February 1, 2010

Thomas W. Hartline, Director
Safety and Mission Assurance
National Aeronautics and
Space Administration
John H. Glenn Research Center
Cleveland, Ohio 44135-3191

SUBJECT: ISSUANCE OF AMENDMENT NO. 14 TO FACILITY LICENSE TR-3 AND AMENDMENT NO. 10 TO FACILITY LICENSE NO. R-93 (TAC NO. J00301)

Dear Mr. Hartline:

The U.S. Nuclear Regulatory Commission (The Commission or NRC) has issued the enclosed Amendment No. 14 to Facility License No. TR-3 and Amendment 10 to Facility License No. R-93 for the Test Reactor and the Mockup Reactor, respectively, at the National Aeronautics and Space Administration (NASA) Plum Brook Reactor Facility (PBRF) in Sandusky, Ohio. These amendments consist of changes that add a new paragraph to Licenses TR-3 and R-93 requiring that NASA assess the residual radioactivity and demonstrate that the stream bed and banks of Plum Brook between the boundary of Plum Brook Station and Sandusky Bay meet the criteria for unrestricted use specified in 10 CFR 20.1402 prior to terminating Licenses TR-3 and R-93.

Prior to issuance of the amendments, the Commission published a Notice of Consideration of Issuance of Amendment to Facility Operating Licenses, Proposed No Significant Hazards Consideration Determination, and opportunity for a Hearing in the *Federal Register* (74 FR 20751) on May 5, 2009. No requests for hearing were received.

The environmental impacts associated with this action were previously evaluated in conjunction with the license amendment authorizing the decommissioning of the PBRF. The Environmental Assessment and Finding of No Significant Impact was published in the *Federal Register* (65 FR 16421) on March 28, 2000.

A copy of our related Safety Evaluation is enclosed. The Notice of Issuance will be included in the Commission's next biweekly Federal Register notice.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agency-wide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web Site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

If you have any questions or need additional information, please contact Chad Glenn at 301-415-6722.

Sincerely,

/RA/

Keith I. McConnell, Deputy Director
Decommissioning and Uranium Recovery
Licensing Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

Docket Nos: 50-30 and 50-185

Enclosures:
1. Safety Evaluation
2. Amendment No. 14 for Facility License TR-3
3. Amendment No. 10 for Facility License R-93

cc: NASA Service List

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OFC	DWMEP	DWMEP	OGC	DWMEP	DWMEP	DWMEP
NAME	CGlenn	SMichonski	JHull NLO as revised	CMcKenney	RTadesse	KMcConnell
DATE	1/12/10	1 /26 /10	1/19/10	1 /21/10	1/27 /10	2/1/10

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National Aeronautics and Space Administration Service List - Chad Glenn, Project Manager

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SAFETY EVALUATION BY THE OFFICE OF FEDERAL AND STATE MATERIALS AND ENVIRONMENTAL MANAGEMENT PROGRAMS REGARDING AMENDMENT NO. 14 TO FACILITY LICENSE TR-3 AND AMENDMENT NO. 10 TO FACILITY LICENSE NO. R-93 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PLUM BROOK REACTOR FACILITY DOCKET NOS. 50-30 AND 50-185

1.0 INTRODUCTION

By application dated January 9, 2009, (ML090140338), as supplemented by a letter dated October 6, 2009 (ML092870784), National Aeronautics and Space Administration (NASA), the licensee, requested that Licenses TR-3 and R-93 be amended. The proposed amendment would add a new paragraph to Licenses TR-3 and R-93 requiring that NASA assess the residual radioactivity and demonstrate that the stream bed and banks of Plum Brook between the boundary of Plum Brook Station and Sandusky Bay meet the criteria for unrestricted use specified in 10 CFR 20.1402 prior to terminating Licenses TR-3 and R-93. The supplement provided additional information that clarified the application, but did not expand the scope of the application nor change the staff's original proposed no significant hazards consideration determination as originally noticed in the *Federal Register* on May 5, 2009 (74 FR 20751).

1.1 Related NRC Activities

On September 3, 2008, the U.S. Nuclear Regulatory Commission (NRC) and NASA participated in a public meeting in the vicinity of the Plum Brook Reactor Facility (PBRF) in Sandusky, Ohio to discuss the results of the licensee's characterization and sampling of offsite contamination in Plum Brook, dose modeling analyses, and their proposed approach for demonstrating compliance with NRC requirements. In this meeting, the licensee proposed to use the dose assessment approach described in NRC's Consolidated Decommissioning Guidance (NUREG-1757) to demonstrate compliance with the NRC requirements for unrestricted use (25 mrem/yr plus as low as reasonably achievable (ALARA)). This is also the dose criterion used in the decommissioning plan for the PBRF. According to NUREG-1757, the dose assessment approach is an acceptable method for the licensee to provide reasonable assurance that the NRC dose requirements will be met. In this approach, a dose assessment is performed using the final concentrations of residual radioactivity. Based on discussions in this meeting (ML082900908), the licensee provided additional information and submitted a license amendment request.

2.0 REGULATORY EVALUATION

The licensee began performing decommissioning of the PBRF with the approval of the decommissioning plan for the PBRF in March 2002. In August 2005, during routine characterization surveys, Cesium-137 (Cs-137) was discovered in the sediment of Plum Brook, an offsite stream. The licensee reported low levels of Cs-137 in offsite sediments along Plum Brook and determined that this material originated in discharges of water during normal reactor operations (1961-1973). The licensee worked with appropriate agencies in developing a sampling plan and initiated sampling.

As part of the regulatory evaluation, NRC consulted and coordinated with the Ohio Department of Health regarding the regulatory entity with jurisdiction for the characterization of this offsite contamination (ML053160001). Based on this consultation, the agencies determined that the offsite contamination from the Plum Brook site is a NASA responsibility and subject to the same Federal regulatory controls as PBRF itself. In a January 2006 public meeting, the licensee presented characterization data and its future sampling plans. In this meeting, the licensee also committed to do what was necessary to define the problem and to protect the public, and NRC committed to consider the contamination in Plum Brook to be part of the PBRF decommissioning, and to not terminate NASA's licenses until Plum Brook was properly addressed.

3.0 TECHNICAL EVALUATION

3.1 Site Description

The PBRF, located in Erie County, Ohio, operated from 1961 to 1973. During reactor operations, liquid effluents containing Cs-137 and Cobalt-60 (Co-60) were discharged into the Pentolite Ditch, which flows into the Plum Brook. The Plum Brook originates south of the PBRF, flows north and terminates in Sandusky Bay on Lake Erie. The stream course distance between the Pentolite Ditch and Sandusky Bay is approximately 6.44 km (4 miles). The land use along the Plum Brook includes areas zoned for residential, agricultural, commercial, municipal, and recreational use. The recreational areas consist of land occupied by the Plum Brook Country Club (PBCC) and the Putnam Nature Preserve, which is owned by the Erie Metro Park district.

When the Cs-137 and Co-60 were initially discharged, they were believed to have been rapidly sorbed onto clay particles. These particles were then transported downstream in the Plum Brook over time, and the movement and the distribution of radionuclides in the Plum Brook has been controlled by the physical transport of the sediments in the stream.

The Plum Brook was divided into four sections for the purpose of characterization. Section 1, the Upper Stream, is the portion of the stream from the PBRF to State Route 2. Section 2, the Lower Stream, is defined as being the portion of the stream from State Route 2 to the center of the PBCC. Section 3, the Upper Flood Plain, is the portion of the stream from the center of the PBCC to US Route 6, and Section 4, the Lower Flood Plain and Estuary, is defined as the portion of the stream from US Route 6 to Sandusky Bay.

Site Description – Evaluation Finding

The staff has determined that the information describing Plum Brook and environs is sufficient to allow the NRC staff to understand the physical characteristics of the site and relationship of the site to surrounding areas.

3.2 Hydrological Characteristics of the Plum Brook

The Plum Brook is characterized as a narrow meandering stream from the PBRF to the interior of the PBCC. Beyond the PBCC, the stream widens into a flood-wetland until it reaches Sandusky Bay. The average stream flow is estimated to vary from approximately 0.094 m^3 (3.3 ft^3) per second to about 0.16 m^3 (5.7 ft^3) per second. In the meandering section, the stream channel is approximately 1.22 to 1.83 meters (m) (4 to 6 feet) below the steep river banks. The water in the channel is from 0.61 m (2 feet) to 3.05 m (ten feet) wide, and approximately 0.30 m (1 foot) in depth under normal flow condition. In contrast, the stream channel in the flood plain and estuary north of the PBCC is considerably wider and the stream banks are much less pronounced. In this section, the water also becomes deeper, ranging from 0.61-1.22 m (2-4 feet) to 1.22-1.52 m (4-5 feet) at the stream mouth in the Plum Brook estuary. Wetland with marsh vegetation extends several hundred feet from the stream on both sides.

Hydrological Characteristics of the Plum Brook - Evaluation Finding

The staff has determined that the information provided on the hydrological characteristics of Plum Brook are sufficient to support the NRC staff's evaluation of the licensee's estimated doses to individuals based on residual activity in Plum Brook.

3.3 Land Use

The Plum Brook watershed from PBRF to Sandusky Bay encompasses approximately 4.14 km^2 (1.6 mi^2). Thirty five percent of this area is zoned for residential use. Recreational, agricultural and commercial land uses account for 22 percent, 18 percent, and 13 percent, respectively. The majority of the residences are located next to the stream as single family units between the PBRF and Sandusky Bay, with an average population density of 10 to 20 persons per square mile. Among the recreational land uses, the PBCC accounts for over half of the acreage for this land use. Three ponds that were once connected to the Plum Brook are located on the PBCC. The rest of the watershed, zoned as recreational, is located north of US Rt. 6 as the Putnam Natural Preserve, with portions of the Preserve occupied by the Plume Brook flood plain and wetland. Most of the land zoned commercial is found between Bogart Road and US Route 2. The commercial properties bordering the stream include motels, a gas station, restaurants, and several small store-front businesses.

Land Use – Evaluation Finding

The staff determined that the licensee has provided sufficient information on land use to allow NRC staff to evaluate the licensee estimated doses to individuals based on residual activity in Plum Brook.

3.4 Source Term

The NRC License Termination Rule (10 CFR part 20, subpart E) states that a site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of the critical group that does not exceed 25 mrem (0.25mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to ALARA levels. NUREG-1757 provides guidance on: (1) demonstrating compliance with the radiological criteria for license termination, specifically guidance to demonstrate compliance with 10 CFR 20 Subpart E; and (2) methods and techniques acceptable to NRC staff for compliance with the license termination criteria.

In NUREG-1757, Volume 2, Section 3.3, guidance is provided on conditions under which radionuclides or exposure pathways may be considered insignificant and may be eliminated from further consideration. NRC staff considers radionuclides and exposure pathways that contribute no greater than 10 percent of the dose criteria to be insignificant contributors. This 10 percent limit for insignificant contributors is an aggregate limitation only. This means the sum of the dose contributions from all radionuclides and pathways considered insignificant will be no greater than 10 percent of the dose criteria of 25 mrem (0.25mSv) per year as defined in 10 CFR part 20, subpart E.

The licensee evaluated the radionuclide inventory in soils from samples collected from the surrounding area of PBRF in the Final Status Survey Plan, Revision 1, Attachment A, dated February 2007. The licensee collected samples from the Emergency Retention Basin and from a suspected spill area south of the Waste Handling Building. These soil samples were considered biased in order to ensure an adequate determination of high isotopic concentrations. A summary of the results from these soil samples are shown in Table 1.

Table 1 Surface Soil Radionuclide Distribution

Am-241*	0.15%
Am-243*	0.16%
C-14*	2.11%
Cm-245*	0.22%
Co-60	1.68%
Cs-137	58.50%
Eu-155*	0.76%
H-3*	22.68%
I-129*	0.53%
Nb-94*	0.30%
Ni-63*	6.96%
Pu-238*	0.17%
Pu-239*	0.16%
Sr-90	5.49%
U-236*	0.12%

*These radionuclides are considered insignificant

For surface soil samples, the doses from all radionuclides, other than Cs-137, Co-60, and Sr-90, contributed only 0.5 mrem per year. This is less than 10 percent of the dose criteria of 25 mrem per year. Therefore, these radionuclides can be considered insignificant. The licensee considers Cs-137, Co-60, and Sr-90, the primary radionuclides of concern.

As reflected in the licensee's October 6, 2009, letter response (ML092870784) to a request for additional information, the licensee selected soil samples from two characterization surveys for analysis at a vendor laboratory. Two sediment samples from the 2004 Pentolite Ditch Characterization Survey and three sediment samples from the 2005 Plum Brook Scoping Characterization Survey were sent to Eberline Services in Oak Ridge, TN and Severn Trent Laboratories in Earth City, MO, respectively. The licensee requested these sediment samples to be analyzed by gamma spectroscopy for tritium, C-14, Ni-63, Sr-90, I-129, isotopic uranium, and isotopic thorium. In addition to these soil samples, the licensee also selected additional soil samples from the PBRF sample archive to be sent to a vendor laboratory for analysis. The selection was biased to choose those samples from each section of the Plum Brook that had the highest Cs-137 concentrations with the premise that these samples would most likely have other radionuclides present. The licensee requested the vendor laboratory to analyze by gamma spectroscopy for H-3, Sr-90, I-129, and isotopic uranium. The licensee concluded that no radionuclides of concern other than Cs-137 and Co-60 are present in the Plum Brook sediments. The licensee calculated that approximately 5 to 7 millicuries of Cs-137 in liquid effluent was released from the facility between 1961 and 1973.

Source Term – Evaluation Finding

The NRC staff has determined that the licensee has adequately demonstrated that only Cs-137 and Co-60 are present in soils/sediments in the Plum Brook and that Cs-137 and Co-60 are the radionuclides of concern. The NRC staff has also determined that the other radionuclides are considered insignificant and can be eliminated from further consideration.

3.5 Sediment/Soil Sampling and Analysis

The licensee conducted several sampling operations of the Plum Brook creek area. The initial scoping survey sampling was conducted in 2005 and covered an eight mile length of the Plum Brook, which included 4.83 kilometers (km) (three miles) upstream of Pentolite Ditch and 8.05 km (five miles) downstream to Sandusky Bay. The sampling for this survey was conducted in accordance with the licensee's administrative Survey Verification Instruction SVI-04. The licensee performed gamma scan surveys using a 2 x 2 Sodium Iodide (NaI) detector and sediment sampling. The licensee collected three one liter soil/sediment samples at each location at depths of 0-15.24 centimeters (cm) (0-6 inches), 17.78-30.48 cm (7-12 inches), and 33.02-45.72 cm (13-18 inches). The licensee identified a total of 19 survey locations. At least two samples were required to be collected at each location. The licensee indicated that the highest measureable Cs-137 and Co-60 were 38.3 pCi/g and 0.45 pCi/g, respectively. The average background activity was 0.14 pCi/g for Cs-137 and 0.13 pCi/g for Co-60.

In 2006, the licensee retained the services of a contractor to characterize and evaluate the Plum Brook creek. The hydrogeologic study evaluated sediment in the following areas:

- Meandering streams
- Stream backwaters
- Ponds
- Floodplain wetlands
- Stream mouth wetlands
- Bay behind barrier island
- Rock fractures bearing groundwater

The contractor used either of two techniques for collecting sediment samples, the manual dual tube geoprobe method or the vibracore method. In the geoprobe method, a five foot long dual tube sampler was driven down to the desired depth or to resistance. In the vibracore method, a backpack mounted gas powered vibrator was attached to the top of a three inch diameter ten foot long aluminum tube. Each tube was then vibrated down into the ground until the desired depth was reached or to resistance.

As indicated above, the licensee identified four major sections of Plum Brook. Section 1, the Upper Stream (meander), covers 2.57 km (1.6 miles) and a watershed area of 1.81 km^2 (0.7 mi^2). Section 2, the Lower Stream (meander) covers 1.61 km (1.0 mile) and a watershed area of 1.53 km^2 (0.59 mi^2). Section 3, the Upper Flood Plain includes 1.37 km (0.85 miles) of stream course and a watershed area of 0.57 km^2 (0.22 mi^2). Section 4, the Lower Flood Plain and Estuary (mouth) includes 0.89 km (0.55 miles) of stream course and 0.28 km^2 (0.11 mi^2) of watershed area.

The licensee collected samples of sediment from approximately 900 locations along the four mile stream course from Pentolite Ditch at PBRF and extending into Sandusky Bay. Core samples were collected at each location to provide for determination of radionuclide concentration versus depth. Over 3,100 sub-samples (aliquots) from these core samples were analyzed by gamma spectroscopy. The sum total includes the total number of sediment samples collected from the initial scoping survey and the follow up characterization and evaluation by a contractor.

On March 20, 2009, the licensee submitted its final Plum Brook characterization and dose pathway analyses reports (ML090900743). During the review of the “Final Detailed Plum Brook Characterization Report” PBRF-TBD-08-005, Revision 1, NRC staff noted that only three sample locations were identified by the licensee in Section 2 (Lower Stream) as opposed to 619 locations in Section 1, 238 locations in Section 3, and 44 locations in Section 4. In the areas that were not adequately surveyed (e.g., stream section 2), the licensee plans to perform a 100 percent survey of the bank area using the same detector that was used during the previous characterization (i.e., Ludlum Model 2350-1 with 44-10 sodium iodide detector, and a gamma-spectrum window set to focus of Cs-137 activity) or an equivalent.

As indicated in Section 1.1, NUREG-1757, Volume 2, recognizes two approaches for demonstrating compliance with 10 CFR part 20, subpart E. These approaches are: (1) dose modeling approach, and (2) Derived Concentration Guideline Level (DCGL) and final status survey approach. The licensee has selected the dose modeling approach to satisfy the unrestricted use criteria specified in 10 CFR 20.1402. In selecting the dose modeling approach, NUREG-1757, Volume 2, Table 2.2 also recognizes that preliminary cleanup goals or DCGLs may be needed to design surveys or guide remediation. The licensee developed DCGLs to guide remediation. The licensee developed surface soil DCGLs for Cs-137 at 14.7 pCi/g, 3.8 pCi/g for Co-60, and 5.4 pCi/g for Sr-90 in the NASA Final Status Survey Plan for the Plum Brook Reactor Facility, dated February 2007. In the NASA technical basis document, titled "Radionuclide Distributions and Adjusted DCGLs for Site Soils", PBRF-TBD-09-001, dated June 2009, the licensee calculated a surrogate DCGL value of 13.34 pCi/g for the Pentolite Ditch and the Plum Brook that includes Sr-90 and Co-60. The DCGL value was an action level used by the licensee to assess and evaluate remediation and to determine if further action is necessary.

Sediment/Soil Sampling and Analysis – Evaluation Finding

The staff has determined that sediment/soil sampling and analyses was reasonable and the staff found the surrogate DCGL value to be acceptable.

3.6 Dose Modeling

A dose assessment was performed by the licensee to verify that the dose from the radionuclides present in the Plum Brook is less than 0.25 mSv/yr (25 mrem/yr). This dose assessment considered the measured concentrations of Cs-137 and Co-60 in the Plum Brook, and the dose was evaluated for four different exposure scenarios.

3.6.1 Critical Group, Scenarios Definition, Exposure Pathways

The four different exposure scenarios considered by the licensee in their dose assessment included: a suburban gardener, a brook-side resident, a country club worker, and a recreationalist. The suburban gardener and brook-side resident are assumed to be located in the stream meander section (i.e., sections 1 and 2) and the country club worker and the recreationalist are located in the flood plain and estuary (i.e., sections 3 and 4). The suburban gardener scenario included a receptor who planted a vegetable garden on soil and sediment that had been taken from the Plum Brook. The pathways considered in this scenario included direct exposure, inhalation, ingestion of soil, and consumption of vegetables from the garden. The brook-side resident scenario considered a resident who lives in a house built on soil impacted by a flood of the Plum Brook. The pathways considered in the resident scenario include direct exposure, inhalation, and ingestion of soil. An alternative brook-side resident scenario was also considered in which the resident also spends time in and consumes vegetables from a garden that has soil that is contaminated. In the country club maintenance worker scenario, it was assumed that contaminated sediment from the Plum Brook was used as fill on walkways at the country club. The pathways considered in this scenario were direct exposure, inhalation, and direct ingestion of soil. The recreationist scenario considered a person who fishes in the estuary and consumes the fish that they catch. The pathways considered in this scenario included direct exposure, inhalation, and ingestion of sediment, and the consumption of fish from the estuary.

Critical Group, Scenarios Definition, Exposure Pathways – Evaluation Finding

The NRC staff finds that the scenarios and exposure pathways selected by NASA for their dose assessment are appropriate and reasonable.

3.6.2 Source Term Abstraction

The results of the radiological characterization of the Plum Brook indicate that the contaminated sediments are not distributed evenly along the stream and that the contaminated sediments tend to be located in small areas of the stream. In addition, the concentration of the radionuclides is not constant with depth. In many cases, the higher activity sediment is not at the surface.

In the dose assessment submitted by the licensee, the source term was modeled as a circular contaminated zone and a circular area of elevated contamination. In most of the scenarios the contaminated zone and area of elevated contamination were modeled as three different vertical layers. The dose from each of the components of the source term was added to calculate the overall dose for a scenario. The concentrations used in the calculation of dose from the contaminated zone were based on the average measured concentration for the stream segment, and the uncertainty in the contaminated zone concentration was based on the standard deviation of these measurements. The concentrations used for the elevated local areas were the maximum measured concentration for the stream segment, and the uncertainty for these concentrations was based on the uncertainty associated with the analytical measurement of these concentrations. It is important to note that the measured concentrations for the radionuclides are for sediment that is located within the Plum Brook. In order for the receptor in the suburban gardener, brookside resident, or PBCC maintenance worker scenarios to be exposed to these concentrations, the sediment would have to be moved from the brook. This could be caused by a natural event, such as a flood event, or by the sediment being intentionally moved from the stream by people. For example, the sediment could be taken from the stream for use as soil in a garden.

The contaminated zone in the suburban gardener scenario was assumed to be 186 m^2 (2002 ft^2) in area with a thickness of 7.62 cm (3 in). The house in the brookside resident scenario was assumed to have a footprint of 186 m^2 (2002 ft^2). The area assumed for the contaminated zone for the alternate brookside resident scenario is 93 m^2 (1001 ft^2), or half the footprint of the house. The area of the contaminated zone of 600 m^2 (6458 ft^2) assumed for the PBCC maintenance worker was based on the assumption that sediment from the Plum Brook was used as landscaping fill on an area that is 100 m (328 feet) long and extends 3 m (9.84 feet) on either side of a golf cart path. The contaminated zone in this scenario is assumed to be 7.62 cm (3 in). The area of 1500 m^2 (16145 ft^2) assumed for the contaminated zone in the recreationist scenario was based on an area of sediment that is accessible to the public.

The localized areas of elevated contamination in the stream meander sections (i.e., sections 1 and 2) were modeled as cylinders that had a 1 m (3.28 feet) radius and an area of 3.14 m^2 (33.79 ft^2). This assumption was based on the measured areas of thirty areas of elevated activity identified in stream section 1. These areas were delineated with a scan survey using a NaI detector. The average area of elevated activity was 2.84 m^2 (30.56 ft^2) and the median area

was 2.25 m^2 (24.21 ft^2) The localized areas of elevated contamination in the flood plain and estuary (i.e., sections 3 and 4) were modeled as cylinders with a radius of 3 m (9.8 feet) and an area of 28.27 m^2 (304.30 ft^2). This assumption was based on measured areas of elevated contamination in the flood plain and an estimated area in the estuary. The radii of two areas of elevated contamination located in the flood plain were measured to be 2.43 m (7.97 feet) and 3.81 m (12.5 feet) using a gamma scan. The radius of the area of elevated contamination in the estuary was estimated to be 2.71 m (8.89 feet) based on the concentration patterns observed for Cs-137 and the professional judgment of a hydrogeologist.

The areas, thicknesses, and concentrations assumed for the source term for the scenarios can be seen in Table 2.

Table 2 Assumed Source Term Properties

	Area m^2	Thickness m (in)	Cs-137 pCi/g *	Co-60 pCi/g *
Suburban Gardener				
Cont. Zone	186	0.076 (3)	1.20 ± 2.80	0.130 ± 0.070
Elev. Local area layer 1	3.14	0.15 (6)	57.8 ± 2.26	1.60 ± 0.210
Elev. Local area layer 2	3.14	0.15 (6)	72.4 ± 2.77	0.653 ± 0.140
Elev. Local area layer 3	3.14	0.15 (6)	20.5 ± 1.10	0.288 ± 0.090
Brookside Resident				
Cont. Zone layer 1	186	0.15 (6)	0.980 ± 1.31	0.110 ± 0.040
Cont. Zone layer 2	186	0.23 (9)	1.42 ± 3.19	0.140 ± 0.080
Cont. Zone layer 3	186	0.23 (9)	1.20 ± 3.39	0.140 ± 0.080
Elev. Local area layer 1	3.14	0.15 (6)	57.8 ± 2.26	1.60 ± 0.210
Elev. Local area layer 2	3.14	0.15 (6)	72.4 ± 2.77	0.653 ± 0.140
Elev. Local area layer 3	3.14	0.15 (6)	20.5 ± 1.10	0.288 ± 0.090
Alternate Brookside Resident				
Cont. Zone layer 1	93	0.15 (6)	0.980 ± 1.31	0.110 ± 0.040
Cont. Zone layer 2	93	0.23 (9)	1.42 ± 3.19	0.140 ± 0.080
Cont. Zone layer 3	93	0.23 (9)	1.20 ± 3.39	0.140 ± 0.080
Elev. Local area layer 1	3.14	0.15 (6)	57.8 ± 2.26	1.60 ± 0.210
Elev. Local area layer 2	3.14	0.15 (6)	72.4 ± 2.77	0.653 ± 0.140
Elev. Local area layer 3	3.14	0.15 (6)	20.5 ± 1.10	0.288 ± 0.090
Cont. Zone in Garden	186	0.23 (9)	1.23 ± 1.78	0.133 ± 0.0436
PBCC Maintenance Worker				
Cont. Zone	600	0.076 (3)	1.38 ± 1.84	0.245 ± 0.0743
Elev. Local area layer 1	28.27	0.15 (6)	14.2 ± 0.890	NA
Elev. Local area layer 2	28.27	0.30 (12)	4.70 ± 0.510	NA
Elev. Local area layer 3	28.27	0.30 (12)	2.90 ± 0.345	NA
Recreationist				
Cont. Zone layer 1	1500	0.15 (6)	1.02 ± 2.56	0.23 ± 0.800
Cont. Zone layer 2	1500	0.30 (12)	0.78 ± 1.69	NA
Cont. Zone layer 3	1500	0.30 (12)	0.35 ± 0.83	NA
Elev. Local area layer 1	28.27	0.15 (6)	20.6 ± 1.4	NA
Elev. Local area layer 2	28.27	0.30 (12)	15.7 ± 0.99	NA
Elev. Local area layer 3	28.27	0.30 (12)	16.8 ± 1.10	NA
Cont. zone layer - fish pathway	1500	0.76 (30)	0.717 ± 0.339	NA
Elev. Local area - fish pathway	28.27	0.76 (30)	17.7 ± 2.57	NA

* multiply pCi/g by 0.037 to obtain the concentration in Bq/g

Source Term Abstraction – Evaluation Finding

The NRC staff finds that the source term concentrations and areas used in the dose assessment are appropriate. In addition, the use of the concentrations measured in the Plum Brook is a conservative assumption for the suburban gardener, brookside resident, and country club maintenance worker scenarios because the sediment must be moved from the stream for these receptors to be exposed to the radionuclides. In addition, mixing of the sediment with clean soil would likely occur in the process of the sediment being removed from the stream and distributed, which would reduce the concentrations of the radionuclides.

3.6.3 Calculations and Input Parameters

The doses for the four scenarios were calculated using the RESRAD code version 6.4. The dose for each scenario was initially calculated using a deterministic analysis. Based on this, the pathways that contributed most to dose were determined. A sensitivity analysis was then performed to determine which parameters were the most sensitive. The parameters that were identified as being the most sensitive parameters were entered into RESRAD with probabilistic distributions, and a probabilistic dose assessment was performed to calculate the dose for the four scenarios. The probabilistic distributions used in this calculation are described in the document “Revised Dose Assessment for Plum Brook Sediments“(PBRF-TBD-08-006).

The parameters used in the modeling of infiltration and groundwater flow, such as the soil density, the hydraulic conductivities, the thickness of the unsaturated zone, the hydraulic gradient of the saturated zone, the well pump rate, and the water shed area were based on information from the report “Hydrogeological Report Plum Brook Reactor Facility” by the U.S. Army Corps of Engineers. A soil ingestion rate of 18.3 g/yr was assumed for the soil ingestion rate for all of the scenarios.

Suburban Gardener

The suburban gardener was assumed to spend 123 hrs per year in a garden that contains contaminated soil. This corresponds to a fraction of time spent outdoors of 0.014. A portion of the garden was also assumed to contain a local area of elevated contamination, and the gardener was assumed to spend 6 hrs per year, or a fraction of 0.0007, outdoors on this area. The contaminated fraction of plant food was assumed to be 0.5 for the contaminated zone calculation and 0.0169 for the elevated local area of contamination. The assumed contaminated fraction of plant food for the elevated area was based on the ratio of the elevated area to the area of the whole garden. The parameters modeled probabilistically for the suburban gardener scenario include the contaminated zone thickness, contaminated zone area, contaminated zone density, fraction of time spent outdoors, depth of roots, contaminated fraction of plant food, and non-leafy vegetable consumption.

Brookside Resident

The house occupied by the brookside resident is assumed to have a footprint of 186 m^2. Of this area, 45.6 m^2 was assumed to be contaminated. The fraction of the house footprint that is over the contaminated zone was accounted for in the RESRAD modeling by adjusting the occupancy factor to account for the time the resident would spend above the contaminated zone. The

fraction of time the resident spends indoors above the contaminated zone was assumed to be 0.125. This was based on multiplying the RESRAD default for the fraction of time that a resident spends in their house by 0.25 to account for the assumption that only one quarter of the footprint of the house was located above the contaminated zone. They were also assumed to spend 80 hrs/yr, or a time fraction of 0.0091, outdoors above the contaminated zone. In the initial brookside resident calculation, the area of local area elevated contamination was assumed to be located in the vicinity of the house, and not under the house. The resident was assumed to spend a fraction of 0.0091 of their time outdoors above this area. The parameters modeled probabilistically for the brookside resident scenario include the contaminated zone thickness, contaminated zone area, contaminated zone density, fraction of time spent outdoors, and the fraction of time spent indoors.

An alternate brookside resident scenario was also evaluated. This scenario differs from the brookside resident in that the indoor occupancy fraction is increased from ¼ to ½, an area of elevated activity is located directly under the house, and the resident consumes vegetables grown in a garden contaminated with radionuclides. In this scenario, the fraction of time spent indoors was assumed to be 0.25 instead of 0.125 to account for the increased area of the house that was assumed to be located over the contaminated zone. In addition, the resident was assumed to spend 74 hrs/yr above the local area of elevated contamination while in their house. The resident was also assumed to spend 123 hours a year in the contaminated garden, which corresponds to a fraction of time spent outdoors of 0.014. The contaminated fraction of plant food was assumed to be 0.5 in the deterministic calculation. The parameters modeled probabilistically for the alternate brookside resident scenario include the contaminated zone thickness, contaminated zone area, contaminated zone density, fraction of time spent outdoors, fraction of time spent indoors, and the contaminated fraction of plant food.

PBCC Maintenance Worker

The PBCC maintenance worker was assumed to spend 15 hours per week during the 30 week golf season on the contaminated zone. This corresponds to a fraction of time spent outdoors of 0.051. The fraction of time spent outdoors was assumed to be 0.0051 for the area of elevated contamination based on the area of the elevated contamination being approximately one tenth of the area of the contaminated zone. The inhalation rate for the PBCC maintenance worker was assumed to be 1.4e4 m^3/yr. The parameters modeled probabilistically for the PBCC maintenance worker scenario include the contaminated zone thickness, contaminated zone area, contaminated zone density, and the fraction of time spent outdoors.

Recreationist scenario

In the recreationist scenario, it was assumed that the fraction of time spent outdoors was 0.0125. This corresponds to approximately 10 hours per week for 10 weeks a year. The inhalation rate was assumed to be 1.4e4 m^3/yr for this scenario. The parameters modeled probabilistically for the recreationist scenario include the contaminated zone thickness, contaminated zone area, contaminated zone density, watershed area, fraction of time spent outdoors, contaminated zone Kd for Cs-137, contaminated zone Kd for Co-60, fish transfer factor for Cs, fish transfer factor for Co, fish consumption, and the contaminated fraction of aquatic food.

The conceptual model used in RESRAD represents a surface water body that becomes contaminated with radionuclides as they are leached from the source term and transported through the saturated zone. This is significantly different than the configuration of contamination present in the Plum Brook since the radionuclides present in the Plum Brook are already present in the stream sediments. To account for this in the RESRAD calculations, the licensee used the mass balance transport model with the unsaturated zone thickness set to 0 to place the saturated zone in direct contact with the contaminated zone. Additionally, a hand calculation was performed by the licensee to verify that RESRAD was calculating the fish dose correctly. In the calculation of the fish ingestion dose, the fish is assumed to be located in the Plum Brook Estuary (stream section 4) because game fish occasionally enter the estuary, but seldom enter the stream. The calculation of the fish ingestion dose also assumes that the fish continuously live in the contaminated area of the stream, which may be a conservative assumption. The RESRAD default value of 5.4 kg/yr of fish was assumed to be consumed in the deterministic dose assessment, and it was assumed that no other contaminated seafood was consumed.

Calculations and Input Parameters – Evaluation Finding

NRC staff finds that the parameters selected for modeling the dose for are appropriate for the scenarios selected and the site.

3.6.4 Dose Assessment Results

The results from the dose assessments performed by the licensee for each scenario are presented in Table 3. The uncertainties in the calculated doses include both the uncertainty in the concentrations of the radionuclides and the uncertainty in the calculated dose due to uncertainty in the input parameters in the RESRAD modeling. This uncertainty was based on the standard deviation of the doses calculated in the probabilistic dose assessment. The combined uncertainty was calculated using standard error functions. The equations used for this were provided in Appendix C of the “Revised Dose Assessment for Plum Brook Sediments“(PBRF-TBD-08-006). The maximum calculated dose was for 1.34e-2 ± 6.75e-3 mSv/yr (1.34 ± 0.675 mrem/yr) for the alternative brookside resident scenario. All of the calculated doses were less than 0.25 mSv/yr (25 mrem/yr).

Table 3 Results of Dose Assessment submitted by NASA

Scenario	Dose from Cs-137 mSv/yr (mrem/yr)	Dose from Co-60 mSv/yr (mrem/yr)	Total mSv/yr (mrem/yr)
Suburban Gardener	2.22e-3 ± 1.28e-3 (0.222 ± 0.128)	1.99e-4 ± 9.95e-5 (0.0199 ± 0.00995)	2.42e-3 ± 1.28e-3 (0.242 ± 0.128)
Brookside Resident	7.38e-3 ± 4.33e-3 (0.738 ± 0.433)	1.86e-3 ± 8.28e-4 (0.186 ± 0.0828)	9.24e-3 ± 4.41e-3 (0.924 ± 0.441)
Alternate Brookside Resident	9.85e-3 ± 6.57e-3 (0.985 ± 0.657)	3.50e-3 ± 1.73e-3 (0.350 ± 0.173)	1.34e-2 ± 6.75e-3 (1.34 ± 0.675)
PBCC Maintenance Worker	2.64e-3 ± 2.12e-3 (0.264 ± 0.212)	9.73e-4 ± 6.95e-4 (0.0973 ± 0.0695)	3.61e-3 ± 2.23e-3 (0.361 ± 0.223)
Recreationist	6.5e-3 ± 3.14e-3 (0.650 ± 0.314)	3.52e-4 ± 2.26e-4 (0.0352 ± 0.0226)	6.85e-3 ± 3.15e-3 (0.685 ± 0.315)

Dose Assessment Results – Evaluation Finding

The NRC staff has reviewed the dose modeling analysis provided to the NRC by the licensee for contamination in the Plum Brook sediments, and the staff concludes that the dose modeling is reasonable and appropriate. NRC staff evaluated the proposed land use scenarios and exposure pathways used in the assessment and finds them acceptable. NRC staff also found that an appropriate conceptual model and input parameters were used in the dose assessment. NRC staff also evaluated the abstraction of the source term from the characterization data and found that this was done appropriately. NRC staff performed independent calculations of the dose from each of the scenarios and found that the calculations submitted by the licensee were performed accurately.

3.7 ALARA

The licensee approached the dose assessment of the Plum Brook sediments using several approaches that can be considered ALARA. The licensee used four different dose assessments that are representative of the geographical area. The staff has determined that the licensee applied these alternative pathways to capture reasonable activities that may take place near the Plum Brook. Although contaminants were detected at various depths within the sedimentation of the Pentolite Ditch and the Plum Brook, the licensee used appropriate values for the area and thickness in assessing the radiation dose from Plum Brook sediments. In addition to these appropriate values, the licensee used the highest or most conservative concentration for Cs-137 and Co-60 for each of the dose scenarios. This resulted in dose calculations that were still substantially below the regulatory limit of 25 mrem per year for the critical group.

In addition, the licensee intends to further reduce the potential dose from radionuclides of PBRF origin in the Plum Brook by digging up isolated hot spots in sediment along the Plum Brook that has an activity above 13.34 pCi/g using hand tools. This activity level corresponds to the same level used upstream in the remediation of the Pentolite Ditch. This remediation will cover the area of the Plum Brook from the Plum Brook station fenceline to the wetlands, and the remediation will be performed during the summer, when the flow rate in the Plum Brook is typically lower and a larger area of stream bank is exposed. In areas of the Plum Brook previously covered by characterization surveys, the locations to be remediated will be based on known GPS coordinates of elevated readings. In the areas that were not previously surveyed (e.g., stream section 2), a 100 percent survey of the bank area will be performed using the same detector that was used during the previous characterization (i.e., Ludlum Model 2350-1 with 44-10 sodium iodide detector, and a gamma-spectrum window set to focus of Cs-137 activity) or an equivalent.

ALARA – Evaluation Finding

The staff has determined that the licensee applied reasonable, appropriate, and conservative approaches for remediation and dose assessments that the staff considers to be ALARA.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Ohio State official was notified of the proposed issuance of the amendment. The State official responded by e-mail that Ohio is in agreement with the proposed action.

5.0 ENVIRONMENTAL CONSEQUENCES

The environmental impacts associated with decommissioning the PBRF were previously evaluated in conjunction with the license amendment authorizing the decommissioning of the PBRF. The Environmental Assessment and Finding of No Significant Impact related to this action was published in the *Federal Register* (65 FR 16421) on March 28, 2000. Based on the review of the proposed activities associated with the dismantling and decommissioning of the PBRF, the NRC staff concluded that the proposed action would not increase the probability or consequences of accidents, no changes would be made in the types of any effluents that may be released off-site, and there was no significant increase in occupational or public radiation exposure. Therefore, there were no significant radiological environmental impacts associated with the proposed action.

6.0 CONCLUSION

Based on the evaluations discussed in this safety evaluation, the NRC staff concludes that with respect to the average member of the critical group, (1) the dose associated with the radionuclides of PBRF origin in the Plum Brook is much lower than 0.25 mSv/yr (25 mrem/yr); and (2) that there is reasonable assurance that such dose will not exceed 25 mrem/yr. NRC staff also concludes that the residual radioactivity in the Plum Brook from radionuclides of PBRF origin will be reduced to ALARA levels.

The NRC has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by the actions proposed in this amendment, (2) such actions will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

- NRC letter to Ohio Department of Health regarding regulatory jurisdiction for off-site contamination in Plum Brook sediments (ML053160001).
- NRC Report on September 3, 2008 public meeting (ML082900916).
- NASA Plum Brook Reactor Facility Request for Amendment to Licenses No. TR-3, Docket No. 50-30 and R-93, Docket No. 50-185 dated January 9, 2009 (ML090140338).
- Notice of Consideration of Issuance of Amendment to Facility Operating Licenses, Proposed No Significant Hazards Consideration Determination, and Opportunity for a Hearing, published in the Federal Register (74 FR 20751) dated May 5, 2009.
- NASA Plum Brook Sediment Characterization Data Summary for the Plum Brook Reactor Facility, Licensed No. TR-3, Docket No. 50-30 and R-93, Docket No. 50-185, dated October 29, 2008 (ML090641013).
- NASA transmittal of Final Detailed Plum Brook Characterization Report (PBRF-TBD-08-005) and Final Report on Dose Pathway Analyses (PBRF-TBD-08-006), dated March 20, 2009 (ML090900743).
- NASA PBRF-TBD-09-001, Radionuclide Distribution and Adjusted DCGLs for Site Soils, dated June 5, 2009 (ML091880290).
- NRC Request for Additional Information to NASA, dated June 11, 2009 (ML091520480).
- NASA Plum Brook Reactor Facility Response to NRC Request for Additional Information dated October 6, 2009 (ML092870784).
- Notice of Environmental Assessment and Finding of No Significant Impact related to the decommissioning of PBRF, published in the Federal Register (65 FR 16421) on March 28, 2000.
- NRC 2006 Consolidated Decommissioning Guidance, Decommissioning Process for materials Licensees, NUREG-1757, Volume 1, Rev. 2, and Volume 2, Rev. 1.
- NASA Plum Brook Remediation Approach Memos, dated 12/09/2009 (ML100120094).
- NASA Plum Brook Remediation Approach Memos, dated 01/06/2010 (ML100120073).

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