STATE OF MISSOURI
Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

April 24, 2014

Mr. Paul Rosasco, P.E.
Engineering Management Support, Inc.
7220 West Jefferson Avenue, Suite 406
Lakewood, CO 80235

RE: Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill, dated January 14, 2014.

Dear Mr. Rosasco:

The Missouri Department of Natural Resources has coordinated review and compiled comments on the "Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill" prepared by Engineering Management Support Inc. (EMSI). This evaluation was requested by the US Environmental Protection Agency (EPA) by letter dated July 3, 2013. Enclosed are comments from Mr. Todd Thalhamer, P.E., by memorandum dated February 13, 2014 and Addendum dated April 14, 2014 and comments from the Missouri Department of Health and Senior Services dated April 24, 2014. The Department agrees with the enclosed comments and requests responses.

If you have any questions pertaining to this letter, please contact me by phone at (573)751-3107; by written correspondence to my attention at the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102; or email to shawn.muenks@dnr.mo.gov.

Sincerely,

HAZARDOUS WASTE PROGRAM

Shawn Muenks

Shawn Muenks, P.E.
Federal Facilities Section

SM:dc

Enclosures

c: Mr. Dan Gravatt, U.S. Environmental Protection Agency
Mr. Chris Nagel, Director, Solid Waste Management Program
Mr. Jonathan Garoutte, DHSS

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# MEMORANDUM
# TODD THALHAMER, P.E.

Hammer Consulting Services; CA License # C055197; ltfire88@gmail.com; 530-391-2230

To: Ms. Brenda Ardrey, CGFM
Operations Section Chief
Solid Waste Management Program
Division of Environmental Quality
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

From: Todd Thalhamer, P.E.

Date: February 13, 2014

**RE: Comments on the Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill – Dated January 14, 2014**

I have reviewed the above mentioned report as requested by the Missouri Department of Natural Resources (DNR). This memorandum presents my initial comments and recommendations on the report. All potential issues in relation to a subsurface smoldering event (SSE) have not been examined and I reserve the right to modify my opinions and recommendations if new information, additional data, research, transcripts, or publications become available.

The following preliminary opinions and recommendations are those of Hammer Consulting Services and provided in my capacity as technical expert/advisor to DNR. These preliminary opinions and recommendations are based on my review of the relevant data and the recommendations provided below may or may not be acted upon by DNR. This memorandum to DNR was produced under a contract between the author and DNR. The statements, recommendations, and conclusions contained in this memo report are not necessarily those of DNR or its employees.

## Initial Comments

Given the environmental worry and the community's sensitivity associated with the entire West Lake disposal complex, Engineering Management Support, Inc. (EMSI), should be advised to disclose in their report that they have worked for and represented the landfill industry and specifically identify that one of the responsible parties, Republic Services, Inc., has been a client.

While the report considers certain potential impacts to the West Lake disposal complex, both before and after construction of the remedy selected by the United States Environmental Protection Agency (U.S. EPA), the report does not discuss the impacts to the community, businesses, and/or emergency responders from the presence of such a subsurface smoldering event (SSE). The report is limited to a discussion from a remedial action point of view and additional social and economic factors should be considered and included in the evaluation.

At times SSEs can be straightforward to evaluate, monitor, and suppress; however, this disposal complex has accepted a mix of radiological, industrial, commercial, municipal, construction and demolition debris, and other wastes with potentially unknown characteristics that complicate the assessment process to the point that no one can state that an SSE at this complex could be easily abated.

The facts are:

- This disposal complex illegally accepted radiologically-impacted material (RIM).
- The RIM is intermixed with and interspersed within the landfilled refuse, debris and fill materials, and unimpacted soil and quarry spoils in Areas 1 and 2 (See EMSI Report, Figure 1, West Lake Landfill Features, dated May 15, 2013).
- The facility did not maintain adequate records to allow for a ready determination of the types and profiles of the waste streams disposed of in the landfill(s).
- In some portions of Areas 1 and 2, the RIM is at or may be near the surface.

Should an SSE in the West Lake Landfill Operable Unit-1 or other area occur, it will potentially cause complications to the engineering solutions provided for in the Record Of Decision (ROD), potential response actions, and to the livelihoods and quality of life of the surrounding community.

## Background Information

The West Lake Landfill Complex is located in Bridgeton, Missouri. The site is listed on the U.S. EPA's Superfund National Priorities List due to the illegal disposal of RIM at the site . The Bridgeton Sanitary Landfill site sits within the West Lake Landfill site and is inactive and no longer accepting waste for disposal.

The West Lake Landfill site has four distinct units:

- Operable Unit 1, Area 1 – Radiologically contaminated wastes
- Operable Unit 1, Area 2 – Mixture of debris
- Bridgeton Sanitary Landfill – Primarily municipal solid waste
- Demolition Landfill

The U.S. EPA oversees the first two units. The Bridgeton Sanitary Landfill, owned by Bridgeton Landfill, LLC, whose parent company is Republic Services, Inc., is overseen by DNR.

## Executive Summary

The executive summary states "An SSE does not create conditions that could carry RIM particles or dust off the site." I disagree with this statement. As discussed later in the report if an SSE surfaces and should the area collapse, the potential exists for creation of a void space, smoke, dust, chemicals and the exposure of RIM to the atmosphere which places at risk the local



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community. To what extent and the level of risk associated with the event is dependent upon the type, duration and magnitude of the event. Smoldering events that propagate to the surface either through fissures, vent holes, or areas that have collapsed can transmit RIM via the smoke, water vapor, and/or dust created by such an event. Depending on site conditions, SSEs can create temperatures high enough to ignite non-RIM waste and/or chemical compounds; however the term "explode" should only be used in the context of methane explosions, which have been documented by industry on a number of occasions while excavating SSEs, and not as part of a "dirty bomb" scenario.

Again, I disagree with the statement contained in the report that "An SSE in the West Lake Area 1 or 2 would create no long-term additional risk to people or the environment." An SSE in the West Lake Area 1 or 2 has the potential to create both short and long term risks to the community and the environment. In fact the current SSE in the Bridgeton Landfill has the potential to impact OU-1 Radiological, Area 1 and other parts of the waste complex because the North and South Quarry are not isolated from the waste complex. One must consider the social and economic risks/impacts as well as the associated environmental worry resulting from such an SSE. This specific community has been impacted by the ongoing SSE within the Bridgeton Landfill portion of the West Lake Complex which has resulted in noxious odors over an extended period. The community, as a result, is now sensitive to the existence of the RIM and its' co-disposal with potentially flammable materials and that such materials are located on and/or near the ground's surface. While I concur that the long term risks from an SSE to some of the engineering components (i.e., soil cover, surface drainage) are minimal, one must examine the other long term issues (e.g., cover systems, gas control systems, slope stability, groundwater, leachate control, odor control, etc.) that have been impacted by similar long-term SSEs. SSEs clearly cause long-term additional risks to people including workers on the landfill property and/or the environment. U.S. EPA is aware of and has access to many case studies including the Kona Landfill in Hawaii which has been smoldering for twenty plus years. These case studies detail the long-term impacts of such events to public health and the environment.

There are likely additional applicable or relevant and appropriate requirements (ARARs) that should be included. It appears the report takes into account only characteristics of a subsurface event and does not carefully consider impacts that would be felt by the surrounding area should such SSE surface. Given the RIM, one should not hope an SSE does not surface; one should plan for the event, design a response, and account for the RIM and other issues such as adequacy of water supply, site access, available response contractors, decontamination, and community safety plans, etc.

Given current circumstances at this specific facility, consideration should be given to an SSE that surfaces or that causes slope stability issues with particular attention given to an area where RIM exists in close proximity to an urban population and a transportation hub, such as an international airport. Local emergency response agencies need to be directly engaged in the planning process and until such time as this occurs, I disagree with the statement that no additional ARARs need to be developed and be readily implementable when an SSE is already known to exist in close proximity to RIM and where no impenetrable barrier exists between the RIM and the existing SSE.



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## Section 2. Subsurface Heating Events

While the authors understand the complexities of heating events not all subsurface heating events at landfills are smoldering events. Heating events can be from biological factors or other chemical reactions such as aluminum dross or other metal oxide reactions. The key to understanding when a heating event becomes an SSE is determining the presence of carbon monoxide. Carbon monoxide is a by-product of incomplete combustion and is one of the crucial indicators in evaluating whether or not an SSE is occurring.

## Section 4. Potential ARARs Relative to an SSE

The authors state no additional ARARs are required. As stated above in Section 1, additional action-specific ARARs may be necessary if an SSE were to develop. Until local emergency response agencies have been consulted, I would recommend revising this section to reflect this possibility.

## Section 5.1 Combustion

While the reference is correct, the authors fail to recognize that an SSE may surface and create flame, smoke, vapors, and gaseous emissions. These conditions are dependent upon a number of environmental factors. The referenced section describes the general nature of a smoldering event and not the outcome of such an event. At closed facilities, some with and without gas control systems, the only indication of an SSE is by nearby residents or first responders when they detect smoke, vapor, odors or other odd/abnormal site conditions. One should not generalize that an SSE will not result in the release of radionuclides through flaming combustion. Radionuclides can be released through the presence of water vapor, dust, smoke, and flames in proximity to them.

Additionally, waste temperatures well above 450° F (232° C) have been documented by industry and the regulatory agency from SSEs as they surface. The temperature range as described by Thalhamer, 2013 is purely to describe typical initial stages of a smoldering event and not the maximum observed temperature. This correlation is not correct and should be corrected. If the SSE is not managed properly or detected, an SSE can propagate to the surface. Temperatures can and have reached levels necessary for ignition of paper, gases, and other material. It is also important to note that a smoldering event at a solid waste landfill can and has ignited methane. Methane gas or other flammable gases or liquids exposed to a smoldering object will ignite; however, the correct mixture of gases must be present for ignition to occur.

EMSI also states that methane production decreases significantly when temperatures are elevated above 160° F (71 °C) and appears to incorrectly conclude that methane will not be present and hence a corresponding explosive release of radionuclides will not occur. This statement indicates the authors may not fully understand the complexities of methane generation in landfills. Current landfill gas data from the Bridgeton Landfill indicates a number of gas extraction wells producing methane at explosive levels at temperatures exceeding 160° F (71° C). Additionally, EMSI states that the wastes or waste materials are at least 30 years old or older; however, the 30 year old rule for waste remains a guideline. There are many US solid waste landfills which have had waste in place for over 30 years that are still producing methane



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in sufficient quantities (i.e., above explosive levels). Until a gas study is completed in Area 1 and Area 2, it should not be assumed that a methane explosion or release of radionuclides will not occur simply because of the age of the waste or gas temperature. The municipal solid waste landfill within the West Lake complex is experiencing these exact conditions.

The authors should revise this section and recognize the possible transition phases of an SSE and that methane will or may continue to be present at temperatures above 160° F.

## 5.2 Increase in Subsurface Temperature

Again the temperature of 480° F (249° C) is not the maximum observed temperatures of an SSE. Landfill temperatures from heating events have been observed over 1,000° F (537° C). The Bridgeton Sanitary Landfill experienced an SSE in the North Quarry beginning in 1992 with temperatures reported as exceeding 800° F (SCS Engineers, 1994). Should an SSE cause slope stability issues ultimately resulting in a failure of an engineered component, radionuclides could be released by any or a combination of the following: water vapor, dust, smoke, and flames.

## 6.1 Direct Combustion

While EMSI claims that direct combustion of the selected capping system would not be affected by a smoldering or flaming fire, the capping system can be impacted by differential settlement from an SSE or heating event and result in aerial deposition of RIM. EMSI should also consider impacts from direct combustion from the North Quarry since OIU-1 are not isolated from the current SSE at the Bridgeton Landfill.

## 7. Conclusion

SSEs at this facility are not theoretical and monitoring protocols and contingency plans should be in place, maintained and readily available for implementation until the site no longer poses a risk. SSEs can cause slope stability issues and could result in the release of radionuclides through water vapor, dust, smoke, and/or flames. The characteristics of SSEs are variable and have the potential to result in the combustion, melting, and/or altering of the stability of the RIM and until such time as Area 1 and 2 are clearly defined by their boundary conditions and waste composition, and isolated from the Bridgeton Landfill one should not eliminate the possibility of an SSE impacting the site workers, first responders, the community, and/or the environment.



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# MEMORANDUM
# TODD THALHAMER, P.E.

Hammer Consulting Services; CA License # C055197; ltfire88@gmail.com; 530-391-2230

To: Ms. Brenda Ardrey, CGFM
Operations Section Chief
Solid Waste Management Program
Division of Environmental Quality
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

From: Todd Thalhamer, P.E.

Date: April 14, 2014

**RE: Addendum to the February 14, 2014 Comments on the Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill – Dated January 14, 2014**

Following my recent on-site visit to the Bridgeton Sanitary landfill on April 2-3, 2014 and having viewed the area where on March 21, 2014, a vegetation fire occurred at the south edge of the Bridgeton Sanitary Landfill's soil borrow area, a number of new issues related to impacts from a surface fire must be considered with regard to the Engineering Management Support, Inc. (EMSI) Report. During my preliminary assessment, I followed the outline of the EMSI Report and did not fully examine and report on the current site conditions and the issues that need to be evaluated and acted upon should a vegetation fire occur within the West Lake Landfill Complex in St. Louis, Missouri. At a minimum, the US EPA consultant needs to amend the report to include potential impacts to the Operable Units from a surface fire and the potential for such a fire to result in a subsurface smoldering event.

While these conditions were not evaluated nor discussed in the EMSI Report and were possibly not identified in the original scope of work, US EPA's consultant should examine the current site conditions (i.e., presence of brush and other vegetation within the Operable Units 1 and 2; characterization of waste including type and nature of chemicals and chemical compounds present in the waste mass and potential for reactions) and discuss the impacts from a wildland fire occurring within fenced areas of the West Lake Landfill Complex or from land adjacent to the complex.

My understanding is that the waste materials within Operable Unit 1, Area 1and Area 2 in addition to the radiologically impacted materials (RIM) have previously been stated as a combination of construction and demolition waste as well as some level of industrial and municipal solid waste, but to my knowledge these waste materials have never been adequately characterized to determine potential chemical reactions from the impacts of a surface fire which would include reactions to water or fire suppression products.

To further complicate this scenario, US EPA recently stated that RIM is known to exist outside the originally defined waste containment areas. US EPA's consultant needs to amend the report to consider whether a vegetation fire, not directly related to an SSE, has the potential to start within the Operable Areas shown in Figure 1 below or move into the Operable Areas from adjacent properties and should then evaluate and consider, at a minimum, the following questions:

- Has US EPA examined for any radiological uptake in the vegetation that has been allowed to grow within the Operable Units?
- How has US EPA accounted for storm water and erosion control issues in the past? And how would US EPA manage the storm water and erosion control once a fire has removed the vegetative cover from the Operable Units?
- Should the local fire agency even respond to a vegetation fire within the Operable Units? Or does this responsibility fall to US EPA personnel?
- If it is safe for the local fire agency to enter the radiological areas to extinguish a surface fire? What level of protection is needed for personnel to enter these areas?
- Should the vegetation just be allowed to burn off?
- What actions should be taken by the emergency management agencies and first responders to protect the first responders and the surrounding community from such a wildfire (i.e., resulting smoke plume and blowing materials, such as ash)?
- Is it possible for a vegetation fire (surface fire) to start a subsurface smoldering event within the Operable Units?
- What control methods have been implemented to prevent this from occurring? Should the heavy brush within the Operable Units be removed? Is the current cover in the Operable Units sufficient to prevent a surface fire from impacting the unclassified waste?

Lastly, with the recent slope movement at Bridgeton and slope failures at other landfills with smoldering events, the EMSI report should include a discussion of potential impacts from a slope failure or significant slope movement from a smoldering event.



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**Figure 1. Significant Vegetation Fire Risks at the West Lake Landfill Complex. St. Louis, Missouri. (Source Google Earth, 8/6/2012)**

**Missouri Department of Health and Senior Services**
P.O. Box 570, Jefferson City, MO 65102-0570 Phone: 573-751-6400 FAX: 573-751-6010
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**Gail Vasterling**
Director

**Jeremiah W. (Jay) Nixon**
Governor

April 24, 2014

Shawn Muenks, Program Manager
Federal Facilities Section, RRA Unit
Hazardous Waste Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO. 65102-0176

Re: The Missouri Department of Health and Senior Services' comments for the document *Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill*; January 14, 2014;

Dear Mr. Muenks:

The Missouri Department of Health and Senior Services (DHSS) has reviewed the referenced document, and provides the following comments.

**Executive Summary**

1. Bullet point items that address radon assume rapid dilution. However, an applicable or relevant and appropriate requirement (ARAR) has been established for flux rates of radon for this site under the Uranium Mill Tailings Radiation Control Act (UMTRCA). Therefore, identify the potential for exceedance of the ARAR based upon flux rates of radon.

2. Bullet point 2 appears to contradict the findings within Section 6.2, Thermal Impacts, regarding dust generation. Bullet point 2 identifies no excess offsite exposure to radiologically-impacted material (RIM) contaminated dust as a result of a subsurface smoldering event (SSE). Section 6.2 identifies the potential for destruction of vegetative cover resulting from an SSE, with adverse effects to include accelerated dust generation. The difference between the Executive Summary and Section 6.2 statement appears to be that the impacts discussed in the Executive Summary assumes that the remedy is in place; whereas impacts discussed in Section 6.2 are pre-remedy. Unfortunately, the Executive Summary does not make the distinction as to whether the impacts assume remedy-in-place or not.

   To eliminate confusion as to whether this bullet point references a pre-or post-remedy condition, clarify specifically whether the conclusions reached within the Executive Summary, and as necessary for other applicable sections of the report, are based upon pre-or post-remedial conditions.

For this statement specifically, if these conclusions are based upon pre-remedial conditions, the statement should be revised to identify a potential for redistribution of RIM due to wind, precipitation, or mechanical disturbances if cover is lost.

3. For the Executive Summary bullet point 3, clearly identify how the remedy design would address an increase in radon flux. The document clearly identifies radon flux rate is a function soil moisture, temperature, and porosity. Two of the soil conditions, moisture and temperature, are expected to increase as a result of an SSE. As a result, increased exhalation is expected from the landfill. An ARAR has been established for flux rates of radon for this site under the UMTRCA. Therefore, address the potential for exceedance of the UMTRCA ARAR.

   Not discussed in this report, and relevant to bullet point 3, is the potential to require a barrier placed over the surface of the landfill to control ambient flux of gases, similar to Bridgeton Landfill. If installed, a soil vapor extraction system (SVES) would be required. Include in the report potential impacts associated with installation of a cover and SVES for Westlake. Revise appropriate sections of this report as necessary.

4. The Executive Summary bullet point 4 cannot be stated given the potential for increased leaching, and potential increase flux of radon for exposure scenarios to include remedial workers onsite involved with a SSE. Also, please discuss the potential for redistribution of radon and radon progeny, nor are modeling results (i.e. RESRAD Offsite) provided in this report to support the theory that potential long-term risks will not occur. This support should be provided and based upon conditions contingent on the cap being in place. Potential impacts to the 2011 Supplemental Feasibility Study (SFS 2011) assuming use of a cover and SVES should be discussed within applicable sections of this document.

**Section 1, Introduction**

5. Section 1, page 2, paragraph 2 identifies conditions that have changed within the Bridgeton Landfill resulting from the SSE. Include in the list a decrease in the leachate quality (higher organic loading, chemical oxygen demand, volatile organic chemicals, etc.)

**Section 3, ROD-Selected Remedy**

6. Section 3, page 7, bullet point 3 recognizes a layer of cobble to be placed over the landfill. Discuss the potential for preferential migration through the cobble, and redistribution of radon and progeny within applicable sections of the document.

**Section 4, Potential ARARs Relative to an SSE**

7. Relative to Section 4, ARARs already established have been provided with a conditional, interpretive statement outlining how each ARAR will be applied to Westlake Landfill. DHSS recommends each ARAR-specific statement be revisited, further defining how the ARAR will apply in the event a SSE occurs.

Lacking chemical specific data resulting from a hypothetical SSE, applicability statements for chemical-specific ARARs should include provisions to modify their scope of coverage in the event a SSE occurs. See Table 5: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria, of the 2011 Supplemental Feasibility Study (SFS 2011) for the listing and applicability statement for each of the ARARs.

8. Discuss any impacts to the estimates of the magnitude of residual risks, as discussed in Section 6.2.1.3.1 of the SFS 2011, and the referenced Appendix H of the Record of Decision (ROD). Specifically, address potential impacts to short-term and long-term effectiveness criteria for both community and workers that may result from preparation for an SSE and in the event an SSE occurs. Both assessments should include risk from increased flux of radon and chemicals to ambient air and groundwater, for both community and workers. Discuss the potential need to reduce emissions through covering and landfill gas extraction, and potential impacts for both community and workers, including any exposures that cannot be controlled.

9. In addition to ARARs, cleanup levels based upon site-specific risk-related factors have been developed for this site. Section 3.4, Cleanup Levels, of the SFS 2011 provides discussion regarding these factors. In the event a contaminant is detected in a specified media, and no ARAR exists or the ARAR is not deemed adequately protective of human health, then a site-specific risk assessment may be required to identify cleanup goals. Alternatively, generic cleanup goals may also be utilized, including but not limited to, EPA Regional Screening Levels for chemical contaminants, or EPA preliminary remediation goals for radionuclides. The potential for use of these alternative factors should be recognized in this document.

10. Provide within Section 4 the list of ARARs that currently are anticipated to apply to a SSE if this document is to be a stand-alone addendum to the SFS. Bridgeton landfill emission data may be referenced for potential chemical-specific ARARs.

    Section 4 should include ambient air standards for radionuclide Nuclear Regulatory Commission 10 CFR 2, titled "Standards for Protection against Radiation, Appendix B to Part 20 - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage". DACs are being used for thorium, and can be applied to all site-related radionuclides. Also, given the list of chemicals of concern could include contaminants resulting from an SSE, sources of acute screening levels for ambient air, and National Ambient Air Quality Standards (NAAQS), where applicable, should be declared as to-be-considered (TBC) requirements. Although screening levels are not *de facto* cleanup standards, their use would be interim until further baseline investigation via risk assessment would be available.

    Similarly, ARARs relating to leachate will need to be addressed. Given a leachate recovery system does not exist beneath RIM-impacted fill, groundwater impacts from an SSE are possible. Therefore, condition of applicability of each water quality standards already chosen for each groundwater ARAR for this site should be modified to include the potential for additional chemicals resulting from leachate if an SSE should occur. Because the ROD list of chemicals of concern (COC) does not address an SSE, and COCs from an SSE cannot be predicted, note the

need for additional investigation being required within the conditional statement of applicability of groundwater ARARs for this site. If necessary, a baseline risk assessment to develop potential remediation goals and listing of additional ARARs may be required.

**Section 5 Potential Impacts of an SSE on the RIM**

11. For Section 5, potential impacts listed on page 10, redistribution of radionuclide from migration of radon and leaching of radionuclides to groundwater, or similar language, should be considered as a fifth potential impact.

12. Corresponding to an SSE under existing conditions, please discuss potential increased exposure by workers to RIM due to increased worker activity within Westlake Landfill to assess and address the SSE. This includes incidental ingestion of soil, inhalation of dust generated during their activity, and external exposures. As the baseline risk assessment does not assess exposures to the extent an SSE would involve, calculation of potential risks to workers may be warranted as part of short-term effectiveness. Discussion in this section regarding update of the baseline risk assessment and implications that apply to use of additional alternative criteria or guidance (i.e. acute screening levels for ambient air) that may apply to the SFS itself is warranted.

13. Not noted in section 5 is that leachate load would increase in groundwater. This has been demonstrated at Bridgeton, where organic and inorganic loads have increased significantly in the leachate collection system. Enhanced radionuclide concentrations would be expected due to disassociation of the radionuclide with organic constituents within the landfill matrix, and increased soil moisture due to exothermic reactions. Resettling of vapor generated by vaporization of entrained liquids in waste or condensation of a vapor front will generate increased leachate volumes. Further discussion on leachate volumes and potential groundwater impacts within this document is therefore warranted.

14. The potential for fissures within the surface soil to occur due to landfill volume reduction, and "settling" of the surface (as currently demonstrated at Bridgeton) should be evaluated. Emissions of radon should increase, as fissures allow for increased flux of soil gas to ambient air. The potential for uptake of surface water into a fissure would also be expected. Pooling and infiltration of surface water in depressions caused by settling is also anticipated. Further discussion of these potential occurrences is warranted.

15. Section 5.2, Increase in Subsurface Temperature, notes … "the heat that has been observed and/or could be generated within the landfill materials within West Lake Areas 1 and 2 could not approach the amount of heat necessary to melt (barium sulfate) or otherwise disrupt the stability of the RIM." Noting that the chemical compounds (form) of the radiounclides have not been determined for Westlake Landfill, the stability of the barium compound may have little or no impact on transport of radionuclides. Barium sulfate was more or less the name of a process waste, mixed with radionuclides and other metals. Whether this compound remains as the matrix for which radionuclide are affixed, or has degraded into or exists as other compounds has not been demonstrated. This comment should be substantiated with radionuclide-specific compound data, or qualified as discussed above. This is further discussed in Section 5.2, Increase in

Subsurface Temperature, emphasizing barium sulfate and its degradation. Amend all relevant sections of this document as necessary.

The long-term impacts associated with organic conversions due to exothermic degradation of landfilled materials and chemistry of the oxidation by-product materials both may have a significant impact on the transport characteristics of radionuclides through the landfill profile. Two pathways of concern include emanation of radon to ambient air and leaching of radionuclides to groundwater.

An assessment of trends with leachate sample results for metals at Bridgeton would also be an additional line of evidence that would provide fate and transport information for radionuclides. Results of investigations for other landfills post-SSE may also be valuable in determining potential long term transport issues. If significant, these findings should be presented in this document.

16. Section 5, Potential Impacts of an SSE on the RIM, page 10 lists four potential impacts to the subsurface in the event an SSE occurs. Lacking is a discussion of potential impacts due to oxidation of organic matter by a SSE, and corresponding fate and transport characteristics of the by-product. Providing this discussion will aid in further assessment of the potential for migration and redistribution of radionuclides.

17. This report, or the SFS, would benefit from a revised conceptual site models (CSM) assuming an SSE with and without the remedy in place. The CSMs would help visually define potential exposure pathway, identify fate and transport issues, and potential routes for redistribution of radon and its progeny. The potential for transport of radon within the course aggregate defined as the bio-intrusion marker should be addressed.

**Section 6, Potential Impacts of an SSE on the Rod-Selected Remedy**

18. Section 6 lacks discussion of potential consequences of radon redistribution, with respect to radon progeny, to the remedy. Of concern is accumulation of radon progeny within the cap. Discussion of potential increases of progeny in the cap is warranted. Potential controls including a synthetic vapor barrier may be considered.

If you have questions or comments, please contact Andrew McKinney at (573) 751-6102.

Sincerely,

Jonathan Garoutte, Chief
Bureau of Environmental Epidemiology

JF/DW/AM/vmp