NRC staff request for further discussion regarding Insignificant Radionuclides of Concern for the groundwater at the Westinghouse Hematite site.
Publicly Noticed Teleconference May 17, 2018

Discussion Timeline

Prior to and subsequent to the submittal of the Hematite Decommissioning Project Final Status Survey Final Report Summary (Westinghouse letter HEM-17-73, dated December 19, 2017 {ML17356A169}) and submittal of the Application for Termination of License SNM-00033 (Westinghouse letter LTR-NRC-17-78, dated December 20, 2017 {ML17355A043}) the NRC staff performed review of the Final Status Survey documents associated with the above submittals.

During the review of documents associated with the groundwater at the Hematite site via email dated February 12, 2018 the NRC provided to Westinghouse preliminary comments on the Post-remediation Groundwater Monitoring Summary, FSSFR Volume 6, Chapter 7. Via email on February 21, 2018 Westinghouse provided to the NRC a response for discussion during the Publicly Noticed Teleconference scheduled for February 22, 2018.

During the Publicly Noticed Teleconference held on February 22, 2018 the NRC and Westinghouse discussed the response to the preliminary comments on the Post-remediation Groundwater Monitoring Summary and determined the path forward would be a revision to FSSFR Volume 6, Chapter 7 which would incorporate the Westinghouse responses. Revision 1 to FSSFR Volume 6, Chapter 7, which incorporated the Westinghouse response was submitted to the NRC on March 13, 2018 (Westinghouse letter HEM-18-11 {ML#17250A376}).

During the Publicly Noticed Teleconference held on February 22, 2018 the NRC staff provided an additional comment to confirm which groundwater samples had confirmed that only U-234, U-235, U-238 and Tc-99 were the primary radionuclides of concern. Via email dated March 13, 2018 Westinghouse provided a response to the comment. Via email dated March 14, 2018 the NRC communicated that at that time it appeared the March 13, 2018 response approach was appropriate.

Via email dated May 14, 2018 the NRC staff provided additional comments regarding groundwater Insignificant Radionuclides of Concern for discussion during the Publicly Noticed Teleconference scheduled for May 17, 2018.

To facilitate discussion regarding the May 14, 2018 NRC comments, as discussed during the May 17, 2018 Publicly Noticed Teleconference the Westinghouse March 13, 2018 response is provided below.

Westinghouse Response March 13, 2018

Discussion - Groundwater Radionuclides of Concern

Prior to the development of the Hematite Decommissioning Plan, a review of all available historical groundwater data was reviewed, and it was concluded at the time that Groundwater in the Jefferson City and Roubidoux HSUs was not impacted by the radionuclides of Thorium, Radium, and was only slightly impacted by Tc-99 and Uranium, but well below the EPA drinking water standard.

The Hematite Radiological Characterization Report (HRCR) summarizes the conclusion that only Uranium isotopes and Technetium-99 are the primary radionuclides of concern in groundwater through review of previously developed groundwater reports. In document EO-09-002, Radionuclide Activity in Bedrock Groundwater, July 2009 it was also concluded that:

> *"The silty clay soil immediately underlying the sources of radioactive contamination in the soil has attenuated migration of radiological contaminants in the soil, thus protecting the potential sources of potable water near the Hematite Site. The planned removal of the contaminated soil associated with these sources will remove the threat to groundwater sources of drinking water.*
>
> *The radioactive contaminants in the soil within the Central Tract Area have migrated into the Silty Clay Aquitard HSU. The silty clay soil severely retards the further downward migration of radioactive contamination to the Sand/Gravel HSU. With two exceptions identified at wells GW-V and GW-X, the silty clay soil also severely retards horizontal migration of radiological contamination.*
>
> *Total uranium does not exceed the background threshold value in the potential sources of drinking water (Sand/Gravel HSU, Jefferson City-Cotter Bedrock HSU, and Roubidoux HSU).*
>
> *Tc-99 has been found in one well in the Sand/Gravel HSU at 1/6th of the drinking water standard (representing dose contribution of less than 1 mrem/year). However, due to the presence of volatile organics exceeding drinking water standards, this potential source cannot be used for drinking water. The furthest extent of Tc-99 contamination is about halfway between the rail line and Joachim Creek, at about 1/500th of the drinking water standard."*

While low levels or Radium and Thorium were detected in isolated areas of the site, from leachate wells installed within the former Burial Pits, it was also concluded that the planned remediation of the impacted area would eliminate any future concern for potential future impacts. Report EO-09-002 goes on to conclude the following:

> *"Radionuclide activity in the bedrock groundwater underlying the Hematite Facility is generally below background levels with the exception of reported positive Tc-99 activity*

in widely spaced bedrock wells PZ-03, BR-01-JC, BR-03-JC, and BR-08-JC. Two of the wells (BR-01-JC and PZ-03) are located on the facility area and the remaining wells (BR-03-JC, BR-08-JC) are located on the Joachim Creek floodplain south of the Hematite Facility. Gross-β activity in the wells BR-03-JC, BR-08-JC, and PZ-03 followed similar trends suggestive of background activity while gross-β activity fluctuated widely in well.

BR-01-JC between June and December 2007. After December 2007 gross-β activity in well BR-01-JC followed trends similar to the remaining bedrock wells. The source of the fluctuations in well BR-01-JC is not definitively known but may be related to the installation of dedicated sampling equipment in the 1" diameter well and subsequent equilibration of the well. Time series analysis of reported Tc-99 and gross- β activity in bedrock groundwater shows that the analytical results are oscillatory around zero activity and are not indicative of Tc-99 groundwater contamination or a developed Tc-99 plume affecting the bedrock groundwater."

The conclusion was drawn that only Tc-99, and to a much lesser extent Uranium, were present in groundwater in detectable levels. Therefore as stated in DP Chapter 14.5.3, *Sampling Method*:

"Groundwater sampling will be conducted following site procedures using a low-flow technique that provides representative samples while reducing investigation derived waste. For each well, unfiltered and filtered groundwater samples will be collected and analyzed; turbidity will be measured in the field on unfiltered groundwater. Samples will be analyzed for gross alpha, gross beta, isotopic Uranium, and Tc-99. Comparison of radionuclide activities in paired filtered and unfiltered samples will be used to determine whether radionuclide migration, if any, is occurring through clay/colloidal transport."

Through RAI's, the analysis for gross alpha and beta was removed, so proceeding forward, the DP only required Iso-U and Tc-99 analysis for ground water.

Furthermore, only Dose to Source Ratios were only carried forward for U and Tc-99 into Chapter 14, as it was known that Ra-226, and Th-232 were both limited to very small areas of the site.

Section 14.1.1 of the DP makes this statement regarding Ra-226 and Th-232 in soil:

"Thorium-232 is present naturally in background soil, and has been identified at concentration greater than the Background Threshold Value for Th-232 at a limited number of locations within the area of the buried waste. Radium-226 (Ra-226 + C) was identified as a ROC and has been identified primarily at two locations in the Burial Pit Area. The elevated Ra-226 was likely introduced into the burial pits with waste as a result of the installation of contaminated equipment into the process operations. Although only low concentrations of Th-232 and Ra-226 have been identified at locations outside of the Burial Pit Area, these radionuclides will be considered ROCs site-wide."

Ra-226 and Th-232 were not considered ROCs for groundwater during the development of Chapter 14, since as stated above, both radionuclides were only ever identified above

background levels in small isolated areas of the site, and entirely in the overburden. Remediation of the Ra-226 area in the northern burial pit was completed in 2014, and remediation of the Th-232 area in the southern Burial pit area was completed in 2013.

As all soil site wide was monitored for Ra-226, and Th-232, with no additional areas identified that exceeded normal background levels, the conclusion that Ra-226 and Th-232 are not ROCs for groundwater is supported.

After submittal of the Hematite Decommissioning Plan, Rev 0, Technical Basis Document HDP-TBD-EHS-001, Subsurface Water Overview, January 2011, was developed and states:

> *"Each of these HSUs has been analyzed to determine whether they are a viable source for drinking water or irrigation water:*
>
> - *The Silty Clay Aquitard HSU is not viable as a sustainable water supply for the purposes of drinking water, irrigation, or industrial use based on its mean hydraulic conductivity (2.85 x 10-5 cm/sec), its low mean matrix permeability (3.48 x 10-8 cm/sec) and its apparent lack of internal interconnected flow pathways. The State of Missouri Well Construction Code (10 CSR 23-3) for the Hematite location requires "No less than twenty feet of casing shall be set above the screened or perforated interval of the well".*
>
> *This restriction would preclude development of a water supply for domestic or irrigation purposes from the Silty Clay Aquitard HSU (unless the State of Missouri approved a variance to its regulations).*
>
> *The Sand/Gravel HSU underlying the immediate facility area has insufficient quantities of shallow water to sustain feasible and economic production based on its limited extent and thickness. The sand and gravel deposits are an effective underdrain for the Silty Clay Aquitard HSU and could provide a viable water resource south of the Site buildings.*
>
> *However, due to the presence of volatile organics exceeding drinking water standards, the Sand/Gravel HSU is currently restricted for use (through deed restrictions) as a source of potable water.*
>
> - *The Jefferson City-Cotter Bedrock HSU is a viable water supply.*
> - *The Roubidoux Bedrock HSU is a viable water supply.*
>
> *Based on 10 CFR 20.1402 and 10 CFR 40, the term "groundwater" is applied to sources of subsurface waters that are sources of drinking water or aquifers that are capable of yielding a significant amount of groundwater to wells or springs. Based on these regulatory descriptions of groundwater, the water in the Sand/Gravel, Jefferson City-Cotter Bedrock, and Roubidoux Bedrock HSUs is groundwater. The term "leachate" is*

used for the water in the Silty Clay Aquitard HSU and is used to describe wells that are screened only in the Silty Clay Aquitard HSU."

"The silty clay soil immediately underlying the sources of radioactive contamination in the soil has attenuated migration of radiological contaminants in the soil, thus protecting the potential sources of potable water near the Hematite Site. The planned removal of the contaminated soil associated with these sources will remove the threat to groundwater sources of drinking water.

The radioactive contaminants in the soil within the Central Tract Area have migrated into the Silty Clay Aquitard HSU. The silty clay soil severely retards the further downward migration of radioactive contamination to the Sand/Gravel HSU. With two exceptions identified at wells GW-V and GW-X, the silty clay soil also severely retards horizontal migration of radiological contamination.

Total uranium does not exceed the background threshold value in the potential sources of drinking water (Sand/Gravel HSU, Jefferson City-Cotter Bedrock HSU, and Roubidoux HSU).

Tc-99 has been found in one well in the Sand/Gravel HSU at 1/6th of the drinking water standard (representing dose contribution of less than 1 mrem/year). However, due to the presence of volatile organics exceeding drinking water standards, this potential source cannot be used for drinking water. The furthest extent of Tc-99 contamination is about halfway between the rail line and Joachim Creek, at about 1/500th of the drinking water standard."

Westinghouse is confident that the determination of the Primary ROCs being Uranium and Tc-99 was appropriate as record research indicates that this was reviewed by the NRC at the time of the DP review as captures in the SER for the DP section 4.5, Groundwater, which states:

"*In the HRCR, the potential radionuclides of concern (ROC) for the site are uranium isotopes (Uranium-234, Uranium-235, and Uranium-238), Technetium-99, Thorium-232, Radium-226, Americium-241, Neptunium-237, and Plutonium-239. The chemical analyses of groundwater samples collected from the monitoring wells completed in various hydrostratigraphic units confirmed that only Uranium-234, Uranium-235, Uranium-238 and Technetium-99 are the primary radionuclides of concern in groundwater.*"

With completion of remediation and restoration activities, program review also concludes that the original conclusion that Ra-226, and Th-232 are not ROCs for groundwater monitoring is sound. At no time during remediation activities was information uncovered, or a situation identified that would have challenged the original conclusions drawn during the development of Chapter 14 of the DP, or the conclusions of the SER for the Hematite DP.

Further Groundwater Discussion May 17, 2017 Comment 1:

The response (March 13, 2018) does not discuss the potential dose contribution from Am-241, Np-237 or Pu-239/240. Neptunium-237, Am-241, and Pu-239 were determined to be insignificant contributor radionuclides for soil. Given that these radionuclides are potentially present in the soil, they are also potentially present in the groundwater. The licensee should address the potential dose for these radionuclides in groundwater using methods that could include, but are not limited to, actual radiological remediation and disposal information to support its conclusion.

Westinghouse Response:

A review of correspondence between the NRC and Westinghouse, specifically DP Chapter 14 RAI HDPC-14-Q1, provides that there were discussions regarding the determination of Np-237, Pu-239/240 and Am-241 as insignificant radionuclides of concern. The response to RAI HDPC-14-Q1 as provided in Westinghouse letter HEM-11-96 {ML111880290} provided the technical basis for determination of Np-237, Pu-239/240 and Am-241 as insignificant radionuclides of concern in soil. The response provided the methodology utilized to determine the dose contribution from Np-237, Pu-239/240 and Am-241.

Dose Contribution from Insignificant Radionuclides as provided in HEM-11-96

Insignificant Radionuclide	Average Concentration (pCi/g)	DCGL	Average SOF	Dose Contribution (mrem/yr)
Am-241	5.1E-03	7.9E+01	6.4E-05	1.6E-03
Np-237 + D	2.0E-02	3.0E-01	6.8E-02	1.7E+00
Pu-239/240	1.6E-03	8.3E+01	2.0E-05	5.0E-04
Total			6.8E-02	1.7E+00

The determination that Np-237, Pu-239/240 and Am-241 were insignificant radionuclides of concern in soil provided a basis for Np-237, Pu-239/240 and Am-241 being insignificant radionuclides of concern in groundwater. The historical groundwater sampling data supported these radionuclides were insignificant.

Historical records indicate there were no further ground disturbance activities in the Burial Pit Area after the cessation of burials in the former Burial Pit Area as discussed in the Historical Site Assessment. With the expressed method of remediation in the Burial Pit Area being excavation the NRC provided to Westinghouse a comment (RAI No. 1-1d) in which it is stated that "*When Westinghouse excavates, they need to obtains samples which meet the DCGLs, and collect and treat the groundwater in the excavation. Westinghouse needs to justify how their proposed action to excavate until DCGLs are met on the surface is adequate to ensure that unacceptable levels of radionuclides will not be transported to the sand/gravel and Jefferson City-Cotter aquifers during the compliance period.*"

Westinghouse provided this response, in part, "*In addition, the response to the follow-up comment on RAI HDP-8-Q6 addresses the collection and handling of water in an excavation and ensuring unacceptable levels of radionuclides will not be transported to the Sand/Gravel and Jefferson City-Cotter HSU's.* ***In summary, the dose modeling presented in DP Chapter 5 demonstrates that the residual radioactivity concentration in pore space water in soil that is less than the DCGL is acceptable and by definition, if the soil meets the DCGL, there will not be groundwater activity concentrations in the future that will cause the 25 mrem/yr to be exceeded.***"

To validate the basis for addressing the radionuclides of concern in groundwater and that there were no adverse effects on groundwater quality as a result of exaction, Section 14.5 of the DP provided that there would be post-remediation groundwater sampling. In addition to demonstrating that the remediation method of excavation did not adversely impact groundwater it also provided verification of the absence of any significant amount of residual radioactivity in the groundwater that could be part of a credible exposure scenario.

With this information, and all other necessary information provided to the NRC, the NRC completed its review of the Hematite Decommissioning Plan and subsequently approved the DP. Of note to the discussion of this topic is the result of the NRC evaluation of groundwater radionuclides of concern as captured in the SER Section 4.5 {ML112101630}, which states:

> "*In the HRCR, the potential radionuclides of concern (ROC) for the site are uranium isotopes (Uranium-234, Uranium-235, and Uranium-238), Technetium-99, Thorium-232, Radium-226, Americium-241, Neptunium-237, and Plutonium-239.* ***The chemical analyses of groundwater samples collected from the monitoring wells completed in various hydrostratigraphic units confirmed that only Uranium-234, Uranium-235, Uranium-238 and Technetium-99 are the primary radionuclides of concern in groundwater***."

Upon approval of the DP and subsequent approval to the commence soil remediation from the NRC it was considered that there would be no potential dose impacts from insignificant radionuclides of concern in the groundwater. This consideration was predicated on the fact that soil remediation would be conducted in accordance with the DP, that there would be no discovery of an anomalous condition that would invalidate the technical basis for approval of the DP, and that the results of the post-remediation groundwater monitoring sampling would verify the absence of any significant amount of residual radioactivity in the groundwater that could be part of a credible exposure scenario.

In particular, the post-remediation groundwater monitoring would validate the discussion on the impacts to groundwater as stated in the Hematite Radiological Characterization Report (EO-09-002) it stated that "*The silty clay soil immediately underlying the source of radioactive contamination in the soil has attenuated migration of radiological contaminates in the soil, thus protecting the potential sources of potable water near the Hematite Site. The planned removal of the contaminated soil associated with these sources will remove the threat to groundwater sources of drinking water*."

Conclusion:

The Westinghouse evaluation of Final Status Survey radiological data along with groundwater monitoring sample result during and post-remediation as submitted to the NRC provide that the potential dose contribution from Am-241, Np-237 or Pu-239/240 were determined to be insignificant.

The determination is based upon the following:

- The technical basis for the determination of Np-237, Pu-239/240 and Am-241 as being insignificant radionuclides of concern for groundwater as accepted by the NRC with the approval of the DP.
- Soil remediation was completed as proposed and in accordance with the DP.
- During remediation there were no discoveries of an anomalous condition that would invalidate the technical basis for approval of the DP. Radium contaminated filter press plates were discovered during remediation. This discovery further proved to support the technical basis for the DP. It is discussed further in the response to the second NRC comment.
- Westinghouse has completed the designated period of post-remediation groundwater monitoring sampling and verified the absence of any significant amount of residual radioactivity in the groundwater that could be part of a credible exposure scenario.

Further Groundwater Discussion May 17, 2017 Comment 2:

The response provided by the licensee states, "As all soil site wide was monitored for Ra-26, and Th-232, with no additional areas identified that exceeded normal background levels, the conclusion that Ra-226 and Th-232 are not ROCs for groundwater is supported." While Ra-226 was not found except for in the burial pits, the amount and form of the Ra-226 found were not initially as expected. As stated in HDP-RPT-FSS-303, "Initially the elevated Ra-226 was thought to have been introduced into the Burial Pits with waste as a result of installing contaminated equipment into the process operations. However, during remediation activities, filter press plates contaminated with radium were found buried which were subsequently determined to have been brought in from offsite and buried, and were never part of any Hematite operation……While the majority of materials located within the burial pits were as anticipated, 215 radium contaminated filter plates made of steel, cast iron, and plastic, about 3 feet by 3 feet in size, were unexpectedly found." As stated in FSSFR Volume 3, Chapter 3, "The filter press plates (see Figure 3-3) are of special interest in that they bore significant amounts of Radium-226 contamination and were determined to not have originated from historic Hematite fuel cycle operations. It was determined that these were brought to the Hematite site from an offsite entity and did not originate from any onsite process or operation. The radium contaminated filter press plates proved to be the source term of the Radium-226 impacted area identified in the Hematite Radiological Characterization Report (HRCR), DO-08-003 {ML092870496}." Given that the amount of Ra-226 was significantly greater than what was expected, the licensee should discuss the technical basis for why Ra-226 should not be an ROC for the groundwater. The discussion may include the chemical characteristics of Radium-226 associated with the filter press plates, as well as physical and chemical environments (e.g. , water saturation, pH, redox and other geochemical conditions) that may impact the fate and transport of Radium-226 in the subsurface.

Westinghouse Response:

As provided in the response to Comment 1, the technical basis for the radionuclides of concern was developed for the DP by Westinghouse and evaluated by the NRC during the DP approval process. The evaluation provided in the HRCR along with other information provided to the NRC encompassed physical and chemical characteristics of the radionuclides present at the site.

The technical basis for why Ra-226 should not be a radionuclide of concern remains unchanged as the technical basis for the radionuclides of concern at the Hematite site has remained unchanged. As described in the comment 1 response above, to invalidate the technical basis for a radionuclide (Ra-226) to not be a radionuclide of concern the following would have had to occur; soil remediation was not conducted in accordance with the DP, or there was discovery of an anomalous condition that would invalidate the technical basis for approval of the DP, or the results of the post-remediation groundwater monitoring sampling would indicated the presence of a significant amount of residual radioactivity in the groundwater that could be part of a credible exposure scenario.

In regards to soil remediation, as indicated by the empirical data gathered during and contained within the various survey area release records as provide in the various Final Status Survey Reports submitted to the NRC, Westinghouse concluded that the remediation of the soil was

carried out in accordance with the DP and was successful. Additionally, the post-remediation groundwater monitoring sample results provided empirical data that supported the conclusion that remediation activities did not adversely impact groundwater.

In regards to the discovery of the Radium contaminated filter press plates it is important to note that the filter press plates resided in the Burial Pit Area in a burial from the time of placement in the 1960's until their discovery and removal after the commencement of soil remediation in March of 2012. As the Historical Site Assessment indicated there were no subsequent soil disturbances in the Burial Pit Area. With nearly 50 years of residence within the soil of the Burial Pit Area it can be surmised that there was little to no change in the physical and chemical properties associated with the Radium contained within the contaminated filter press plates. This is primarily demonstrated by the data gathered during the site characterization process and subsequently by radiological survey data during remediation.

The Radium contaminated filter press plates were assumed to originate from the Mallinckrodt Chemical Works facility in St. Louis, MO, a former owner of the Hematite Facility at the time of suspected burial of the filter press plates. Research of Mallinckrodt operations conducted by HDP of the Mallinckrodt Chemical Works in St. Louis, MO provides that this was a facility where insoluble Radium solids were removed from a Raffinate solution using a Filter Press System. The Filter Press system is designed to mechanically remove solids from a solution that are held in suspension, but not dissolved in the solution. Based on this research Westinghouse has reached the logical conclusion that the residual Radium contamination on the filter press plates was in a chemically insoluble form. This would support the fact that the amount of Radium identified on the filter press plates was significant, while the characterization groundwater samples identified minimal Ra-226, if any.

In addition to the insolubility characteristic of the Radium contamination on the filter press plates as described in the HRCR "*The silty clay soil immediately underlying the source of radioactive contamination in the soil has attenuated migration of radiological contaminates in the soil, thus protecting the potential sources of potable water near the Hematite Site."* the ability to of the underlying clay proved to very effective in attenuating the migration of the Radium from the location of the buried filter press plates.

Westinghouse has reviewed the depth of excavation in the location of the filter press plates and determined that they were contained entirely in the overburden (maximum depth of 12 ft bgs), and never comingled with the saturated zone (which begins at approx. 30 ft bgs). The surrounding soil was predominately clay (a natural aquitard), and the Radium contaminated filter press plates along with the contaminated overburden were entirely removed.

Furthermore, Ra-226 is a strong gamma emitter, and is easily identifiable in soil using hand held scanning instrumentation. All areas in the northern Burial Pit Area where the filter press plates were located are MARSSIM Class 1 areas, and were subject to a 100% GWS, along with confirmatory soil sampling. The results of the FSS have been reported, with no identified exceedances of the Ra-226 $DCGL_w$.

Conclusion:

Westinghouse considers the technical basis developed for the DP, and subsequently acknowledge by the NRC by approval of the DP, to be valid in regards to Ra-226 not being a radionuclide of concern in the groundwater.

The determination is based upon the following:

- The technical basis for the determination of Ra-226 not being a radionuclide of concern for groundwater as accepted by the NRC with the approval of the DP.
- Soil remediation was completed as proposed and in accordance with the DP.
- Although the Radium contaminated filter press plates were discovered during remediation, the fact that a significant amount of Ra-226 then expected does not invalidate the technical basis. Rather, it validates the ability of the silty clay to attenuate the migration of contamination. If this were not the case none of the groundwater samples collected over a period of thirty plus years were ever identified that would have indicated potential Ra-226 contamination in the groundwater that originated from contamination area of the filter press plates. This discovery further proved to support the technical basis for the DP.
- Westinghouse has completed the designated period of post-remediation groundwater monitoring sampling and verified the absence of any significant amount of residual radioactivity in the groundwater that could be part of a credible exposure scenario.