ORAU Team **Dose Reconstruction Project for NIOSH** External Coworker Dosimetry Data for the Hanford Site	Document Number: ORAUT-OTIB-0030 Effective Date: 11/07/2006 Revision No.: 00 PC-1 Controlled Copy No.: _____ Page 1 of 10
Subject Expert: Steven E. Merwin Document Owner Approval: Signature on File Date: 03/10/2005 Edward F. Maher, Task 5 Manager Concurrence: Signature on File Date: 03/11/2005 Richard E. Toohey, Project Director Approval: Signature on File Date: 03/23/2005 James W. Neton, Associate Director for Science	Supersedes: None

TABLE OF CONTENTS

LIST OF TABLES

RECORD OF ISSUE/REVISIONS

ISSUE AUTHORIZATION DATE	EFFECTIVE DATE	REV. NO.	DESCRIPTION
03/23/2005	03/23/2005	00	New technical information bulletin to provide information to allow ORAU Team dose reconstructors to assign doses to certain workers at the Hanford site who have no or limited monitoring data, based on site coworker data. First approved issue. Initiated by Steven E. Merwin.
03/23/2005	11/07/2006	00 PC-1	Approved page change revision due to release of ORAUT-OTIB-0052 Rev 00. Updates required language on page 3 in Section 1.0. Lists ORAUT-OTIB-0052 Rev 00 as a reference on page 5 in Section 5.0. Rewrites item 5 on page 7 in Section 7. Completes Section 8.0 on page 8. Adds Table 3 to page 10 in Section 8.0. Incorporates formal internal review comments. Per new document requirements, added a Table of Contents. This revision results in an increase in assigned dose and a PER is required. Training required: As determined by the Task Manager. Initiated by Matthew H. Smith. Approval: Signature on File 10/18/2006 John M. Byrne, Document Owner Signature on File 10/17/2006 Edward F. Maher, Task 5 Manager Signature on File 10/25/2006 Kate Kimpan, Project Director Signature on File 11/07/2006 James W. Neton, Associate Director for Science

1.0 PURPOSE

Technical information bulletins (TIBs) are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historical background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained. TIBs may be used to assist NIOSH staff in the completion of individual dose reconstructions.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy facility" as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 (42 U.S.C. § 7384l(5) and (12)).

The purpose of this TIB is to provide information to allow ORAU Team dose reconstructors to assign doses to workers at the Hanford Site who have no or limited monitoring data, based on site coworker data. The data in this TIB are to be used in conjunction with ORAUT-OTIB-0020, "Use of Coworker Dosimetry Data for External Dose Assignment."[1]

2.0 BACKGROUND

The ORAU Team is conducting a series of coworker data studies to permit dose reconstructors to complete certain cases for which external and/or internal monitoring data are unavailable or incomplete. Cases not having complete monitoring data may fall into one of several categories, including:

- The worker was unmonitored and, even by today's standards, did not need to be monitored (e.g., a non-radiological worker).
- The worker was unmonitored, but by today's standards would have been monitored.
- The worker may have been monitored but the data are not available to the dose reconstructor.
- The worker may have partial information, but the available information is insufficient to permit a dose reconstruction to occur.

As described in ORAUT-OTIB-0020, some cases not having complete monitoring data can be processed based on assumptions and methodologies that do not involve coworker data. For example, many cases falling in the first category above can be processed by assigning ambient external and internal doses based on information in the relevant site Technical Basis Documents (TBDs).

As described in the Hanford External Dosimetry TBD,[2] Hanford began operations in 1944 using in-house dosimeter and processing technical support. Routine Hanford practices appear to have required assigning dosimeters to all workers who entered a controlled radiation area. The trends in the number of workers who were monitored, the number of monitored workers with positive recorded dose, and the collective dose do not show any abrupt changes that may be indicative of significant changes in photon dosimetry or assignment of dosimeters.[2] Additionally, there does not appear to be any significant administrative practice that would jeopardize the integrity of the recorded dose of record.

3.0 GENERAL APPROACH

As described in ORAUT-OTIB-0020[1], the general approach to developing coworker data for cases without external monitoring data involves two phases. The first phase (Phase I) permits cases to be processed when a "best and final" estimate of dose is not required for claim determination. The second phase (Phase II) facilitates the assignment of "best and final estimates" of dose, when necessary. This initial revision of this TIB provides coworker external dosimetry summary statistics applicable to Phase I dose reconstructions; coworker dose distributions applicable to Phase II dose reconstructions will be made available in a subsequent revision.

4.0 APPLICATIONS AND LIMITATIONS

1. Revision 0 of this document provides Hanford site coworker data and information that may be used only for clearly non-compensable cases for which a higher external dose can be assigned than was likely to have been actually received. Revision 1 of this document will provide dose distributions and additional information based on the data presented herein to permit the processing of clearly compensable cases or cases requiring a best estimate analysis.

2. Some Hanford Site workers may have worked at one or more other major sites within the DOE complex during their employment history. Thus, the data presented herein must be used with caution to ensure that for clearly non-compensable, unmonitored external doses from multiple site employment have been overestimated. This will typically require the availability of External Coworker Dosimetry Data TIBs for all relevant sites.

3. Summary statistics based on Hanford dosimetry data presented in this TIB do not extend beyond 1989 because at the time this TIB was drafted, data beyond 1989 were not available from the Comprehensive Epidemiologic Data Resource (CEDR). However, the absence of these data (and the subsequent development of dose distributions) should not interfere with the processing of most Hanford cases having a lack of external dosimetry data since well before 1989 the monitoring and reporting practices at the site ensured that essentially all workers with a potential for external radiation exposure were monitored and the results are readily accessible. Should the need arise and sufficient data become available, coworker dosimetry data beyond the year 1989 will be presented in a subsequent revision to this TIB.

4. The data presented in this TIB address penetrating radiation from gamma radiation and non-penetrating radiation from beta radiation (or low-energy photons for work involving Pu). Neutron data are not presented. However, the locations within the Hanford site at which neutron exposures were possible are limited to certain site areas and facilities, and the site TBD establishes a method for assigning neutron doses when relevant.[2] Therefore, the TBD should be used as the basis for assigning neutron doses, when relevant, in addition to the photon and/or beta doses assigned in accordance with this TIB.

5. For the years 1972 and later, external on-site ambient doses should not be included in addition to the co-worker doses assigned in accordance with this TIB, because any such doses would have been included in the dosimetry results reported by the site which were used as the basis for the coworker dose distributions presented below.[2] Prior to 1972, co-worker doses assigned in accordance with this TIB must be supplemented by the appropriate external on-site ambient dose in accordance with the instructions in ORAUT-PROC-0060.[4]

5.0 REFERENCES

1. ORAU Team, ORAUT-OTIB-0020, Use of Coworker Dosimetry Data for External Dose Assignment, Rev. 00, December 29, 2004

2. ORAU Team, ORAUT-TKBS-0006-6, Technical Basis Document for the Hanford Site – Occupational External Dose, Rev. 01, January 9, 2004.

3. NIOSH (National Institute for Occupational Safety and Health), External Dose Reconstruction Implementation Guideline, Rev. 0, OCAS-IG-001, Office of Compensation Analysis and Support, Cincinnati, Ohio, 2002.

4. ORAU Team, ORAUT-PROC-0060, External On-Site Ambient Dose Reconstruction for DOE Sites, Rev. 00, January 31, 2005.

5. ORAU Team, ORAUT-OTIB-0017, Interpretation of Dosimetry Data for Assignment of Shallow Dose, Rev 00., January 11, 2005.

6. ORAU Team, ORAUT-OTIB-0052, Parameters to Consider When Processing Claims for Construction Trade Workers, Rev. 00, August 31, 2006.

6.0 HANFORD COWORKER DATA DEVELOPMENT

Dosimetry data for monitored Hanford workers from the CEDR databases maintained by the U.S. Department of Energy (DOE) were selected for this evaluation. The CEDR data evaluated represented primarily annual penetrating and non-penetrating dosimetry data provided by the Hanford site, which pertain to the shielded and "open-window minus shielded" dosimetry readings, respectively, and exclude neutron doses. Starting in 1982, multiple badge readings are recorded in CEDR for some Hanford workers; however, this was a relatively small fraction of the total, and the adjustments made for partial years of employment (see Section 7) are likely to account for any data that do not encompass a full year. Also, starting in 1983 the CEDR data included the reported shallow dose, not the non-penetrating dose. Thus, for these years, the non-penetrating doses were derived by subtracting the reported penetrating doses from the reported shallow doses.

Between 1957 and 1971, the Hanford Site film dosimeter included a third measurement (in addition to the standard shielded and open-window measurement) using a special filter covering a portion of the film designed to allow the assessment of X-ray doses. Thus, doses in this time period were reported as beta, gamma, and X-ray. A fraction (0.65) of the X-ray dose was assumed to contribute to non-penetrating dose, and the remainder (0.35) was assumed to contribute to penetrating dose. Since the CEDR data include the X-ray doses reported by the site for this period, the coworker dose evaluations described in this TIB include an upward adjustment of the reported beta and gamma doses during this period by adding 65% and 35% of the reported X-ray doses, respectively, to arrive at the reported non-penetrating and penetrating doses.

The validity of the CEDR data was confirmed by selecting a sampling of claimant dosimetry data submitted by the site as part of the EEOICPA Subtitle B program and comparing it to the pertinent CEDR data. A review of annual data for ten claimants covering 297 worker-years of employment at Hanford indicated excellent agreement between the two data sets. Specifically, the reported penetrating and non-penetrating data in the CEDR database were found to correspond to the reported external and "skin minus external" annual doses reported in the site Radiological Exposure System. It is concluded that the CEDR data are acceptable for the development of coworker doses for the

Hanford Site, with adjustments made for the reported X-ray doses as appropriate, as described above.

Adjustment for Missed Dose

According to the External Dose Reconstruction Implementation Guideline,[3] missed doses are to be assigned for null dosimeter readings to account for the possibility that doses were received but not recorded by the dosimeter or reported by the site. Annual missed doses are calculated by multiplying the number of null badge readings by the dosimeter limit of detection (LOD) and summing the results. These values are used as the 95th percentile of a lognormal distribution for the purpose of calculating probability of causation; thus, in IREP the calculated missed doses are multiplied by 0.5 and entered in Parameter 1, and a value of 1.52 is entered in Parameter 2, to represent the geometric mean and geometric standard deviation, respectively.

The assignment of missed doses for monitored workers is particularly significant for Hanford claimants prior to 1951 when workers were monitored weekly, and between 1951 and 1957 when workers were monitored biweekly. Table 1 lists the maximum annual missed dose by era and type of radiation (penetrating gamma and non-penetrating) based on information presented in the site TBD[2] and ORAUT-OTIB-0017.[5]

Table 1. Missed external doses based on Hanford Occupational External Dosimetry TBD[2] and ORAUT-OTIB-0017.[5]

Period	Penetrating LOD (rem)	Non-penetrating LOD (rem)[a]	Exchange frequency	Maximum annual missed dose (rem)	
				Penetrating	Non-penetrating
1944[a]-1950	0.04	0.05	Weekly	2.080	2.600
1951-1956	0.04	0.05	Biweekly	1.040	1.300
1957	0.04	0.05	Varied[b]	0.720	0.900
1958-1971	0.04	0.05	Monthly	0.480	0.600
1972-1994	0.02	0.03	Monthly[c]	0.240	0.360
1994-present	0.01	0.05	Monthly[c]	0.120	0.600

a. Hanford instituted a weekly exchange and the use of film dosimeters in October 1944.
b. The exchange frequency was biweekly through May 1957, then monthly. A total of 18 exchanges were assumed for the year.
c. The TBD indicates that either monthly or quarterly exchange frequencies were used. Monthly exchanges have been assumed here to ensure favorability to the claimant.

Special Considerations

Certain aspects of the external dosimetry practices at the Hanford Site documented in the TBD[2] were considered in the analysis of the site data. These include:

- In some cases, values less than the dosimeter LOD were reported by the site. For example, values as low as 10 or 20 mR were reported even though the penetrating LOD was considered to be 40 mrem (or 40 mR) prior to 1972.

- The data available to analyze coworker doses represent annual dose summaries for individual workers. Because these data include partial work years, the average annual doses reported tend to underestimate the average annual doses received by employees who worked an entire year.

As described in Section 7.0 below, a favorable to claimant approach was adopted in the development of coworker dose summaries, and this approach should account for any underestimate of doses to radiological workers at the Hanford site based on the considerations described above.

7.0 HANFORD COWORKER ANNUAL DOSE SUMMARIES

Based on the information and approaches described above, Hanford coworker annual external dosimetry summaries were developed for use in the evaluation of external dose for certain claimants potentially exposed to workplace radiation, but with no or limited monitoring data provided by DOE. These summaries were developed using the following steps:

1. As described in Section 6.0 above, the penetrating and non-penetrating doses available from CEDR, which represented annual summary data, were modified to account for partial years of employment. This adjustment was made by analyzing the NOCTS employment data for Hanford workers and adjusting the reported doses upward by an appropriate multiplier corresponding to the average fraction of a year an employee worked at the site. For example, if in a particular calendar year the average employment period for all Hanford employees in NOCTS was 11 months, the CEDR annual doses were multiplied by 12/11, or 1.09. This permits the dose reconstructor to assign an appropriate prorated dose to account for partial years of employment or potential exposure. A factor of 4 was applied for the year 1944 when monitoring at the site did not begin until October.

2. For the years 1957 through 1971, when X-ray doses were reported separately in addition to the reported gamma and beta doses, but were not included in the reported annual penetrating and non-penetrating doses, the penetrating and non-penetrating doses were modified by adding 35% and 65% of the reported positive X-ray doses, respectively.[2,5]

3. The 50th, 95th and 99th percentile annual penetrating and non-penetrating doses were derived for two scenarios: excluding and including reported zeroes.

4. The 50th, 95th and 99th percentile doses based on the exclusion of zeroes were used as the basis for the coworker data set, since these are representative of radiological worker doses which are the principal focus of the coworker studies. However, to ensure favorability to the claimant, for penetrating radiation the percentile doses with zero results included were evaluated, and if the addition of one-half of the maximum annual non-penetrating missed doses (listed in Table 1) to these percentile doses resulted in values exceeding the percentile doses based on the exclusion of zeroes, the latter were replaced with the former. Missed doses were not added to both the penetrating and non-penetrating results because the non-penetrating results reported by the site reflect the difference between the open-window and shielded measurements, and assigning missed dose to both measurements would result in a double counting since a positive shielded measurement exceeding the non-penetrating MDL would appear as a positive open-window measurement. To ensure favorability to the claimant, the non-penetrating MDLs were assigned in the calculations (since they exceed the penetrating MDLs), and the values were apportioned to the penetrating doses (since penetrating doses are assigned as gamma radiation, which in IREP cannot have a negative effect because the radiation effectiveness factors for gammas are equal to or greater than for >15 keV electrons).

5. The results are presented in Table 2 below. These percentile doses should be used for selected Hanford workers with no or limited monitoring data using the methodologies outlined in Section 7.0 of ORAUT-OTIB-0020.[1]

Doses to organs impacted only by penetrating radiation (e.g., organs other than the skin, breast and testes) are calculated based only on the “Gamma” columns in Table 2 combined with the appropriate organ dose conversion factors (DCFs).[3] Doses to the skin, breast and testes (and any other cancer location potentially impacted by non-penetrating radiation) are determined based on both the

"Gamma" and "Non-penetrating" columns; gamma doses are assigned as photons with an energy range consistent with information in the external dosimetry TBD for the Hanford site,[2] and non-penetrating doses are assigned as electrons >15 keV with corrections applied to account for clothing attenuation or other applicable considerations, or photons <30 keV, depending on the employment location and job description.

8.0 PENTRATING DOSE VALUES BASED ON ORAUT-OTIB-0052 GUIDANCE FOR SELECTED CONSTRUCTION TRADE WORKERS

Table 3 contains penetrating dose values that have been adjusted using the guidance given in Section 8.0 of ORAUT-OTIB-0052, "Parameters to Consider When Processing Claims for Construction Trade Workers."[6] This guidance is applicable for construction trade workers who meet the criteria given in Section 3.0 of ORAUT-OTIB-0052.[6]

Table 2. Annual Hanford external coworker doses modified to account for missed dose (rem).

Year	Gamma 99th%	Gamma 95th%	Gamma 50th%	Non-pen 99th%	Non-pen 95th%	Non-pen 50th%
1944	3.096	2.176	1.300	3.363	1.448	0.240
1945	3.294	2.430	1.336	4.215	0.631	0.071
1946	2.917	2.125	1.448	5.944	1.421	0.297
1947	2.113	1.708	1.369	3.130	1.081	0.222
1948	1.805	1.541	1.334	5.400	1.096	0.149
1949	1.818	1.572	1.357	3.895	1.076	0.215
1950	2.107	1.721	1.357	3.222	1.535	0.239
1951	2.263	1.278	0.685	4.276	2.047	0.212
1952	2.504	1.541	0.721	2.782	1.046	0.155
1953	2.691	1.815	0.779	2.828	1.477	0.188
1954	3.053	1.863	0.720	2.438	1.260	0.175
1955	3.246	2.059	0.717	2.230	1.287	0.200
1956	3.344	2.306	0.682	2.262	1.189	0.141
1957	3.325	2.318	0.650	1.755	0.942	0.119
1958	3.236	2.599	0.321	1.326	0.695	0.074
1959	2.867	2.237	0.300	2.120	1.122	0.127
1960	3.276	2.756	0.311	2.622	1.419	0.162
1961	3.293	2.877	0.364	1.938	1.001	0.075
1962	3.406	3.018	0.452	1.695	0.805	0.108
1963	3.389	2.981	0.406	1.715	0.760	0.050
1964	3.437	3.018	0.505	1.954	0.690	0.042
1965	4.849	3.880	0.881	2.338	0.905	0.098
1966	3.574	2.690	0.524	1.881	0.841	0.056
1967	4.118	3.179	0.385	3.161	1.476	0.073
1968	3.473	2.801	0.436	2.253	0.890	0.084
1969	3.529	2.905	0.354	2.147	0.923	0.075
1970	3.689	3.159	0.323	2.623	1.267	0.092
1971	3.776	2.726	0.394	2.978	1.237	0.165
1972	3.458	2.339	0.293	1.060	0.565	0.090
1973	3.380	2.142	0.246	1.729	0.535	0.055
1974	3.473	2.099	0.283	1.253	0.513	0.068
1975	3.337	1.933	0.283	1.201	0.549	0.080
1976	3.091	1.667	0.226	0.741	0.359	0.069
1977	3.748	2.188	0.206	1.026	0.365	0.052
1978	2.934	1.252	0.214	0.530	0.237	0.034
1979	2.967	1.257	0.202	0.662	0.276	0.044
1980	2.658	0.968	0.203	0.551	0.293	0.045
1981	2.596	1.103	0.191	0.620	0.425	0.092
1982	2.980	1.432	0.191	0.533	0.329	0.057
1983	3.081	1.933	0.180	0.603	0.261	0.045
1984	2.785	1.643	0.191	0.723	0.321	0.034
1985	2.911	1.849	0.180	0.834	0.297	0.034
1986	2.851	1.985	0.180	0.714	0.312	0.022
1987	2.260	1.048	0.195	0.403	0.135	0.015
1988	0.360	0.236	0.180	0.101	0.045	0.011
1989	0.508	0.236	0.180	0.124	0.034	0.011

Table 3. Annual Hanford external penetrating coworker doses modified in accordance with ORAUT-OTIB-0052 (rem).

Year	Gamma 99th%	Gamma 95th%	Gamma 50th%
1944	3.814	2.526	1.300
1945	4.092	2.882	1.350
1946	3.564	2.455	1.508
1947	2.439	1.871	1.397
1948	2.007	1.637	1.348
1949	2.025	1.681	1.379
1950	2.430	1.889	1.380
1951	2.909	1.529	0.699
1952	3.246	1.898	0.750
1953	3.507	2.281	0.831
1954	4.014	2.348	0.748
1955	4.284	2.622	0.743
1956	4.421	3.076	0.695
1957	4.395	3.245	0.650
1958	4.411	3.639	0.329
1959	3.900	3.132	0.310
1960	4.466	3.859	0.315
1961	4.490	3.907	0.389
1962	4.649	4.106	0.512
1963	4.625	4.054	0.449
1964	4.692	4.106	0.588
1965	6.669	5.312	1.114
1966	4.883	3.645	0.614
1967	5.645	4.381	0.420
1968	4.742	3.801	0.491
1969	4.820	4.068	0.375
1970	5.081	4.422	0.332
1971	5.166	3.817	0.432
1972	4.770	3.269	0.338
1973	4.661	2.964	0.273
1974	4.790	2.939	0.324
1975	4.600	2.706	0.324
1976	4.327	2.334	0.245
1977	5.177	3.063	0.216
1978	4.108	1.753	0.227
1979	4.154	1.760	0.211
1980	3.649	1.355	0.212
1981	3.634	1.544	0.196
1982	4.172	2.005	0.196
1983	4.313	2.706	0.180
1984	3.899	2.300	0.196
1985	4.075	2.589	0.180
1986	3.991	2.780	0.180
1987	3.165	1.467	0.201
1988	0.456	0.259	0.180
1989	0.712	0.283	0.180