled.

Not Delivered (ND) The ND code indicates that a scheduled sample kit was not delivered by the Lab. The sample should be rescheduled.

Not Evaluated (NE) The NE code shows a sample was obtained but a decision was made not to analyze the sample because the sample was redundant to other measurements or determined to be unnecessary.

No Sample (NS) The NS code means that a sample kit was delivered to the designated residence; however, it was not used and remained outside at the residence on the scheduled pickup date. The Lab notifies Internal Dosimetry of no samples. Internal Dosimetry then contacts Field Dosimetry. The sample should be rescheduled.

Cancelled Sample (CS) The CS code means that a scheduled sample was subsequently cancelled.

6.3.4 Scheduling In Vivo Bioassay Measurements

Summary In vivo measurements with reason codes of baseline, end-of-assignment, termination, periodic, and contractor-request are scheduled by Field Dosimetry using REX. The IVRRF has allocated to each contractor specific blocks of time for counting workers, and Field Dosimetry schedules their workers into those blocks. Whole body counts are scheduled by the day; chest and other counts are scheduled by the day and hour. Counts with the reason code "Special" may be scheduled directly with IVRRF, if necessary, although it is preferred to use REX if possible. Special counts may take precedence over other scheduled measurements.

Typical Measurements Field Dosimetry initiates the request for periodic in vivo measurements by completing the Dosimetry Change Request form (Exhibit 6.1) and entering the information into the REX database.

The REX in vivo scheduling program identifies workers who are specified for a periodic in vivo exam in the coming month. Field Dosimetry then schedules whole body exams for individual workers using the contractor allocations of count times provided by the IVRRF. Each night REX sends an electronic file to the IVRRF containing the names of workers scheduled for exams the next day.

Unscheduled workers will also be accepted, although some rescheduling might be required.

Contractor Request Contractor-requested measurements are made by Field Dosimetry or the Internal Dosimetrist. An Explanation for Supplemental "Contractor Request" Bioassay Form (Exhibit 6.2) should be completed to explain the reason for the measurement and sent to HRRP.

Recounts Recounts are measurements performed on the same day as a positive count to confirm the initial measurement. Measurements performed at a later date as follow-up or because a same-day recount could not be performed are assigned the "special" code.

Special Special in vivo measurements are performed in response to identified potential intake or as follow-up to a periodic measurement that exceeds a screening level. These measurements may be requested by the Internal Dosimetrist or the event contractor. Timely completion of special measurements is a high priority and may preempt a scheduled measurement for a worker.

6.3.5 \Reporting Results of In Vivo Measurements

Valid Results

Internal Dosimetry is verbally notified if a measurement result exceeds the reporting level and is faxed a copy of the measurement results. The reporting levels for routinely scheduled in vivo measurements are shown in Appendix A. In addition, results from special measurements are faxed to Internal Dosimetry, along with a verbal notification, regardless of the level of the results. Internal Dosimetry, in turn, relays the results to Field Dosimetry with recommendations for follow-up, if necessary. Results are electronically transmitted to the REX database, usually within two weeks of the measurements.

No Results

Invalid results or no results may be obtained for an in vivo measurement for a variety of reasons, such as a preliminary count that was followed by a record count on the same day, radon daughter interference, equipment problems, or interference from medically administered radioactivity. A comprehensive list of no-result codes is provided in Appendix B, Table B.13.

6.3.6 Reporting "No Shows"

Whether or not a worker reported for an in vivo measurement can be determined from the REX System. Following each day's measurements, IVRRF staff send an electronic "show" file to REX, listing workers who reported to IVRRF for exams, including unscheduled walk-ins. Walk-ins are scheduled at the time they show up at IVRRF. The actual measurement results are not part of this file.

REX generates a report by retrieving the "show" file and matching it with the day's schedule file. Matches and walk-ins appear as "shows." Workers scheduled but not listed in the "show" file are identified as "no-shows."

6.4 Follow-Up Measurements and Reports

Follow-up measurements and their associated documentation are handled as described in the following subsections.

6.4.1 Indirect Bioassay Measurements

The need for follow-up indirect bioassay measurements depends on the initial measurement result and its relationship to the screening levels of Appendix A.

≤ Screening Level

If the indirect bioassay measurement result is at or below the screening levels of Appendix A, no follow-up is performed by Internal Dosimetry and a computer-generated letter similar to Exhibit 6.3, is completed and sent to Field Dosimetry to be forwarded to the worker or the worker's manager.

> Screening Level

If the result is above the screening levels of Appendix A, different actions are taken, depending on the reason for the sample, according to the practices discussed in Chapter 2.0. If the reason code is for a baseline or special measurement, any result above the reporting level is investigated. If the reason code is for a periodic, contractor-request, end-of-assignment, or termination measurement, the result is compared with 1) the expected result because of any prior assessed intakes, and 2) a level that would possibly indicate an intake resulting in a CEDE greater than 10 mrem (see Appendix A). If the result is greater than expected or implies that an

intake greater than the 10-mrem dose criterion has occurred, the result is investigated. Otherwise, a letter similar to Exhibit 6.3 is completed and sent to the worker and a copy to the HRRP for inclusion in the worker's radiation exposure file. A notification is also provided to Field Dosimetry. For Fluor Hanford and CH2M Hill Hanford Group workers, the letter is sent directly to the worker and a notification is sent to Field Dosimetry. No follow-up is performed by Internal Dosimetry.

Recounts

If a routine- or priority-processed urinalysis for alpha-emitting nuclides exceeds the screening level but not the contractual detection level, Internal Dosimetry commonly requests recounts. This step reduces random false-positive results that ensue from counting statistics alone. If both recounts are less than the screening level, a letter similar to Exhibit 6.3 is sent to the worker and a copy to the HRRP for inclusion in the worker's radiation exposure file. A notification is also provided to Field dosimetry. For Fluor Hanford and CH2M Hill Hanford Group workers, the letter is sent directly to the worker and a notification is sent to Field Dosimetry. If at least one recount is at or above the screening level, then Internal Dosimetry notifies Field Dosimetry and initiates a formal assessment of possible internal dose. Details about the assessment of internal dose are discussed in Chapter 3.0.

Recounts may be ordered under other circumstances at the discretion of the Internal Dosimetrist. Such recounts are appropriate to verify an unexpectedly high measurement.

Reanalysis

If a result exceeds the screening level for an analysis that required only an aliquot of the original sample, Internal Dosimetry may request reanalysis of that sample, provided that sufficient sample remains. If two reanalyses are below the screening level, the initial result is considered unconfirmed. If one reanalysis is also at or above the screening level, Internal Dosimetry notifies Field Dosimetry and initiates a formal assessment of possible internal dose. Details about the assessment of internal dose are discussed in Chapter 3.0.

6.4.2 In Vivo Measurements

The need for follow-up in vivo measurements depends on the measurement result and its relation to the screening levels listed in Appendix A. For in vivo measurements, the reporting levels are equal to the decision levels for the nuclides measured, except for naturally occurring ^{40}K, ^{208}Tl, and ^{214}Bi. IVRRF staff attempt to recount all unexpected positive results on the same day, if possible. IVRRF staff report results of both initial and recount measurements to Internal Dosimetry. Internal Dosimetry then reviews the reported results against the applicable screening levels (see Appendix A) before determining the final disposition.

Preliminary Report

The worker receives a preliminary report on the results of in vivo measurements at the end of each visit to the IVRRF (see Exhibit 6.4). The preliminary report places the results of the measurements into one of four categories, and one of the four alternatives is printed in the body of the letter as appropriate:

- less than the decision level (results do not exceed criteria for follow-up)
- false-positive initial indication (for chest counts only)
- not immediately available (e.g., final calculations by computer are delayed or calculation/evaluation by hand is required)

- exceeded the decision level.

Final Report

≤ Screening Level

Where several screening levels may exist, depending on whether the measurement is a baseline or routine periodic assay, Internal Dosimetry determines the applicable screening level for each case. When a result is finalized, and if the result is at or below the screening level and is not associated with an incident, no follow-up is performed by Internal Dosimetry. If the information in the preliminary report needs no change, no further correspondence is necessary. If the final result differs from the preliminary report but no evaluation is necessary, the letter shown in Exhibit 6.5 is completed and sent to the worker. A copy of the letter is placed in the worker's radiation exposure file and a notification is provided to Field Dosimetry.

Final Report

≥ Screening Level

If the result is above the screening level, different actions are taken depending on the reason for the measurement, according to the practices discussed in Chapter 2.0. If the reason code is for a baseline, any result above the reporting level is investigated. If the reason code is for a periodic, contractor-request, end-of-assignment, or termination measurement, the result is compared with 1) the expected result because of prior assessed intakes, and 2) a level that might indicate an intake resulting in a CEDE greater than 10 mrem (see Appendix A). If the result is greater than expected or implies that an intake greater than the 10-mrem dose criterion has occurred, the result is investigated. Otherwise, the letter shown in Exhibit 6.5, with the appropriate box checked, is sent to the worker. A copy is placed in the worker's radiation exposure file, and Field Dosimetry is notified. No follow-up is performed by Internal Dosimetry.

6.5 Radiation Exposure (REX) Database

The results of all bioassay measurements are permanently retained in the REX database. The staff of Field Dosimetry, Internal Dosimetry, the IVRRF, and the Lab have access to only those parts of the REX database that are essential to their task responsibilities.

6.6 References

Health Physics Society (HPS). 1996. *Performance Criteria for Radiobioassay*. HPS N13.30-1996, McLean, Virginia.

Pacific Northwest National Laboratory (PNNL). *In Vivo Moniotirng Program Manual*, PNL-MA-574. Richland, Washington. (Internal manual.)

Exhibit 6.1. Dosimetry Change Request

DOSIMETRY CHANGE REQUEST

Date:

Mail to:
Dosimetry
P7-04

FAX 373-2041

Manager's Name: _____ *(Print)* Phone: _____

Manager's Signature: _____

Fac./Area RadCon Name: _____ *(Print)*

Fac./Area RadCon Signature: _____

PLEASE NOTIFY US OF ANY/ALL CHANGES THAT APPLY

Company:

Name: | Payroll No./HID:

Job Title: | Dept. ID:

Building: | Area: | MSIN:

PLEASE REVIEW THE FOLLOWING TO ASSURE THAT ALL OF THE APPROPRIATE DOSIMETRY IS BEING REQUESTED FOR THE EMPLOYEE.

Change Dosimeter Exchange Frequency to:

Effective Date: _____
Dosimetry Use Only

Hanford Standard Dosimeter
- ☐ Annual
- ☐ Quarterly
- ☐ Monthly

Combination Neutron
- ☐ Annual
- ☐ Quarterly
- ☐ Monthly

PNAD
- ☐ Assign
- ☐ Discontinue

☐ DISCONTINUE DOSIMETER *(no longer needed, likely annual dose less than 100 mrem/yr)*

Invivo Requirements:

☐ Schedule
- ☐ WB (3-minute whole body count)
- ☐ WC (10-minute whole body count)

☐ Chest
- ☐ CA (Am^{241}, Pu)
- ☐ CU (U^{235}, Th^{234})
- ☐ CC (All)

☐ Discontinue In-Vivo For: _____

Effective Date: _____
[1] _____ Type Freq Anal. Req.
[2] _____ Type Freq Anal. Req.
Dosimetry Use Only

Excreta Bioassay Requirements:

☐ Plutonium ☐ Tritium
☐ Uranium ☐ Other _____
☐ Strontium-90

☐ Discontinue Bioassay for: _____

Effective Date: _____
[1] _____ Iso Req Month Freq Year
[2] _____ Iso Req Month Freq Year
[3] _____ Iso Req Month Freq Year
[4] _____ Iso Req Month Freq Year
Dosimetry Use Only

Home Address *(necessary only for Bioassay delivery)*

_____
Street (If Route, please provide a map)

_____
City *State* *Zip Code*

Remarks: _____

PNNL Dosimetry Operations: | Date:

A-6000-618 (06/00)

Exhibit 6.2

Explanation For Supplemental "Contractor Request" Bioassay

Worker's Name: _____

Payroll No. or Hanford ID No: _____

The following measurement(s) is requested under the Contractor Request reason code as a one-time supplement to the worker's normal routine (periodic) bioassay monitoring program, or as a stand-alone request for a worker not normally on a routine program. The reason for this supplemental bioassay does not meet the criteria for "Special" bioassay, as defined in the Hanford Internal Dosimetry Program Manual, PNL-MA-552.

Bioassay Analysis	Bioassay Date

Reason for Contractor Request supplementary bioassay:

_____

_____

_____

_____

_____

Results of these measurements will be compared with the corresponding screening levels for similar periodic measurements and investigated only if a screening level is exceeded.

This documentation of a Contractor Request Bioassay will be filed in the worker's permanent radiation exposure file.

Requesting Authority: _____ **Date:** _____

Send completed form to Hanford Radiation Records Program, MSIN P7-01

Exhibit 6.3. Sample Form - Bioassay Urine Sample Results

* * * * * * * * * *

STRICTLY PRIVATE

* * * * * * * * * *

Date: 07/18/2003 HID:

Name: Org Cd: D9TRP

Dept Id: 118004

Bioassay Examination Report

The analysis of your excreta sample collected on 06/19/2003 has been completed for the following tests: U ISOTOPIC (IU)

Results do not exceed the criteria for follow-up measurement nor do they change previous assessments of internal dose or current bioassay measurement schedules.

Records of this and your other bioassay examinations are maintained in your personal exposure file. Contact your company's radiation protection or radiation dosimetry office on 376-1707 if you have any questions regarding your occupational radiation exposure status.

This statement was prepared by Hanford Internal Dosimetry.

REX-GR10

Exhibit 6.4

PRELIMINARY ANALYSIS OF IN VIVO EXAMINATION

NAME:
PAYROLL:
REASON CODE:
EXAM DATE:

Preliminary analysis of your in vivo examination(s) indicates:

_____ (1) Your in vivo measurements are completed, and the results do not exceed the criteria for follow-up.

_____ (2) Your first in vivo measurement indicated the possible presence of internal radioactivity from occupational sources. However, the results from your second count, usually longer and more sensitive did not indicate the presence of radioactive material from occupational sources. Your first count may have been a false positive result, expected to occur about 5 percent of the time, or caused by other factors including the presence of naturally occurring radon progeny.

_____(3) Final analysis of the examination data is not immediately available. This may be due to a temporary suspension of the analysis portion of the computer software or a need to review the quality of the detection system performance. The results of this examination will be provided to your company's radiation protection organization when available.

_____ (4) Your measurement exceeds a screening level. This can result from a random, statistical fluctuation in the background measured by the detector, very low-level skin contamination, an intake of naturally occurring or medical-related radioactive material not related to your work, or an occupational intake. A further review of the examination will be performed and your radiation protection organization will be notified of the results. Follow-up measurements may be required.

If you have any questions, please contact your radiation protection representative listed below.

Contractor Name:
Contact Name:
Contact Phone:

Please note: This report is based on a preliminary evaluation of your measurement by computer and is subject to change based upon additional review. If there is a change from the above reported results, Personnel Dosimetry will notify your company's radiation protection organization.

Exhibit 6.5. Sample Letter - In Vivo Measurements Results

STRICTLY PRIVATE

Date: 09/27/2003

Name: IM ATEST
PR No: 12345

IN VIVO EXAMINATION REPORT

The preliminary analysis or subsequent review of your 09/26/03, whole body exam indicated the possible presence of radioactivity, and the possibility of additional measurements may have been discussed with you. A detailed review of the measurement spectrum has since been performed, with the conclusion indicated by the box(es) checked below:

☐ FALSE POSITIVE – Your result does not truly reflect the presence of radioactivity and has been identified as a "false positive" result. The extreme sensitivity of our measurements makes the slight variation in background levels from one person to another sometimes appear as a detected result when analyzed by the computer. An in-depth technical review of the measurement showed interference that the computer interpreted as radioactivity. These false-positive results are a fact-of-life associated with highly sensitive measurements, and are expected in as many as five percent of our measurements.

☐ MEDICAL – The detected radioactivity is associated with medical applications. It could result from a nuclear medicine procedure you had recently, or if you were recently in close contact with someone who had such a procedure. Typical radionuclides in this category include thallium-201, thallium-202, iodine-131, and technetium-99m.

☐ ENVIRONMENTAL – The detected radioactivity is attributed to non-occupational sources.

☐ CONSISTENT WITH PRIOR EVALUATION – The detected radioactivity is consistent with a previously evaluated intake and does not require a new investigation.

☐ BELOW OCCUPATIONAL SCREENING LEVELS – The detected radioactivity could be attributable to occupational intake, but is below the screening levels used for investigation and dose assessment. Any implied doses are below 10 mrem committed effective dose equivalent.

Based on this determination, no further measurements are required and no additional investigation will be performed. Records of this and your other bioassay examinations are maintained in your personal exposure file. If you have questions concerning this, please contact Robert Jones at 376-1707.

Hanford Internal Dosimetry

cc: Radiation Exposure File