

<b>Office of Compensation Analysis and Support</b>	Document Number: Battelle-TBD-6001 Appendix B Effective Date: 1/03/2008 Revision No. 1
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<b>Appendix B – DuPont Deepwater Works</b>	
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12/18/2007	12/18/2007	0	Appendix to Battelle-TBD-6001 describing the use of the TBD for claims at DuPont Deepwater Works
1/03/2008	1/03/2008	1	Correct error in table B.4

## DUPONT DEEPWATER WORKS

### B.1 Introduction

This document serves as an appendix to Battelle-TBD-6001, Site Profiles for Atomic Weapons Employers that Refined Uranium and Thorium. This appendix describes the results of document research specific to this site. Where specific information is lacking, research into similar facilities described in the body of this Site Profile is used.

### B.2 Site Description

DuPont Deepwater Works was a DuPont facility located in Deepwater NJ. The name of the facility was officially changed from “Dye Works” to “Chambers Works” on 4/7/1944<sup>5</sup>.

Operations involving uranium at the DuPont Deepwater Works began early in 1942 when DuPont was conducting experiments with uranium hexafluoride (UF<sub>6</sub>) under contract to the Office of Scientific Research and Development (OSRD). The method employed utilizing natural uranium oxide and converted it to uranium tetrafluoride (UF<sub>4</sub>) and then to uranium hexafluoride (UF<sub>6</sub>). When MED was chartered, it took over the OSRD contracts. DuPont operations for MED included conversion of black oxide (U<sub>3</sub>O<sub>8</sub>) and sodium diuranate to orange oxide (UO<sub>3</sub>) and then to brown oxide (UO<sub>2</sub>), production of uranium tetrafluoride (UF<sub>4</sub>) from uranium oxide (UO<sub>2</sub> and UO<sub>3</sub>), production of uranium peroxide (UO<sub>4</sub>2H<sub>2</sub>O) from scrap uranium for subsequent production of UO<sub>2</sub>, production

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of uranium hexafluoride (UF<sub>6</sub>) from UF<sub>4</sub>, production of uranium metal using the magnesium process and various related research activities. DuPont continued its research activities for AEC until late 1947<sup>5</sup>. No documentation was found indicating there were other sources of radiation at Deepwater Works.

### ***B.2.1 Site Activities***

DuPont Deepwater Works conducted work on several projects for the MED. Several involved producing non-radioactive chemicals<sup>5</sup>. These include project number 9595 (under Letter Contract W-7414 Eng. 2), project number 9757 (under Letter Contract W-7414 Eng. 6), and project number 9233 (under Letter Contract W-7414 Eng. 8).

Project number 9634 was conducted under Letter Contract W-7414 Eng. 3. The letter contract was dated 11/20/1942 and the project was approved by DuPont's Executive Committee on 12/23/1942. Construction was completed in three stages which started production on 2/13/1943, 4/28/1943 and 6/5/1943. The scope of work under this contract included converting U<sub>3</sub>O<sub>8</sub> to UO<sub>2</sub>, converting UO<sub>2</sub> to UF<sub>4</sub>, and converting UF<sub>4</sub> to uranium metal.

Letter Contract W-7414 Eng 3 indicated the U<sub>3</sub>O<sub>8</sub> would be supplied by the Government. However, on 12/30/1942, Letter Contract W-7414 Eng. 22 was issued to direct DuPont to build a facility to produce the U<sub>3</sub>O<sub>8</sub> from various types of uranium scrap. This became Project number 9803 and was approved by DuPont's Executive committee on 3/31/1943. The 100 Section of the plant was operational on 8/16/1943 and the 200 Section of this plant was operational on 10/1/1943.

The original research work was conducted at the Jefferson Lab in Building J-16<sup>6</sup>. This building was demolished and several feet of earth removed sometime between 1943 and 1945. Building J-26 was eventually built at that location.

The other two projects were located in buildings 708 and 845<sup>6</sup>. A portion of building 708 was demolished in 1945. The rest of the building along with several feet of earth was removed in 1953. A radiological survey was conducted of building 845 in 1977 and 1983.

### **B.3 Occupational Medical Dose**

No information regarding occupational medical dose specific to DuPont Deepwater Works was found. Information to be used in dose reconstructions for which no specific information is available is provided in ORAUT-OTIB-0006, the dose reconstruction project technical information bulletin covering diagnostic x-ray procedures.

### **B.4 Occupational Internal Dose**

Air samples were collected at the Deepwater Works on various occasions at a variety of locations between 4/3/1944 and 6/7/1945. A total of 252 air samples were collected. These air samples were analyzed by assuming they fit a lognormal distribution. The

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geometric mean of that distribution was 181 dpm/m<sup>3</sup> with a geometric standard deviation of 5.73. These air samples included primarily operational areas but also included some general areas of the facility as well as operational areas while equipment was shutdown. The distribution would therefore not necessarily be representative of operational personnel. Therefore, exposure estimates will rely on three categories of workers. People routinely working with uranium (operators) will be given the 95<sup>th</sup> percentile of the air concentration distribution. People working in the vicinity but not normally operating equipment (Supervisors) will be given the 50<sup>th</sup> percentile of the distribution. People not routinely in the vicinity of the uranium will be given the 5<sup>th</sup> percentile of the distribution. This is summarized in the table below.

Category	Description	dpm/m <sup>3</sup>
Operators	Routinely working with uranium	3199
Supervisors	Routinely in the area	181
Clerical	Not routinely in the area	10.23

Dose calculated from these intakes are entered into IREP as alpha radiation with a “constant” distribution. These values will also be used to determine an ingestion intake per OCAS-TIB-0009<sup>4</sup>.

## B.5 Occupational External Dose

To estimate the external dose to workers at the Deepwater Works facility, Table 7.3 of the TBD will be used. This table includes dose estimates for the major tasks that were performed at Deepwater Works. In 1942, research into the production of uranium hexafluoride (UF<sub>6</sub>) was the only uranium work reported to have occurred. Therefore, for 1942, the values for Fluorination operations will be used. For 1943 through the end of operations, the values for the “Boil-down and Denitration” operation will be used. These values are larger than most other operations applicable to Deepwater.

## B.6 Residual Contamination

Even though the last building was released to DuPont in 1949, the last decontamination survey (described below) was completed in late 1948<sup>7</sup>. Therefore, the operational dose estimates in section B.4 and B.5 will be used through 1948. After 1948, there was still the potential for dose from residual contamination remaining in the buildings. The dose estimate from this residual contamination is described below.

The initial research conducted in 1942 at Deepwater Works was conducted in building J-16. This building was demolished and several feet of earth removed sometime between 1943 and 1945<sup>6</sup>.

Building 708 was partially demolished in 1945. This building was eventually shutdown, decontaminated and released to DuPont in 1949. The final survey of the building was

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conducted on 12/30/1948. This survey indicated the northwest tile wall was the most contaminated location in the building. The survey measured beta and gamma dose rates along the wall at several distances from the center of the contaminated area including the center of the contaminated area. The measurements were taken at these locations on contact with the wall as well as one foot away, two feet away, four feet away, six feet away and twenty feet away from the wall. These measurements were conducted on all five floors of the building with the exception of the second and third floors. That section of the wall was not accessible from those floors<sup>8</sup>.

The survey also recorded measurements on the floor on all five floors of the building. All of these measurements indicated direct alpha results of less than 500 dpm/100cm<sup>2</sup> and the highest beta gamma dose rate three feet above the floor as 0.05 mrep/hr. Building 708 was released to DuPont and in 1953 the building was demolished and several feet of soil were removed.

Building 845 was released to DuPont on 11/15/1948 after decontamination<sup>7</sup>. The decontamination effort consisted of removing all apparatus, contaminated ducts, pipes, tanks, concrete bases, and wood floors as well as sandblasting the concrete floors. The whole interior was washed with water under pressure. A survey conducted on 10/6/1948 indicated all direct alpha measurements were less than 500 dpm/100cm<sup>2</sup>. The survey also indicated beta and gamma radiation levels three feet above the floor were less than 0.03 mrep/hr<sup>9</sup>.

The building remained standing and was again surveyed in 1977<sup>6</sup> and 1983<sup>10</sup>. The 1983 survey provided only a range of values with no indication of the average or typical contamination levels. The 1977 survey however, indicated average measurements as well as maximum measurement. This survey also indicates areas of maximum measurements were typically small areas.

The survey indicated beta gamma direct contact dose rates typically around 0.1 mrad/hr on most floors, walls, and ceilings. These readings were not corrected for background radiation so they are slightly high. Every floor of the plant had higher dose rates in small areas. This estimate will assume a dose rate of 0.2 mrad/hr as a favorable average dose rate. Since this is a contact beta plus gamma dose rate, corrections must be made to determine a whole body gamma and whole body beta dose rate.

As part of a test to determine the effectiveness of sandblasting, a survey was conducted in building 845 on 8/30/1948 and 8/31/1948<sup>11</sup>. Part of this survey measured the open window dose rates (beta plus gamma) from three spots on the floor. Measurements were taken on contact with the floor and at waist height (three feet above the floor). The contact readings were 2.6, 2.6, and 15 mrep/hr. The corresponding three foot readings were 0.5, 0.5, and 1.0 mrep/hr. These measurements imply the readings taken three feet above the floor were 5.2, 5.2 and 15 times lower than the contact readings. Based on this, this estimate will use a value of five to estimate the whole body beta plus gamma dose rates from the contact dose rates. Therefore, the average whole body beta plus gamma dose rate is assumed to be 0.04 mrad/hr.

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The ratio of beta to gamma from uranium contamination can vary from one to one to as high as 10 to one depending on the geometry, the amount of self shielding, and a number of other factors. For the purposes of this appendix, the more favorable approach to the claimant would be to assume a one to one ratio. Therefore, this appendix will assume the 0.04 mrad/hr is composed of a whole body gamma dose rate of 0.02 mr/hr and a beta whole body dose rate of 0.02 mr/hr. Skin of the extremities (hands and forearms) will be assumed to be exposed to the contact dose rate of 0.2 mrad per hour.

While work schedules and locations can vary throughout a large facility such as Deepwater Works, a favorable assumption would be that individuals were exposed to these levels for 2000 hours per year. While it is recognized that some individuals would have worked overtime, it is also very likely they worked in other areas of the site since building 845 was primarily used for storage in later years. This also makes the use of 2000 hours per year a bounding estimate. As such, this portion of the dose estimate will be considered a constant value with no statistical distribution.

With these assumptions in place, this dose estimate will assume for the residual period, an annual whole body dose of 80 mrem. This is divided into 40 mrem deep dose and 40 mrem shallow dose (beta). Extremities will be estimated with an annual dose of 400 mrem assumed to be beta plus 40 mrem deep dose.

Direct alpha contamination measurements of the floor were conducted after decontamination of buildings 708 and 845. These measurements indicated the values were less than 500 dpm/100cm<sup>2</sup>. The 1977 survey of building 845 confirmed this was still the case even though isolated spots of higher contamination were also found. The isolated spots were primarily less than 500 cm<sup>2</sup> in area but six spots on the first floor ranged up to 5000 cm<sup>2</sup>. These readings indicate fixed contamination that can not be easily resuspended into the air. The fact that the 1948 survey results are near the same values of the 1977 survey results indicates that the contamination is generally not being resuspended or removed in any other fashion. However, in order to account for small amounts of uranium that may have become airborne, a resuspension factor was applied to the 500 dpm/100cm<sup>2</sup> value. This resulted in an estimated airborne concentration of 0.05 dpm/m<sup>3</sup>. Again, it will be assumed that an individual was exposed to this level of airborne contamination for 2000 hours per year. This estimate will therefore be considered a bounding estimate and no statistical distribution will be associated with it. These values will also be used to determine an ingestion intake per OCAS-TIB-0009.

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**Table B.1 INTERNAL DOSE PATHWAYS - Inhalation of Airborne Radionuclides****Assumptions:**

Intakes are in dpm per calendar day.

<b>Job Category</b>	<b>Year</b>	<b>Operation Phase</b>	<b>Relevant Nuclide</b>	<b>Intake (dpm/d)</b>	<b>TBD Reference or Research Justification</b>
Operators	1942-1948	Operations	U234	25245	Air sample data
Supervisors/Laborers	1942-1948	Operations	U234	1428	Air sample data
Office	1942-1948	Operations	U234	81	Air sample data
All	1949 to July 2006	Residual	U234	0.329	appendix text

**Table B.2 INTERNAL DOSE PATHWAYS - Ingestion****Assumptions:**

Intakes are in dpm per calendar day.

<b>Job Category</b>	<b>Year</b>	<b>Operation Phase</b>	<b>Relevant Nuclide</b>	<b>Intake (dpm/d)</b>	<b>TBD Reference or Research Justification</b>
Operators	1942-1948	Operations	U234	438	Air sample data
Supervisors/Laborers	1942-1948	Operations	U234	25	Air sample data
Office	1942-1948	Operations	U234	1.4	Air sample data
All	1949 to July 2006	Residual	U234	.00385	appendix text

**Table B.3 EXTERNAL DOSE PATHWAYS - Whole Body**

<b>Job Category</b>	<b>Year</b>	<b>Operation Phase</b>	<b>Whole body (mr/yr)</b>	<b>TBD Reference or Research Justification</b>
Plant Floor High	1942	Operations	642	TBD-6001 Table 7.3
Plant Floor Low	1942	Operations	321	TBD-6001 Table 7.3
Supervisor	1942	Operations	160	TBD-6001 Table 7.3
Clerical	1942	Operations	16	TBD-6001 Table 7.3
Plant Floor High	1943-1948	Operations	1161	TBD-6001 Table 7.3
Plant Floor Low	1943-1948	Operations	583	TBD-6001 Table 7.3
Supervisor	1943-1948	Operations	291	TBD-6001 Table 7.3
Clerical	1943-1948	Operations	29	TBD-6001 Table 7.3
All	1949 to July 2006	Residual	40	Appendix Text

**Table B.4 EXTERNAL DOSE PATHWAYS - Skin****Assumptions:**

Doses are entered into IREP as Electron &gt;15kev

These doses are in addition to the Whole Body doses in Table B.3

<b>Job Category</b>	<b>Year</b>	<b>Operation Phase</b>	<b>Hand/Forearms (mr/yr)</b>	<b>Other Skin (mr/yr)</b>	<b>TBD Reference or Research Justification</b>
Plant Floor High	1942	Operations	39785	3562	TBD-6001 Table 7.3
Plant Floor Low	1942	Operations	19966	1781	TBD-6001 Table 7.3
Supervisor	1942	Operations	9965	891	TBD-6001 Table 7.3
Clerical	1942	Operations	996	89	TBD-6001 Table 7.3
Plant Floor High	1943-1948	Operations	770	227	TBD-6001 Table 7.3
Plant Floor Low	1943-1948	Operations	387	114	TBD-6001 Table 7.3
Supervisor	1943-1948	Operations	193	57	TBD-6001 Table 7.3
Clerical	1943-1948	Operations	19	6	TBD-6001 Table 7.3
All	1949 to July 2006	Residual	400	40	Appendix Text