

OFFICE OF INSPECTOR GENERAL U.S. Department of Energy

AUDIT REPORTOAI-M-17-03December 2016





Department of Energy Washington, DC 20585

December 23, 2016

MEMORANDUM FOR THE ASSOCIATE ADMINISTRATOR FOR SAFETY, INFRASTRUCTURE, AND OPERATIONS

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FROM:

April G. Stephenson Assistant Inspector General for Audits and Inspections Office of Inspector General

SUBJECT:

<u>INFORMATION</u>: Audit Report on the "Followup Audit of the Department's Heavy Water Inventory"

BACKGROUND

The Department of Energy and National Nuclear Security Administration (NNSA) inventory of heavy water is a vital national security asset. Heavy water, primarily managed and stored at the Y-12 National Security Complex (Y-12), is used in NNSA Weapons Activities to produce parts for weapons system life extension programs and to support National Ignition Facility (NIF) nuclear weapon design and simulation missions. Additional heavy water inventories are located at the Oak Ridge National Laboratory, used primarily for non-Weapons Activities such as Spallation Neutron Source research and development, and at the Savannah River Site, which maintains an inventory unusable for current programs and planned for future disposal.

In July 2008, our report on *Nuclear Weapons Programs Heavy Water Inventory* (DOE/IG-0798) identified the need to secure new sources of heavy water because the inventory was likely to be depleted by 2019. Management agreed with the prior report, and in response, a heavy water assessment was completed in 2009 that defined options to meet heavy water requirements. In 2010, the Department obtained additional heavy water from the Department of Defense. Also, NNSA officials told us that they had not been supplying heavy water to non-Weapons Activities, essentially establishing a reserve for NNSA missions, although an NNSA official said they would consider requests from other programs under certain circumstances. In 2012, Y-12 replaced its traditional production process for lithium deuteride weapons parts, which required heavy water, with the Direct Material Manufacturing process, which recycles these weapons parts and significantly decreased the demand for heavy water to the Department's mission, we initiated a followup audit to determine whether the Department was effectively managing its inventory of heavy water.

RESULTS OF AUDIT

We determined that, while the Department had taken several actions to address heavy water requirements to meet mission needs through fiscal year (FY) 2031, management of the heavy

water inventory may not ensure a sufficient supply for Weapons Activities beyond that time. Specifically, we found the following:

- The Department's current inventory of usable heavy water is its only source of material for Weapons Activities. The United States has not had a heavy water production capability since 1996, and there are no current plans to construct a capability. According to Y-12 documentation, establishment of a new production capability would require a rough estimated lead time of 10-15 years. Also, according to NIF officials, there are no current plans for a recycle or re-enrichment capability, and the estimated lead time to develop such a capability would be approximately 3-4 years. Furthermore, heavy water cannot be purchased from other countries for Defense Programs or Stockpile Stewardship Program missions due to international nonproliferation agreements. Finally, due to the lack of sources, NNSA has not been supplying heavy water to non-Weapons Activities, and other Department users such as the Office of Science (Science) must now purchase it from United States suppliers that obtain heavy water from foreign producers. For example, the Department recently purchased 32 tons of heavy water from Iran that cannot be used for Weapons Activities according to the terms of the agreement. As such, six tons will be used by the Oak Ridge National Laboratory, and the remainder will be sold to private industry. While this may alleviate short-term Science needs, future purchases are subject to market fluctuations in price and potential sales restrictions enacted by the foreign countries producing the heavy water. For example, Canada began restricting sales of heavy water to the United States a few years ago.
- Long-term requirements for Defense Programs and the Stockpile Stewardship Program may be uncertain. Y-12 currently uses the Direct Material Manufacturing process that recycles weapons parts containing lithium deuteride and does not require the addition of heavy water. However, it plans to implement a new capability to produce these parts, which may require heavy water. Heavy water demand has not been forecasted for the new capability. Also, future NIF requirements are uncertain, pending a decision on the reconfiguration of NIF's laser using a Direct Drive technique that could significantly increase the demand for heavy water.

According to Department officials, actions to address Weapons Activities heavy water requirements after FY 2031 were not taken because, based on Nuclear Materials Management forecasts developed in 2012, when Y-12 fully implemented the Direct Material Manufacturing process, the Department determined that the heavy water inventory was adequate to meet program requirements through FY 2031 and beyond, which would afford sufficient time to prepare plans to meet needs beyond that date. Thus, the Department did not have any concerns regarding the long-term availability of heavy water.

As such, the Department had not established a point, such as an inventory level or other trigger point, when it would begin to pursue other options for acquiring heavy water for Weapons Activities. However, given the uncertainty of heavy water requirements beyond 2031, the long lead time to establish a production capability, and the estimated lead time to develop recycle or re-enrichment capabilities, the Department may be at risk of being unable to meet all of its Weapons Activities heavy water requirements in the long term. Furthermore, future non-Weapons Activities work requiring heavy water may also not be completed. Thus, establishing a guideline for when additional action needs to be taken may be prudent. Accordingly, we made recommendations to help ensure heavy water is available in the long term.

MANAGEMENT RESPONSE

NNSA management agreed with our recommendations and stated that its current processes and plans address the areas of concern. NNSA stated that it currently provides annual forecasts for accountable nuclear materials. These analyses have determined that NNSA has an adequate inventory of heavy water to meet all forecasted needs for the next 15-20 years with inventory remaining beyond that point, which NNSA considered sufficient time to prepare plans to meet needs should requirements change. NNSA also stated that the report overstated the risk regarding the lead time required to resume a production capability. According to NNSA, the acquisition of heavy water from the Department of Defense provided reserves that were adequate to meet weapons component manufacturing needs beyond any conceivable planning horizon. NNSA further stated that current plans were to use recycled heavy water for NIF applications starting in about 5 years and that NNSA would ensure that plans were in place to establish a recycle capability. In addition, NNSA stated that its planning and forecasting processes already accounted for the uncertainties highlighted in the report. However, NNSA agreed to continue to closely monitor and forecast heavy water requirements and, should future estimates indicate that demand may exceed potential future inventories, take action to evaluate alternate approaches for meeting those requirements using established program and project management principles as appropriate.

We acknowledge that NNSA has current processes and plans in place to address accountable nuclear materials. As stated in the report, we also agree that the heavy water inventory is adequate to meet forecasted needs through FY 2031, with some inventory remaining. We further agree that the heavy water obtained from the Department of Defense provided reserves for Defense Programs activities; however, we noted that it was not usable for certain NNSA requirements. In particular, it did not meet NIF's specifications for Stockpile Stewardship Program activities. In addition, we could not confirm NNSA's assertion that it planned to use recycled heavy water for NIF applications in about 5 years. According to the 2016 Nuclear Materials Management Plan, recycled heavy water will not be used at NIF until sometime between FYs 2031-2040. Because NNSA committed to continuing to closely monitor and forecast heavy water requirements, we considered NNSA's response and planned actions responsive to our recommendations. Management's formal comments are included in their entirety in Appendix 3.

Attachment

cc: Deputy Secretary Administrator, National Nuclear Security Administration Chief of Staff

FOLLOWUP AUDIT OF THE DEPARTMENT'S HEAVY WATER INVENTORY

TABLE OF CONTENTS

Audit Report

Details of Finding	1
Recommendations	5
Management Response and Auditor Comments	6
Appendices	
	7

1.	Objective, Scope, and Methodology	1
2.	Prior Report	9
3.	Management Comments1	0

DETAILS OF FINDING

The Department of Energy and its semiautonomous agency, the National Nuclear Security Administration (NNSA), had taken actions to ensure sufficient heavy water inventory to meet Defense Programs life extension program (LEP) and Stockpile Stewardship Program weapons design and simulation requirements through fiscal year (FY) 2031. Specifically, in response to our prior report on Nuclear Weapons Programs Heavy Water Inventory (DOE/IG-0798, July 2008), a heavy water assessment was completed in 2009 that defined heavy water requirements and identified several options to meet those requirements. Also, the Department secured an additional inventory of heavy water from the Department of Defense in 2010. However, the Department does not consider the Department of Defense a future source of additional heavy water. Furthermore, NNSA officials told us that they had not been supplying heavy water to non-Weapons Activities customers, essentially establishing a reserve for NNSA missions, although an NNSA official told us they would consider requests from other programs under certain circumstances. Finally, in 2012, the Y-12 National Security Complex (Y-12) replaced its traditional production process for lithium deuteride weapons parts, which required heavy water, with the Direct Material Manufacturing process, which recycles the weapons parts and significantly decreased the demand for heavy water.

Inventory Availability and Requirements

According to NNSA officials, the Department's actions provided reasonable assurance that the heavy water inventory would be sufficient to meet Defense Programs and Stockpile Stewardship Program mission requirements through FY 2031, with some inventory remaining. However, the Department may be at risk of being unable to meet all of its heavy water requirements in the long term due to the lack of a production capability that requires a rough estimated lead time of 10-15 years to establish according to Y-12 documentation; uncertainties related to recycle or re-enrichment capabilities; inability to purchase heavy water for Defense Programs and the Stockpile Stewardship Program; dependence of non-Weapons Activities users on foreign heavy water producers; and uncertainties regarding requirements, which demonstrate the need for establishment of a point at which NNSA will take action to obtain additional heavy water.

Available Sources

The Department's current inventory of usable heavy water is its only source of this material for Weapons Activities. There has been no capability to produce heavy water in the United States since 1996, and there are currently no plans to develop a new production or recycle capability. Also, rough estimated lead times for construction of a production capability are 10-15 years according to Y-12 documentation. Furthermore, even though National Ignition Facility (NIF) officials told us that a private vendor may be able to recycle NIF's depleted heavy water in the future, NIF officials confirmed they do not plan to pursue this capability unless the inventory becomes constrained, and according to a Lawrence Livermore National Laboratory subject matter expert, the estimated lead time would be approximately 3-4 years. While a large quantity of heavy water is stored at the Department's Savannah River Site, the quality of the heavy water does not meet specifications required for use in the Department's current programs and the

Department has determined that it would not be cost effective to explore alternatives to get the material into a useable form, according to Savannah River Site management. Therefore, the heavy water inventory at the Savannah River Site is planned for future disposal.

Also, due to international nonproliferation agreements, heavy water cannot be purchased for Weapons Activities such as Defense Programs or the Stockpile Stewardship Program, which further serves to increase the Department's dependence on the existing inventory. As a result, NNSA has not approved requests for heavy water for non-Weapons Activities users, including Science's (Science) Oak Ridge National Laboratory that uses heavy water in a variety of research activities. Thus, such users purchase heavy water from foreign countries or United States suppliers that obtain heavy water from foreign producers. For example, the Department recently purchased 32 tons of heavy water from Iran that cannot be used for Weapons Activities according to the terms of the agreement. Therefore, six tons will be used by the Oak Ridge National Laboratory, and the remainder will be sold to private industry. While this may alleviate short-term Science needs, future purchases are subject to market fluctuations in price and potential sales restrictions enacted by the foreign countries producing the heavy water. For example, Canada has supplied heavy water to the United States in the past. However, according to the United States.

Defense Programs Requirements

While heavy water requirements are analyzed and forecasted annually, there may be uncertainties regarding requirements for Defense Programs parts production for weapon system LEPs beyond the current planning period of 2031. Specifically, heavy water is a component of the lithium deuteride compound, which is used to produce lithium deuteride weapons parts at NNSA's Y-12 facility. Currently, Y-12 uses the Direct Material Manufacturing process, which recycles weapons parts that contain lithium deuteride. Prior to implementing Direct Material Manufacturing, Y-12 used a wet chemistry purification and production process that required heavy water to be added during the process. According to an NNSA official, due to concerns regarding the current lithium production facility, Y-12 plans to implement a new Lithium Production Capability by 2028 that will include the ability to use Direct Material Manufacturing paired with the traditional wet chemistry purification process or available new technologies. In our recent report, Lithium Operations at the Y-12 National Security Complex (OAI-L-16-05, December 2015), we noted that Direct Material Manufacturing had been less productive than expected and was originally not intended to be a permanent process. Furthermore, Lithium Production Capability planning documentation noted that the traditional process will likely be used in the future to counteract contamination that accumulates over time and is present during Direct Material Manufacturing. According to Y-12 officials, they expect to use Direct Material Manufacturing until approximately FY 2031, at which time the traditional wet chemistry purification process may need to be implemented. Despite this potential use, demand for heavy water in the new Lithium Production Capability has not yet been forecasted. However, according to NNSA officials, new technologies expected to be available in time for the new Lithium Production Capability would decrease the demand for a new supply of heavy water for Defense Programs requirements. Examples of these new technologies include deuterium gas capture and recycle as well as recycling machine dust from production processes.

Stockpile Stewardship Program Requirements

In addition, future heavy water requirements for Stockpile Stewardship Program missions performed at NIF may be uncertain. Specifically, a potential reconfiguration of NIF's laser using a Direct Drive technique that may enable NIF to produce inertial fusion energy for power production will increase the amount of heavy water needed. NIF officials told us that they did not know when a decision will be made regarding implementing this technique. NIF uses heavy water in the existing inventory to support the Stockpile Stewardship Program by performing research for nuclear weapons design and conducting simulations of nuclear weapons capabilities. According to NNSA officials, if the Direct Drive technique is used to reconfigure NIF's laser, it will increase the heavy water requirement from 1.79 metric tons to approximately 2.1 metric tons per fiscal year. With the Direct Drive technique, if NIF does not have sufficient heavy water then the laser energy has to be dropped by 50 percent to prevent optical damage, and at that level cannot perform its Stockpile Stewardship Program missions.

Long-Term Activities

According to Department officials, actions to address heavy water requirements for Weapons Activities after FY 2031 were not taken because, based on Nuclear Materials Management Plan forecasts developed in 2012 when Y-12 implemented the Direct Material Manufacturing process, the Department determined that the heavy water inventory was sufficient to meet current program requirements and there were not any concerns regarding the long-term availability of heavy water. Also, Department officials told us that the Nuclear Materials Management Plan's 15-year planning window allows time to identify and respond to emerging requirements. While we agree that the heavy water inventory appears to be sufficient to meet requirements through FY 2031, given the long lead time needed to implement a production capability, the uncertainties related to recycle or re-enrichment capabilities, lack of acquisition alternatives for Weapons Activities heavy water supply, and uncertainties regarding heavy water requirements, the Department may be at risk of being unable to meet all of its Weapons Activities requirements in the long term.

Also, the Department has not established a point, such as an inventory or other trigger point, when it will begin to pursue other options for acquiring heavy water for Weapons Activities. This point is important because the Department estimated that a rough lead time of 10-15 years would be needed to implement a heavy water production capability. In addition, according to NIF officials, the lead time for recycle or re-enrichment capabilities would be approximately 3-4 years. Furthermore, NIF officials stated they do not plan to pursue a recycle or re-enrichment capability until their inventory becomes constrained. However, officials did not define the inventory level they considered constrained. As such, establishment of a trigger point would help ensure the Department takes action in sufficient time to accomplish the method of obtaining additional heavy water.

Mission Impacts

The Department may lack sufficient heavy water to meet Weapons Activities mission needs beyond 2031 due to the long lead time to establish a production capability, uncertainty of recycle and re-enrichment capabilities, lack of acquisition alternatives for Defense Programs and Stockpile Stewardship Program users, and uncertainties regarding requirements. Without a sufficient supply of lithium deuteride and heavy water, Defense Programs mission goals for LEPs may be delayed or not met. In addition, without a sufficient supply of heavy water, NIF may not meet its Stockpile Stewardship Program weapons design and aboveground simulation mission requirements, because NIF cannot operate at full power without heavy water to grow its laser crystals.

Moreover, future non-Weapons Activities work requiring heavy water may also not be completed, such as Science's one-of-a-kind Spallation Neutron Source research and development efforts, due to reliance on foreign producers for their heavy water supply. While the Department currently considers such sources reliable, we noted that there are no long-term purchase agreements in place and purchases are subject to changing pricing and potential sales restrictions.

RECOMMENDATIONS

To ensure heavy water is available in the long term to meet future mission requirements, we recommend that the Associate Administrator for Safety, Infrastructure, and Operations:

- 1. Require the establishment of trigger points at which management needs to develop a more aggressive action plan for implementation of a recycle capability or other means to acquire additional heavy water.
- 2. Prepare feasibility and cost benefit analyses of recycle or re-enrichment technologies or other alternatives at established trigger points, and then select and proceed with the preferred course of action, consistent with established program and project management principles.

MANAGEMENT RESPONSE

NNSA management agreed with our recommendations and stated that its current processes and plans address the areas of concern. NNSA stated that it currently provides annual forecasts for accountable nuclear materials. These analyses have determined that NNSA has an adequate inventory of heavy water to meet all forecasted needs for the next 15-20 years with inventory remaining beyond that point, which NNSA considered sufficient time to prepare plans to meet needs beyond that timeline should requirements change. NNSA also stated that the report overstated the risk regarding the lead time required to resume a production capability. According to NNSA, the acquisition of heavy water from the Department of Defense provided reserves that were adequate to meet weapons component manufacturing needs beyond any conceivable planning horizon. NNSA further stated that current plans were to use recycled heavy water for NIF applications starting in about 5 years and that NNSA would ensure that plans were in place to establish a recycle capability. In addition, NNSA stated that its planning and forecasting processes already accounted for the uncertainties highlighted in the report. However, NNSA agreed to continue to closely monitor and forecast heavy water requirements and, should future estimates indicate that demand may exceed potential future inventories, take action to evaluate alternate approaches for meeting those requirements using established program and project management principles as appropriate

Management's formal comments are included in Appendix 3.

AUDITOR COMMENTS

We acknowledge that NNSA has current processes and plans in place to address accountable nuclear materials. As stated in the report, we also agree that the heavy water inventory is adequate to meet forecasted needs through FY 2031, with some inventory remaining. We further agree that the heavy water obtained from the Department of Defense provided reserves for Defense Programs activities; however, we noted that it was not usable for certain NNSA requirements. In particular, it did not meet NIF's specifications for Stockpile Stewardship Program activities. In addition, we could not confirm NNSA's assertion that it planned to use recycled heavy water for NIF applications in about 5 years. According to the 2016 Nuclear Materials Management Plan, recycled heavy water will not be used at NIF until sometime between FYs 2031-2040. Because NNSA committed to continuing to closely monitor and forecast heavy water requirements to ensure action can be taken in sufficient time to meet potential future long-term requirements, we considered NNSA's response and planned actions responsive to our recommendations.

OBJECTIVE, SCOPE, AND METHODOLOGY

Objective

The objective of this audit was to determine whether the Department of Energy was effectively managing its inventory of heavy water.

Scope

This audit was conducted between April 2015 and December 2016 at the Y-12 National Security Complex in Oak Ridge, Tennessee, and the Savannah River Site in Aiken, South Carolina. We also obtained information from National Nuclear Security Administration Headquarters in Washington, DC; Lawrence Livermore National Laboratory in Livermore, California; Oak Ridge National Laboratory in Oak Ridge, Tennessee; and Department Office of Science Headquarters in Washington, DC. The audit scope included the Department's current and future heavy water inventory and needs. This audit was conducted under Office of Inspector General (OIG) project number A15OR035.

Methodology

To accomplish the audit objective, we:

- Reviewed applicable laws, regulations, policies, and procedures pertaining to the management of nuclear materials;
- Reviewed prior reports issued by OIG;
- Analyzed historical mission data and future demand for heavy water; and
- Researched current requirements and future production capabilities for heavy water.

We conducted this performance audit in accordance with generally accepted Government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective. Accordingly, the audit included tests of controls and compliance with laws and regulations necessary to satisfy the audit objective. In particular, we assessed compliance with the *GPRA Modernization Act of 2010* and found that performance measures had been established for heavy water capabilities. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. We relied on computer-processed information to achieve our audit objective. Based on a recent review of the Y-12 National Security Complex and Savannah River Site's information technology controls performed by KPMG LLP on behalf of OIG, we determined that the data was sufficiently reliable for the purpose of the audit objective.

National Nuclear Security Administration management waived an exit conference for this audit on December 13, 2016.

PRIOR REPORT

Audit Report on <u>Nuclear Weapons Programs Heavy Water Inventory</u> (DOE/IG-0798, July 2008). This audit found that although the National Nuclear Security Administration (NNSA) heavy water inventory of 108 metric tons, as of October 2007, would be adequate to meet near-term requirements, NNSA was likely to fully deplete the inventory by 2019 without new sources of the material. NNSA had not established a path forward to secure new sources of heavy water but had identified several alternatives to meet future heavy water requirements. Furthermore, no comprehensive feasibility and cost-benefit analysis had been performed to determine the most effective approach to securing new sources. Finally, NNSA had not established a reserve stock needed to meet program needs until a new source of heavy water was secured and to meet future contingencies.

MANAGEMENT COMMENTS



Department of Energy Under Secretary for Nuclear Security Administrator, National Nuclear Security Administration Washington, DC 20585



July 18, 2016

MEMORANDUM FOR RICKEY R. HASS ACTING INSPECTOR GENERAL

FROM:	FRAN	VK G. K	(LO	TZ 🖓	471	18/2016	
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 SUBJECT:
 Comments on the Office of Inspector General Draft Report

 Titled Followup Audit of the Department's Heavy Water

 Inventory (2015-00858/A15OR035)

Thank you for the opportunity to review and comment on the subject draft report. We appreciate the Office of Inspector General's acknowledgement of actions the National Nuclear Security Administration (NNSA) has taken to address mission needs for heavy water through Fiscal Year (FY) 2030 and beyond. Consistent with the auditors' two recommendations, we agree that NNSA should: a) maintain trigger points at which management would need to develop an action plan for implementation of a recycle capability or other means to acquire additional heavy water; and b) employ established program and project management principles to evaluate supply alternatives should a trigger point be reached. NNSA's current processes and plans address these areas, and we consider both recommendations closed.

NNSA currently provides annual forecasts for accountable nuclear materials (specifically addressing consumption of low-tritium heavy water), in accordance with DOE Order 410.2, *Management of Nuclear materials*. The Y-12 National Security Complex also provides detailed analysis of heavy water in their annual nuclear material management plan. As noted in the report, these analyses have determined that the National Nuclear Security Administration (NNSA) has an adequate inventory of heavy water to meet all forecasted needs for the next 15 to 20 years, with inventory remaining beyond that point. This provides sufficient time to prepare plans to meet needs beyond that timeline should requirements change.

NNSA's planning and forecasting processes have already adequately accounted for the uncertainties highlighted in the report as appropriate, and the report provides no new information or analysis that would cause us to question our forecasts. Current plans are to use recycled heavy water for Inertial Confinement Fusion applications starting in approximately five years, and we will ensure plans are in place to establish a recycle capability to meet this need. We will continue to closely monitor and forecast our heavy water requirements and, should future estimates indicate that demand may exceed potential future inventories, we will take action to evaluate alternate approaches for meeting those requirements using established program and project management principles as appropriate.



Finally, the report overstates the risk from lead-time required to resume a production capability. As discussed with the auditors, acquisition of heavy water from the Department of Defense effectively eliminated the need for production in the foreseeable future, and we would have sufficient time to react if additional demands are forecast. Weapons component manufacturing is at no risk of a supply disruption, as this activity consumes a relatively small amount of material, and reserves are adequate to meet requirements beyond any conceivable planning horizon.

We have provided technical and general comments under separate cover to address the concerns above and enhance the clarity and factual accuracy of the report. If you have any questions regarding this response, please contact Mr. Dean Childs, Director, Audit Coordination and Internal Affairs, at (301) 903-1341.

FEEDBACK

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If you want to discuss this report or your comments with a member of the Office of Inspector General staff, please contact our office at (202) 253-2162.