Summary of Actions to Address the
February 29, 2012 National Remedy Review Board Consultation Comments
for Operable Unit 1 of the West Lake Landfill Superfund Site

Prepared by U.S. EPA, Region 7
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Purpose

The National Remedy Review (NRRB) conducted a consultation for the West Lake Landfill Superfund Site (Site) Operable Unit 1 (OU-1) on February 29, 2012. This NRRB review was performed because the anticipated costs of the remedial alternatives evaluated in the 2011 Supplemental Feasibility Study (SFS) were greater than $25 million. The NRRB provided Region 7 with its consultation comments in the final draft memorandum dated February 28, 2013 (attached). That consultation and subsequent additional feedback from NRRB members and EPA headquarters resulted in Region 7 directing the West Lake potentially responsible parties (PRPs) to perform several additional investigations and studies at the Site.

Below is a summary of the Site, site actions, new investigations, and related findings that were developed, in large part, to specifically address how EPA has carefully considered all of the items and suggestions as detailed in the February 28, 2013, NRRB memorandum. As required by CERCLA and the NCP, information documenting EPA's consideration of the NRRB comments and other information supporting the reevaluation of the 2008 OU-1 ROD will be published in the OU-1 Administrative Record. Please be aware that Region 7 recently received input from the Missouri Department of Natural Resources (MDNR) regarding certain statements and conclusions that are reflected in this document. The Region is continuing to work with MDNR regarding their comments and will address any outstanding issues during the January 9, 2017 NRRB presentation. At this time, MDNR is planning to participate in the NRRB Meeting.

Brief Site Summary

A complete description of the Site can be found in the November 28, 2017 Draft of the Remedial Investigation Addendum. The Site is a 200-acre, inactive solid waste disposal facility that accepted wastes for on-site landfilling from approximately the 1950s through 2005. The Site is located in Bridgeton, Missouri, approximately 18 miles from downtown St. Louis and within 1.5 miles of the Missouri River and the St. Louis Lambert International Airport. Industrial, commercial, and residential properties are located near or adjacent to the Site. The Site is composed of three operable units. Operable Unit-1 (OU-1) consists of areas at the Site where radionuclides or radiologically impacted materials (RIM) have been identified within soil and solid waste materials, including two landfill disposal areas (Areas 1 and 2), a small parcel of land known as the Buffer Zone, and the adjacent Lot 2A2 of the Crossroads Industrial Park. Operable Unit-2 (OU-2) consists of several inactive fill areas containing non-radiological wastes such as sanitary waste and demolition debris. The EPA has designated Operable Unit-3 (OU-3) to specifically address groundwater contamination, both radiological and non-radiological, site-wide.

Additional Site Actions and Evaluations Performed Since 2012

Below is a list of additional investigations performed since 2012 by EPA, the PRPs, or MDNR to gather additional information regarding the Site and to address items that could impact the implementation of the OU-1 remedial action. The results of these investigations and how they are incorporated into EPA's evaluation of the OU-1 remedial alternatives are referenced in the OU-1 Remedial Investigation Addendum (RIA) and Final Feasibility Study (FFS).

- Gamma overflight of Site using ASPECT (2013)
- Groundwater monitoring and evaluations (2012-2014)
- EPA off-site air monitoring (2014-2015)
- On-site air monitoring (2015-present; on-going per EPA direction)
- Perimeter sediment sampling (2016-2017 per EPA direction with 100% splits)
- Stormwater sampling (2016-present; on-going per EPA direction)
- State of Missouri vicinity sampling of soil, sediment, dust, surface water and air (2013 and 2015)
- EPA Off-Site soil investigation of nearby recreational facility (2014)
- Collection of additional RIM characterization samples in Areas 1 and 2 (2013-2015)
- Leaching test on RIM (2016)
- EPA RIM radon emanation study (2016)
- On-going collection and analysis of temperature, settlement data, gas composition, and leachate from the adjacent Bridgeton Landfill, where a subsurface smoldering event has been occurring (2010-present; on-going)
- Installation of a non-combustible cover over surficial RIM and collection of additional surface soil samples in Area 1 and Area 2 (2016- on-going per EPA direction)
- Installation of a heat extraction system (cooling loops) and additional temperature monitoring probes in Bridgeton Landfill (2016 per EPA direction)
- Expansion of the ethylene vinyl alcohol cover at the Bridgeton Landfill (2017 per EPA direction)
- EPA sampling of dust, wipe and soil samples from two homes in Spanish Village (2017)

Discussion of NRRB Comments

1. <u>Site Groundwater Characterization</u>

- **NRRB Comment:** The NRRB suggested that the Region consider adding wells at the Site to better delineate the vertical and lateral extent of potential Site-related contamination previously identified from limited sampling in Areas 1 and 2. The NRRB went on to state that "[t]hese additional wells would be instrumental in clarifying the presence of isolated groundwater contamination versus a groundwater plume in the complex subsurface geologic setting and would help inform a decision about whether CERCLA response authority is warranted to address any additional

contamination." In addition, the NRRB also requested that the Region reconcile apparent discrepancies in how the concentrations of groundwater contamination were portrayed in the NRRB package.

- **Region's Response:** In response to the NRRB comments, EPA re-evaluated groundwater conditions at the Site and has ultimately concluded that a further groundwater remedial investigation and, if warranted, an evaluation of groundwater remedial alternatives should be performed under a separate operable unit, designated as OU-3. In May 2012 and January 2013, EPA directed the PRPs to perform comprehensive groundwater sampling of all monitoring wells at the Site. Sampling was performed in July-August 2012; again, in April, July, and October-November 2013; and finally, in March 2014. These sampling efforts included the collection of over 300 samples from more than 80 monitoring wells, including 8 new monitoring wells installed in 2013. In addition, from 2012 through 2014, the USGS, working on behalf of the EPA, performed groundwater evaluations and research based on this new sampling data and available historical data, and compiled background water-quality data in the vicinity of the Site. This work included the identification of 12 nearby water-supply wells, sample collection from these wells by EPA or USGS, data reviews, and scientific groundwater studies/interpolations for the Site. The results of this work are documented in a report issued by USGS on December 17, 2014 (updated on June 10, 2015), titled *Background Groundwater Quality, Review of 2012-14 Groundwater Data, and Potential Origin of Radium at the West Lake Landfill Site*. The study documented landfill leachate effects in 47 on-site monitoring wells and an association between wells with leachate effects and radium above the MCL. While the USGS concluded that "[t]here is considerable uncertainty in determining the origin of above-MCL concentrations of combined radium" at the Site, there are four general hypotheses for the origin of radium above MCL's at the Site: (1) leaching of RIM, (2) radium within the range of natural background, (3) leaching from non-RIM wastes, and (4) mobilization of naturally occurring radionuclides due to landfill leachate.

  Additionally, in 2016 sequential batch leaching tests were performed on samples of RIM. The results of those tests identified a potential for radionuclides in RIM to leach. Based upon the findings of the USGS report and the leaching test results, and in consideration of the NRRB's comments, the Region is initiating additional investigation of groundwater at the Site under OU-3. This investigation will include adding wells at the Site to better delineate the vertical and lateral extent of potential site-related contamination previously identified from limited sampling in Areas 1 and 2.

  EPA will ensure that information on groundwater contaminant concentrations presented in the final OU-1 RIA accurately portrays the existing groundwater data set.

2. Waste Characterization

A. Location of RIM

- **NRRB Comment:** The NRRB commented that "inconsistencies in the waste characterization may have led to significant uncertainties in determining the location and volume of RIM in the landfill." Specifically, the NRRB noted that "the remedial investigation (RI), the 1982 Nuclear Regulatory Commission (NRC) Radiological Survey and the 1988 NRC report described the RIM to be in an identifiable and relatively localized area" whereas the Region's presentation materials characterized the location of RIM as "intermixed throughout the landfill matrix" and "dispersed both laterally and vertically." The NRRB also observed that certain RI boring data indicating deeper RIM contamination was footnoted as not credible or representative due to the potential that RIM was knocked into the boring holes during drilling or logging activities.

- **Region's Response:** In response to these concerns, EPA directed the PRPs to perform additional investigations to clarify the location, distribution, and volume of RIM. Investigations performed since the NRRB consultation in Area 1 and Area 2 using percussion and sonic drilling have resulted in more than 180 additional borings and subsequent core sampling or Gamma Cone Penetration Tests (GCPT). Down-hole gamma logging was performed in each boring and scanning for gamma and alpha radiation was conducted on each core. In total, an additional 224 core samples were collected from Area 1 and Area 2 during the investigations in 2013-2015. Also, investigations in 2016 associated with a removal action to install a non-combustible cover on portions of OU-1 resulted in the collection of 129 additional surface samples in Area 1 and Area 2.

  The results of the additional investigations largely confirm the occurrences of RIM identified in the 1982 and 1988 NRC study and reports. However, additional RIM has been identified in portions of Area 1 and Area 2 both laterally and vertically. The current estimated extent and depth of RIM below the ground surface in Area 1 is greater than that estimated in the previous investigations. Samples that identify RIM have been collected at a maximum depth of 429 above mean sea level (amsl) in Area 1, which is about 20 feet below the maximum depths identified in the original NRC investigation. The RIM previously identified by the NRC (NUREG/CR-2722, 1982) was located at 455 amsl, or about 20 feet below the ground surface at that time. Of note is that portions of Area 1 are now covered with additional solid waste which was placed in 2004 which effectively places RIM more than 90 feet below the current ground surface. This more recently placed solid waste is not expected to contain RIM nor has RIM been identified in portions of any borings which go through this more recently added solid waste.

  The additional investigations also provided additional evidence that RIM is present in Area 2 at the previously identified depths. Additional borings were collected near the

previously identified “deep” RIM (WL-210 at 49.5 feet below the surface, or 428 amsl, and WL-235 at 24.5 feet below the surface, or 457 amsl). Down-hole gamma scans of these new borings, AC-24 and AC-25, confirm elevated gamma readings at 431 amsl and 457 amsl respectively. The elevated downhole gamma measurements near the bottom of the original borings, WL-210 and WL-235, were thought to potentially be caused by “drag down” from shallower RIM occurrences within the borings. However, because borings AC-24 and AC-25 were drilled using sonic drilling techniques to minimize the potential for drag down and because the downhole gamma measurements returned to a baseline before reaching the bottom of the boring, the Region believes that the elevated gamma readings are not due to drag down of shallower contamination. Elevated downhole gamma measurements from the confirmation borings were encountered at depths similar to the original borings, indicating a gamma source(s) in close proximity. However, samples which did not exceed the definition of RIM were collected from these borings at or near the depths of the elevated gamma readings.

Because the RIM materials were placed at the Site in the 1970’s and limited documentation or evidence exists as to how and exactly when these materials were placed on specific portions of the Site, explanation for each deep occurrence of RIM in OU-1 is limited. There are several possible explanations for deeper RIM occurrences. First, the surface elevations of all portions of Area 1 and Area 2 throughout the 1970’s can only be estimated and therefore some caution must be taken before concluding that RIM has been found at depths significantly deeper than where it was originally placed. The various investigations have spanned several decades of time with the NRC investigations in 1981, the original Remedial Investigation in 1994-1997, and the additional characterization work in 2013-2015. Second, solid waste decomposed between the time when the RIM was used as cover as early as 1973 and the present day which would have contributed to RIM being located below where it was originally placed. Differential settlement and leachate production had the potential to shift the location and occurrence of RIM within the landfill. This could have resulted in changes in the location, depth, thickness, and volume of RIM not only from when the radiological materials were first placed in the landfill but to some extent between. Finally, historical aerial photography shows that at various time periods since 1973 stock piling of quarry spoils and other materials occurred on portions of Area 1 and Area 2. The weight of certain stockpiled materials on top of areas where RIM had been placed could have caused further compaction and thereby movement of the RIM and waste materials.

For the purpose of the volume estimates of RIM in Area 2, the gamma data from WL-210, WL-235, AC-24 and AC-25 are included in the gamma data set for the Site. This is consistent with how other borings in OU-1 with similar gamma/ analytical signatures are being considered.

As a result of the new investigations, the Region required that an expanded conceptual site model be developed and presented in the RIA. The conceptual site model incorporates the results of the additional investigations and further consideration of historical aerial photography, historical landfill permits, and documentation from the NRC investigations.

In particular, the conceptual site model provides an updated description of the historical placement of radiological materials at the landfill and the subsequent utilization of these materials for general landfilling operations, including daily, intermediate, and final cover placement over refuse. The RIA specifically identifies 18 borings that indicate more than one discrete interval of RIM is present, including 4 borings in Area 1 (1D-9, AC-1, AC-2B, and AC-3) and 14 borings in Area 2 (AC-24, AC-26A, PVC-4, PVC-5, PVC-6, PVC-7, PVC-10, PVC-40, NRC-21, NRC-22, WL-209, WL-210, WL-214, and WL-235). These 18 borings include 8 borings (PVC and NRC borings) previously identified by the NRC. According to documentation summarized in the 1976 NRC inspection report, approximately 43,000 tons of radiological material were brought to the Site in 1973 using five different hauling companies over a three-month period. These materials may have been stockpiled and used for landfilling operations for a time period continuing after the last of the radiological materials were brought to the Site. Consideration of a longer period of time during which radiological materials may have been moved and placed at the Site in part explains the presence of RIM in discontinuous volumes and varied thickness in some portions of Area 1 and Area 2.

Consideration of historical landfill permitting from the time frame shortly after the radiological materials were brought to the Site provides additional information related to pertinent landfill operations that occurred during the time period when radiological materials may have been moved and placed at the Site. In addition to an expanded discussion of the historical placement of radiological material, figures have been included in the RIA that depict an estimate of the change in the landfill surface height between various time frames, based on available aerial photography. These figures and additional considerations have resulted in refinement of the conceptual site model regarding the locations of RIM at the Site and the variation in the thicknesses of RIM occurrences from a few inches to several feet.

Additional information regarding characterization of the RIM at the Site is provided in the attached PowerPoint, “Extent and Distribution of RIM.”

B. Volume of RIM

- **NRRB Comment:** The NRRB suggested that the Region carefully examine the data and information contained in the RI and NRC reports to ensure that the location and volume of RIM is accurately characterized and, if necessary, consider conducting further investigations possibly using test trenches. Furthermore, the NRRB suggested

the range of alternatives should include options for addressing the likely volume and location (including hot spots) of RIM at the Site.

- **Region's Response:** As noted by the NRRB, volume estimates provided in the RI included uncertainty. The Region agrees that uncertainties in the volume of RIM could negatively impact the alternatives analysis process. To address these uncertainties, Region 7 required that all Site data, including additional data from the recent investigations, be incorporated into a three-dimensional geostatistical model to provide a refined volume estimate of RIM within OU-1.

  Using 3-dimensional geostatistical methods, or more specifically indicator kriging, on the more robust data set currently available provides more certainty to the probability that RIM can be said to be present in portions of the Site for which there is no data. An estimate of RIM volume based on this methodology reduces subjectivity and facilitates a repeatable estimate of the volume. The Region acknowledges that, as with any statistical estimate, there are uncertainties associated with the volumes which have been described in the FFS. However, the Region considers these RIM volume estimates to be sufficient to perform the nine criteria evaluation of the proposed remedy alternatives.

RIM Volume Estimates (bcy)			
	2017 FFS	2011 SFS	Difference
Area 1	58,700	33,500	+25,200
Area 2	251,000	302,000	-51,000
OU-1 total	309,700	335,500	-25,800

Based upon the geostatistical modeling, the current volume estimates of RIM in Area 1 and Area 2 have been updated to include all the available validated data. Comparisons between the updated RIM volume estimates and the estimates presented to the NRRB are provided in the table above. In contrast, the estimated volume of RIM presented in the 1982 NRC investigation report was 150,000 cubic yards which assumed an average thickness of two meters of RIM over an area of approximately 16 acres. As stated in the previous response, the Remedial Investigations have largely confirmed the presence of RIM at the locations previously determined by the NRC and have identified additional RIM both laterally and vertically in some portions of Area 1 and Area 2.

The Region also notes that in order to access and excavate all of the RIM, approximately 1,537,000 cubic yards of vertical overburden and excavation setback must be excavated from OU-1, including 827,000 cubic yards in Area 1 and 710,000 cubic yards in Area 2. The vertical overburden and any materials associated with the excavation setback are proposed to be managed on-site. After the excavation of RIM is complete, it is expected that some of these materials may be used as fill in Area 1 and Area 2.

All of the additional data, and its interpretation, is contained in the RIA. Based on these data and interpretations, Region 7 has concluded that the Site has been characterized sufficiently to complete the FFS, and to perform the evaluation of the remedy alternatives.

With the more refined definition of the location and volume of RIM, Region 7 has required that Respondents include three partial excavation alternatives in the FFS in addition to the full excavation and containment only remedies. These alternatives include excavation and off-site disposal of:

(1) RIM containing Radium-226 and Radium-228 (or Thorium-230 and Thorium-232) above 1,000 pCi/g;

(2) RIM containing Radium-226 and Radium-228 (or Thorium-230 and Thorium-232) above 52.9 pCi/g down to a depth of 16 feet; and

(3) RIM which is defined as Radium-226 and Radium-228 (or Thorium-230 and Thorium-232) above 7.9 pCi/g that could cause an unacceptable risk to a receptor based on anticipated industrial land use. This alternative provides for excavation of RIM to the depth necessary after regrading to prevent unacceptable risks to an industrial worker.

Risks from the RIM at the Site will increase over time because some of the radionuclides are not in secular equilibrium, e.g. Thorium-230 concentrations are greater than Radium-226 concentrations currently. The OU-1 baseline risk assessment estimates that risks from the RIM to a reasonable maximally exposed receptor based on anticipated land use are expected to exceed 10^{-3} in the next 1,000 to 9,000 years. It also indicates that RIM closer to the surface causes the majority of the risks. Each of these partial excavations will still require an appropriate cap considering some RIM would still remain at the Site.

The 1,000 pCi/g partial excavation alternative is based on the consideration that RIM in Area 1 and Area 2 contains similar radionuclides as those associated with uranium mill tailings described in EPA's Uranium Mill Tailings Radiation Control Act (UMTRCA) regulations (40 C.F.R. Part 192). The environmental impact study and Federal Register notices associated with these regulations describe mill tailings as typically containing up to 1,000 pCi/g of Radium-226 (OSWER Directive No. 9200.4-25). The 1,000 pCi/g alternative requires excavation of RIM which includes radium and thorium at the upper end of the concentrations typically associated with uranium mill tailings. Because radium and thorium are not in secular equilibrium, in growth of radium will occur after this remedy alternative is complete for up to approximately 9,000 years. However, all thorium greater than 1,000 pCi/g would be removed which limits ingrowth of radium to no more than 1,000 pCi/g. Therefore, excavation and off-site disposal of RIM at concentrations greater than 1,000 pCi/g will permanently eliminate the presence of radioactive materials at the Site that could be considered higher than typical uranium mill tailings.

Under this partial excavation alternative, the volume of RIM to be removed is currently estimated to consist of about 38,690 cubic yards. However, under this alternative RIM requiring removal is present as deep as 429 amsl in Area 1 and as deep as 449 amsl in Area 2. In particular, for Area 1 this includes RIM located underneath portions of the Bridgeton Landfill as deep as approximately 90 feet below the ground surface. As a result, approximately 506,000 cubic yards of vertical overburden and excavation setback must be excavated from Area 1 and 152,700 cubic yards of vertical overburden and excavation setback must be excavated from Area 2 in order to access all the RIM that exceeds 1,000 pCi/g. Some of the vertical overburden and excavation setback materials may contain RIM at concentrations less than 1,000 pCi/g and will be managed on-site. These materials are not considered for off-site disposal and are expected to be used as fill for Area 1 and Area 2 as needed.

	Maximum RIM Depth	RIM Volume	Overburden Volume
Area 1	428 amsl	7,690 yd^3	498,800 yd^3
Area 2	449 amsl	31,000 yd^3	170,600 yd^3

The 52.9 pCi/g partial excavation alternative combines consideration of the radium cleanup goal from UMTRCA Subpart C and with identification of RIM that could be considered Principal Threat Waste. The UMTRCA Subpart B regulations include a radium cleanup goal of 5 pCi/g over background (40 C.F.R. § 192.12) UMTRCA. According to EPA's principal threat waste guidance, while there are no "threshold levels" of risk that correspond to "principal threat," generally treatment alternatives should be evaluated in those instances where toxicity and mobility combine to pose a potential risk of 10^{-3} or greater. Since 10^{-3} is an order of magnitude greater than the upper end of the risk range of 10^{-4}, evaluating radium concentrations an order of magnitude higher than the UMTRCA soil standards was considered a suitable benchmark to evaluate. This partial excavation alternative was based upon the concept of attempting to remove waste that might constitute a principal threat waste. In accordance with CERCLA, treatment for the excavated material would be considered to the maximum extent practicable

A depth limit was added to this alternative to address potential deep excavation implementation considerations for removal of a relatively small volume of RIM. Prior to the additional investigations of RIM in 2015, a depth of 16 feet was selected which was thought to result in excavation of a majority of the RIM in Area 1 and Area 2 consistent with statements made in the previous NRC investigations. As stated in an earlier response, more recent investigations identified additional RIM, some of which is deeper than 16 feet below the ground surface. The table below shows the estimated volume of RIM associated with this alternative which represents about 17% of the RIM in Area 1 and about 29% of the RIM in Area 2. At this time, an alternative depth for removal of RIM above 52.9 pCi/g has not been proposed but could be explored during remedial design.

The updated draft FFS includes evaluation of treatment for the excavated RIM/waste materials. Consideration of treatment of the excavated RIM material includes a rotating trommel combined with a segmented gate system which will first attempt to separate solid waste from contaminated soil, followed by further segregation of the soil with a segmented gate system to achieve a reduction in volume. Several challenges exist with implementation of these technologies on solid waste and therefore a full scale pilot study must be performed in order to evaluate the effectiveness of these technologies. In addition, the off-site disposal facility has indicated that stabilization of contaminated solid wastes materials may be necessary as part of the final disposal at their facility. This stabilization would result in a reduction in mobility. The potential for stabilization will be dependent on the characterization of the waste sent to the disposal facility. If either of these treatment technologies are implemented successfully, EPA's preference for treatment for principal threat wastes would be met for the excavated RIM. RIM at concentrations significantly above 52.9 contained in deeper portions of Area 1 and Area 2 may constitute a principle threat and are not proposed to be excavated and potentially treated.as part of this remedy. Therefore, this remedy may not remove all the principal threat wastes contained at the Site. The table below presents the volume estimates for RIM and overburden associated with this alternative.

	Maximum RIM Depth	RIM Volume	Overburden Volume
Area 1	Depth limited to 16'	10,200 yd^3	49,400 yd^3
Area 2	Depth limited to 16'	73,700 yd^3	160,000 yd^3

The future land use alternative, otherwise known as the Risk Based Partial Excavation Alternative, identifies the volume of RIM that would cause an unacceptable risk to the reasonable maximum exposed receptor in the future, which is an on-site storage yard worker. This alternative is described in more detail in item 3 below.

3. Future Land Use

- **NRRB Comment:** The NRRB believed that using background-based standards and UMTRCA unrestricted use criteria may have led to overstating the volume of RIM that would have to be excavated and possibly treated under a "complete rad removal" alternative. The NRRB suggested that the Region recalculate the volume of RIM to be removed using a more reasonable future use assumption of industrial/commercial.
- **Region's Response:** As described above, the Region required the PRPs to develop three additional excavation alternatives in the FFS, one of which is a future land use alternative based on identifying RIM (Combined Radium or Combined Thorium greater than or equal to 7.9 pCi/g) that would cause an unacceptable risk to the

reasonable maximum exposed receptor in the future. This future receptor was evaluated as an on-site storage yard worker consistent with the baseline risk assessment. Because Area 1 and Area 2 are solid waste landfills, residential use is not reasonably anticipated in the future. This worker is estimated to spend 4 hours a day working outside in the storage yard which is assumed to be located on Area 1 and Area 2. The worker then spends the other 4 hours of every day inside a building located immediately adjacent to Area 1 and Area 2. This scenario is currently estimated to require the excavation of all RIM down to a depth of 2.2 feet below the projected regrading surface, followed by backfilling with materials which do not contain RIM. This results a 2.2 foot barrier between the remaining RIM and the surface prior to the installation of an appropriate cap. This 2.2 foot barrier or shielding reduces the risk to the evaluated future storage yard worker to at or below $1*10^{-4}$ prior to installation of the cap, and therefore provides an additional level of protectiveness beyond a capping only remedy. This alternative also includes the off-site disposal of all RIM materials encountered during regrading, which prevents additional RIM from being placed in Area 1 and Area 2.

This partial excavation alternative is currently estimated to excavate and dispose of 8,600 cubic yards of RIM consisting of about 800 cubic yards from Area 1 and 7,800 cubic yards from Area 2. The majority of this RIM is located near the current surface in the higher elevation portions of Area 1 and Area 2. For this alternative, the off-site disposal of RIM may result in the need for stabilization at the disposal facility, partially addressing the preference for treatment of RIM which may be considered a principle threat waste. The detailed evaluation of this alternative has only recently been submitted to the Region and more details will be provided with the forthcoming NRRB presentation.

4. Principal Threat Waste

- **NRRB Comment:** The NRRB stated that based on the data, it appeared there is discrete, accessible highly toxic principal threat waste at this site. The NRRB suggested that the Region carefully consider the range of alternatives developed for this site and explain in its decision documents how the preferred alternative, when selected, will be consistent with CERCLA and NCP, or publish an explanation as to why not.

- **Region's Response:** Based on all of the existing data, including additional data collected subsequent to the SFS, EPA has determined that principal threat wastes may exist within OU-1. This is supported by 1) analytical results from the fate and transport samples confirming that under certain conditions radionuclides can leach from RIM; 2) the current maximum thorium and radium concentrations at 58,919 pCi/g and 4,941 pCi/g, respectively; and 3) consideration of future ingrowth of radionuclides in RIM due to radioactive decay. The Region has required risks be

evaluated in the baseline risk assessment, and in the long-term effectiveness evaluations in the FFS, to 1,000 years and 9,000 years in the future to ensure that the effect of ingrowth is fully considered.

In light of the presence of principal threat wastes in the landfill, the Region's evaluation of remedial alternatives gives consideration to CERCLA's preference for treatment consistent with: CERCLA § 121(b)(l)'s preference for treatment "to the maximum extent practicable"; CERCLA § 121(d)(l)'s requirements regarding protectiveness and applicable or relevant and appropriate requirements; 40 C.F.R. § 300.430(a)(l)(iii)(A)'s expectation that "treatment [be used] to address the principal threats posed by a site, wherever practicable"; and 40 C.F.R. § 300.430(f)(l)(ii)(E)'s preference for treatment "to the maximum extent practicable" while protecting human health and the environment, attaining ARARs identified in the ROD, and balancing the five primary criteria listed in the NCP. As such, each of the remedial alternatives are evaluated for inclusion of treatment of all or portions of the principal threat wastes and evaluate whether treatment is technically practicable.

As suggested by the NRRB, the Region has further considered and carefully evaluated multiple treatment options as set forth in the FS, SFS, and FFS. These documents collectively present the evaluation of potential treatment technologies identified in EPA's Technology Reference Guide for Radioactively Contaminated Media (EPA, 2007), including physical stabilization (i.e. cement), chemical separation, and vitrification as well as waste volume reduction methodologies and the application of apatite and/or phosphate solutions for possible treatment of waste materials and/or groundwater for the remedial action for OU-1. EPA thinks that the evaluation conducted to date provides a sound basis for a determination of whether any specific treatment technologies are practicable for principal threat waste at the Site, as required by CERCLA and the NCP.

5. Remedy Performance

A. Removal/Excavation

- **NRRB Comment:** The NRRB suggested that the Region consider developing an alternative that includes sorting and removing the RIM in a precise manner using performance standards for the excavation process.

- **Region's Response:** It is feasible to excavate RIM, and in particular, RIM that is near the surface. Removing higher concentrations of RIM or removing RIM near the surface would reduce the long-term risks at the Site. While excavation of RIM does carry a risk of exposure to remediation workers and community, these risks can likely be managed to within or less than EPA's acceptable risk range using engineering controls, health and safety protocols, and best management practices. As a result, EPA has required further evaluation of full and partial excavation of RIM alternative in the FFS as described above.

The Region notes that RIM contains gamma emitting radionuclides which can be identified in the field and potentially further sorted using instantaneous measurement instrumentation. However, the presence and prevalence of Thorium-230 in RIM, which does not emit gamma radiation measurable by such equipment, will prevent these techniques from being effective sorting tools for all RIM and especially concentrations as low as 7.9 pCi/g. The excavation remedies evaluated in the FFS utilize a combination of instantaneous measurements from field instruments and sampling with analytical analysis when necessary in order to ensure that 1) the appropriate RIM is excavated; 2) RIM is loaded into transportation containers in an appropriate manner to protect the transporter; and 3) RIM brought to any disposal facility meets the facility's waste acceptance criteria.

Separation and sorting technologies proposed for full and certain partial excavation alternatives will achieve a reduction of volume. The Region notes, however, that while separation technologies reduce the volume of contamination, an unintended consequence may be that the RIM that must be transported and disposed of contains relatively higher concentrations of radionuclides. As a result, any separation technologies utilized to sort RIM must also consider the waste acceptance criteria of the disposal facility, as well as health and safety considerations associated with the management of a smaller volume of RIM that contains higher concentrations of radionuclides.

B. Treatment

- **NRRB Comment:** The NRRB suggested that the Region reconsider treatment alternatives or provide more explanation for ruling out an in-situ or ex-situ solidification/ stabilization process that is specifically designed for both the high sulfate content and saturated conditions found at this site. Furthermore, the NRRB stated that "treatment can include measures taken to reduce volume" and went on to propose the region look at volume separation techniques to achieve volume reduction.

- **Region's Response:** The Region required the PRPs to conduct a review of existing literature to identify any additional treatment technologies which could be applied to the radiological wastes at this site and expand the evaluation of any previously considered technologies. Area 1 and Area 2 contain municipal solid wastes, construction and demolition debris, and other unconsolidated wastes which have aged for more than four decades. As a result, the radiological materials which were mixed with soils prior to being brought to the landfill and used for various landfilling operations have impacted or contaminated some of the other wastes materials in portions of Area 1 and Area 2. In general, review of the boring logs indicate the portions of Area 1 and Area 2 where RIM have been identified include soil, demolition debris, and solid wastes and in some cases mixtures of all three. Therefore, the evaluation focused on whether various technologies for treatment of radiological materials have ever been applied effectively in solid waste landfills

which include mixed media. The evaluation considered several treatment technologies including solidification, chemical separation, soil washing, flotation, vitrification, and apatite/phosphate based treatment in addition to commercial sorting technologies. Many of these technologies have been used effectively to treat radionuclides in soil. The Region was unable to find an application of these technologies to treat radionuclides in municipal solid wastes. Therefore, application of the in-situ treatment technologies is not expected to be effective. Effective application of most ex-situ treatment technologies is predicated on whether the radiological material can be separated or segregated from non-soil materials, such as solid wastes or demolition debris.

The Region specifically required the PRPs to evaluate the effectiveness of apatite/phosphate-based treatment of the RIM in OU-1. This treatment technology has been used effectively to treat groundwater for radionuclides including uranium, however, no applications of this technology to treat either radium or thorium isotopes have been found. (As noted previously, the groundwater portion of this remedy will be evaluated in a future decision document.) As stated above, no known application of the use of apatite or other phosphate-based materials exists for radionuclides within a broader matrix of MSW. It is uncertain whether apatite solids or solutions can be sufficiently distributed within the heterogeneous matrix of landfill debris to ensure adequate treatment, particularly since Area 1 and Area 2 appear to be in generally unsaturated conditions, which is not conducive to this type of treatment. Even if significant volumes of RIM which consist primarily of soil were located, injection of apatite into those areas is not anticipated to be effective because it would be nearly impossible to maintain saturation in those areas to the extent necessary for effective treatment.

Effective application of most ex-situ treatment technologies is predicated on whether the radiological material can be separated or segregated from non-soil materials, such as solid wastes or demolition debris. Methodologies to separate the RIM from the other media to support additional treatment alternatives such as stabilization were explored. The Region has required further consideration in the FFS of the effectiveness of the various sorting technologies, including the use of segmented gate systems supported by rotating screens or trommel screens to separate solid waste from soil. Uncertainties with the implementability and effectiveness of these technologies have been identified. A full-scale pilot test would need to be performed during remedial design to determine the effectiveness of these technologies particularly because of the prevalence of Thorium-230 in RIM and the inability for gamma scanning equipment to measure Thorium-230. Radium and Thorium are co-located to at large extent, but thorium is generally present at higher concentrations. Therefore, sorting of higher concentrations of RIM is expected to be more effective than sorting at lower concentrations of RIM that consists of undetectable levels of radium-226 but still contains significant levels of Thorium-230. In particular, sorting materials with radionuclides at concentrations as low as the definition of RIM

(7.9 pCi/g combined radium and thorium) is not likely to be effective because Radium-226 concentrations will likely be consistent with background while thorium-230 may remain at concentrations greater than 7.9 pCi/g. The Region has required the PRPs to include in the FFS consideration of how such pilot testing could impact the estimated costs and schedules for applicable alternatives.

C. Short-Term Effectiveness

- **NRRB Comment:** The NRRB suggested that the Region re-evaluate the alternatives against the nine criteria pursuant to 40 C.F.R. § 300.430(e)(9)(iii). The NRRB noted that comparison of the short-term effectiveness of the three action alternatives was presented as risk estimates that are presumed to potentially occur to nearby residents during remedy implementation; however, risks posed by excavating RIM can be mitigated through the use of engineering controls and an approved health and safety plan as necessary to prevent unacceptable risks. The NRRB also noted that industrial injuries/fatalities are not generally environmental risks that should be considered in a short-term effectiveness analysis and that consideration of risks from accidents should be limited to those that could expose workers or the community to possible releases of contaminated materials along with reasonable response actions. The NRRB noted that environmental justice concerns, and in particular consideration of sensitive or potentially high-exposure subpopulations, should be evaluated as part of the short-term and long-term effectiveness criteria. Finally, the NRRB noted that the short-term effectiveness provisions in the NCP do not include funding as a consideration.

- **Region's Response:** The Region has required that all risks posed by the excavation of RIM be evaluated with full consideration of the use of engineering controls and an approved health and safety plan to mitigate these risks to both on-site workers and the community. Current estimates of risks without consideration of any engineering controls for off-site residents are within the acceptable risk range for all remedial alternatives evaluated in the FFS. These risks are therefore expected to decrease further with the effective use of engineering controls.

  The Region further notes that significant risks have been estimated for the reasonably maximum exposed remediation worker for some alternatives due in part to gamma exposures that cannot be mitigated through the use of personal protective equipment. Instead, these risks must be mitigated by limiting the time individual workers are exposed likely by rotating workers. Careful consideration of this and other best management practices (BMPs) to minimize these risks will be needed. Therefore, the short-term effectiveness evaluation for each of the remedy alternatives presented in the FFS carefully considers all these items and is in accordance with the provisions for short-term effectiveness provided in the NCP.

  In addition, the Region has required only risks posed by industrial accidents that could expose remediation workers or the community to RIM be considered for the

short-term effectiveness evaluation, along with consideration of any appropriate response actions to minimize or prevent any resulting exposures.

The Region also required an updated environmental justice screen be conducted for the Site and the results of this screen are to be fully incorporated into the FFS. No communities with EJ concerns were identified, although there were areas of lower income and older individuals. As such, communication with the public will include more traditional communication methods such as paper mail and flyers since there may not be access to electronic methods of communication.

In the FFS, the short-term effectiveness provisions do not include funding as a consideration.

D. Long-Term Effectiveness

- **NRRB Comment:** The NRRB suggested that the Region consider examining additional information on alternative cap designs plus fate and transport of groundwater that supports long-term protectiveness.

- **Region's Response:** The Region required the PRPs to conduct an expanded evaluation of long-term effectiveness for all the remedy alternatives, with particular emphasis on the long-term performance of all capping systems considering the ingrowth of Radium-226 over the next 1,000 to 9,000 years. In addition, the Region required an expanded evaluation of alternative capping systems to take into consideration site-specific climate concerns (humid environment), radon emissions resulting from ingrowth of radium, and long-term protectiveness impacts from erosion, flooding, and bio intrusion.

  Additional sampling and analyses were conducted to evaluate leachability of the RIM. The data shows that RIM has the potential to leach. In order to ensure long-term effectiveness of the capping alternatives EPA emphasizes that UMTRCA standards are the driving ARARs for containment/capping remedies and that the associated agency guidance, provided in (Technical Guidance for RCRA/CERCLA Final Covers (Apr. 2004)), must be considered for the design and implementation of any capping system for OU-1 remedies that leave RIM at the Site to address infiltration. Groundwater ARARs will also be evaluated as part of the future OU-3 FFS.

  The Region has determined uncertainties related to the local groundwater geochemistry, local groundwater gradient, and identified complications from the adjacent OU-2 landfill cells' leachate collection system may have also impacted groundwater at the Site and require additional investigation. EPA has created OU-3 to address groundwater. EPA is developing the scope and associated statement of work for a remedial investigation of this separate operable unit.

6. Applicable or Relevant and Appropriate Requirements

A. UMTRCA

- **NRRB Comment:** EPA's UMTRCA standards would appear potentially relevant and appropriate for ARAR purposes when evaluating factors like the longevity/integrity of a unit serving as a repository for centuries. The NRRB noted that even if UMTRCA standards are considered as an ARAR, meeting those standards may not ensure protectiveness over the long-term for several reasons, including RIM at levels currently measured at up to 57,300 pCi/g of thorium, as well as the increasing daughter ingrowth concentrations of radium 226/228, radon 222, and the increase in toxicity projected to peak at about 700,000 pCi/g over time (1,000 years). The NRRB suggested that the Region evaluate whether the alternatives under consideration for Area 2 will meet the UMTRCA standards as ARARs, as well as any NRC standards (and guidance that might serve as TBCs) that exist for licensed facilities storing or disposing of radiological waste.

- **Region's Response:** The Region has required a detailed discussion of the UMTRCA regulations in the ARARs portion of the FFS. EPA has determined that the standards for control of residual radioactive materials in Subpart A of EPA's UMTRCA regulations (40 C.F.R. § 192.02), which include limits on radon flux and protection of groundwater, are relevant and appropriate for the design and implementation of a cap over the waste management portions of the Site. The Region acknowledges that concentrations of RIM in portions of Area 1 and Area 2 exceed the upper end of what is considered typical for high activity uranium tailings (300-1,000 pCi/g). The Region has expanded the evaluation of ARARs to account for RIM which exceeds 1,000 pCi/g. Specifically, the NRC low level waste regulations contained in 10 C.F.R. Part 61 are being evaluated. These higher concentrations as well as the impacts due to ingrowth of radium-226 that will occur over the next 9,000 years were fully incorporated into the evaluations ensure the various remedy alternatives can meet the UMTRCA standards and are protective of human health. EPA has also determined that the UMTRCA standards for cleanup of radioactive materials in the top 15 centimeters (40 C.F.R. § 192.12) are relevant and appropriate for all of OU-1, except for the portions of the Site that are utilized as waste management units. The region has expanded the evaluation of ARARs to account for RIM which exceeds 1,000 pCi/g. Specifically, the NRC low level waste regulations contained in 10 C.F.R. Part 61 are being evaluated. OSWER Directive No. 9200.4-25 was cited as a to-be-considered for the selection of subsurface clean-up goals. This directive provides guidance that the sub-surface clean-up standards in 40 C.F.R. § 192.12 should only be utilized in cases where subsurface contamination is very limited and recommends using the surface clean up standard of 5 pCi/g plus background as a subsurface standard as long as this is protective.

  With regard to long term protectiveness, the Region has required the FFS include risk calculations based on consideration of the future ingrowth of Radium-226. As noted

by the Board, the UMTRCA standards were written with the intent of either controlling or cleaning up uranium mill tailings, which typically contain concentrations of Radium-226 up to about 1,000 pCi/g. The present-day mean concentrations of Radium-226 in Area 1 and Area 2 are estimated to be 88 pCi/g and 102 pCi/g, respectively, while the maximum radium concentration present in all of OU-1 is approximately 5,000 pCi/g. Additionally, the present-day mean concentrations of Thorium-230 (parent of Radium-226) estimated for Area 1 and Area 2 are 1,232 pCi/g and 1,569 pCi/g, respectively, while the maximum Thorium-230 concentration in all of OU-1 is approximately 58,800 pCi/g.

As discussed in previous responses, Radium-226 concentrations will increase according to the decay of Thorium-230 until reaching equilibrium at which time the concentration of Radium-226 will be equal to Thorium-230. Because these radionuclides decay at a constant rate according to their half-lives (1600 years for Radium-226 and 75,400 years for Thorium-230), the time required for this equilibrium to be reached can be determined and has been calculated to take slightly less than 9,000 years. At that point in time, Radium-226 concentrations will reach a maximum which cannot be greater than the Thorium-230 concentrations. Because the half-life of Thorium-230 is so long, decay of Thorium-230 over 1,000 years will result in approximately 1% reduction and over 9,000 years will result in approximately 8% reduction. Therefore, a conservative estimate of the peak or maximum future Radium-226 concentrations in OU-1 is the present day Thorium-230 concentrations provided above.

Consistent with EPA's risk assessment guidance, the baseline risk assessment and FFS contain conservative risk estimates based on concentrations at the 95% upper confidence limit (UCL) of the mean. Therefore, the risk estimates provided in the risk assessment and the FFS were determined using exposure point concentrations greater than the mean concentrations provided above. Future risks are presented for the baseline case in the BRA and after implementation of each remedy alternative at 1 year, 1,000 years, 9,000 years in the FFS, fully accounting for the increase in risk due to Radium-226. The Region notes current estimates provided in the BRA and FFS show that Radium-226 concentrations will increase by a factor of approximately 10 in Area 1 and approximately 15 in Area 2. These estimates are partly based on the more than 400 analyses of both Radium-226 and Thorium-230 from samples collected at the Site. The NRC presents a conservative estimated of future Radium-226 ingrowth using a factor of 100 in the 1982 report. This conservative estimate was appropriate considering the NRC had only 12 analytical results for Thorium-230 for all of Area 1 and Area 2. This conservative approach is no longer needed because ingrowth estimates can now be made using the comprehensive data set for Thorium-230 collected since the NRC investigations. The long-term risks estimated for all the remedies, including cap-in-place remedies, which fully incorporate ingrowth considerations are within or less than the CERCLA risk range of 10^{-6} to 10^{-4}.

It is recognized that for the alternatives leaving RIM in place, including RIM at concentrations greater than 1,000 pCi/g, the landfill must be designed and maintained in a manner which will ensure that the remedy will remain protective over the extended period of time for which ingrowth will occur.

B. RCRA

- **NRRB Comment:** The NRRB suggested that the Region carefully consider the appropriateness of using RCRA Subtitle D regulations as an ARAR for RIM, where Radium-226 activity will increase by a factor of thirty-five 1,000 years from now.

- **Region's Response:** The Region has determined that RCRA Subtitle D is not the appropriate guiding ARAR at this Site. Instead, the Region has required the Respondents consider UMTRCA and RCRA Subtitle C requirements as guiding ARARs and/or TBCs. The basis for this includes:

  (1) RIM (Radium-226 and Thorium-230) rather than MSW accounts for the majority (>95%) of the risk posed by the Site. Therefore, the disposal unit for these waste materials must be designed to be protective of the radiological contaminants.

  (2) New analytical data indicates the potential for RIM to leach.

  (3) Statements regarding the disposal of non-radiological industrial wastes contained in historical reports (i.e., 1982 and 1988 NRC reports). Therefore, the disposal unit for these waste materials must be designed to be protective of these industrial wastes.

  (4) The unique nature and concentration of the RIM is such that there is a need to borrow from regulations and guidance to provide assurance of containment and long-term protectiveness of the remedy.

  The Region decided that measures specified in RCRA Subtitle C closure criteria should be used to supplement the design of an overall capping system in order to meet UMTRCA performance standards. The goal is to ensure that this unique waste can be adequately contained and the remedy is protective for all materials present at the Site using the landfill cover performance criteria at 40 C.F.R. § 264.111 and landfill cover design requirements at 40 C.F.R. § 264.310.

  While the RCRA Subtitle C regulations provides useful information regarding cap design objectives, EPA believes the specific design criteria in the technical guidance are even more helpful in guiding cap design. Therefore, the Region has identified certain portions of those guidance as TBC requirements. The 1989 Technical Guidance Document provides design guidance on final cover systems for hazardous waste landfills and surface impoundments. This guidance addresses multilayer cover design to provide long-term protection from infiltration of precipitation. The 2004 Draft Technical Guidance provides design information regarding cover systems for

municipal solid waste (MSW) and hazardous waste (HW) landfills being remediated under CERCLA and RCRA Corrective Action, and sites regulated under RCRA. This guidance includes updated information related to development of design criteria, use and types of geo-synthetics such as geo-synthetic clay liners, alternative materials and designs, performance monitoring, maintenance of cover systems, and other issues.

C. FAA

- **NRRB Comment:** With regard to the Federal Aviation Administration (FAA) Guidance, the NRRB agreed with the Region that this guidance is not an ARAR. During the presentation, the Region mentioned an agreement between the landowner and the FAA addressing property that may be partially addressed by the FAA guidance. The NRRB also noted that while important to acknowledge, the agreement between the landowner and the FAA Guidance is not an ARAR and does not otherwise limit EPA's broad response authority under CERCLA.

- **Region's Response:** While EPA does not view the FAA guidance as an ARAR, we are carefully considering whether certain provisions that address mitigation measures in the FAA Advisory Circular, 150/5200-33B, and FAA ROD are potential TBCs. We also agree that the agreement is not an ARAR and does not curtail EPA's ability to require the implementation of a protective remedy. That said, the Region is ensuring that the FFS fully considers the issue of attractive nuisance of birds and the possibility of aircraft bird strikes under the short-term effectiveness criteria in the alternatives analysis and the importance of properly addressing these issues in coordination with the necessary stakeholders.

D. Executive Orders

- **NRRB Comment:** The NRRB noted that while executive orders are important considerations, the ones described in the presentation did not represent the kind of promulgated, enforceable, generally applicable (or waivable) regulations or standards that qualify as ARARs. However, to the extent they are considered as remedy drivers, the Region should evaluate and explain in its future decision documents how these orders provide for a protective remedy.

- **Region's Response:** The Region will not identify executive orders that do not meet the definition of ARARs. The region is considering the portions that may be identified as TBCs in the FFS to the extent they provide guidance to ensure a protective remedy in accordance with the requirements of CERCLA and EPA's CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006 (Aug. 1988). The Region will evaluate and fully explain in the decision documents all ARARs and TBCs and any considerations beyond those standards.

E. Degree of Specificity in Description of ARARs

- **NRRB Comment:** The NRRB noted that some of the citations included in the ARARs tables provided in the SFS may not be described in enough detail pursuant to the *CERCLA Compliance with Other Laws Manual*, EPA/540/G-89/006 (Aug. 1988).

- **Region's Response:** The Region is ensuring that the ARARS and TBCs are described in sufficient detail in the FFS.

7. Cost/Discount Rate

- **NRRB Comment:** The NRRB commented that the Region should either: (1) use a discount rate of 7% for all present worth calculations (as was done for the 2008 ROD), or (2) provide an explanation and sensitivity analysis in accordance with EPA guidance. The NRRB also suggested that if a 2.3% rate is carried forward that both the 7% and 2.3% rates be provided, with appropriate explanation, for comparison purposes.

- **Region's Response:** The Region has required Respondents to provide present worth calculations in the FFS using a 7% discount rate. The Respondents have also provided present worth calculations using 0.7% rate which is the 30-year real interest rate in OMB Circular A-94 Appendix C Revised November 2016, that while not applicable to the CERCLA response action is provided for information purposes along with a sensitivity analysis.

8. Long-Term O&M Costs of Cap

- **NRRB Comment:** The NRRB suggested that the Region recalculate (and explain in its decision documents) the cost of the containment alternative to include all of the components of the cap, what perpetual operation and maintenance is required for each of these components (which likely includes repair and replacement), and the costs associated with that work.

- **Region's Response:** The Region has required that the FFS take into consideration the issues of operation and maintenance for all of the capping remedies under consideration. It should be noted that all partial excavation remedies also require a cap that is compliant with UMTRCA and the technical guidance that address Subtitle C caps. Regular inspections, maintenance, and sampling is included in the costs, as well as periodic replacement costs for monitoring wells. It is not anticipated that full replacement of the cap will be necessary provided appropriate on-going inspections and maintenance, which are accounted for in the cost estimate, are performed.

Attachments:

1. Final Draft February 28, 2013 National Remedy Review Board Discussions Regarding the Remedy at the West Lake Landfill Superfund Site
2. December 2017 Extent and Distribution of RIM