
Evaluation of DUF₆-G-Q-STU-001 (ALARA Analysis Supporting Approval of Authorized Limits)

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Evaluation of DUF₆-G-Q-STU-001 (ALARA Analysis Supporting Approval of Authorized Limits)

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NOTATION

The following is a list of the acronyms and abbreviations, including units of measure, used in this report.

ALARA	as low as reasonably achievable
ALI	annual limit on intake
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
AqHF	aqueous hydrogen fluoride (hydrofluoric acid)
CaF ₂	calcium fluoride
DAC	derived air concentration
DOE	U.S. Department of Energy
DUF ₆	depleted uranium hexafluoride
EIS	environmental impact statement
FANP	Framatome ANP, Inc.
g	gram
GNF	Global Nuclear Fuels
HF	hydrogen fluoride
i.e.	<i>id est</i> (that is)
J.D.	doctor of law
M.B.A.	master of business administration
M.S.	master of science
μCi	microcurie
mL	milliliter
mrem	millirem
NCRP	National Council on Radiation Protection and Measurements
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OSHA	U.S. Occupational Safety and Health Administration
pCi	picocurie
Ph.D.	doctor of philosophy
ppm	part(s) per million
Rev.	revision
U ₃ O ₈	uranium sesquioxide
UDS	Uranium Disposition Services, LLC
yr	year(s)

EXECUTIVE SUMMARY

In April 2004, Argonne National Laboratory (ANL) was retained by Oak Ridge National Laboratory (ORNL) to provide an expedited technical review of the report titled *ALARA Analysis Supporting Approval of Authorized Limits for Unrestricted Release of Hydrogen Fluoride and Calcium Fluoride* (DUF₆-G-Q-STU-001) (referred to here as the UDS ALARA Analysis Report, in which UDS stands for Uranium Disposition Services, LLC and ALARA denotes “as low as reasonably achievable”). The UDS ALARA Analysis Report was prepared to document the technical bases for approval by the U.S. Department of Energy (DOE), pursuant to Directive DOE O 5400.5, of authorized release limits that would apply to aqueous hydrogen fluoride (AqHF) and calcium fluoride (CaF₂), which will be generated by two depleted uranium hexafluoride (DUF₆) conversion facilities planned for construction near Portsmouth, Ohio, and Paducah, Kentucky.

In support of a proposal to sell AqHF and CaF₂ for unrestricted use, the UDS ALARA Analysis Report presents the results of radiological-impact and cost-benefit analyses for each of three alternative limits on residual radioactive material: 9 pCi/mL uranium, 3 pCi/mL uranium, and 1.5 pCi/mL uranium (as measured in the AqHF). These alternatives were formulated based on release limits applicable to AqHF releases from two similar uranium conversion facilities operating under licenses issued by the U.S. Nuclear Regulatory Commission (NRC). The 9-pCi/mL limit applies at the Global Nuclear Fuel facility near Wilmington, South Carolina; the 3-pCi/mL limit applies at the Framatome ANP facility near Richland, Washington; and the 1.5-pCi/mL limit is half of the Framatome ANP facility’s 3-pCi/mL limit.

For the proposed release limit of 3 pCi/mL uranium (as measured in AqHF), the UDS ALARA Analysis Report projects the external dose to the maximally exposed individual (identified as being an industrial plant worker) from AqHF and CaF₂ to be 0.088 mrem/yr and 0.13 mrem/yr, respectively, in the worst plausible-use scenario. These individual doses are several orders of magnitude below both the DOE primary dose limit of 100 mrem/yr (for individual members of the public) from all sources and pathways and the DOE dose constraint of 25 mrem/yr (for individual members of the public) from any single DOE activity. In addition, the projected individual doses are well below the level of a few millirem per year recommended for property releases in DOE guidance documents. For the 3-pCi/mL release limit, collective doses from AqHF and CaF₂ are projected to be 0.0005 person-rem and 0.002 person-rem, respectively, which are significantly below the level of 10 person-rem recommended for property releases in DOE guidance documents. When individual and collective doses from a proposed release of property from DOE control are projected to be as low as these (i.e., below 1 mrem/yr for the most exposed individual and below a collective dose of 10 person-rem), DOE guidance authorizes the appropriate DOE field office manager to approve the authorized limits and survey protocols without obtaining written approval from the Assistant Secretary for Environment, Safety, and Health.

Using a health detriment cost rate of \$6,000 per person-rem, the upper limit of the range suggested in DOE guidance, the UDS ALARA Analysis Report estimates the projected health detriment cost would not exceed \$35 for any of the alternative limits on residual radioactive

material in the AqHF and CaF₂. Consistent with DOE guidance, the report concludes that this is well below a health detriment cost that would justify installing additional equipment to further reduce dose. Hence, a quantitative optimization study was not performed.

As alternatives to the disposition of AqHF through unrestricted sale and use, the UDS ALARA Analysis Report identifies conversion of AqHF to solid CaF₂ followed by disposal of the CaF₂ either as low-level radioactive waste (in a DOE-controlled or NRC-licensed landfill) or as solid waste in a radiologically uncontrolled facility, such as a hazardous waste landfill or a municipal or industrial solid-waste landfill. However, these disposition alternatives were not analyzed in depth because of their high costs, the low doses projected for sale and use of AqHF, and the expected marketability of AqHF.

In total, the ANL review team received and reviewed three versions of the UDS ALARA Analysis Report. Based on the latest version, the review team has determined that the dose analyses described in the UDS ALARA Analysis Report for worker and non-worker members of the public expected to be involved in the sale and use of AqHF and CaF₂ conversion products are reasonable and follow a commonly accepted approach. Also, the team concludes that a reasonable range of alternative release limits for sale and use of AqHF and CaF₂ is analyzed and that the level of analysis for health detriment costs is appropriate. Notwithstanding, the review team offers certain suggestions that it believes, if adopted, would enhance the overall quality of the UDS ALARA Analysis Report.

EVALUATION OF DUF₆-G-Q-STU-001 (ALARA ANALYSIS SUPPORTING APPROVAL OF AUTHORIZED LIMITS)

by

N. L. Ranek, A. G. Croff, J.-J. Cheng, J. L. Gillette, and H. I. Avci

1 INTRODUCTION

The U.S. Department of Energy (DOE) has selected Uranium Disposition Services, LLC (UDS)¹ to proceed with disposition of the inventory of depleted uranium hexafluoride (DUF₆) for which DOE has management responsibility. To accomplish this task, UDS will construct and operate facilities at two DOE-owned sites, one near Paducah, Kentucky, and another near Portsmouth, Ohio, to convert DUF₆ to uranium oxide (principally U₃O₈). The off-gas treatment system for the conversion process will produce aqueous hydrogen fluoride (AqHF), also known as hydrofluoric acid, and a relatively small amount of calcium fluoride (CaF₂), each containing some residual radioactive material.

As part of its contractual charge, UDS must identify and implement a disposition for all three products generated by the DUF₆ conversion facilities: uranium oxide, AqHF, and CaF₂. The *UDS DUF₆ Conversion Product Management Plan* (DUF₆-UDS-PLN-004, September 2003) concludes that a viable commercial market exists for AqHF, which, if not sold, would have to be neutralized, producing a relatively large quantity of additional CaF₂. Although CaF₂ has very limited market potential, there is some possibility that it also could be sold. If these potential markets could be developed, DOE would save the costs of neutralizing AqHF and/or disposing of the CaF₂ neutralization product. Accordingly, UDS has decided to seek approval from DOE for unrestricted release of both AqHF and CaF₂ that would be generated if AqHF could not be sold or if sales were interrupted. If AqHF were sold, the relatively small quantity of CaF₂ still being generated by the DUF₆ conversion process off-gas treatment system would most likely be disposed of as waste. The main product of conversion, depleted uranium oxide, will be reused to the extent possible or disposed of as waste, if no practical reuse option is found.

DOE grants approval for releases of property containing residual radioactive material through a process identified in directive DOE O 5400.5, *Radiation Protection of the Public and the Environment* (January 1993). Among other steps, this process involves derivation using the DOE ALARA (as low as reasonably achievable) process of authorized limits. It is further described in Section 3.1 below. In a report titled *ALARA Analysis Supporting Approval of Authorized Limits for Unrestricted Release of Hydrogen Fluoride and Calcium Fluoride* (DUF₆-G-Q-STU-001) (referred to here as the UDS ALARA Analysis Report), UDS has documented its derivation of authorized limits for the release of AqHF and CaF₂. Since all CaF₂ that would be released would be generated by neutralizing AqHF, whether from the off-gas

¹ UDS is a limited-liability corporation having Burns and Roe Enterprises, Inc., Duratek Federal Services, Inc., and Framatome ANP, Inc. as participants.

treatment system or from unsold AqHF product, any residual radioactive material (i.e., uranium) released in CaF₂ would first appear in AqHF. Therefore, the authorized limits sought by UDS would be monitored only in the AqHF.

In April 2004, Argonne National Laboratory (ANL) was retained by Oak Ridge National Laboratory (ORNL) to provide an expedited technical review of the UDS ALARA Analysis Report. To accomplish this, a team was formed consisting of Nancy L. Ranek (M.S., J.D.), Allen G. Croff (M.S., M.B.A.), Jing-Jy Cheng (Ph.D.), and Halil I. Avci (Ph.D.) from the Environmental Assessment Division, and Jerry L. Gillette (M.S.) from the Decision and Information Sciences Division. These reviewers were chosen based on their combined knowledge and expertise in the areas of DUF₆ conversion processes, radiation dose calculation, radiation risk assessment, economic evaluation, and DOE requirements and guidance regarding the release of property containing residual radioactive material. In total, the ANL review team received and reviewed three versions of the UDS ALARA Analysis Report.

2 PURPOSE

The purpose of this report is to document the ANL review team's approach to completing a technical evaluation of the UDS ALARA Analysis Report and to provide the results of that evaluation. Section 3 describes the criteria and approach. Section 4 documents the results.

3 TECHNICAL EVALUATION

3.1 CRITERIA

The UDS ALARA Analysis Report documents the technical bases for the derivation, pursuant to directive DOE O 5400.5, *Radiation Protection of the Public and the Environment*, of authorized limits for the unrestricted release for sale or use of AqHF and CaF₂, which, as previously stated, would be generated at two DUF₆ conversion facilities being constructed by DOE. Accordingly, directive DOE O 5400.5 and the guidance documents that support it (see Table 1) provide the criteria on which the ANL review team based its evaluation of the UDS ALARA Analysis Report.

TABLE 1 DOE Guidance Documents for Release of Property Containing Residual Radioactive Material Pursuant to Directive DOE O 5400.5

Document Number	Title
Draft DOE G 441.1-XX (April 4, 2002)	<i>Control and Release of Property with Residual Radioactive Material, for use with DOE 5400.5, Radiation Protection of the Public and the Environment</i>
DOE-STD-ALARA1draft (April 14, 1997)	<i>Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR 834 and DOE 5400.5 ALARA Program Requirements, Volume 1, Draft</i>

As set forth in the DOE directive and guidance documents, the DOE process for releasing property containing residual radioactive material involves the following steps:

- Identification of several sets of potential maximum allowable concentrations for residual radioactive material to serve as alternative sets of authorized limits to be evaluated using the “as low as reasonably achievable” (ALARA) process²;
- Verification that each alternative set of authorized limits would comply with the DOE public dose constraint (25 mrem/yr to any individual member of the public);
- Selection through the ALARA process of the one alternative set of authorized limits that yields an annual dose to the most exposed individual member of the public that is as far below the DOE public dose constraint as is practicable, with an individual dose goal of less than a few mrem and a collective dose goal of less than 10 person-rem;
- Coordination with the U.S. Nuclear Regulatory Commission (NRC) or the responsible Agreement State agency;
- Development of survey and/or test methods, including provisions for quality assurance, to be used for demonstrating compliance with the proposed authorized limits;
- Acquisition of DOE approval of the proposed authorized limits; and
- Placement in the DOE permanent record and in the public record of documentation supporting the property release.

3.2 APPROACH

In evaluating each version of the UDS ALARA Analysis Report, the reviewers considered a variety of issues, which are listed below.

² The ALARA process is a logical procedure for evaluating alternative operations, processes, and other measures for the purpose of judging which alternative provides the optimum level of public health protection. The ALARA process is designed to identify which alternative would reduce exposure to radiation and emission of radioactive material into the environment by as much as is reasonable, taking into account societal, environmental, technological, economic, practical, and public policy considerations.

Overall clarity and presentation, including:

- Is the ALARA Analysis Report clearly and logically organized?
- Are assumptions and assertions made in the ALARA Analysis Report reasonable and justified by logic or reference?
- Were the references cited in the ALARA Analysis Report available, and do they actually support the claims in the ALARA Analysis Report for which they were cited?
- Does the ALARA Analysis Report contain information or assumptions that are internally inconsistent or that lack consistency with other DUF₆ project data?
- Are the conclusions and recommendations in the ALARA Analysis Report justified by the information contained therein?
- Is the presentation of the ALARA Analysis Report acceptable (i.e., is it reasonably free of grammatical, spelling, and typographical errors)?

Procedural adequacy, including:

- Does the ALARA Analysis Report contain the necessary elements described in DOE directives and other DOE guidance?

General technical approach, including:

- Does the ALARA Analysis Report adequately describe and account for potential uses following release of the materials being considered for release?
- Do the calculations in the ALARA Analysis Report conform to applicable principles of chemistry, chemical process design, and nuclear engineering?
- Are numerical values extracted from various industry standards and guidance documents applied properly in the ALARA analysis?
- Are the technical aspects of the ALARA analysis adequately documented and supported?

Dose assessment calculations, including:

- Are plausible exposure conditions identified?
- Are radiation sources appropriately defined in terms of dimensions, volume, concentration, and specific radioactivity?

- Are radiation exposure receptors and the associated exposure pathways appropriately defined?
- Are the assumptions made for exposure scenarios and parameters adequately stated?
- Are radionuclide annual limit on intake (ALI) and derived air concentration (DAC) for workers appropriately applied in calculating radiation doses to the receptors?
- Are appropriate comparisons made of calculated dose results with regulatory dose limits, proposed release criteria, and published recommendations for property releases?
- Are appropriate methods (including computer codes), together with proper assumptions and parameters, used to calculate doses?

Economic analysis, including:

- Is the approach used consistent with DOE guidance and is it properly applied?
- Are the values recommended in the DOE guidance for monetary equivalence of radiation exposure used correctly?
- Are the economic analyses numerically correct (assuming that the dose calculations are correct)?
- Are the non-health detriments identified and properly evaluated?
- Are the conclusions drawn from the economic analyses sufficiently justified?

In total, the ANL review team received and reviewed three versions of the UDS ALARA Analysis Report: Rev. 0 (dated February 2004), Rev. 0A (dated April 2004), and Rev. 0B (dated May 2004). The process started in April 2004, when the review team performed a quick review of the February 2004 (Rev. 0) version of the report. The results, consisting of comments and suggestions that were mostly procedural in nature, were submitted to ORNL. Also in April 2004, UDS revised the report and resubmitted it as Rev. 0A. The ANL team reviewed all aspects of Rev. 0A. In early May 2004, the ANL team submitted a consolidated list of comments to ORNL. The UDS authors responded to the comments, revised the report, and reissued it as Rev. 0B on May 17, 2004. The approach of the review team to evaluating Rev. 0B of the UDS ALARA Analysis Report consisted primarily of assessing the manner in which UDS incorporated the team's consolidated comments on Rev. 0A. This approach was taken because the review team was not tasked with providing detailed comments on Rev. 0B of the UDS ALARA Analysis Report, or with certifying its adequacy or recommending its acceptance or rejection by DOE.

4 RESULTS

This section presents the results of the ANL review team's evaluation of Rev. 0B of the UDS ALARA Analysis Report.

4.1 GENERAL FINDINGS

The UDS ALARA Analysis Report presents the results of radiological-impact and cost-benefit analyses for each of three alternative limits on residual radioactive material, as measured in the AqHF: 9 pCi/mL uranium, 3 pCi/mL uranium, and 1.5 pCi/mL uranium. These alternatives were formulated based on release limits applicable to AqHF releases from two similar uranium conversion facilities operating under licenses issued by the U.S. Nuclear Regulatory Commission (NRC). The 9-pCi/mL limit applies at the Global Nuclear Fuel facility near Wilmington, South Carolina; the 3-pCi/mL limit applies at the Framatome ANP facility near Richland, Washington; and the 1.5-pCi/mL limit is half of the Framatome ANP facility's 3-pCi/mL limit.

For the proposed release limit of 3 pCi/mL uranium, the UDS ALARA Analysis Report projects the external dose to the maximally exposed individual (identified as being an industrial plant worker) from AqHF and CaF₂ to be 0.088 mrem/yr and 0.13 mrem/yr, respectively, in the worst plausible-use scenario. These individual doses are several orders of magnitude below both the DOE primary dose limit of 100 mrem/yr (for members of the public) from all sources and pathways and the DOE dose constraint of 25 mrem/yr (for members of the public) from any single DOE activity. In addition, the projected individual doses are well below the level of a few millirem per year recommended for property releases in DOE guidance documents. For the same release limit, collective doses from AqHF and CaF₂ are projected to be 0.0005 person-rem and 0.002 person-rem, respectively, which are significantly below the level of 10 person-rem recommended for property releases in DOE guidance documents. When individual and collective doses from a proposed release of property from DOE control are projected to be as low as these (i.e., below 1 mrem/yr for the most exposed individual and below a collective dose of 10 person-rem), DOE guidance authorizes the appropriate DOE field office manager to approve the authorized limits and survey protocols without obtaining written approval from the Assistant Secretary for Environment, Safety, and Health.

The UDS ALARA Analysis Report estimates the projected health detriment cost would not exceed \$35 for any of the alternative limits on residual radioactive material in the AqHF and CaF₂. Health detriment costs were calculated using a rate of \$6,000 per person-rem, the upper limit of the range suggested in the DOE guidance document titled *Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR 834 and DOE 5400.5 ALARA Program Requirements* (DOE-STD-ALARA1draft; April 14, 1997). Consistent with the same guidance document, the report concludes that the health detriment costs for all alternative release limits being considered are well below a cost that would justify installing additional equipment to further reduce dose.

As alternatives to the disposition of AqHF through unrestricted sale and use, the UDS ALARA Analysis Report identifies conversion of the AqHF to solid CaF_2 followed by disposal of the CaF_2 either as low-level radioactive waste (in a DOE-controlled or NRC-licensed landfill), or as solid waste in a radiologically uncontrolled facility, such as a hazardous waste landfill or a municipal or industrial solid-waste landfill. However, the UDS ALARA Analysis Report does not analyze these disposition alternatives in depth because of their high costs and the low doses projected for sale and use of AqHF.

In association with the findings described above, the review team also finds that the dose analyses described in the UDS ALARA Analysis Report for worker and non-worker members of the public expected to be involved in the sale and use of AqHF and CaF_2 conversion products are reasonable and follow a commonly accepted approach. Furthermore, the team concludes that a reasonable range of alternative release limits for the sale and use of AqHF and CaF_2 is analyzed and that the level of analysis for health detriment costs is appropriate.

4.2 SUGGESTIONS FOR ENHANCEMENT

The ANL review team offers the following suggestions, which the review team believes, if adopted, would enhance the overall quality of the UDS ALARA analyses and report:

- **Additional information appears to be needed to support release under the proposed authorized limits of CaF_2 for direct disposal in off-site, non-DOE landfills not authorized by the NRC or an Agreement State to receive low-level radioactive waste.**

The report indicates that CaF_2 produced during normal operations and released under the proposed authorized limits may be sold, but could possibly become waste. Also, CaF_2 generated from neutralization of the AqHF product, if the AqHF could not be sold, may become waste. The report notes that if CaF_2 were to be managed as waste, landfill workers would be exposed to very little radiation because the material would arrive at the landfill in closed containers and “landfill operations would be subject to controls [on the exposure of workers to CaF_2] imposed by OSHA.” The report contains no further discussion of individual or collective worker radiation exposures from receipt of CaF_2 produced during normal operations at off-site non-DOE landfills not authorized by the NRC or an Agreement State to receive low-level radioactive waste. According to the guidance in Draft DOE G 441.1-XX, DOE may establish authorized limits and release protocols for disposal in such non-DOE landfills only if, in addition to deriving authorized limits using the ALARA process, assurance has been obtained and documented that the property to be disposed of will meet the waste acceptance criteria and any State requirements for disposal of radioactive material applicable to the intended disposal facility(s). The review team questions whether the UDS ALARA Analysis Report provides sufficient documentation to support approval by DOE of direct disposal under the proposed authorized limits in

off-site non-DOE landfills not authorized by the NRC or an Agreement State to receive low-level radioactive waste. The review team believes that to sufficiently support direct disposal of CaF_2 in such landfills, the ALARA Analysis Report should either clearly evaluate information about both (1) the dose that the individual member of the public most exposed to radiation under the disposal scenario would be expected to receive and (2) the collective dose to members of the public under that scenario, or clearly explain why such information is not being evaluated. In addition, pursuant to Draft DOE G 441.1-XX, DOE approval of authorized limits for disposal of wastes containing residual radioactive material in off-site non-DOE landfills not authorized by the NRC or an Agreement State to receive low-level radioactive waste should be supported by the following supplemental information: (1) an evaluation to ensure that groundwater will be protected consistent with the objectives of the applicable State regulations and guidelines; (2) an assessment to ensure release of the landfill property would not be expected to require remediation under DOE 5400.5 or other applicable requirements for release of property containing residual radioactive material as a result of DOE disposals; and (3) evidence that the disposal has been coordinated with and is acceptable to the landfill authority (e.g., municipal or private operator) implementing the acceptance criteria, and with State representatives responsible for implementing solid-waste regulations. The review team understands that these latter three informational requirements are not necessarily within the scope of the ALARA Analysis Report. They are mentioned here primarily for completeness.

- **More complete justification would be appropriate for the assumption that a total of only five industrial workers would be exposed.**

The report predicts that radiological exposures of industrial workers in plants using AqHF or CaF_2 released from the DUF_6 conversion facilities will be negligible and most likely undetectable. Even so, in an effort to provide a conservative bounding estimate of such exposures, the Paducah and Portsmouth DUF_6 conversion plant workers are used as surrogates, and a total of five workers is assumed. Since the number of industrial facilities that may purchase the AqHF, the number of industrial workers that may frequent the area surrounding the systems containing the AqHF at each facility, and the concentration of AqHF (and thus uranium) present at each facility are not known, it seems possible that the total number of exposed industrial workers could easily vary in unknowable ways. Accordingly, the review team believes it would be appropriate to provide a more complete justification for the assumption that a total of only five workers would be exposed.

- **More complete justification would be appropriate for the assumption about population distributions surrounding the industrial facilities that may use AqHF and CaF₂.**

The report predicts radiological exposures of non-worker members of the population in areas surrounding industrial plants using AqHF or CaF₂ released from the DUF₆ conversion facilities to be almost nonexistent. Even so, in an effort to provide a bounding estimate of such exposures, the Paducah and Portsmouth DUF₆ conversion plants and their surrounding populations are used as surrogates. No justification is offered for the assumption that the population distributions surrounding the Paducah and Portsmouth DUF₆ conversion plants represent the claimed bounding situation for the purpose of estimating collective dose to the populations surrounding the industrial facilities that may use AqHF and CaF₂ after they are sold. The review team believes it would be appropriate to provide a more complete justification for this assumption. Notwithstanding, the review team notes that the collective dose estimates for all three alternative release limits are several orders of magnitude below 10 person-rem. Draft DOE G 441.1-XX indicates that if the collective dose is estimated to be less than 10 person-rem, an optimization study is probably not necessary and the primary focus of the ALARA analysis is more likely to be on doses to individuals.

- **More clear justification would be appropriate for not calculating collective doses for receptor groups using the sum of external and internal exposures.**

Collective doses for receptors in the industrial worker and non-worker general public groups were calculated using the individual internal radiation dose rate under the worst plausible-use scenario. For the transportation worker group, collective doses were calculated using the individual external radiation dose rate. Collective doses for all receptor groups should be calculated using the sum of external and internal exposures, or justification should be more clearly provided for doing otherwise.

- **An explanation would be appropriate for omitting workers at commercial landfills from the groups of receptors for which collective doses are calculated.**

The receptors for which collective doses are calculated in order to estimate health-detriment costs are: industrial workers at plants using AqHF or CaF₂ released from the DUF₆ conversion facilities; transport workers involved in moving AqHF or CaF₂ from the DUF₆ conversion facilities to users; and non-worker members of the population in areas surrounding industrial plants using AqHF or CaF₂ released from the DUF₆ conversion facilities. Another possible receptor for which collective doses were not calculated would be workers at

commercial landfills who would handle containers of sludge generated by industrial use of AqHF. While the report indicates that workers at commercial landfills are expected to receive very little radiation exposure, the omission of this group's exposure from the calculation of collective doses is not expressly justified. Draft DOE G 441.1-XX indicates that collective doses relating to secondary uses need be addressed only if they are likely to significantly affect the incremental collective dose (e.g., by more than 10 percent). Accordingly, the review team believes the report should at least explain the omission of the collective dose for workers at commercial landfills who would handle containers of sludge generated by industrial use of AqHF in the context of this guidance.

- **Additional information would be appropriate to support the conclusion that 1.5 pCi/mL of uranium would be so difficult to measure in AqHF that it would not be a commercially workable release limit.**

The role of measurement sensitivity is discussed as a non-health factor to be considered in selecting a recommended release limit. Based on this factor, Alternative C (1.5 pCi/mL) is judged to be unfavorable because it has not been proven to be commercially workable, while Alternative B (3 pCi/mL) and Alternative A (9 pCi/mL) have been proven at the Framatome ANP (FANP) facility in Richland, Washington, and the Global Nuclear Fuel (GNF) facility in Wilmington, North Carolina, respectively. The review team believes insufficient information is provided to support a conclusion that 1.5 pCi/mL of uranium would be so difficult to measure that it would not be a commercially workable release limit. This conclusion is based on information contained in Appendix E, Table E-5, in the final Portsmouth and Paducah DUF₆ conversion facility Environmental Impact Statements (EISs). Table E-5 indicates that the process-control specifications for HF, based on vendor specifications for the FANP facility in Richland, Washington, limit uranium in the HF to less than 0.5 ppm (less than 0.22 pCi/ml). In addition, Table E-3 indicates that the expected uranium content of HF acid from the FANP facility is only 0.08 pCi/mL. If such vendor specifications are being routinely met, these data raise the question of why it would be burdensome to measure compliance with a release limit of 1.5 pCi/mL.

- **Comparison of the proposed release criteria with screening levels for unconditional clearance of materials from ANSI N13.21 carries no meaning in terms of relative levels of potential radiation exposure.**

The second sentence in Section 4.2 states that all of the alternative release limits considered in the UDS ALARA Analysis Report “are significantly below the recommended screening levels for unconditional clearance of materials to the general public provided in the ANSI N13.12 Standard of 30 pCi/g for uranium.” This comparison may not be appropriate because the

release criteria listed in ANSI N13.12 were derived by considering release of solid materials such as construction concrete, scrap metals, or contaminated soils. They were not intended for use with process liquids and gases, as is clearly stated in the document. Therefore, even though the proposed release criteria of 3 pCi/mL of uranium in AqHF is much lower than the release criteria of 30 pCi/g from ANSI N13.12, the comparison carries no meaning in terms of relative levels of potential radiation exposures, and the review team believes it should be omitted. Notwithstanding, the review team notes that the individual dose rates calculated for releases when AqHF is assumed to contain 3 pCi/mL uranium are well below 1 mrem/yr, which the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) advocate as a negligible dose rate.

- **Parameters and assumptions used to estimate radiation doses are not always provided.**

Parameters and assumptions used to estimate the radiation doses, including exposure conditions, radiation sources, human receptors, exposure pathways, and exposure parameters, are not always provided in Section 4.3.1, “Radiological Assessment.” Therefore, it is difficult to check the accuracy of some of the results. A few examples of parameters that were not provided include the source characteristics used to define external exposures for transportation workers, the stack release rate of uranium in terms of pCi per unit time used to calculate dose for non-worker members of the public, the population distributions used to calculate the collective dose for non-worker members of the public, and the isotopic composition of uranium used for performing dose calculations.

- **Dose estimates shown in Table 4-3 may be low by a factor of 1.82.**

In the text preceding Table 4-3 in Section 4.3.1.1, the following statement, which apparently applies to the equation in Table 4-3, Note 1, appears: “It is assumed that HF vapor has the same radiological composition with HF solution.” The review team interprets this statement to mean that, when using the equation in Table 4-3, Note 1, UDS assumed the uranium concentration in terms of grams uranium per gram of HF to be the same for the HF vapor phase as for the *aqueous HF*. If this understanding of the UDS assumption is correct, then the dose estimates shown in Table 4-3 are low by a factor of 1.82. Furthermore, the equation in Table 4-3, Note 1, would need to be changed to the following:

$$\text{Activity/yr from Isotope} = \text{Annual HF Breathed (g HF/yr)} \times \text{Contributed Activity Level in AqHF (pCi/mL)} / \text{Density (g/mL)} \times 1/0.55 \text{ (g AqHF/g HF)} \times 10^{-6} \text{ (\mu Ci/pCi)}$$

If the review team's understanding of the text preceding Table 4-3 is not correct, then the team suggests that the text should be modified to better explain the correct assumption applicable to the equation in Note 1.

5 CITATIONS

Uranium Disposition Services, LLC, *DUF₆ Conversion Product Management Plan*, DUF₆-UDS-PLN-004, September 2003.

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Uranium Disposition Services, LLC, *ALARA Analysis Supporting Approval of Authorized Limits for Unrestricted Release of Hydrogen Fluoride and Calcium Fluoride*, DUF₆-G-Q-STU-001, Rev. 0A, April 2004.

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U.S. Department of Energy, *Radiation Protection of the Public and the Environment*, DOE O 5400.5, Washington, D.C., January 1993.

U.S. Department of Energy, *Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR Part 834 and DOE 5400.5 ALARA Program Requirements*, Volume 1, Draft, DOE-STD-ALARA1draft, Washington, D.C., April 1997.

U.S. Department of Energy, *Control and Release of Property with Residual Radioactive Material*, for use with DOE 5400.5, *Radiation Protection of the Public and the Environment*, Draft DOE G 441.1-XX, Washington, D.C., April 4, 2002.