HEALTH AND SAFETY RESEARCH DIVISION

Environmental Restoration and Waste Management Non-Defense Programs
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Radiological Survey Results at 18 Cliff Street,
Beverly, Massachusetts (VB012)

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ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted a radiological survey at 18 Cliff Street, Beverly, Massachusetts. The survey was performed in May 1991. The purpose of the survey was to determine if uranium dust from work performed under government contract at the former Ventron facility had migrated off-site to neighboring areas. The survey included a surface gamma scan and the collection of soil samples for radionuclide analyses.

Results of the survey demonstrated no radionuclide concentrations or radiation measurements in excess of the DOE Formerly Utilized Sites Remedial Action Program guidelines.
INTRODUCTION

The Metal Hydrides Corporation facility in Beverly, Massachusetts (which became the Ventron Corporation in 1965), was one of many companies performing work during the 1940s associated with the development of nuclear energy for defense-related projects under contract to the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC). Operations conducted under government contract at such sites included the procurement, storage, and processing of uranium oxides, salts, and metals, and the subsequent machining of these products. As a result of activities involving these materials, equipment, buildings, and land at some of the sites became radiologically contaminated with small amounts of the material resulting in low levels of contamination on the properties. At contract termination, release limits and decontamination operations were typically applied in conformance with standards currently deemed adequate for purposes of health and environmental protection. Subsequent to original assessments and the release of these facilities, new research and information have resulted in the development of more stringent guidelines for release of such facilities for unrestricted use. Furthermore, in some instances, documentation is limited or nonexistent, and conditions at a specific site may be unknown. It is the policy of the U.S. Department of Energy (DOE) to verify that radiological conditions at such facilities comply with existing guidelines.\(^1\) The Formerly Utilized Sites Remedial Action Program (FUSRAP) was established by DOE in 1974 to assist in assessment and cleanup activities at these sites.

The radiological survey detailed in this report was performed under the FUSRAP program and is one of several conducted in May 1991 on properties in the vicinity of the former Ventron facility by members of the Oak Ridge National Laboratory (ORNL) at the request of DOE. The city of Beverly lies on Massachusetts Bay ~15 miles northeast of the central Boston area. The former Ventron facility, now owned by Morton International, is located at the confluence of the Bass and Danvers rivers on Congress Street near the Beverly-Salem bridge (Fig. 1, p. 6).\(^2\)

From 1942 through 1948, the Metal Hydrides Corporation converted uranium oxide to uranium metal powder at the facility under contract to the MED in support of the war effort. As better methods for production of uranium metal were developed, Metal Hydrides

\(^1\) The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division of Oak Ridge National Laboratory under DOE contract DE-AC05-84OR21400.
shifted its operations toward recovering uranium from scrap uranium and turnings from the slug fabrication plant at Hanford, Washington.\textsuperscript{1} Contracts between Metal Hydrides and the government were completed in 1954.

Following a radiological screening survey at the site in 1977, a comprehensive survey was performed in 1982 (ref. 2). In 1987, DOE contractors removed the uranium-contaminated roof from a Ventron building, which had begun to leak. Radioactive materials remaining on the site do not pose a health hazard under present use conditions but could cause radiation exposure to workers if excavation or major renovation took place on the property. DOE plans a complete characterization study of the site in 1992 and the initiation of remedial action soon thereafter.

The survey of the residential property reported in this document and surveys of other surrounding properties are part of DOE's continuing program to assess the former Ventron site and plan for remedial action. The objective of the surveys was to determine if uranium from plant operations had migrated off-site to neighboring areas including Beverly Harbor, and if so, to what degree. The relative location of this vicinity property to the former Ventron site is shown in Fig. 2 (p. 7). The radiological surveys consisted of measurements of radiation levels over the ground surface of the properties and analysis of soil, sediment, and other material samples for the presence of radionuclides.

SURVEY METHODS

A comprehensive description of the survey methods and instrumentation used in this survey is given in \textit{Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program}, ORNL/TM-8600 (April 1987)\textsuperscript{3}.

SURFACE RADIATION MEASUREMENTS

Gamma radiation levels were determined using a portable NaI gamma scintillation meter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels in counts per minute (cpm) are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates in \(\mu R/h\). Using a Geiger-Mueller pancake detector, beta-gamma radiation levels in cpm were measured over selected paved or structural surfaces, and then converted to mrad/h. Alpha measurements were made on the roof of the shed to the rear of the property using a Bicron ratemeter connected to an ORNL ZnS scintillation probe and converted to disintegrations per minute over 100 cm\(^2\) (dpm/100 cm\(^2\)).
SOIL SAMPLING AND ANALYSES

Surface and subsurface soil samples were systematically collected over the property in a pattern sufficient to obtain a characterization of the radionuclide content of the soil. All soil samples were analyzed to determine $^{238}$U, $^{232}$Th, and $^{226}$Ra concentrations.

SURVEY RESULTS

Current DOE guidelines for sites included within the FUSRAP are summarized in Table 1 (p. 11). Typical background radiation levels for the Beverly, Massachusetts, area are presented in Table 2 (p. 12). These data are provided for comparison with the survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil, debris, and other samples.

Photographs made in May 1991 of the property at 18 Cliff Street, Beverly, Massachusetts are shown in Figs. 3 through 5 (pp. 8 and 9). Figure 5 is a photograph of the survey team collecting data on the cliff and beach behind the house. A diagram of the property is shown in Fig. 6 (p. 10).

SURFACE RADIATION MEASUREMENTS

Results of the surface gamma scan are shown on Fig. 6 (p. 10). Surface gamma exposure rates ranged from 7 to 26 $\mu$R/h. The maximum value, a factor of 3 higher than the typical range of background radiation levels in the Beverly, Massachusetts, area (6 to 9 $\mu$R/h, Table 2) was measured on contact with the dark granite foundation of the house. Higher than background values are frequently observed in association with materials such as granite or brick, which inherently contain slightly elevated concentrations of naturally occurring radionuclides.

Beta-gamma dose rates ranging from 0.02 to 0.04 mrad/h were determined from measurements taken on the shed roof at rear of the property. Alpha activity measurements in two locations near the surface of the shed roof were 40 and 66 dpm/100 cm$^2$. All measurements were comparable to background levels measured in the vicinity.

SOIL SAMPLING AND ANALYSES

Soil sample locations are shown in Fig. 6 (p. 10) and results of analyses are listed in Table 3 (p. 13). Sample locations S1, S2, S3, and S9 were selected from the cliff leading to the bay behind the property, while sample locations S4 through S8 were within the property boundaries. Maximum concentrations of $^{226}$Ra and $^{232}$Th in surface soil (0–15 cm) were 1.6 and 1.7 pCi/g, respectively; maximum values in subsurface soil were
1.6 pCi/g for each of the radionuclides. These results are comparable to typical background levels in the Beverly area (Table 2, p. 12) and below DOE guidelines (Table 1, p. 11). Uranium-238 concentrations in surface soil ranged from 1.9 to 9.8 pCi/g, and in subsurface soil were 1.6 to 40 pCi/g. Uranium-238 concentrations in most of the samples from 18 Cliff Street were above typical background soil levels in the Beverly area (Table 2, p. 12) but below guidelines of 35 to 40 pCi/g that have been applied at other FUSRAP sites (Table 1, p. 11). Soil sample S9B containing 40 pCi/g $^{238}$U was taken at low tide from a location in the bay that would be submerged during high tide. At one time or another, that area would probably have been subjected to residues from the Ventron site. Since the actual areal extent of contamination indicated by elevated $^{238}$U concentrations in sample S9B is probably less than 100 m$^2$ (the areal extent upon which the guideline value is based, Table 1, p. 11), the average $^{238}$U concentration will not exceed the guideline.

Although neither $^{137}$Cs nor $^{40}$K were associated with any MED operations or processing activities at the Ventron site, samples are routinely analyzed for their presence. These analyses showed that samples S4A and S4B contained 11 and 4.6 pCi/g $^{137}$Cs, respectively. Although these concentrations are slightly higher than those typically found in background areas, they are well below the guideline for $^{137}$Cs (Table 1, p. 11). Cesium–137 is a man-made radionuclide present worldwide in atmospheric fallout from nuclear weapons testing. It is frequently found in soil taken from areas where rainwater collects, such as the driplines of roofs and low-lying areas in and around parking lots or thoroughfares.

Sample S6B contained 24 pCi/g potassium-40 ($^{40}$K) while all other samples from this property contained less than 17 pCi/g. Potassium-40 is a naturally occurring, pervasive radionuclide found in many biological and environmental materials, including normal food and human tissues. Worldwide, the concentration of $^{40}$K in soil ranges from 3.5 to 22 pCi/g$^4$. Potassium-40 is added in large amounts as potash to fertilizers and is frequently encountered in enhanced concentrations in locations subjected to agricultural activities, including areas impacted by runoff or gardening. Potassium-40 is also a minor constituent of coal and is present in the ash resulting from coal combustion. Coal ash was observed in some soil samples from 18 Cliff Street.

**SIGNIFICANCE OF FINDINGS**

The results of the radiological survey at 18 Cliff Street, Beverly, Massachusetts, demonstrated no radionuclide concentrations or radiation measurements above established DOE guidelines.
REFERENCES


Fig. 1. Diagram showing general location of the former Ventrion site.
Fig. 2. Diagram showing location of 18 Cliff Street, Beverly, Massachusetts, in relation to the former Ventron site.
Fig. 3. View looking southeast at the house at 18 Cliff Street, Beverly, Massachusetts.

Fig. 4. View looking northwest at the house at 18 Cliff Street, Beverly, Massachusetts.
Fig. 5. Photograph showing survey team collecting data from the cliff behind 18 Cliff Street, Beverly, Massachusetts. The house is the second from the right.
Fig. 6. Surface gamma exposure rates and soil sample locations at 18 Cliff Street, Beverly, Massachusetts.
Table 1. Applicable guidelines for protection against radiation (Limits for uncontrolled areas)

<table>
<thead>
<tr>
<th>Modes of exposure</th>
<th>Exposure conditions</th>
<th>Guideline value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma radiation</td>
<td>Indoor gamma radiation level (above background)</td>
<td>20 µR/h&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Radionuclide concentrations in soil (generic)</td>
<td>Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 100-m&lt;sup&gt;2&lt;/sup&gt; area</td>
<td>5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g averaged over 15-cm-thick soil layers more than 15 cm below the surface</td>
</tr>
<tr>
<td>226 Ra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>232Th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>230Th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derived concentrations</td>
<td>238U</td>
<td>Site specific&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Concentration limit in surface soil above background levels based on dose estimates from major exposure pathways</td>
<td></td>
<td>80 pCi/g over a 100-m&lt;sup&gt;2&lt;/sup&gt; area of contamination&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>137Cs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guideline for non-homogeneous contamination (used in addition to the 100-m&lt;sup&gt;2&lt;/sup&gt; guideline)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Applicable to locations with an area ≤25 m&lt;sup&gt;2&lt;/sup&gt; with significantly elevated concentrations of radionuclides (&quot;hot spots&quot;)</td>
<td>$G_A = G_i \cdot (100/A)^{1/2}$ where $G_A = \text{guideline for &quot;hot spot&quot; of area (A)}$ $G_i = \text{guideline averaged over a 100-m&lt;sup&gt;2&lt;/sup&gt; area}$</td>
</tr>
</tbody>
</table>

<sup>a</sup>The 20 µR/h shall comply with the basic dose limit (100 mrem/yr) when an appropriate-use scenario is considered.


<sup>d</sup>DOE guidelines specify that every reasonable effort shall be made to identify and to remove any source that has a concentration exceeding 30 times the guideline value, irrespective of area (Adapted from Revised Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites, April 1987).

Table 2. Background radiation levels and concentrations of selected radionuclides in soil in the Beverly, Massachusetts, area

<table>
<thead>
<tr>
<th>Type of radiation measurement or sample</th>
<th>Radiation level or radionuclide concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
</tr>
<tr>
<td>Gamma exposure rate at 1 m above ground surface (μR/h)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6–9</td>
</tr>
<tr>
<td>Concentration of radionuclides in soil (pCi/g)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>²³²Th</td>
<td>0.8 – 0.9</td>
</tr>
<tr>
<td>²²⁶Ra</td>
<td>0.7 – 0.9</td>
</tr>
<tr>
<td>²³⁸U</td>
<td>0.7 – 1.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Values obtained from three locations in the Beverly area.
Table 3. Concentrations of radionuclides in soil samples from 18 Cliff Street, Beverly, Massachusetts

<table>
<thead>
<tr>
<th>Samplea</th>
<th>Depth (cm)</th>
<th>Radionuclide concentration (pCi/g)b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>226Ra</td>
</tr>
<tr>
<td>S1</td>
<td>0–8</td>
<td>1.6 ± 0.03</td>
</tr>
<tr>
<td>S2</td>
<td>0–10</td>
<td>1.4 ± 0.06</td>
</tr>
<tr>
<td>S3</td>
<td>0–10</td>
<td>1.5 ± 0.07</td>
</tr>
<tr>
<td>S4A</td>
<td>0–15</td>
<td>0.80 ± 0.03</td>
</tr>
<tr>
<td>S4B</td>
<td>15–30</td>
<td>1.1 ± 0.02</td>
</tr>
<tr>
<td>S5A</td>
<td>0–15</td>
<td>0.94 ± 0.04</td>
</tr>
<tr>
<td>S5B</td>
<td>15–30</td>
<td>0.97 ± 0.02</td>
</tr>
<tr>
<td>S6A</td>
<td>0–15</td>
<td>0.80 ± 0.02</td>
</tr>
<tr>
<td>S6B</td>
<td>15–30</td>
<td>0.85 ± 0.04</td>
</tr>
<tr>
<td>S7A</td>
<td>0–15</td>
<td>1.4 ± 0.05</td>
</tr>
<tr>
<td>S7B</td>
<td>15–25</td>
<td>1.4 ± 0.02</td>
</tr>
<tr>
<td>S8A</td>
<td>0–15</td>
<td>1.5 ± 0.02</td>
</tr>
<tr>
<td>S8B</td>
<td>15–30</td>
<td>1.6 ± 0.04</td>
</tr>
<tr>
<td>S9A</td>
<td>0–15</td>
<td>0.69 ± 0.02</td>
</tr>
<tr>
<td>S9B</td>
<td>15–30</td>
<td>0.81 ± 0.04</td>
</tr>
<tr>
<td>S9C</td>
<td>30–45</td>
<td>0.81 ± 0.05</td>
</tr>
</tbody>
</table>

*Sample locations are shown on Fig. 6 (p. 10).

Indicated counting error is at the 95% confidence level (± 2σ).

*Systematic samples are taken at locations irrespective of gamma exposure rates.*
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