HOMESTAKE
Grants Reclamation Project

Homestake Mining Company of California
David W. Pierce
Closure Manager

July 31, 2020

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Mr. Ron Linton, Project Manager
Project Manager, Materials Decommissioning Branch
Decommissioning, Uranium Recovery & Waste Programs
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
MS T-5A10, 11545 Rockville Pike
Rockville, MD 20852

RE: HMC Response to NRC's "Request for Additional Information, Final Status Survey and Disposition Survey Report for Piping Materials," Docket No. 040-08903, License No. SUA-1471, EA-16-114

Dear Mr. Linton:

On April 20, 2020, the Homestake Mining Company of California (HMC) received the above-referenced Request for Additional Information (RAI) (ADAMS Accession No. ML20107J517) from the Nuclear Regulatory Commission (NRC) regarding HMC's September 20, 2018 response (ML18269A123) to an earlier RAI from the NRC (ML18205A460) on the Final Status Survey (FSS) of the former land application areas (ML18186A577) and disposition of respective piping materials at the HMC Grants Reclamation Project (Site). This submittal provides responses to NRC's April 20, 2020 RAI (ML20107J517).

Should you have any questions or comments regarding these RAI responses, please contact me at dpierce@homestakeminingcoca.com or (505) 290-2187.

Sincerely,

David W. Pierce

David Pierce
Closure Manager
Homestake Mining Company, Grants, New Mexico

cc: R. Linton, NRC, Rockville, Maryland (electronic copy)
Regional Administrator, NRC, Region IV (hard copy)
M. McCarthy, Barrick, Salt Lake City, Utah (electronic copy)
D. Lattin, Barrick, Elko, Nevada (electronic copy)
G. George, Davis Wright Tremain, San Francisco, California (electronic copy)
R. Whicker, ERG, Albuquerque, New Mexico (electronic copy)

NMSS01
NMSS

HMC Responses to RAI from NRC: FSS of Land Application Areas and Disposition Survey Report for Piping Materials

On July 2, 2018, Homestake Mining Company of California (HMC) submitted to the U.S. Nuclear Regulatory Commission (NRC) a Final Status Survey (FSS) report for former land application areas at HMC's Grants Reclamation Project (Site) (ADAMS Accession No. ML18186A577). On August 17, 2018, the NRC responded with a request for additional information (RAI), primarily with respect to the disposition of remnant piping associated with irrigation of the land application areas near the Site (ML18205A460). HMC's September 20, 2018 response (ML18269A123) included reference to an attached 2014 "*Disposition Survey Report for Piping Materials*" associated with the land application areas (ERG, 2014), and on April 20, 2020 the NRC responded with a second round RAI, primarily concerning the disposition of piping from the land application irrigation project and radiological contamination surveys that were performed as described in the 2014 Report (ERG, 2014). The following information provides the NRC's April 2020 RAIs, followed by HMC's response.

RAI No. 1: *Please provide a clear description of the disposition of the PVC piping material associated with the land application program.*

HMC Response: Currently, all piping materials associated with the land application program, including gated PVC pipe used for flood irrigation, and previously buried HDPE pipe that supplied offsite groundwater to center pivot irrigation systems, have been removed from the land application areas and staged inside Controlled Areas of the Site. The above-ground center pivot sprinkler systems and all related piping have also been removed and staged in the Controlled Area. HMC has decided to dispose of all land application piping materials and center pivot irrigation equipment in the Small Tailings Pile (STP) in conjunction with final decommissioning activities at the Site.

RAI No. 2: *Please provide survey results for PVC piping that address the release limits established in the Guidelines or provide a justification why the release criteria applied to PVC piping address the release limits established in the Guidelines.*

HMC Response: The "Guidelines" referenced in this RAI refers to NRC guidance entitled "*Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material*" (NRC, 1993). HMC's radioactive materials license (RML) No. SUA-1471 references two different NRC guidance documents that contain criteria for unrestricted release of potentially contaminated equipment, including the Guidelines in License Condition (LC) 14, and in LC 32, NRC's Regulatory Guide (RG) 8.30 "*Health Physics Surveys in Uranium Recovery Facilities*" (NRC, 2002).

As with many uranium recovery (UR) licensees, since early editions of these NRC guidance documents were published nearly four decades ago (NRC, 1983a and 1983b), HMC has long interpreted the release criteria for "*uranium and associated decay products*" as stated in Row 1, Table 1 in the

Guidelines as equivalent to the criteria currently provided in Table 2 of RG 8.30 for UR facilities. RG 8.30 specifically states in a footnote to Table 2 that the release criteria for unrestricted use in Table 2 were taken from RG 1.86 (NRC, 1974) and the Guidelines. The implication seems clear, that the release criteria specified in RG 1.86 and the Guidelines were evaluated by NRC for applicability at UR facilities, and only the criteria deemed appropriate were included in RG 8.30 for publication and use by licensees in the UR industry.

A public meeting report from the NRC (ML093510155) regarding a 2009 NRC Workshop for in-situ UR facilities (November 17-18, 2009), states that *"The staff has determined that Regulatory Guide 8.30 will be the standard until it is revised. A draft revision will be issued for public review and comment."* Because a revision to RG 8.30 has not been issued for public comment or for use by UR licensees, the existing guidance remains the NRC "standard" today, and applicable release criteria for surface contamination at UR facilities are reflected in the content of Table 2 in RG 8.30, entitled *"Surface Contamination Levels for Uranium and Daughters on Equipment To Be Released for Unrestricted Use, on Clothing, and on Nonoperating Areas of UR Facilities."*

The NRC previously informed HMC that staff *"have not found any history suggesting that the table values in RG 8.30 were to be used in place of the Guidelines, and that the Guidelines are the only generally acceptable Commission-approved procedures for releasing material for unrestricted use for materials licensees"* (ML19256B148). This position appears inconsistent with the plain language in RG 8.30 that explicitly describes *"...health physics surveys that are acceptable to the NRC staff for protecting workers at uranium recovery (UR) facilities"* and for *"surveys of equipment and packages leaving the UR facility"*.

HMC believes that RG 8.30 is the current NRC "standard" for UR facilities, and that reference to the Guidelines in LC 14 is unnecessary to ensure compliance with Commission-approved release criteria as RG 8.30 is referenced in LC 32. To reduce redundancy in existing license conditions, HMC recently requested an amendment to the license that proposed elimination LC 14 and its reference to the Guidelines (ML19183A432). In rejecting the request (ML19256B148), NRC staff noted that *"...it would take extraordinary measures to approve an alternate procedure for releasing equipment and other materials for unrestricted use."*

In the same rejection letter (ML19256B148), the NRC referred HMC to more recent guidance from the NRC regarding release criteria as presented at the NRC's 2009 in-situ UR workshop which included discussion of the history and applicability of the Guidelines (ML093510816). The NRC presentation stated that *"Equilibrium status is relevant in assessing release criteria for isotopes, mixtures, and groups listed in the FC 83-23 Guidelines"* and that *"Release criteria for natural uranium in the Guidelines does not include radium or thorium"* (ML093510816). This implies that any Th-230 and/or Ra-226 in surface contamination at UR facilities warrants far more restrictive release criteria than are currently indicated for *"uranium and daughters"* in RG 8.30. However, the presentation also indicated that RG 8.30 *"will be revised to incorporate these recommendations"*, and since this revision has not occurred, the current version of RG 8.30 remains the NRC standard for UR facilities.

Had the authors of current or previous versions of RG 8.30 believed that separation of radioactive decay products (progeny) from parent uranium species during the milling process (including long-lived Th-230 and Ra-226 progeny), warranted application of the more restrictive release criteria for Th-230 and Ra-226 in Row 2, Table 1 in the Guidelines, it is reasonable to expect that they would have included the more restrictive criteria in Table 2 of RG 8.30 and clearly explained the basis, applicability and use of these criteria at UR facilities. This expectation also applies to release criteria for beta/gamma emitters as indicated in the Guidelines, an issue repeatedly cited by NRC with respect to potential deficiencies in HMC's procedures for equipment release surveys (ML19256B148; ML20107J517; ML19120A145).

Based on a review of recent equipment release survey results at the HMC Site, if the more restrictive release criteria for Th-230 and Ra-226 in Row 2, Table 1 of the Guidelines were to be applied at this Site, the equipment used by contractors to support Site operations may seldom be releasable and operations could be severely impacted. HMC has been applying the surface contamination release criteria from RG 8.30 (removable and total gross alpha activities of 1,000 and 5,000 dpm/100cm^2 respectively) for decades, and the NRC has not raised related concerns until recently. It is reasonable to conclude that historically, NRC has considered the release criteria in RG 8.30, and corresponding criteria for *"uranium and associated decay products"* in Row 1, Table 1 in the Guidelines, as regulatorily aligned and applicable to uranium in any combination with its progeny, and in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings, and related 11e.(2) byproduct material wastes.

Due to the potential impact of NRC's recent communications on acceptable criteria for unrestricted release of equipment from the HMC Site, HMC commissioned a detailed technical review and evaluation of the historical progression of regulatory initiatives and related technical guidance documents from NRC and other agencies concerning release limits for radiological surface contamination. The results of this study, provided in the attached White Paper (Attachment 1), support HMC's historical understanding and application of equipment release limits at the Site, and suggest that HMC should not be required to further justify continued application of these limits moving forward as they are consistent with the plain language contained in both RG 8.30 and the Guidelines.

RAI No. 3: *Please provide the following information related to the use of the cloth for determining removal surface activity levels on the PVC:*

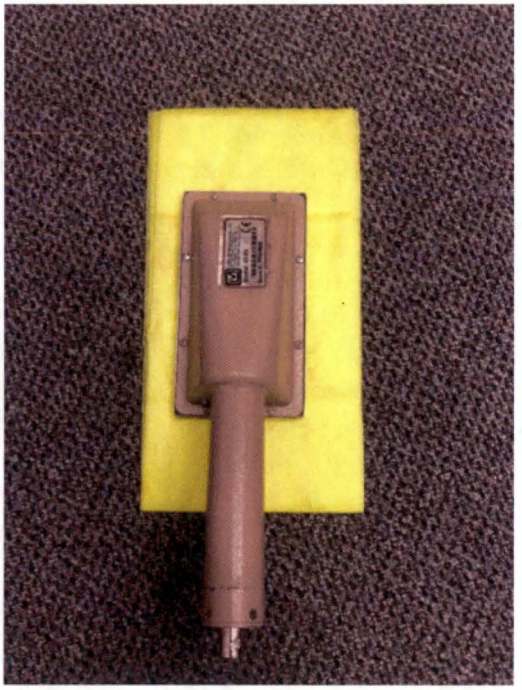
a) *Please provide the dimensions of the large area cloth used to wipe the inside of the piping and what percentage of the area of the large area cloth was placed under the detector during the sample counting time.*

b) *Please describe how the activity measured on the large area wipe is related to any 100 square centimeters (cm^2) area of the inside of the piping, including total surface area wiped and the assumed fraction of surface radioactivity transferred from the piping to the large area wipe.*

HMC Response: The following information describes the approach used to measure the removable contamination within the PVC pipe. The methods were performed as recommended in the footnotes to Table 1 of the Guidelines:

> *The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally, and the entire surface should be wiped.*

HMC used a folded Masslinn cloth of dimensions 12 inches by 5 inches. Approximately 100 square centimeters of area of the interior of the pipe was wiped by hand using the cloth. Following the wipe, the Ludlum 43-93 scintillator detector was placed on the Masslinn cloth with the detector face over the area containing the removable material. In general, the area of the 43-93 detector completely covered the wiped area on the Masslinn cloth since a hand was used to apply pressure to the cloth while wiping. The following images are provided to show context to the process.



The total activity calculated from the detector is representative of the total area wiped using the cloth. In this case, the total activity reported by the detector was representative over a 100 cm^2 area.

RAI No. 4: *Please provide the following information related to the determination of MDA for survey equipment used to release PVC piping materials as described in the Survey Report:*

a) *Please provide a description of the expected potential radionuclide mixture remaining on the deactivated PVC piping materials.*

b) *Based on the response to (a) above, please provide counting efficiency calculations that consider the potential radionuclide mixture remaining on the deactivated PVC piping materials.*

c) *Please provide an appropriate methodology for determining scan MDA or provide a justification for why the equation in Section 3.2.2 in the Survey Report is acceptable.*

d) *For alpha and beta (as appropriate) surveys, please provide a demonstration that the calculated static and scan MDAs meet regulatory requirements. Please include a discussion on how scan speed, distance between detector and potentially contaminated surface, and detector orientation will be controlled during surveys (see discussion in ADAMS Accession No. ML15295A045 and ML16050A513).*

e) *For the gamma arrays, please provide the following:*

i. *Please clarify whether the GM tubes are the Ludlum model 44-9 (as stated in Section 3.1 of the Survey Report) or an LND GM tube (as stated in Table 2 of the Survey Report). If the LND GM tube is used, please specify the model number.*

ii. *The MDA for two of the gamma arrays is close to the release limit of 5000 dpm alpha/100 cm^2 and is impacted by the background radiation during scanning measurements. Please clarify the number of work-days the scanning measurements were performed on the PVC piping and whether MDA was recalculated at certain intervals or if a single MDA calculation was performed and applied to all measurements.*

iii. *Please provide a brief description on how the MDA for each GM array was calculated.*

HMC Response: Although the information requested in RAI No. 4 is no longer relevant based on HMC's decision not to release any piping or other irrigation equipment associated with the land application program, the following information is provided in response to this RAI:

a) Samples of residual scales inside of center pivot piping indicate that sources of residual surface activity are primarily limited to natural uranium and small amounts of Pb-210. These samples should contain a mixture of radionuclides representative of residual contamination in the PVC piping or any other piping associated with the land application program. Ra-226 levels in the scale were consistent with typical background levels for soils. Th-230 was not analyzed for the scale samples as the levels of Th-230 measured in offsite groundwater used for irrigation in the land application areas were consistent with typical background levels for groundwater (see data and further discussion on this issue in HMC's response to RAI No. 6).

b) Counting efficiency and lower limit of detection (LLD) calculations that account for different radionuclide mixtures are not required for gross alpha surface contamination measurements at UR facilities based on the release criteria specified in RG 8.30 and the criteria specified for natural uranium "and associated decay products" in the Guidelines. RG 8.30 specifies an LLD of 500

dpm/100 cm^2 for gross alpha surface contamination (10% of the 5,000 dpm/100 cm^2 limit for alpha contamination).

c) Section 3.2.2 utilized the direct MDA equation as defined in the report. According to the Guidelines Table 1 footnote c, the average limit should not be averaged over an area of more than 1 square meter. The pipe scanner utilized 12 LND GM tubes in three arrays of 4 detectors each, with each array comprising a combined active detector area of 62 cm^2 and used a scanning speed and counting interval of 5 cm/s and 10 seconds, respectively. Using these scanning parameters, each GM array covered a total area of approximately 0.3 m^2, or one-third of the allowable area for the average limit per counting interval.

d) HMC is not aware of any NRC regulations that specify MDA values for surface contamination surveys, but LC 32 references RG 8.30 which recommends an LLD of 500 dpm/100 cm^2 for gross alpha surface contamination. The calculated MDA's for the GM arrays did not meet this specification, and appeared only marginally sensitive enough to detect alpha surface activity at the 5,000 dpm/100 cm^2 release criterion. While this raises valid questions regarding quantitative demonstration of compliance with the release criteria, the point is no longer relevant as HMC is no longer considering the release of any piping materials associated with the land application project (all of these materials will be disposed in the STP in conjunction with final Site decommissioning activities).

e) The following information is provided in response to this part of RAI No. 4:

i. The GM tube use for the arrays was LND Model 7311, which is the same basic GM tube used for the Ludlum Model 44-9 detector (the housing for the 44-9 includes an attached handle and related differences in the configuration of electronic cabling).

ii. The pipe surveys were completed over a three-day period (May 7, 13, and 14, 2014). A single MDA was calculated based on efficiencies and background counts on the first day, and this MDA was applied to all subsequent measurements. Again, questions regarding the MDA for surveys of the PVC piping material are no longer relevant as HMC is no longer considering release of any piping materials associated with the land application project. All of these materials have been removed from the land application areas (including buried HDPE pipeline) and are currently stockpiled in the Controlled Area for eventual disposal in the STP.

iii. Each array was calibrated as a single detector with all counts routed to a single channel. The detector efficiency and background used for the MDA were calculated from the average of the initial counts to establish quality control (QC) limits. The 10 initial QC counts and efficiency calculation were determined using the following technique:

a. The source was placed on the first detector of the four in a given array.

b. A one-minute count was performed and recorded.

c. The source was moved to the second detector in the array and the count was repeated and recorded.

d. The process was repeated until 10 source counts were complete for the entire array.

e. The source was removed, and 10 background counts were obtained for the array of 4 detectors.

f. The efficiency was determined using the average of the 10 source counts minus the average of the 10 background counts and divided by the emission rate of the source.

The calculated efficiency and background for each array was then used to determine the MDA for each independent array.

RAI No. 5: *Please provide a schedule for submitting specific surveys for buried PVC piping proposed to be left in place in the land application areas.*

HMC Response: HMC is no longer proposing to leave buried pipeline in place in the land application areas. All piping associated with the land application irrigation systems, including buried pipelines, have now been removed and stockpiled within the Controlled Area for eventual disposal in the STP. As such, radiological release surveys will not be performed on the subject piping.

RAI No. 6: *Please provide additional information on the determination that Th-230 was not found in applied irrigation water at levels significantly different than background in local groundwater. Please include any potential impact from any individual well(s) exceeding background Th-230 values.*

HMC Response: The word "significantly" was not intended in a statistical sense as statistical comparisons with Th-230 concentrations in local background groundwater aquifers have not been performed. However, summary statistics for available Th-230 groundwater monitoring data for the irrigation supply wells (Figure 1) show low concentrations that are generally comparable to an average, population-weighted background level for groundwater in the U.S. of 0.04 pCi/L as cited in the Toxicological Profile for Thorium (ATSDR, 2019).

While the average Th-230 concentration in the south supply wells is about twice the national average background value cited above, the average is highly skewed by a few individual high measurements, the median is consistent with the national average background value, and all recorded levels are still low, well below the World Health Organization's (WHO) Guideline Level for Th-230 in drinking water [1 Bq/L (27 pCi/L)] (WHO, 2008). The WHO Guideline Levels for radionuclides in drinking water are based on a dose limit of 0.1 mSv/yr (10 mrem/yr) and were derived using dose conversion factors from the International Commission on Radiological Protection (ICRP) Publication 60 (ICRP, 1990). In addition, all recorded values in the northern irrigation supply wells, and 90% of all recorded Th-230 values from the south irrigation supply wells, are below the Site's groundwater quality standard of 0.3 pCi/L for Th-230 as specified in LC 35(B).

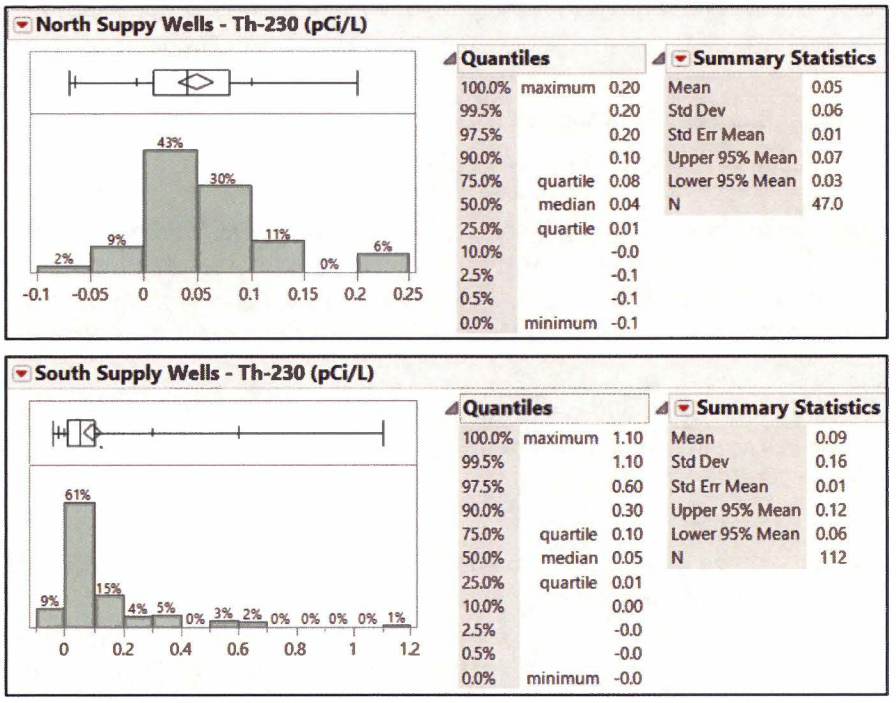


Figure 1: Distribution of measured Th-230 concentrations in groundwater supply wells for the northern irrigation areas (top) and southern irrigation areas (bottom).

Finally, data and assessments that support a qualitative characterization of negligible Th-230 levels in groundwater supply wells for the land application irrigation program, and negligible radiological impacts to soil during the program, are provided in HMC's Land Application Assessment (ML17270A066) as developed and submitted to NRC in 2017 in compliance with Condition 14 of the Confirmatory Order issued by the NRC on March 28, 2017.

RAI No. 7: *Please specify whether the reported surface soil sample concentration values of Ra-226 in Tables 5, 7, 9, and 11, in the Final Status Survey Report include background contribution (i.e., gross values) or if these values represent background-corrected values (i.e., net activity).*

HMC Response: The reported Ra-226 concentrations in the cited tables are all gross values (inclusive of local background levels), and with the exception of the one identified "hotspot" in the Section 28 center pivot irrigation area (which, as reported, was successfully remediated to meet the Ra-226 soil release criterion), these values are all generally consistent with a reported U.S. national average background soil concentration of 1.1 pCi/g and an average value of 1.5 pCi/g for the State of New Mexico (Myrick et al., 1983). The NRC-approved background Ra-226 concentration for soils at the Site is 5.5 pCi/g as specified in the approved 1993 Decommissioning and Reclamation Plan (DRP) (AKG and Jenkins, 1993a and 1993b) and as incorporated in Amendment 15 of SUA-1471 (HMC, 1995).

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2019. Toxicological profile for Thorium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

AK Geoconsult Inc. and Jenkins Environmental Inc. (AKG and Jenkins). 1993a. Homestake Reclamation Plan Revision 10/93. Volume I Text, Tables and Figures. October.

AKG and Jenkins. 1993b. Homestake Reclamation Plan Revision 10/93. Volume 2, Appendices. October.

Environmental Restoration Group (ERG). 2014. Disposition Survey Report for Piping Materials. December 2014.

Homestake Mining Company of California (HMC). 1995. Completion Report for Reclamation of Off-Pile Areas at the Homestake Mining Company of California Uranium Mill. Grants Operation. License SUA-1471. November 1995.

International Commission on Radiological Protection (ICRP). 1991. 1990 Recommendations of the ICRP. ICRP Publication 60. Annals of the ICRP, 21(1.3). Oxford, Pergamon Press.

Myrick, T.E.; Berven, B.A.; Haywood, F.F. 1983. Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S. Health Physics, Vol. 45, No. 3 (September 1, 1983, pp. 631-642).

U.S. Nuclear Regulatory Commission (NRC). 1974. Termination of Operating Licenses for Nuclear Reactors. Regulatory Guide 1.86. June 1974.

U.S. Nuclear Regulatory Commission (NRC). 1983a. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials. September 1983.

U.S. Nuclear Regulatory Commission (NRC). 1993. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials. April 1993.

U.S. Nuclear Regulatory Commission (NRC). 1983b. Health Physics Surveys in Uranium Mills. Regulatory Guide 8.30. June 1983.

U.S. Nuclear Regulatory Commission (NRC). 2002. Health Physics Surveys in Uranium Recovery Facilities. Regulatory Guide 8.30. Revision 1. May 2002.

World Health Organization (WHO). 2008. Guidelines for Drinking-water Quality. Third Edition. Incorporating the First and Second Addenda. Volume 1: Recommendations.

ATTACHMENT 1

White Paper: History and Current Circumstances of Radiological Surface Contamination Criteria for Unrestricted Release of Material and Equipment from Uranium Recovery Sites

History and Current Circumstances of Radiological Surface Contamination Criteria for Unrestricted Release of Material and Equipment from Uranium Recovery Sites

July 7, 2020

I. Introduction

Homestake Mining of California (HMC) has prepared this white paper to provide a justification for our historic and continued application of the surface contamination release limits specified in license conditions (LC) 14 and 32 of radioactive materials license SUA-1471 at the Grants Reclamation Project. In it, we address recent uncertainties within and between the uranium recovery industry and U.S. Nuclear Regulatory Commission (NRC) staff on the appropriate and protective criteria to be used for the unrestricted release or unrestricted use of materials and/or equipment from licensed uranium recovery facilities (conventional mills and *in situ* uranium recovery (ISRs)) and/or restricted areas within them.

Our objective is to ensure that the regulatory limits for radiological surface contamination on material and/or equipment to be released from the HMC site are consistent with the NRC staff's historical technical positions and intent with respect to applicability at uranium recovery facilities. This primarily involves the circumstances, technical appropriateness and applicability of Regulatory Guide 8.30, Rev 1, 2002 (*Health Physics Surveys at Uranium Recovery Facilities*) as specified in LC 32, and HMC's historic application of respective release criteria consistent with NRC's older, generic *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials* as specified in LC 14. In order to do so, we have reviewed a large number of historical documents (primarily prepared by NRC but also from other agencies as well) that present recommendations, requirements, and/or otherwise discuss the technical basis for criteria to be used for unrestricted release ("clearance") and/or license termination.

II. Scope

In this paper, we make five key points. We describe the technical basis for each followed by what we believe are the main conclusions from this analysis and recommendations for a path forward. The key points of this paper are summarized below:

1. U.S. NRC Regulatory Guide 8.30 Rev 1, 2002 (*Health Physics Surveys at Uranium Recovery Facilities*) represents the standard as stated to represent "...health physics surveys that are acceptable to the NRC staff for protecting workers at uranium recovery (UR) facilities" and for "surveys of equipment and packages leaving the UR facility." (See Section III.1)
2. Compliance with the release criteria given in RG 8.30 have historically been applied by HMC and accepted by the NRC as consistent with identical criteria listed for uranium and

its decay products in the "Guidelines" (FC 83-23) referenced in LC 14[1]. In recent years, NRC has developed a different interpretation, that the relative amounts of uranium and its decay products in mixtures at UR facilities are an important decision factor in determining which grouping (Row) of the FC 83-23 Table 1 (Table 1 herein) is applicable. This relates to the nuclear condition of "secular equilibrium," which, for our purposes here, is the condition in which uranium's major decay products (thorium and radium in particular) exist in the mixture at equivalent levels of radioactivity to each other and/or with their uranium parent. This interpretation is expected to result in technical difficulties for HMC with respect to achieving compliance[2]. We believe these difficulties would have been considered and addressed by NRC when RG 8.30 was developed and published for use by licensees in the uranium recovery industry (See Section III.2).

It is reasonable to expect that the release criteria for various categories of radionuclides found in the Guidelines referenced in LC 14 (FC 83-23 – Table 1 below)[3] were considered by the authors of RG 8.30 when defining acceptable methods for application of these criteria specifically for uranium recovery facilities (Table 2 herein), choosing to include only the criteria deemed appropriate and realistically achievable at uranium recovery sites. HMC's review of the historical progression of regulatory initiatives and related technical guidance publications supports the historical interpretation of applicable release limits at uranium recovery facilities (See Section III.3).

---

[1] *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, FC 83-23, April 1993.

[2] For example, given the typical 15-25% detection efficiencies for field alpha survey instruments, loss due to filter paper self absorption, variability of scanning techniques and potentially elevated alpha backgrounds in uranium recovery facilities, the 20 dpm/100 cm^2 limit in Row 2 of the criteria given in the Guidelines (FC 83-23) may not be detectable and the 100 dpm/100cm^2 limit may also be quite challenging to achieve with analogue based survey equipment..

[3] Throughout this paper, "Release Criteria and/or Criteria Table" refer to the surficial contamination criteria (dpm/100 cm^2) consistently appearing in similar tables (with essentially identical nuclide categories and limits) that appeared in US NRC Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, 1974 and other equivalent NRC fuel cycle and material facility related criteria issued at about that same time (mid 1970s). These include, e.g., *Annex A, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, 1976, subsequent versions of this document under the identifier FC 83-23 (1983, 1989, 1993), US NRC Regulatory Guide 8.30, US DOE and US Army analogs. These and other similar references are described within the text.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b,c,f]	MAXIMUM[b,d,f]	REMOVABLE[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1,000 dpm $\beta\gamma$/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

TABLE 1 – From U.S. NRC FC 83 – 23 (1993)

TABLE 2

Surface Contamination Levels for Uranium and Daughters on Equipment To Be Released for Unrestricted Use, on Clothing, and on Nonoperating Areas of UR Facilities*

Average**	5,000 dpm alpha per 100 cm^2	Average over no more than 1m^2
Maximum**	15,000 dpm alpha per 100 cm^2	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha per 100 cm^2	Determined by smearing with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the smear

* These values are taken from Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" (Ref. 23), and from "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source. or Special Nuclear Material," Division of Fuel Cycle and Material Safety, USNRC, Washington, DC 20555, August 1987 (Ref. 24). Available in NRC Public Document Room for inspection and copying for a fee.

** The value includes both fixed and removable contamination.

TABLE 2 – From U.S. NRC Regulatory Guide 8.30 (2002)

3. In recent UR licensing actions, NRC staff have continued to invoke both FC 83-23 for "release for unrestricted use" as well as RG 8.30 for "removal to unrestricted areas." We are unaware of any technical or regulatory basis for making this distinction and the title of Table 2 of RG 8.30 is very clear on the intended application of the criteria listed: "Surface Contamination Levels for Uranium and Daughters on Equipment to Be Released for Unrestricted Use, on Clothing, and on Nonoperating Areas of UR Facilities." This language does not state or imply conditional applicability for release only to nonoperating areas of a UR facility, but explicitly states release for "unrestricted use." If contamination on clothing or equipment is below these criteria, then they can be released to nonoperational (*unrestricted*) areas at a licensed UR facility for unrestricted future use (See Section III.4).
4. In recent years, NRC has been moving toward use of a risk informed, dose-based standard rather than a proscriptive, numerically based approach to establish release criteria for clearance of materials, facility decontamination and decommissioning, and license termination; but official changeover has been delayed.[4] Postponement of this action allowed licensees at that time to continue use of numerically based criteria (e.g., FC 83-23 Table 1) to the extent authorized by existing license condition. The history of NRC's initiatives in this regard, pertinent to aspects of this paper, are summarized in Appendix A.
5. The criteria themselves as they have been historically applied at U recovery facilities are protective from both dose and relative risk informed perspectives (Section III.3).

Based on HMC's findings as summarized above, and as further justified in the text that follows, we conclude that the release criteria for radiological surface contamination on material and/or equipment at the HMC site should remain consistent with NRC's published criteria for specific use at uranium recovery facilities (i.e., application of RG 8.30 criteria). Use of the criteria in Table 2 of RG 8.30, i.e., alpha activity from "uranium and its decay products" (or any similar phrase[5]), is correctly interpreted to mean alpha activity from natural uranium in any combination with any of its uranium series progeny, and in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings and other similar 11e.(2) byproduct material wastes. No distinction is required for the degree of secular equilibrium due to the potentially infinite combinations or mixtures of uranium series nuclides that can result from the processing of natural uranium ores and/or solutions at uranium recovery facilities, including former mill sites. This approach is both protective and consistent with that which has been applied in the US uranium industry and by multiple US government agencies for almost 50 years.

---

[4] It was initially proposed rulemaking in 1998, and later addressed by Commission action in 2005, on revising 10 CFR 20 with dose-based release limits. See Appendix A.

[5] Several slightly different phrases have been used over the years by different authors and agencies for natural uranium in some combination with its uranium series radionuclides, e.g., uranium and its decay products, uranium and its daughters, uranium and progeny. Based on many years of experience in the uranium mining and recovery industries, the authors believe that these phrases mean essentially the same thing as discussed further in the text, i.e., natural uranium in any combination of its progeny, in the chemical and physical forms associated with uranium recovery facilities (mills and ISRs), mill tailings and other 11.e (2) byproduct material wastes.

III. Technical Basis

This section presents our technical basis for the positions described above. We have identified a number of historical documents and summarized their technical content to support this technical basis. We have relied upon these documents to address the following topics:

III.1. Circumstances and Continued Applicability of U.S. NRC Regulatory Guide 8.30, Rev 1, 2002

III.2. Relevance of Equilibrium of Uranium Decay Series Radionuclides at Uranium Recovery Facilities

III.3. Dose Based Perspectives for and Other Applicable Sources for Unrestricted Use or Area Release Limits

III.4. Recent NRC UR Facility Licensing Actions Regarding Unrestricted Release Criteria

Additionally, for informational purposes, we provide in Appendix B a chronological listing that presents the evolution of NRC documents defining contamination release limits.

III.1 Circumstances and Current Applicability of US NRC Regulatory Guide 8.30, Rev1, 2002

The language in RG 8.30 is clear in regard to its application to surface contamination levels on materials and equipment to be released from the licensee's control:

> "This guide does not cover surveys to prevent the release of radioactive material to unrestricted areas or surveys to measure the exposure of the public to radioactive materials in effluents, except for surveys of the skin and clothing of workers leaving the UR facility and surveys of equipment and packages leaving the UR facility."

RG 8.30 presents its regulatory position on this in its Section 2.7 as well as in the title of its Table 2 (Table 2 herein), that the numerical criteria limits presented in Table 2 are intended as unrestricted release and use criteria since these criteria are applicable to "equipment to be released for unrestricted use" and/or "surveys of equipment and packages leaving the UR facility."

Not withstanding the above, RG 8.30 (Rev. 1) is current and represents and defines, as stated therein "...health physics surveys that are acceptable to the NRC staff for protecting workers at uranium recovery (UR) facilities..." and for "surveys of equipment and packages leaving the UR facility."

There does not appear to be a basis for contradicting the contents of RG 8.30's specific guidance for UR facilities with much more generic interpretations that predate it, e.g., NRC 1995[6] (see discussion on this document in Section II.3, Reference 2). If the authors of RG 8.30, Rev 1 believed older guidance and associated generic interpretations were relevant to U recovery facilities they

[6]NRC Memorandum, Michael Weber to distribution, *Final Draft of Surface Contamination Guidelines for Materials*, US NRC Division of Waste Management, April 20, 1995.

would have applied it. They did not. It is reasonable to conclude that they considered the continued application of the historical criteria (1000/5000 dpm/100cm^2) adequately protective for natural uranium in any combination with its progeny, in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings, and related 11e.(2) byproduct material wastes and that older generic interpretations of the criteria were neither operationally practical nor applicable to U recovery facilities.

These positions are supported by the references below.

1. Minutes of the 2009 US NRC/National Mining Association Uranium Recovery Workshop – On November 17-18, 2009, a public meeting was held in Denver, Colorado to present information to the uranium recovery industry to facilitate the preparation of applications for uranium recovery licenses. A summary of the meeting was provided in an NRC Memorandum. [7] Action item 4 regarding Personnel Contamination Limits of this memorandum states, "**The staff has determined that Regulatory Guide 8.30 will be the standard until it is revised. A draft revision will be issued for public review and comment.**" [Emphasis in original.]

   Since NRC has not yet issued draft revisions to RG 8.30 for public review and comment, RG 8.30 remains "the standard."

2. NRC Staff Regulatory Guide Periodic Review of RG 8.30 in April 2019 – A Regulatory Guide Periodic Review of RG 8.30 was performed in April 2019 by staff of the U.S. NRC Uranium Recovery Branch (ML19141A091). In this review, the staff identified several "known technical or regulatory issues with the current version of the Regulatory Guide." These issues included:

   a) Did not fully incorporate the changes to 10 CFR Part 20 when those regulations were revised in 1992.... still refers to the undefined terms "soluble" and "insoluble" instead of the inhalation classes D, W, and Y.
   b) RG 8.30, Rev.1 does not address how to evaluate a uranium compound (uranyl peroxide) that is not listed in Appendix B to 10 CFR Part 20.
   c) Not consistent with what terminology is used by NRC licensees, e.g., using "inactive area" and "active area" rather than "unrestricted area" and "restricted area."
   d) Did not address beta-gamma emitting radionuclides found in contamination at uranium recovery facilities.
   e) Guidance on how to assess the lower limit of detection for contamination surveys not currently part of RG 8.30.
   f) Guide does not adequately address considerations for calculating internal exposures from nuclide mixtures in air per 10 CFR 20.1204(g).

   However, it is noted this review did not identify as a known technical or regulatory issue

[7] NRC Memorandum, Stephen Cohen, Uranium Recovery Branch Team Leader, to Bill Von Till, Chief Uranium Recovery Licensing Branch, December 22, 2009.

the quantitative surface contamination levels for uranium and daughters on equipment to be released for unrestricted use or in unrestricted areas in its Table 2 (See our Table 2). Accordingly, it is reasonable to conclude that the numerical criteria presented in Table 2 of the guide, without further interpretation or clarification, remain "...acceptable to the NRC staff for protecting workers at uranium recovery facilities..." and for "surveys of equipment and packages leaving the UR facility."

3. Status of RG 8.30 regarding the current position of the US NRC – NRC regulatory guides typically have a clause at the beginning of the document stating something to the effect that this regulatory guide presents methods acceptable to the NRC. For example, RG 8.30 begins, "This guide is being revised to describe health physics surveys that are acceptable to the NRC staff for protecting workers at uranium recovery (UR) facilities..." Accordingly, unless a regulatory guide has been officially rescinded and/or otherwise revised, its content presents the current methods acceptable to the NRC.

   We are not aware of any basis for contradicting or reinterpreting the contents of RG 8.30's specific guidance as applied to the radiological conditions and health physics circumstances of UR facilities, or replacing it with different and more restrictive criteria from preexisting generic guidance. It is reasonable to conclude that any previous and/or generic interpretations of the criteria were considered by the authors of RG 8.30 when they defined acceptable methods for application of these criteria specifically to the radiological environments of U mills and ISRs.

III.2 Relevance of Equilibrium of Uranium Decay Series Radionuclides at Uranium Recovery Facilities

In recent years, NRC UR staff has suggested that the relative amounts of uranium and its decay products in mixtures at UR facilities are an important decision factor in determining which grouping (Row) of the FC 83-23 Table 1 (Table 1 herein) is applicable since one or more of the progeny (e.g., radium) "has been separated" from its uranium parent. This relates to the nuclear condition of "secular equilibrium," which, for our purposes here, is the condition in which uranium's long lived, alpha emitting decay products (thorium and radium in particular) exist in the mixture at equivalent levels of radioactivity to each other and/or with their uranium parent. Is the material defined as "uranium and its decay products" (or variations of terms as discussed herein – See Footnote 5) in Row 1, or should the material be defined by the Row 2 group, including the transuranic nuclides (plutonium, americium, neptunium), several radium and thorium isotopes and others? The implication is that differing combinations of decay products may involve differing levels of radiotoxicity and therefore more restrictive limits are necessary. Specifically, note the difference in the numerical criteria between material that is defined as "uranium and its decay products" in Row 1 vs. material for which the criteria of Row 2 could apply.

This argument implies that in a natural uranium series mixture, "separation" and/or "depletion" from an equilibrium concentration of decay products somehow enhances the radiological risk; that less radioactivity per unit mass requires more restrictive surficial contamination limits. This is not scientifically logical.

We note that any "separation" of radium (or any other nuclide in the uranium series decay chain) associated with UR facilities is not necessarily with intent, but is a result of the normal chemical and/or physical processes associated with uranium recovery and/or tailings management. Regardless of the isotopic mixture, the licensed material at these facilities is natural uranium and some combination of its decay products, in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings and other similar 11e.(2) byproduct material wastes. The relative isotopic mixture would not be expected to significantly influence the bioavailability, solubility, particle size and other metabolic characteristics dictated by the chemical and physical nature of these materials which are much more important factors in defining their radiological hazards (radiotoxicity – see, e.g., Brown and Chambers[8]). See also the discussion related to the "secular equilibrium" issue in Reference No. 2 in Section III.3.

An important example is demonstrated by the basic design of ISR facilities in operation in the US today. The circulating solutions (lixiviant) used to dissolve and recover uranium *in situ* are generally selective for uranium, and relatively small amounts of the equilibrium level decay products in the host formation are mobilized by the lixiviant (primarily Ra-226, depending on importance of calcium chemistry in the formation). Additionally, the ion exchange resin used for uranium capture is also uranium ion specific.

The basic feed to an ISR plant is therefore not in secular equilibrium. (For details on the radiological characteristics of US ISR facilities, see Brown 2019.[9]) The fact that the majority of uranium progeny remains in the host formation and are not brought to the surface (as is the case with conventional uranium mining and milling) has been considered an environmental and radiological protection advantage of this technology. As indicated above, NRC UR staff have recently defined radium contamination resulting from the 11e.(2) byproduct material wastes produced by these facilities as FC 83-23 Row 2 material since it "has been separated." We would ask, if it were in full equilibrium, and therefore the contamination contained several times more radioactivity/gram, the less restrictive limits would apply since its in equilibrium? This makes no sense.

We suggest that any "separation" of radium (or any other nuclide in the uranium series decay chain) associated with UR facilities is not an objective for separation, but is a result of the normal chemical and/or physical processes associated with uranium recovery and/or tailings management. The isotopic mixture itself does not significantly affect the chemical or physical characteristics or other parameters as mentioned above that would increase the radiological hazard (radiotoxicity) of the material.

It is recognized that a presentation entitled *Radiological Issues at ISR Facilities* by a staff member of the U.S. NRC Uranium Recovery Branch at the December 2009 U Recovery Workshop (Denver, Co) discussed this subject and presented several historical project examples that had developed project specific numerical criteria for circumstances involving uranium or thorium series

[8] Brown S and Chambers D, *Importance of Uranium Recovery Facility Product Characteristics for Dose Assessment and Assignment*, Health Physics, Volume 114, Number 4, April 2018.
[9] Brown S, *Occupational Radiation Protection Aspects of Alkaline Leach Uranium in Situ Recovery (ISR) Facilities in the United States,* Health Physics Radiation Safety Journal, Vol. 117, July 2019.

radionuclides that were not in equilibrium. Not all historical examples were UR facilities but these sites had processed uranium series radionuclides for some purpose. Approaches to establish these criteria varied. The author concluded that if material is not in equilibrium, the FC 83-23 Row 2 limits would apply. However, in several of these examples, there was "intent" to separate a uranium series radionuclide for producing a product with potentially different physical, chemical or metabolic characteristics and therefore a different radiotoxic profile than the material associated with UR facilities. Accordingly, these comparisons to UR facilities were not necessarily valid. There are several other positions presented therein appearing to be in conflict with the evidence and conclusions from our research as described in this paper.

All of the FC 83-23 Row 2 radionuclides (Row 2 of our Table 1) have been used for varying purposes in government and industry over many years and individually present unique radiation safety challenges due to their radiotoxicity and the metabolic properties of the compounds they have been associated with. A historical circumstance as to why "another Ra-226" criterion was included in this additional category along with the transuranics in the early 1970s may have been to address the highly bioavailable (soluble/high absorption rate), dispersible, and highly toxic radium compounds that were being produced and used in the US Radium industry of the 1920s-1950s (referring particularly to the dial painting industry and tragic experience of the dial painters; infamous radium dial plants in Ottawa Ill and Newark/Orange NJ). By the 1950s, the relationship of severe radium intakes and toxicity (high occurrence of bone sarcomas and other fatal maladies in the dial painters) were finally obvious, which resulted in requiring essentially "100% containment" (i.e., glove boxes) similar to plutonium and the other transuranic radionuclides. Such requirements are not necessary or appropriate in U recovery plants.

In the U recovery industry and for U tailings management, Ra 226 has always been considered another U progeny and this always has been and still is considered protective. The basis for the "20/100 dpm/100 cm^2 Ra 226 criteria" most likely has nothing to do with radiation protection requirements in the U recovery industry and all to do with severe human exposures to highly toxic and bioavailable radium salts in another industry a long time ago.

It is therefore reasonable to conclude that the authors of RG 8.30 considered the continued application of the historical criteria (1000/5000 dpm/100cm^2) adequately protective for natural uranium in any combination with its progeny, in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings and related 11e.(2) byproduct material wastes. Had RG 8.30 criteria been intended to apply only to uranium and its short-lived Th-234 and Pa-234 progeny, and not to long-lived alpha decay products that become separated from uranium in the form of byproduct waste material from the milling process, the authors of RG 8.30 would have recognized and specified this distinction in the text and/or footnotes to Table 2 of RG 8.30, and Table 2 would have included additional groupings of radionuclide categories as provided in earlier generic guidance documents (e.g. RG 1.86 and FC 83-23). It is reasonable to expect that the authors of RG 8.30 vetted the release criteria in Table 2 carefully with respect to applicability at UR facilities, and the generic, more restrictive criteria in the earlier guidance documents were intentionally excluded from RG 8.30 as not relevant. Additionally, as previously referenced (See Footnote 2), the authors of RG 8.30 would have recognized the

operational limitations at a UR facility to "detect" 20/100 dpm per 100 cm^2 as quite challenging if not impossible.

III.3 Dose-Based Perspectives and Other Applicable Sources for Unrestricted Use or Area Release Limits

We have reviewed and summarize in this section a number of pertinent regulatory guidance documents that discuss corroborative and/or alternative surface contamination limits including technical analyses that support the use of a dose-based approach for determining appropriate radiological criteria for unrestricted release. The following references are presented as source documents and their relevance and implications to the subject of this paper are discussed below.

1. *A Summary of NRC's Interim Radiological Cleanup Criteria and Current Dose Bases,* Decommissioning and Regulatory Issues Branch, U.S. Nuclear Regulatory Commission, November 1992 (http://www.westvalleyfactsofwny.org/radcrit.htm. Last accessed 27 June 2020).

In the mid-1980s, NRC staff initiated development of the technical basis to support a rulemaking to codify final cleanup standards for radiological contamination. This rulemaking was an outgrowth of the NRC's long-term effort to establish decommissioning requirements.[10] However, since the rulemaking to establish quantitative radiological criteria for decommissioning "may not be completed for another two years or so," NRC issued this document to address the problem of what criteria should the NRC use in the interim to determine whether sites have been sufficiently decontaminated so that they may be released for unrestricted use. In preparing this paper, the NRC staff identified the full range of existing cleanup criteria used by the NRC and estimated the doses associated with the criteria.

In its Section 1.2, doses associated with the existing NRC criteria from FC 83-23 and RG 1.86 are presented, and the relevant criteria with associated doses are extracted below. The right-hand column indicates "dose bases" calculated using RESRAD that per NRC's text here, "contains contemporary dosimetry and exposure assumptions." This data also appears in NUREG/BR-0241, *NMSS Handbook for Decommissioning Fuel Cycle and Materials Licensees.*[11]

---

[10] Final Rule, General Requirements for Decommissioning Nuclear Facilities, 53 FR 24018, June 27, 1988. The purpose of this rulemaking was to amend NRC regulations to set forth technical and financial criteria for decommissioning licensed nuclear facilities. However, regarding matters pertaining to quantitative limits for residual radioactivity, NRC stated it " is planning to implement this guidance as soon as possible. The selection of an acceptable level is outside the scope of this rulemaking."

[11] *NMSS Handbook for Decommissioning Fuel Cycle and Materials Licensees*, NUREG/BR-0241, App C – *Interim Radiological Cleanup Criteria for Decommissioning*, 1997.

Table 1. Acceptable Contamination Criteria and Associated Dose Bases in NMSS Policy and Guidance Directive FC 83-23

Contamination	Criterion	Stated Dose Basis+	Estimated Dose Basis (EDE)+
Average, fixed U-nat, 235U, 238U, and decay products	5000 dpm/100 cm2	None	~13mrem/yr
Average, fixed 226Ra, 228Ra, transuranics, etc.	100 dpm/100 cm2	None	~0.2mrem/yr#
Average, fixed Th-nat, 232Th, 90Sr, etc.	1000 dpm/100 cm2	None	~28 mrem/yr#
Avg. and max. external beta-gamma dose	0.2-1 mrad/hr at 1 cm	None	~20 mrem/yr

Table 3 – Acceptable Contamination Criteria from Policy Guidance Directive FC 83-23 and Their Associated Dose Bases From NUREG/BR-0241

Several implications of these dosimetric equivalents appear obvious:

a) For all nuclide categories, the doses associated with their respective criteria are less than the annual public exposure limit for licensed facilities of 100 mrem per 10 CFR 20.1301.

b) All associated doses are approximately equivalent to or less than the 25 mrem annual public exposure criteria per Subpart E (License Termination), 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use.*

c) Since the associated dose basis for Row 2 is a small fraction of that for the other rows (e.g., 1.5% of Row 1), the Row 2 limits could be increased by a factor of 100/1.5 = 66 to achieve an equivalent radiological risk as Row 1. That is, the "radium limits" could be increased from 100 dpm/100 cm^2 to $\geq$ 5000 dpm/100 cm^2 (i.e. 6600 dpm/100 cm^2) and maintain an equivalent acceptable risk/dose (see also discussion of Reference 3 further in this Section).

2. *Final Draft of Surface Contamination Guidelines for Materials*, Michael Weber to distribution, US NRC Division of Waste Management, April 20, 1995

The stated purpose of this draft document was to address a number of technical issues that had been raised regarding the application of the surface contamination limits during decommissioning in Table 1 of FC 83-23, which was presented as Attachment 1 of this document. Attachment 2 of this document provided some supplemental information on the FC 83-23 criteria, which was intended to clarify these technical issues and ensure that the limits are consistently applied.

There are several useful clarifications in this document on the composition (i.e., definition) of natural uranium, and the alpha/beta ratios of the uranium series as related to alpha vs. beta activity. However, a clarification in this document that we understand NRC uranium recovery staff are relying upon to have relevance to the subject of this paper is in Attachment 2, Section II, Item D that states:

> Groupings 2 and 3[12] include the following specific radionuclides from the naturally occurring uranium, thorium, and actinium decay series: Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, Ra-223, and Ra-224. The guidelines for these particular radionuclides are applicable **only** when the radionuclide has been separated from the materials that precede it in the decay series. [Emphasis added.]

NRC staff have recently taken the position (See Section III.2) that since there are circumstances at U mills and ISRs where, e.g., radium has been "separated" in some way from the other equilibrium progeny in the decay chain, that the Row 2 limits would be applicable to radium at U mills and ISRs. We do not believe that was the intention of this clarification and we would submit that the authors of RG 8.30 did not either. Rather, the "separation" referenced in this document implied intent to produce a new radiological end-product (e.g. a radium compound as a product rather than a byproduct waste material) with potentially different chemical and physical characteristics and therefore metabolic characteristics with potentially increased dose equivalency. Again, this was discussed in detail in Section III.2

Furthermore, it is noted that (1) this 1995 document was a "Draft" (2) Its stated purpose was to address some technical issues associated with **decommissioning,** not necessarily material clearance, and (3) within the extensive research we did for this white paper, we found no reference to it relative to uranium sites in any of the over 40 years of documents used as source material for establishing unrestricted release and /or clearance criteria.

3. E. Abelquist, *Decommissioning Health Physics, A Handbook for MARSSIM Users*, Medical Physics Series, 2001.

Abelquist references the associated doses from Table 1 of NUREG/BR-0241 (our Table 3) in his Section 4.2, *Dose Based Release Criteria and the NRC Decommissioning Rulemaking.* Ablequist notes that:

> It is remarkable that three of the groupings are generally consistent with NRC's 25 mrem/year dose criterion (10 CFR 20, Subpart E, Radiological Criteria for License Termination). The estimated dose of 0.2 mrem/year from the Ra 226, Ra 228, transuranic grouping indicates that the Regulatory Guide 1.86 [ED. NOTE: similarly FC 83-23] guideline of 100 dpm/cm^2 for those radionuclides should be increased by roughly a factor of 100 to yield the same dose.

Abelquist also references in his Table 4.4, NRC Default Derived Concentration Guideline Level (DCGL) for building surface contamination from NUREG/CR-5512, *Residual Radioactive Contamination for Decommissioning*, V 3, Table 5.19.[13] From Abelquist, a value of particular relevance for uranium recovery facilities is Ra 226 = 1120 dpm/100cm^2 w/o progeny; 315 w/progeny.

As suggested by Abelquist, and as we also have suggested in discussion on Reference 1 in this Section, the data in NUREG/BR-0241 (Table 3 above) forms the basis for the physics that if 13

[12] This is a reference to Rows 2 and 3 of its Attachment 1 (Our Table 1 herein).

[13] We have Vol 1 of this document but have not been able to obtain Vol 3.

mrem/yr (i.e. @ 5000 dpm/100cm^2) is considered protective for U and decay products, then from a dose/risk informed perspective, the radium limit can be 13/0.2 = 65 X 100 = 6500 which is similar to 5000.

4. ANSI N13.12-1999, *Surface and Volume Radioactivity Standards for Clearance* (Dose Based Limits), 1999.

Based on the dose modeling described therein, no individual will receive more than 10 μSv/y (1.0 mrem/y) as the primary dose criterion using the values in its Table 1 (See our Table 4 below). NRC used the definition and assessment of exposure scenarios and associated dose modeling from this document as part of the technical basis for SECY-02-0133 and endorsed its use for the intended revision of 10 CFR 20 (See Reference No. 6 below and Appendix A).

Radionuclide Groups [a] Surface	Screening Levels (S.I. Units) [b]	Screening (Conventional Units) [b]
	Bq/cm² or Bq/g) [c]	dpm/100 cm²
Group 1 Radium, Thorium, and Transuranics: 210Po, 210Pb, 226Ra, 228Ra, 228Th, 230Th, 232Th, 237Np, 239Pu, 240Pu, 241Am, 244Cm,and associated decay chains (d), and others (a)	0.1	600
Group 2 Uranium and Selected High Dose Beta-Gamma Emitters: 22Na, 54Mn, 58Co, 60Co, 65Zn, 90Sr, 94Nb, 106Ru, 110mAg, 124Sb, 134Cs, 137Cs, 152Eu, 154Eu, 192Ir, 234U, 235U, 238U, Natural Uranium (e), and others (a)	1.0	6000

(a) To determine the specific group for radionuclides not shown, a comparison of the effective dose factors, by exposure pathway, listed in Table A.1 of NCRP Report No. 123I (NCRP 1996) for the radionuclides in question and the radionuclides in the general groups above shall be performed and a determination of the proper group made, based on similarity of the factors.
(b) Rounded to one significant figure.
(c) The screening levels shown are used for either surface activity concentration (in units of Bq/cm2), or volume activity concentration (in units of Bq/g). These groupings were determined based on similarity of th1e scenario modeling results, as described in Annex B.
(d) For decay chains, the screening levels represent the total activity (i.e., the activity of the parent plus the activity of all progeny) present
(e) Where the Natural Uranium activity equals 48.9% from 238U, plus 48.9% from 234U, plus 2.25% from 235U

Table 4 – Screening Levels for Clearance – Excerpt from Table 1 of ANSI 13.12-1999

5. *Application of the Concepts of Exclusion, Exemption and Clearance*, International Atomic Energy Agency, IAEA RS-G-1.7, 2004.

The primary purpose of this document was to address acceptable levels of long-lived radionuclides in commodities – wood, metal, foodstuffs, etc., with regards to radiological criteria for exclusion, exemption, and clearance. An annual exposure rate of 1 mSv (100 mrem) was used to develop the numerical criteria for volumetric activity concentrations (Bq/gram). The document does not address surficial activity concentrations but was referenced as a source document by NRC staff in SECY-02-0133 (See Reference No. 6).

6. SECY-02-0133, *Control of Solid Materials: Options and Recommendations for Proceeding*, U.S. NRC, 2002.

In support of the subsequent NRC Rulemaking,[14] the staff prepared this SECY that recommended proposing an amendment to 10 CFR 20 to apply volumetric and surficial release limits for solid materials based on a 1 mrem/yr, (0.01 mSv/yr) dose criterion and methodologies of ANSI N13.12, volumetric or mass concentrations based on IAEA RS-G-1.7 and NUREG 1640 (References 4, 5 and 7 respectively in this Section).

[14] Proposed Rule, *Radiological Criteria for Controlling the Disposition Of Solid Materials*, SECY-05-0054, March 31, 2005. (See discussion of this document in Appendix A)

In SECY-02-0133, NRC states:

> … the NRC has included a set of surface concentrations in Table 2 of Appendix E of 10 CFR Part 20.[15] Table 2 groups nuclides in a manner similar to the existing table in Regulatory Guide 1.86, which has been in use for several years. Licensees would have the option of applying to the Commission for case specific approval to release material at radionuclide concentration levels higher than those in Table 2 of the proposed amendments…
>
> …Solid material would be considered acceptable for release if its radionuclide concentrations do not exceed the levels in Table 2. The levels in Table 2 are based on the definition in 49 CFR 173.403[16] for surface concentrations not requiring DOT regulation to provide consistency between these two Federal agencies regarding material needing no further regulation.

It is noted that no further interpretation is provided for the equivalent of "U … and associated decay products" in its Table 2 which is reproduced as our Table 5 below.

Table 2 Surface Concentration Levels

Radionuclide Groupings	Release Level – Total Surface Activity	
	pCi/cm²	dpm/100 cm²
Beta-gamma emitters (nuclides with decay modes other than alpha emission and without regard to half-lives)	11	2400
U-natural, Th-natural, U-235, U-238, Th-232, Th-228, Th-230, U-depleted, and associated decay products; and alpha emitters with half-lives of less than 10 days	11	2400
Radionuclides with alpha or spontaneous fission decay modes and with half-lives equal to or greater than 10 days	1.1	240

Table 5 – Surface Concentration Levels, SECY-02-0133

[15] This proposed action was to amend Part 20 per the details of this rulemaking. See Appendix A.

[16] DOT defines contamination (49 CFR 173.403) as the "presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm² (about 2400 dpm / 100 cm²) for "beta and gamma emitters and low toxicity alpha emitters" (natural U and Th are defined as such when contained in ores or physical and chemical concentrates). Note that DOT has also made a distinction here for the alpha emitters associated with ores and milling concentrates as "low toxicity alpha emitters." This is similar to our interpretation of the distinction NRC implied in the 1995 Draft document (Reference # 2 above) with the nuclides in "groupings 2 and 3" of FC 83-23 Table 1 which *are. applicable* ***only*** *when the radionuclide has been separated from the materials which precede it in the decay series, i.e.,* implying that if different chemical species are produced, these products could be of greater radiological risk and/or toxicity than those in group (Row) 1.This is not the case at UR facilities as discussed in detail herein –See Section III.2).

7. *Radiological Assessments for Clearance of Materials from Nuclear Facilities,* U.S. NRC Division of Systems Analysis and Regulatory Effectiveness, NUREG-1640, June 2003.

This report provided a comprehensive description of calculations and their results that estimated annual doses, normalized to a unit concentration, following the clearance (removal of radiological controls by the licensing authority) of specific materials (scrap iron and steel, copper, aluminum and concrete rubble).

The estimated doses were calculated probabilistically to account for a large number of possible variations in each of the 86 scenarios. Authors state that these scenarios encompassed the full range of realistic situations likely to yield the greatest normalized doses. Each scenario was analyzed with the 115 radionuclides considered most likely to be associated with materials from licensed facilities. The design basis of the analyses was to realistically model current processes, to identify critical groups on a nuclide-by-nuclide basis, and to enable the conversion of a dose criterion to volumetric and surficial concentrations (Bq/cm^3 and Bq/cm^2 respectively).

For demonstration purposes, values extracted for two nuclides of particular interest for this paper, Ra-226 and U-238, are converted below to conventional surface contamination units as follows:

From Table 2.1, *Normalized Effective Dose Equivalents to Critical Groups for all Materials*:

> Example 1: Ra-226 as surficial contamination on/in steel = 7.0 uSv/yr per Bq/cm^2 = 0.7 mrem yr per 5400 dpm/100 cm^2 or **at 1 mrem / yr = 7700 dpm/100 cm^2**
>
> Example 2: U-238[17] as surficial contamination on/in steel = 2.5 uSv/yr. per Bq/cm^2 = 0.25 mrem/yr per 5400 dpm/100 cm^2 = **21, 600 dpm/100 cm^2 at 1 mrem/yr.**

8. US DOE Order 5400.5, *Radiation Protection of the Public and Environment* (1993), and 10 CFR 835.

DOE Order 5400.5 presents numerical surface contamination guidelines in its Figure IV-1. This figure is reproduced below as our Table 6. Note that DOE makes no special interpretation or distinction for specific U progeny in this document. However, regarding the uranium series and related alpha emitters, it is noted that this category is discussed further in the US DOE memo of February 16, 2010 (Reference No. 9 below) issued specifically to address alternative means of measuring alpha emitters in uranium contamination. It is assumed that this DOE Order would have been the source for the position reinforced and expanded upon in the 2010 Memo (Reference No. 9).

[17] Note that U-234 is presented in Table 2.1 with approximately equivalent EDE values and since U nat is almost 50% each on activity basis, the dpm/100 cm^2 per 1 mrem/yr. result for "U nat" would be essentially the same.

Figure IV-1
Surface Contamination Guidelines

Radionuclides[2]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[2] Average[1,3]	Maximum[1,3,5]	Removable[1,4]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231.	RESERVED	RESERVED	RESERVED
Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232.	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay product, alpha emitters.	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[2]	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3/ Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

4/ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5/ The maximum contamination level applies to an area of not more than 100 cm2.

Table 6 – Surface Contamination Guidelines, DOE Order 5400.5

9. *Radiological Control Technical Position Providing an Alternative Means of Measuring Alpha Emitters in Uranium Contamination to Demonstrate Compliance with Title 10, Code of Federal Regulations, Part 835*, Memo for Distribution, US DOE, February 16, 2010.

It is noted that 10 CFR 835, *Occupational Radiation Protection*, contains "Surface Contamination Values" in its Appendix D. Those pertinent to "uranium and its progeny (daughter products)" were extracted from this large table, reproduced in this DOE memo and presented below as our Table 7. Appendix D of 10 CFR 835 introduces its table of surface contamination values with the following text:

> The data presented in Appendix D are to be used in identifying the need for posting of contamination and high contamination areas in accordance with § 835.603(e) and (f) and identifying the need for surface contamination monitoring and control in accordance with §§ 835.1101 and 835.1102.

Although the technical focus of this memorandum (use of beta/gamma as alternative for alpha measurements) is beyond the scope of this paper, it is nonetheless relevant and important to note that the surface contamination values presented in 10 CFR 835 Appendix D and referenced in this DOE memorandum are identical to the unrestricted use and release limits presented in RG 8.30 Table 2, Row 1 of FC 83-23 and many of the other documents referenced herein for natural uranium and associated progeny categories.

Appendix D, "Surface Contamination Values"

Surface Contamination Values in dpm/100 cm^2

Radionuclide	Removable	Total (Fixed + Removable)
U-nat, U-235, U-238, and associated decay products	[7]1,000	[7]5,000
***	***	***

[7] These limits apply only to the alpha emitters within the respective decay series.

TABLE 7 – Surface Contamination Values, US DOE Memo for Distribution, February 2010.

It is further noted by DOE that these limits apply only to the alpha emitters in the respective decay series. In other words, the 1000/5000 dpm per 100 cm^2 criteria apply to Th-234, Th-230 and Ra-226 as well as U-238 and U-234 in the uranium series.

We conclude that this was a related factor in the need for looking at alternative survey methods for beta/gamma emitters due to the difficulty of measuring alpha. Although not directly related to the scope of this paper, DOE's text immediately following this table is generally instructive regarding the measurement of natural uranium and progeny, particularly since it is DOE's position that the 1000/5000 dpm per 100 cm^2 criteria are applicable to the other alpha emitters in the uranium decay series and that beta/gamma measurements can be used directly in lieu of alpha measurements under certain conditions. This implies in DOE's view that the specific mixture of progeny (degree of "equilibrium") is not relevant.

10. *Guide of Good Practices for Occupational Radiological Protection In Uranium Facilities,* US DOE, DOE-STD-1136-2017.

Table 4-1 of DOE-STD-1136-2017 reproduces in its entirety the surface contamination values from Appendix D of 10 CFR 835. This table is very similar to Table 1 of FC 83-23 and specifically regards to "uranium and progeny," essentially the same as the values of RG 8.30, Table 2. This was depicted in our Table 7 above. Again, it is noted that DOE has provided some clarification on the limits for U-nat, U-235, U-238, and associated decay products with a footnote that states these limits apply only to the alpha emitters within the respective decay series. Accordingly, it appears DOE's intention is that the 1000/5000 dpm per 100 cm^2 criteria can include any combination of Th-234, Th-230 and Ra-226 as well as U-238 and U-234 in the uranium series.

11. *UMTRA Project Environmental Health and Safety Plan,* DOE/UMTRA-150224-0006, US Department of Energy, Uranium Mill Tailings Remedial Action Project Office, February 1989.

This document is of particular relevance to the HMC site as it sets forth US DOE health and safety criteria for the safe management of uranium mill tailings. For release of tools and equipment for unrestricted release, it references RG 1.86 and in general, applies the dpm/100 cm^2 criteria for the "Unat and associated decay products" category (Row 1 of RG 1.86 Table 1, which are the same values as Table 2 of RG 8.30). The document also suggests site-specific release limits may be

necessary in cases where appreciable amounts of specific alpha emitters are found w/o associated equilibrium decay products, but it does *not* invoke the much more restrictive FC 83-23 Row 2 limits.

The document states:

> Tools and equipment that are potentially contaminated with mill tailings and are to be released for unrestricted use shall be monitored and decontaminated, if necessary, before release. Release limits for natural uranium and its daughters, as specified in NRC Regulatory Guide 1.86 and DOE Order 5400.3 [subsequently cancelled], are 5000 dpm alpha per 100 sq cm (average), 15,000 dpm alpha per 100 sq cm (maximum) and 1000 dpm alpha per 100 sq cm (removable). ... Site specific release limits may be necessary in areas where specific alpha emitters such as Ra-226 or Th-230 are found without appreciable amounts of the other uranium daughter isotopes.

12. *Army Radiation Safety Program*, US Army, Department of the Army Pamphlet 385–24, 2015.

From its Section 5.3, Radioactive Contamination: "ANSI N13.12 is to be used except for compliance with NRC contamination limits. In the absence of other regulatory or advisory guidance, a surface is contaminated if either the removable or total radioactivity is above the levels in Table 5-3." This table is identical to Table 1 of ANSI 13.12-1999 (Our Table 4 above).

III.4 Recent NRC UR Facility Licensing Actions Regarding Unrestricted Release Criteria

In recent uranium recovery licensing actions, NRC staff have invoked the numerical release criteria from both FC 83-23 and RG 8.30. As applicable to uranium recovery facilities, we believe they are identical (Table 1, Row 1 of FC 83-23 and Table 2 of RG 8.30). Since RG 8.30 is intended as the most relevant NRC guidance for health physics surveys and release of materials from UR facilities, it is unclear why earlier, more generalized FC 83-23 criteria are now being invoked by NRC as applicable to UR facilities as well. The cited regulatory rationale for this interpretation (reference NRC staff presentation at the Uranium Workshop of December 2009 – See Section III.2) is unclear and seems inconsistent with the regulatory position on release limits specified in Section 2.7 of RG 8.30 and the title of its Table 2.

In the three examples cited below, it appears that NRC staff have made a distinction between what criteria are applicable for ***release for unrestricted use*** (referencing language in FC 83-23) vs. criteria applicable for ***removal to unrestricted areas*** (we assume intending to reference language in RG 8.30), but even this "distinction" is confusing in the example extracted texts below.[18]

Since 10 CFR 20.1003 indicates *unrestricted area means an area, access to which is neither limited nor controlled by the licensee,* no licensee action is required after the item has been properly surveyed and released to the unrestricted area. If an item has been properly surveyed and

[18] Note that RG 8.30 uses the phrase "unrestricted areas" several times for purposes of applicability of its Table 2 release criteria, in context of areas both within the licensed facility ("non-operating areas") as well as in the public domain.

released without restrictions, it has been controlled.

We are unaware of any historical technical or regulatory basis for making this distinction and from a practical operational perspective, we cannot understand how an item meets the criteria for "removal to an unrestricted area" and is not acceptable for "unrestricted use" and/or vice versa. It is difficult to believe that the authors of FC 83-23 vs. RG 8.30 actually had two different applications/definitions in mind with the slightly differing phraseology. We believe that if indeed NRC does make a distinction between these two situations, it should explain the basis for the distinction and how it would be put into practice. Specific citations where NRC has applied the different criteria as described above are as follows:

1. Dewey Burdock SER (License No. SUA-1600; Docket No. 40-9075)

   > Regulatory Guide 8.30 (as revised), Table 2, shall apply to the removal to unrestricted areas of equipment, materials, or packages that have the potential for accessible surface contamination levels above background.
   >
   > Release of surficially contaminated equipment, materials, or packages for unrestricted use shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526) or suitable alternative procedures approved by NRC prior to any such release.

2. Ross ISR (License No. SUA-1601; 2014)

   > Release of surficially contaminated equipment, materials, or packages for unrestricted use shall be in accordance with the NRC guidance document, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526) or suitable alternative procedures approved by NRC prior to any such release...
   >
   > Regulatory Guide 8.30 (as revised), Table 2 shall apply to the removal to unrestricted areas, of equipment, materials, or packages that have potential accessible surface contamination levels above background radiation levels. The contamination control program shall provide sufficient detail to demonstrate how the licensee will maintain radiological controls over the equipment, materials, or packages that have the potential for accessible surface contamination levels above background, until they have been released for unrestricted use as specified in the Guidelines, and what methods will be used to limit the spread of contamination to unrestricted areas.

3. Crow Butte SER (No. SUA-1534; Docket No. 40-8943)

   > Release of surficially contaminated equipment, materials, or packages for unrestricted use

shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526), or in accordance with a suitable alternative program which shall be approved by NRC prior to any such release.

The Guidelines or approved alternative program shall also apply to the removal of equipment, materials, or packages from restricted areas that have the potential for accessible surface contamination levels above background regardless of the intent to release these items for unrestricted use.

Regulatory Guide 8.30 (NRC, 2002a) is the standard by which the NRC staff evaluates alpha contamination control for personnel monitoring and releasing material for unrestricted use. The NRC staff is currently revising Regulatory Guide 8.30. When Regulatory Guide 8.30 (NRC, 2002a) is revised, a draft revision will be issued for public review and comment. If the alpha contamination control limits are revised in the update to Regulatory Guide 8.30, the standard license condition discussed in Section 5.3.4 of this SER requires the applicant to adopt the revised limits.

IV. Conclusions and Recommendations

Based upon our review, we conclude the following:

1. NRC Regulatory Guide 8.30 Rev 1, 2002 represents the "NRC standard" and it defines "...health physics surveys that are acceptable to the NRC staff for protecting workers at uranium recovery (UR) facilities" and for "surveys of equipment and packages leaving the UR facility." It is reasonable to conclude that older, generic interpretations of the traditional numerical release criteria were considered by the authors of RG 8.30 when they defined acceptable methods for application of these criteria specifically to UR facilities and they intentionally chose *not* to incorporate them. Although there are several slightly different phrases that have been used over the years by different authors and agencies for natural uranium in some combination with its uranium series radionuclides, based on many years of experience in the uranium mining and recovery industries, we believe that these phrases mean the same thing, i.e., natural uranium in ***any*** combination with ***any*** of its progeny, in the chemical and physical forms associated with uranium recovery products, conventional mill tailings and other similar 11e.(2) byproduct material wastes. The US uranium industry and multiple US government agencies have used these criteria for almost 50 years and in general, have interpreted the application of these criteria in this way.

2. The numerical surface contamination release criteria themselves (e.g., first row of Table 1, FC 83-33 and/or Table 2 of RG 8.30), as has been historically applied at U recovery facilities are fully protective, from both dose and relative risk-informed perspectives. Dose equivalency assessments of these criteria performed by NRC staff and others demonstrate annual doses much less than the annual public exposure criteria in 10 CFR 20.1301 and are approximately equivalent to or less than the 0.25 mSv (25 mrem) annual public exposure criteria per Subpart E (License Termination), 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use.*

3. NRC staff are invoking both FC 83-23 for "release for unrestricted use" and RG 8.30 for "removal to unrestricted areas" in recent licensing actions. We are unaware of any technical or regulatory basis that justifies making this distinction and from a plain interpretation of the title of Table 2 in RG 8.30 and practical operational perspective, it is not clear how an item meets criteria for "removal to an unrestricted area" and is not acceptable for "unrestricted use." If some specific technical distinction were intended rather than unintentionally implied by use of imprecise language, NRC should explain and clarify this. In fact, both RG 8.30 and FC 83-23 are relatively clear that surface contamination criteria acceptable for unrestricted use and for release to unrestricted areas are the same. We find it unlikely that different authors just chose slightly different words to mean the same thing.
4. Since the first row of Table 1 of FC 83-23 is identical to Table 2 of RG 8.30 Rev. 1, and ignoring any "generic interpretations" that predate the U mill/U recovery facility specificity of RG 8.30 Rev 1, the applicable surface contamination criteria in FC 83-23 and RG 8.30 are equivalent and it appears unnecessary and redundant to invoke both documents in license conditions. Accordingly, in lieu of the use of dose-based criteria in future versions of RG 8.30 (See Appendix A), the current version of RG 8.30 still represents "the NRC standard" and only Table 2 of RG 8.30 need be invoked for uranium recovery facilities.

Accordingly, to ensure that the surficial levels of radiological contamination on material and/or equipment released from the HMC site meet NRC's intent and are fully protective, we propose the following:

Based on HMC's findings as documented and justified in the text of this paper, we conclude that the release criteria for radiological surface contamination on material and/or equipment at the HMC site should remain consistent with NRC's published criteria for specific use at uranium recovery facilities (i.e. application of RG 8.30 criteria). Use of the criteria in Table 2 of RG 8.30, i.e., alpha activity from "uranium and its decay products" (or any similar phrase), is correctly interpreted to mean alpha activity from natural uranium in any combination with any of its uranium series progeny, and in the chemical and physical forms typically associated with uranium recovery products, conventional mill tailings and other similar 11e.(2) byproduct material wastes. No distinction is required for the degree of secular equilibrium due to the potentially infinite combinations or mixtures of uranium series nuclides that can result from the processing of natural uranium ores and/or solutions at uranium recovery facilities, including former mill sites. This approach is both protective and consistent with that which has been applied in the US uranium industry and by multiple US government agencies for almost 50 years.

Appendix A
NRC History and Perspectives on the Use of Risk Informed, Dose-Based Criteria for Materials Clearance and Release for Unrestricted Use

NRC has been moving toward a risk informed approach to regulation for some years and beginning in the late 1990s, initiated rulemaking to apply dose-based criteria for license termination and for the unrestricted clearance of materials from licensed facilities. Section A.1 identifies several important NRC documents and actions related to the agency's intention to develop these dose-based criteria. Related to these earlier rulemaking initiates, Section A.2 discusses the evolving Risk Informed/Performance Based Philosophy of NRC in recent years. Some concluding remarks on the topic of this Appendix are presented in Section A.3.

These discussions are included as an Appendix to the RG 8.30 white paper because we believe that the recent position of NRC staff that UR licenses must continue to use the numerical criteria of FC 83-23 is inconsistent with the broader staff guidance and direction as clearly articulated by this history. As stated by NRC (63 FR 64132, November 18, 1998): *The criteria that eventually emerge from this rulemaking effort are intended to replace the surface contamination values in Policy and Guidance Directive FC 83–23.* However, as discussed in the main text, UR licenses that have been issued in recent years nonetheless continue to include conditions requiring a convoluted interpretation of the applicability of FC 83-23 criteria for uranium recovery facilities (in particular, see Section III.4 of the main text).

The dose-based initiative and the associated technical basis the NRC staff developed for it fully support that the use and application of dose-based, risk informed criteria are appropriate, and its application is fully consistent with NRC's intent, particularly in Homestake's circumstances (former U milling site). The dosimetric implications of the unrestricted release criteria in Table 2 of Regulatory Guide 8.30, Rev 1, as discussed in the main text of the white paper (e.g., See Section III.3, References No. 1 and No. 3) as they have been historically applied for approximately 50 years at U recovery facilities are protective from both dose and relative risk informed perspectives.

We are fully aware that the information cited in this appendix largely arises from NRC proposals that were not completed. However, we include this discussion because we believe them to be illustrative and informative.

A.1. History of NRC Rulemaking (Initiated in 1998) – Intention to Revise 10 CFR 20 for Radiological Criteria for License Termination and for Clearance of Materials Using Risk Informed, Dose-Based Criteria

1. *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination*, U.S. NRC, 63 FR 64132, November 18, 1998.

This notice provided supplemental information regarding implementation of NRC's Final Rule on Radiological Criteria for License Termination (License Termination Rule, LTR), which was issued on July 21, 1997 (62 FR 39058), including use of dose-based criteria. FC 83-23 as a decommissioning criterion was intended to be superseded by the LTR but in this notice, NRC clarified that until dose-based release criteria are developed, "...licensees may continue to use FC 83-23 to the extent authorized by their license." Note that it is our understanding that in recent

times, NRC staff have taken the position that licensees still *must* use FC 83-23 and therefore have been assigning license conditions that require it, but that is not what it appears this notice and other documents referenced herein suggest. We believe it was intended to apply to licensees at that time and use of the word "may" could have suggested an option to continue to use numerical criteria if authorized by their existing license or use of the dose based criteria as was intended at that time. Instructive text from the notice follows:

> The surface contamination criteria in Regulatory Guide 1.86 have been applied by reactor licensees for license termination only. However, for materials licenses (under 10 CFR Parts 30, 40, and 70), the guidelines in Policy and Guidance Directive FC 83–23 have been used by licensees for two purposes: (a) as criteria for license termination, and (b) as criteria for unrestricted release of equipment and other materials during operations. On June 30, 1998, the Commission directed the NRC staff to develop a dose-based regulation for clearance of equipment and materials having residual radioactivity. The criteria that eventually emerge from this rulemaking effort are intended to replace the surface contamination values in Policy and Guidance Directive FC 83–23. Until that time, licensees may continue to use the criteria in Policy and Guidance Directive FC 83–23 for unrestricted release of equipment and material, to the extent authorized by their licenses.... The values in Table 1 [of this notice], 10 CFR 20, are intended to replace the tables in the above two documents for license termination purposes....

And the document goes on to state:

> ...Table 1 does not include screening values for radionuclides that emit alpha particles, or for soil contamination. The NRC staff is assessing current screening approaches for sites with alpha emitters and for soil contamination. For such sites, **licensees are encouraged to use, in the interim period, site-specific dose assessments based on actual site conditions** [regards to screening values for building surface contamination; Emphasis added]

2. SECY-05-0054, Proposed Rule: Radiological Criteria for Controlling the Disposition of Solid Materials, March 31, 2005.

The stated purpose of this document and proposed rulemaking was to request NRC Commission approval to amend 10 CFR Part 20, *Standards for Protection Against Radiation*, to include radiological criteria for controlling the disposition ("clearance") of solid materials that have no, or very small amounts of residual radioactivity resulting from licensed operations and which originate in restricted or impacted areas of NRC-licensed facilities. As part of its rationale for the rulemaking, NRC stated:

> However, because the current approach does not derive from a specific regulation, NRC's decisions in this area are inefficient in that they lack an overall risk basis, consistency, and regulatory finality. Therefore, the proposed rule is intended to improve NRC's regulatory process by incorporating risk-informed criteria into the Commission's regulations for disposition of solid material.

NRC also noted that it had completed several technical studies to evaluate alternatives for controlling the disposition of solid materials. The results of these studies were presented in a number of attachments to SECY-05-0054, including the following:

- Draft Regulatory Analysis, *Amendments to 10 CFR Part 20 on Radiological Criteria for Controlling the Disposition of Solid Materials*, March 2005
- SRM-SECY-02-0133, *Control of Solid Materials: Options and Recommendations for Proceeding*, October 25, 2002 (See main text, Section III.3 Reference 6)
- NUREG-1812, *Generic Environmental Impact Statement for Controlling the Disposition of Solid Materials*, Draft Report for Comment, March 2005

The NRC staff considered a range of alternate approaches for disposition of solid material. These alternatives included a rule allowing:

a) Unrestricted release of solid material (i.e., the clearance approach) using a 1 mrem/year (0.01 mSv/yr.) dose criteria per the recommendations and methods of ANSI 13.12 and NUREG-1640

b) An approach in which all solid material goes to a licensed low-level waste (LLW) disposal facility (i.e., the prohibition approach)

c) A limited disposition approach, including disposal in EPA/State approved landfills, re-use options on case by case basis

The NRC staff decided to propose to the Commission the limited disposition approach that was believed a balanced consideration of technical issues and overall stakeholder concerns. The approach as proposed to the Commission would limit release of solid material, meeting a 1 mrem/yr. (0.01 mSv/yr.) dose criterion, from licensed control to a set of limited disposition paths, as noted above.

In reading the detail in this and the referenced support documents attached to SECY-05-0054, it appears that the NRC staff chose a compromise approach in the interest of Stakeholder concerns. Accordingly, dose-based criteria were developed as replacement for the historical numerical criteria (e.g., as in FC 83-23 and RG 1.86). These dose-based criteria are presented along with their technical basis in SECY-02-0133

Further, it was the NRC staff's stated intent to supplement the proposed rule's dose criterion of 1 mrem/yr. (0.01 mSv/yr.) with tables of measurable nuclide concentrations to facilitate confirmation that the dose criterion has been met, e.g., using values and approaches from ANSI N13.12, IAEA RS-G-1.7 and NUREG 1640 (See also main text Section III.3, References #4, #5 and #7 respectively) that relate measurable nuclide concentrations to a dose of 1 mrem/yr. (0.01 mSv/yr.). The volumetric and surficial nuclide concentration tables were intended to be contained in a new Appendix E to 10 CFR Part 20. (See Table 5 in the main text for the intended measurable nuclide concentrations.)

3. Commission Voting Record (CVR), SECY-05-0054 – Proposed Rule: *Radiological Criteria for Controlling the Disposition of Solid Materials* June 1, 2005.

Although the Commission unanimously disapproved of the Staff recommendations as proposed to revise 10 CFR 20 at that time, none of their objections were related to replacing the historical numerical release criteria with a dose-based approach. Their objections were primarily related to competing priorities at that time, lack of perceived immediate need and for two Commissioners, that the 'limited disposition option" was inadequate and too complicated and the "unrestricted option" was preferred by them. In fact, all of the commissioners indicated their support of the dose-based approach for clearance and specifically the use of the 1 mrem/year per the methodologies described in ANSI 13.12 and NUREG-1640.

One can conclude that given the extensive analysis and studies performed by the NRC staff between 1998 and 2005, use of surficial numerical clearance criteria, derived from a 1 mrem/yr. dose basis, in general represents the technical position of the NRC staff, as presented in Table 1 of ANSI 13.12 (Table 4 in the main text) and as they described in detail in SECY-02-0133 using its Table 2 (Table 5 in the main text). Examples of some specific Commissioners' comments as stated in the CVR for SRM-SECY-05-0054 follow:

From Chairmen Diaz:

> The 1 mrem/yr. (.01 mSv/yr.) dose criterion is based on scientific analysis and regulatory considerations and is a generic constraint well below levels established to ensure protection of public health and safety. ... I believe that we should defer publication of the proposed rule at this time. The key issue in making this difficult decision is the fact that the Agency is currently faced with several high priority and complex tasks upon which the Commission needs to focus.

From Commissioner McGaffigan:

> I believe this rule package would serve as a good starting point on which to proceed, should a majority of the Commission decide to do so now or sometime in the future, but I do not support the staff's preferred option. As I stated in my vote on SECY-02-0133, I believe this rulemaking should provide for the unrestricted release of material less than 10 uSv/yr. (1 mrem/yr.), consistent with IAEA guidance and largely consistent with ANSI 13.12.

From Commissioner Merrifield:

> I think a future Commission will have two very good options for its consideration; the proposed rule encompassed by this paper and a 1 millirem unrestricted release program.

From Commissioner Lyons:

> A radiation dose level below 1 millirem per year is protective of public health and safety. ... The drafted rule, releasing materials with dose levels below one 1 millirem per year only into specific applications, is unnecessarily complicated. It does not reflect the scientific fact that these materials can be safely released for all applications. By allowing only specific uses, there is an implication that the

material is not really safe for complete release – that implication is not consistent with the scientific facts.

A.2. Risk Informed/Performance Based Philosophy of NRC; ALARA and Optimization Considerations

A "Risk Informed/Performance Based" approach to regulation and compliance has been a fundamental principal at NRC for a number of years.[19] Similar to an ALARA or "Optimization" approach to radiation protection (see e.g., International Commission on Radiological Protection, ICRP Publication 55, 1989: *Optimization and Decision Making in Radiation Protection*), the basic concepts involve better alignment of the degree of regulation and controls necessary based on actual levels of radiological risk.

It is appropriate to consider the very small radiological risks associated with the contamination and related unrestricted release levels historically and currently being used as documented in the many references discussed in Section III.3 of the main text. Given the performance based, risk informed approach that NRC has appropriately incorporated into regulation, we believe that any public dose above background from release criteria as historically applied in U recovery (e.g., RG 8.30, Rev 1) is fully protective, compliant and ALARA. Several of the NRC documents discussed herein or in Section III.3 of the main text clearly note the absence of a risk informed basis for the current approach and support incorporating risk informed criteria, for example:

From SECY-02-0133, page 20:

> The NRC's proposed approach represents an improvement over its current approach because it provides a clear, risk-informed dose criterion and associated radionuclide concentrations for the disposition of solid materials.

From SECY-05-0054, page 2:

> ...the current approach does not derive from a specific regulation, NRC's decisions in this area are inefficient in that they lack an overall risk basis, consistency, and regulatory finality. Therefore, the proposed rule is intended to improve NRC's regulatory process by incorporating risk-informed criteria into the Commission's regulations for disposition of solid material.

From NUREG-1812, page xiii:

> In March 2002, a report issued by the National Academy of Sciences ... stated that NRC's current approach is incomplete and inconsistent and concluded that NRC should therefore undertake a process to evaluate a broad range of alternatives to provide clear risk-informed direction on controlling the disposition of solid materials. The report also recommended that an individual dose standard of 1 mrem/yr. provides a reasonable starting point for the process of considering alternatives for a dose-based standard.

---

[19] As specifically relevant to uranium recovery facilities, see NUREG/CR-6733. A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees, USNRC 2001.

APPENDIX B
Evolution of NRC Documents Defining Contamination Release Limits

We have compiled the following chronology of the appearances of the "Criteria Table" in NRC documents in order to demonstrate the NRC historical perspective on this subject.

- 1970. U.S. Atomic Energy Commission document used for reactor and material licensees: *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material* (Accession # 9006010010, 54023:193-196). The term "associated decay products" is used in conjunction with the U-nat release group, and was assumed to imply the historical, uranium industry wide definition as discussed at Footnote 2 and elsewhere in the text.
- 1974. Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*
- 1976. Annex A, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material* (the term "associated decay products" is also used)
- 1983. Policy and Guidance Directive FC 83-23, *Termination of Byproduct, Source and Special Nuclear Material Licenses.* No technical changes noted from 1976 *Guidelines.*
- 1983. Regulatory Guide 8.30, *Health Physics Surveys in Uranium Mills* ("associated decay products" replaced with "uranium and daughters" but is assumed to be identical in its definition – See Footnote 2); references sources of criteria as Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (1976) and the 1976 version of *Guidelines for Decontamination.*
- 1987. FC 83-23, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material.* Title changed to same as the 1976 *Guidelines* but no technical changes from the 1983 version.
- 1993. Revision of FC 83-23. Same title; no technical changes.
- 1998. 63 FR 64132, *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination* provides supplemental information on the license termination rule including use of dose-based criteria. FC 83-23 as decommissioning criteria was intended to be superseded BUT this notice clarified that until dose-based release criteria are developed, licensees MAY continue to use FC 83-23 to the extent authorized by their license. (See Appendix A which traces the history and identifies several important NRC documents and actions related to development of these dose-based criteria)
- 2002. Rev 1 of RG 8.30. *Health Physics Surveys at Uranium Recovery Facilities* (See Section III.1 above). Release criteria and terminology remain the same; references source of criteria as 1987 version of FC 83-23 and RG 1.86.
- 2005. Proposed Rule: *Radiological Criteria for Controlling the Disposition of Solid Materials;* SECY-05-0054. This was notice of Proposed Rulemaking to amend 10 CFR 20

with use of dose-based criteria and associated volumetric concentration limits for clearance but was postponed by the Commission. It is noted that this regulatory imitative has been primarily focused on the clearance of solid materials, e.g., recyclable metals such as iron, steel, copper, etc. in which the primary radiological characteristic of interest is the volumetric concentration (e.g., Bq/gram; pCi /cm^3), although it also did address surficial contamination criteria.