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REVIEW OF THE SMALL-SCALE ROAD PILOT PROJECT ON PRIVATE LAND IN FLORIDA SUBMITTED BY MOSAIC FERTILIZER, LLC

October 1, 2024

U. S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation and Indoor Air

Radiation Protection Division

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Acronyms and Abbreviations:

CPG	Critical Population Group
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
EPA	Environmental Protection Agency
LR	Limerock
NESHAPs	National Emissions Standard for Hazardous Air Pollutants
ORIA	Office of Radiation and Indoor Air
PG	Phosphogypsum
Ra-226	Radium-226
RAP	Reclaimed asphalt pavement
RCA	Recycled concrete aggregate
RCRA	Resource Conservation and Recovery Act
TFI	The Fertilizer Institute

I. Executive Summary:

This document details the review performed by the U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Radiation Protection Division (EPA or the Agency), in response to the request for approval of the *Small-scale Road Pilot Project on Private Land in Florida* submitted by Mosaic Fertilizer, LLC in March 2022 (Mosaic 2022a), and updated by the *Revised Request for Approval of Use of Phosphogypsum in Small-scale Pilot Project*, submitted in August 2023 (Mosaic 2023).

The purpose of this review was to evaluate, via the processes identified in 40 CFR 61.206 and EPA guidance, whether the request and risk analysis submitted by Mosaic were sufficient to demonstrate that the project as proposed fell below risk thresholds previously defined by EPA for approval of other uses of phosphogypsum (also referred to as PG). Review of the Mosaic request was performed by a technical team led by the Radiation Protection Division in consultation with other EPA program offices.

The Agency's review found that Mosaic's request is complete per the requirements of 40 CFR 61.206(b). The review additionally found that Mosaic's risk assessment is technically acceptable, and that the potential radiological risks from the proposed project meet the regulatory requirements of 40 CFR 61.206(c); that is, the project poses no greater radiological risk than maintaining the phosphogypsum in a stack. Therefore, the small-scale pilot project may be approved by the Agency per 40 CFR 61.206. Approval by the Agency would be specific to the pilot project as described in the Mosaic request, and indicates only that this project meets the approval requirements of the Subpart R NESHAP. Mosaic must still comply with all other federal, state, or local laws, regulations, or restrictions on the use of phosphogypsum. Mosaic has informed EPA that it is seeking approval under the Subpart R NESHAP before seeking other regulatory approvals (Mosaic 2022b).

The risk analysis submitted by Mosaic is based upon the generic risk assessment scenarios previously submitted by The Fertilizer Institute (TFI) in 2019 to support road construction projects that could vary in location and design. EPA's review evaluated the current submission in the context of previous risk assessments and other technical work that has been performed on the topic of road use. The technical review concludes that the risk assessment submitted with this request is appropriate to evaluate the pilot project road built using phosphogypsum in the manner described in Mosaic's request. In cases where actual parameters of the proposed pilot project vary from the parameters used in the risk assessment calculations (e.g., the dimensions of the road and concentration of radium-226 [Ra-226] in phosphogypsum), the generic risk assessments overestimate the potential risks associated with the pilot project. Specifically, the generic risk assessments are based on roads that are longer, wider, and contain phosphogypsum with a higher concentration of radium-226, and therefore overestimate the potential dose from the proposed pilot project.

§61.206 requires that to be approved, a proposed use must be at least as protective as maintaining the phosphogypsum in a stack. EPA further defined this benchmark as causing an additional lifetime risk of fatal cancer no greater than 3×10^{-4} (3 in 10,000, or .03%) (57 FR 23311-23312, June 3, 1992). Mosaic's risk analysis states that numerical estimates of the total lifetime risks of fatal cancer to workers moving phosphogypsum and constructing the project are less than 2×10^{-6} (2 in 1,000,000, or .0002%). Estimated risks to users of the road (facility employees not associated with construction of

the pilot project) are significantly less than 1×10^{-6} (1 in 1,000,000, or .0001%). Estimates of risk to the nearest members of the public are likewise significantly less than 1×10^{-6}. EPA's review supports Mosaic's statement that "…the radiological risk for the 2022 Mosaic Pilot Study is likely less than 1 in 1 million," (Mosaic 2022a, p. 6), and based on EPA's evaluation of the risk assessment, the proposed project study meets the Agency's threshold value and risks to workers and the public will not exceed 3×10^{-4} (3 in 10,000, or .03%). From a technical standpoint, therefore, the risk of this use can be considered to be no greater than the risk of maintaining the phosphogypsum in a stack.

The risks analyzed in this document are the risks associated with this specific project, and this review does not imply approval of any other request. Any use other than the pilot project addressed by this report would require a specific separate application, risk assessment, and review. EPA's full review process, including risk assessment, must take place for each request for other use of phosphogypsum, and approvals are granted on a case-by-case basis.

II. Content of Mosaic's Request Submitted to EPA:

Mosaic requested meetings with EPA in December 2021, and in March 2022 to discuss submission of a request for approval of a pilot project using phosphogypsum in road base. Mosaic submitted a draft request under §61.206 on March 18, 2022 and a final request on March 31, 2022. In this request, Mosaic identified that they would like to construct, in collaboration with researchers at the University of Florida, a small-scale pilot project using phosphogypsum in road base in test road sections on Mosaic's New Wales facility. Mosaic requested to construct three 200-foot sections of road with varying mixtures of phosphogypsum in the road base in order "to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge construction." (Mosaic 2022a, p. 4) After reviewing Mosaic's initial request, EPA submitted questions on September 9, 2022, via email, and Mosaic provided additional information in response to EPA's questions on December 22, 2022. On August 23, 2023, Mosaic sent EPA a revised request for approval that changed several of the pilot road study specifications after receiving input from the Florida Department of Transportation (Florida DOT, or FDOT). The main design changes include: 1) increasing the length of the test sections from 200 feet to 500 feet, 2) increasing the length of the control sections from 200 feet to 300 feet, 3) adding one more set of test and control sections for evaluating a mixture of phosphogypsum and reclaimed asphalt pavement (RAP). These changes result in the total length of the pilot road increasing to 3200 feet and the total amount of PG to be used to approximately 1200 tons. Soil, groundwater, and lysimeter monitoring for all sections will also be expanded (Townsend et al., 2024).

The phosphogypsum used in the project will come from the New Wales South stack. Sampling performed to date indicates that phosphogypsum from the stack has an average radium-226 activity concentration of approximately .56 bequerel per gram (Bq/g), or 15.1 picocuries per gram (pCi/g) (Mosaic 2022a). The test sections of road will be 7.3 meters (24 feet) in width and the road base containing phosphogypsum will be 25.4 centimeters (10 inches) in thickness, with a density ranging from 1.8-2.0 g/cm^3 (115-126 lb/ft^3). The project road will be paved with 10 centimeters (4 inches) of asphalt, and the pavement will not contain phosphogypsum (Townsend et al., 2024). See Figure 3 for a schematic cross section of the road.

Figure 1: Overhead view of New Wales facility. Location of the pilot project road and nearest residence are highlighted. Mosaic property is shown in blue (Mosaic 2024b).

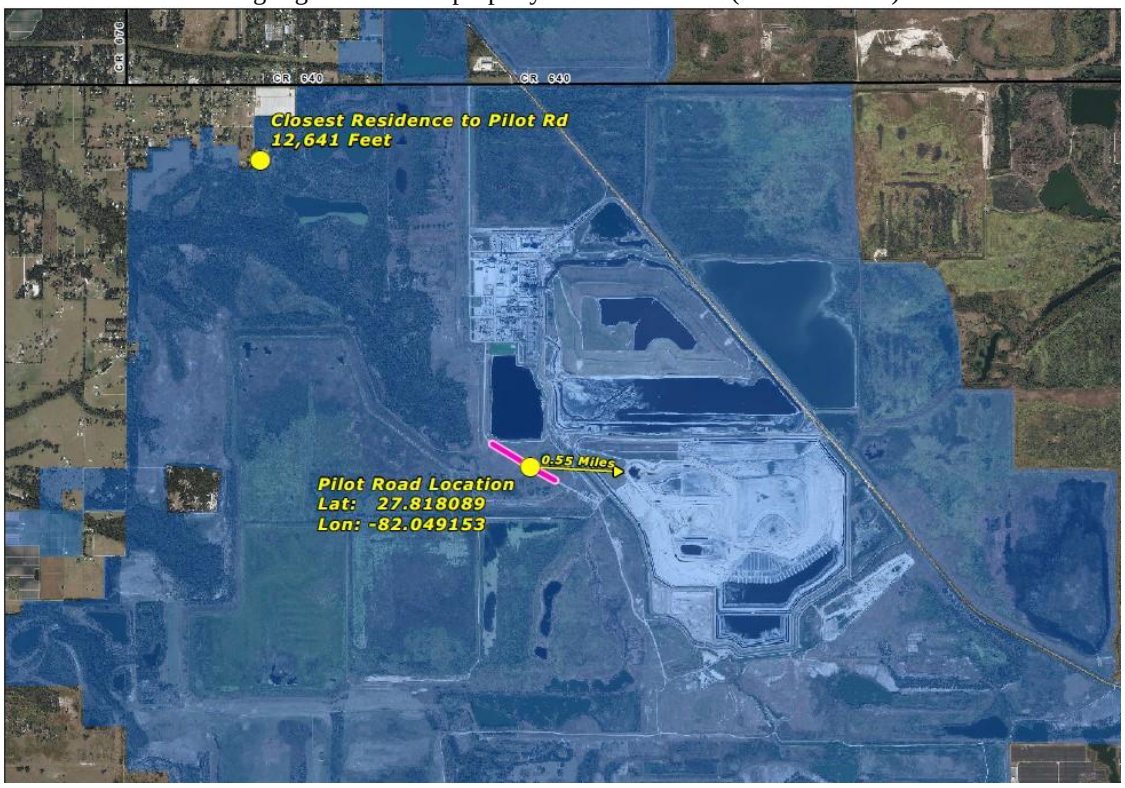
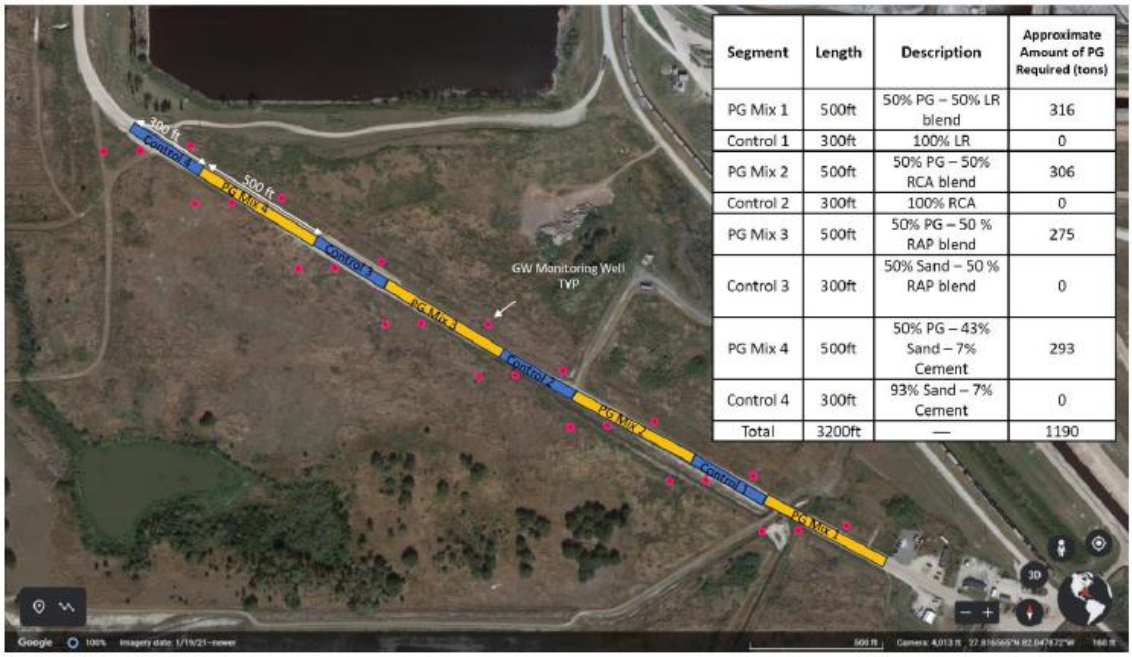
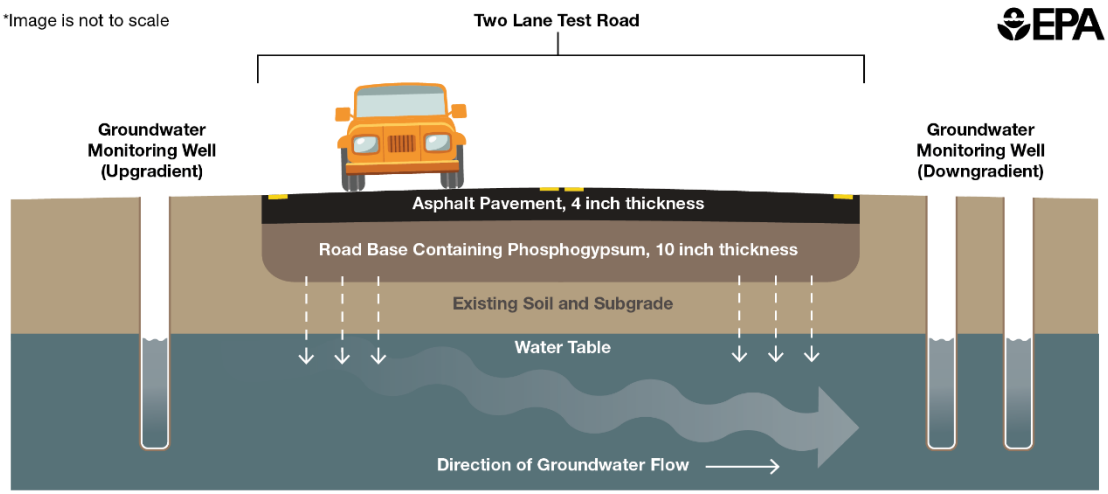


Figure 2: Overhead view of the revised, lengthened pilot project. Test sections are depicted in yellow, control sections in blue, and groundwater monitoring well locations in magenta.



Segment	Length	Description	Approximate Amount of PG Required (tons)
PG Mix 1	500ft	50% PG – 50% LR blend	316
Control 1	300ft	100% LR	0
PG Mix 2	500ft	50% PG – 50% RCA blend	306
Control 2	300ft	100% RCA	0
PG Mix 3	500ft	50% PG – 50 % RAP blend	275
Control 3	300ft	50% Sand – 50 % RAP blend	0
PG Mix 4	500ft	50% PG – 43% Sand – 7% Cement	293
Control 4	300ft	93% Sand – 7% Cement	0
Total	3200ft	—	1190

Figure 3: Cross-section of the proposed pilot project road.



Mosaic developed its risk assessment by adapting the generic risk assessments for road use prepared for the Fertilizer Institute (Arcadis 2019) to the specific scenarios associated with the proposed pilot project. The risk assessment documentation was incorporated into Mosaic's request by reference, and is discussed in detail below, in "Results of Risk Assessment." After reviewing Mosaic's initial request, EPA submitted questions on September 9, 2022, via email, and Mosaic provided additional information in response to EPA's questions on December 22, 2022. Mosaic submitted its revised application dated August 23, 2023. EPA held a virtual meeting with Mosaic in November 2023 and submitted additional questions by email on December 15, 2023. Mosaic provided responses to those questions on February 7, 2024. EPA's analyses are based on the full suite of information submitted by Mosaic.

Mosiac's submissions related to the proposed pilot project are listed below, in chronological order of reciept:

March 31, 2022: *Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 C.F.R § 61.206, Small-scale Road Pilot Project on Private Land in Florida.* (Mosaic 2022a.) This document contains the formal request by Mosaic. The risk assessment and radiological monitoring plan, both by Arcadis, are included in the document as Appendices 9 and 10.

December 22, 2022: *Response to EPA September 9, 2022 Request for Information; Small-scale Pilot Project*. (Mosaic 2022b.) This document responds to EPA questions and describes leach testing results, modeling results, and site hydrogeology.

August 23, 2023: *Revised Request for Approval of Use of Phosphogypsum in Small-scale Pilot Project*. (Mosaic 2023) Cover letter from Pat Kane to Jonathan Walsh describes changes made to the proposed project. *Phosphogypsum – Road Pilot Study – Radiological Risk Review – Update* (Arcadis 2023) is attached to this correspondence.

February 7, 2024: *Request for Approval of Use of Phosphogypsum in Small-scale Pilot Project; November 27, 2023, Meeting; Response to Questions*. (Mosaic 2024a). Question responses and Mosaic presentation slides in body of letter. Environmental study design document, *Beneficial Use of Mosaic Phosphogypsum* (Townsend, et al. 2024) attached, together with other reference materials on phosphogypsum road use.

March 26, 2024: Updated map provided at EPA's request (Mosaic 2024b).

III. Scope of EPA's review:

40 CFR §61.206 sets the requirements for a request for other uses of phosphogypsum. The purpose of this review was to determine whether the requirements of §61.206 have been met, to inform a decision by the Assistant Administrator for Air and Radiation.

The technical review is primarily focused on radiological risk posed by the pilot project, which is the basis for the regulation of phosphogypsum under the Clean Air Act and approval of other uses of phosphogypsum under 40 CFR §61.206, the text of which is included below. EPA additionally used its completeness review to fully document the pilot project, including design of the environmental studies that address both radiological and non-radiological contaminants associated with the project. Approval under 40 CFR §61.206 does not relieve Mosaic of the responsibility to comply with other federal, state, or local laws, regulations, or restrictions on the use of phosphogypsum. The relevant section of the regulation is included below:

A. § 61.206 Distribution and use of phosphogypsum for other purposes.

(a) Phosphogypsum may not be lawfully removed from a stack and distributed or used for any purpose not expressly specified in § 61.204 or § 61.205 without prior EPA approval.

(b) A request that EPA approve distribution and/or use of phosphogypsum for any other purpose must be submitted in writing and must contain the following information:

(1) The name and address of the person(s) making the request.

(2) A description of the proposed use, including any handling and processing that the phosphogypsum will undergo.

(3) The location of each facility, including suite and/or building number, street, city, county, state, and zip code, where any use, handling, or processing of the phosphogypsum will take place.

(4) The mailing address of each facility where any use, handling, or processing of the phosphogypsum will take place, if different from paragraph (b)(3) of this section.

(5) The quantity of phosphogypsum to be used by each facility.

(6) The average concentration of radium-226 in the phosphogypsum to be used.

(7) A description of any measures which will be taken to prevent the uncontrolled release of phosphogypsum into the environment.

(8) An estimate of the maximum individual risk, risk distribution, and incidence associated with the proposed use, including the ultimate disposition of the phosphogypsum or any product in which the phosphogypsum is incorporated.

(9) A description of the intended disposition of any unused phosphogypsum.

(10) Each request shall be signed and dated by a corporate officer or public official in charge of the facility.

(c) The Assistant Administrator for Air and Radiation may decide to grant a request that EPA approve distribution and/or use of phosphogypsum if he determines that the proposed distribution and/or use is at lease as protective of public health, in both the short term and the long term, as disposal of phosphogypsum in a stack or a mine.

(d) If the Assistant Administrator for Air and Radiation decides to grant a request that EPA approve distribution and/or use of phosphogypsum for a specified purpose, each of the following requirements shall be satisfied:

(1) The owner or operator of the stack from which the phosphogypsum is removed shall determine annually the average radium-226 concentration at the location in the stack from which the phosphogypsum will be removed, as provided by § 61.207.

(2) All phosphogypsum distributed in commerce by the owner or operator of a phosphogypsum stack, or by a distributor, retailer, or reseller, or purchased by the end-user, shall be accompanied at all times by certification documents which conform to the requirements § 61.208.

(3) The end-user of the phosphogypsum shall maintain records which conform to the requirements of § 61.209(c).

(e) If the Assistant Administrator for Air and Radiation decides to grant a request that EPA approve distribution and/or use of phosphogypsum for a specified purpose, the Assistant Administrator may decide to impose additional terms or conditions governing such distribution or use. In appropriate circumstances, the Assistant Administrator may also decide to waive or modify the recordkeeping requirements established by § 61.209(c).

IV. Structure of EPA's review:

EPA published a guidance document titled "Applying to EPA for Approval of Other Uses of Phosphogypsum: Preparing and Submitting a Complete Petition Under 40 CFR 61.206" (EPA 2005), hereafter referred to as the "Workbook", to clarify expectations for submissions and reviews for other uses of phosphogypsum. EPA's review was structured according to Section 2.4 of the Workbook, *What steps will EPA take to review and approve my petition?* Per the Workbook, EPA's process is to first determine whether sufficient information has been submitted by any applicant to be considered a complete application, and then to perform a technical review of the information submitted.

This document reflects the findings of EPA ORIA's completeness and technical reviews, and has been crafted to support an EPA decision on a request for other use per §61.206. Should EPA publish a notice of pending approval, then this review document, together with all materials submitted and cited by Mosaic, will be made available for public review and comment. Adverse comments will be addressed before a final approval of the project is issued.

V. Results of EPA's Completeness Review:

The purpose of the completeness review is to determine whether EPA has received all of the information required by the regulation in sufficient detail to review a request and draw conclusions.

Section 2.4 of the Workbook identifies three elements of a completeness review:

> *Element 1: A demonstration that the potential radiological risk from the alternative use is at least as protective as placement of phosphogypsum in a stack or mine.*

Mosaic has provided a complete description of the intended pilot project, including detailed explanations of why the exposure scenarios for the proposed project are bounded by the parameters of the generic risk assessments developed for TFI. See the Mosaic 2022a, Appendix 9, *Radiological Risk Review*, and Arcadis 2023, *Phosphogypsum – Road Pilot Study – Radiological Risk Review - Update*. Sufficient information has been provided to allow EPA to perform a technical review of risks to the public from the proposed pilot project. EPA's review is documented in the section of this document titled "Results of EPA's Technical Review."

> *Element 2: A description of the proposed monitoring scheme covering both radiological and non-radiological parameters, with sufficient detail to demonstrate that the project does not adversely affect the environment, or a justification for why monitoring is not needed.*

Initial information on Mosaic's environmental sampling and monitoring plans are described in Appendix 10 of its March 2022 request, *Proposed Monitoring Plan*. The petition commits to dosimetry for contract workers building the road, radon and radioactive particulate air sampling, and gamma radiation rate measurements before and after construction (Mosaic 2022a, p. 4). Groundwater monitoring will address both radiological and non-radiological parameters (Mosaic 2022a, pp. 4, 5; Townsend et al. 2024). The Agency maintains the ability to condition any proposed approval upon specific requirements for radiological monitoring and sampling, as deemed necessary.

In its December 2022 response to questions sent by EPA, Mosaic provided additional information on the consideration of groundwater, as well as its reasoning for focusing on sampling groundwater, rather than surface water or the unsaturated zone. Detailed information on initial modeling results and planned groundwater studies is included in *Beneficial Use of Mosaic Phosphogypsum* (Townsend et al 2024). Additionally, Mosaic will need to remain in compliance with the groundwater protection requirements of its wastewater permit with the state of Florida, in addition to the state's permitting requirements under the National Pollution Discharge Elimination System.

> *Element 3: Some discussion and documentation that the description of the project lies within generally accepted methodologies for such research, and that the proposed use is legitimate (i.e., not considered "disposal").*

Road construction using phosphogypsum was identified as a potential use for phosphogypsum at the time Subpart R was amended to allow the approval of alternate uses. The radiological risks from this use were evaluated by EPA in the background document to the amended rule (EPA 1992). The stated goal of the project is to demonstrate that phosphogypsum mixtures are able to meet the materials engineering specifications of the Florida DOT.

Legal requirements for a complete request are listed at 40 CFR 61.206(b), and included in Section III of this report, Scope of EPA's Review. Section B. 1. of Mosaic's 2022 request, *Components of the Petition*, lists relevant information for each requirement in the order that they are listed in §61.206 (Mosaic 2022a, p. 11). Appendix B of the EPA Workbook includes a completeness checklist. It is included below. Checklist items from the Workbook are listed in italics, each followed by the information provided by Mosaic relevant to that checklist item:

Petition Completeness Checklist

• *The name and address of the person(s) making the request*.

Patrick Kane, Vice President, EHS Enterprise Operations
13830 Circa Crossing Drive, Lithia, FL 33547

• *A description of the proposed use(s), including the following:*

A detailed description of the small-scale study (field test, control test, QA/QC Plans, illustrative diagrams/pictures)

Descriptions of the proposed project and tests are found in Mosaic 2023, Arcadis 2023, and Townsend et al. 2024. Key elements of the proposed project are summarized in the introductory section of this report and discussed in the technical review section.

How the phosphogypsum will be handled or processed during each stage of the study, including closure (if applicable)

Techniques used to blend the phosphogypsum with aggregate materials and construct the road are described in Mosaic 2022a, Appendix 9, *Radiological Risk Review*, page 3.

Goals of the study and how performance will be measured

"The purpose of the small-scale pilot is to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge construction." (Mosaic 2022a, p. 4)

Characteristics of the phosphogypsum to be used (radium-226 concentration, as defined below, as well as analyses of other characteristics of the waste such as toxic or hazardous constituents and mobility of constituents, presence of hazardous air pollutants)

Notice that the analyses described above exist, and provide those analyses to any potential user upon request.

Radium concentration in the source phosphogypsum is included in Mosaic2022a, Appendix 12, *New Wales Stack Data*. Information on radiological and non-radiologial parameters is included in Mosaic 2022b, Item 1, p. 2. Leach testing for non-radiological parameters has been performed and is described in Townsend et al. 2023.

• *The location of each facility, including suite and/or building number, street, city, county, state, and zip code, where any use, handling, or processing of the phosphogypsum will take place. If the mailing address is different, provide it too.*

Mosaic New Wales Stack, 3095 Hwy 640, W. Mulberry, FL 33860 (Mosaic 2022a, p. 11)
Map coordinates are included in Mosaic 2022a, Appendix 11, *Site Map – Location of Road* and Mosaic 2024b.

• *The quantity of phosphogypsum to be used by each facility.*

Identified in the revised Mosaic request as "approximately 1200 tons." (Mosaic 2023, p. 2)

• *The average concentration of radium-226 in the phosphogypsum to be used. This information may be available from the owner of the stack. The sampling must have been done within the past 12 months according to the procedures in 40 CFR 61.207. Include a copy of the necessary 40 CFR 61.208 certification with your petition.*

The Petition Completeness Checklist included in the guidance exceeds the legal requirements of the regulation; §61.206(b)(6) requires only "The average concentration of radium-226 in the phosphogypsum to be used" for purposes of the request. Mosaic has included summary data for Ra-226 sampling in Mosaic 2022a, Appendix 12, *New Wales Stack Data*. EPA has determined that these sampling results, as reported, are adequate for the purposes of reviewing the small-scale pilot project. More refined sampling is not required for the application, because the risk assessment scenarios reviewed by EPA are based on Ra-226 activity concentration values that are roughly double the average value reported by Mosaic. The conclusions of the risk assessment will remain valid even if the Ra-226 activity in the phosphogypsum that is used turns out to be higher. Should the project be approved, §61.206(d) requires that sampling that conforms with §61.207 must be performed on the actual phosphogypsum used for the project, and repeated annually for the duration of phosphogypsum removal from the stack.

• *A description of any measures which will be taken to prevent the uncontrolled release of radium-226, radon, or other hazardous constituents into the environment. This includes description of any monitoring plans for air and water pathways and worker exposure,leak prevention programs, and QA/QC measures.*

Handling of phosphogypsum is described in Mosaic 2022a, p. 12.

Appendix 10, *Proposed Monitoring Plan* (p. 4) describes radiological sampling including dosimetry, radon and radioactive particulate air sampling, and gamma rate measurements.

• *An estimate of the maximum individual risk and incidence associated with the proposed use, including the ultimate disposition of the phosphogypsum or any product in which the phosphogypsum is incorporated. Include a copy of the risk assessment procedures, assumptions, and results. If you use a non-EPA model, provide a copy of the model and all needed documentation to understand and use the model.*

As stated in Section 2, Scope of the Petition, "The Petition calculates the risk of the small-scale pilot road study by adjusting the risk determined in the October 2019 and April 7, 2020 TFI risk assessments based on the shorter duration of exposure for the pilot study. Mosaic adjusted the exposure times to reflect the exposures for the Pilot Study." Quantitative risk estimates are contained in Mosaic

2022a Appendix 9, *Radiological Risk Review*. EPA's review of the risk assessment is detailed in the section of this document titled "Results of EPA's Technical Review".

• *How the phosphogypsum will be handled at the study site, including procedures to prevent unauthorized access and handling of excess materials.*

The pilot project will be located on an access-controlled private industrial site. Section I, Components of the Petition, states that "Mosaic employees will handle all offloading of PG from the stack to trucks used to haul PG to road site. PG will be unloaded to a prepared staging area for mixing with aggregates as described in Section II and Appendix 9. All PG will be handled consistent with FDOT requirements for road construction" (Mosaic 2022a p.12). Techniques used to blend the phosphogypsum and construct the road are further described in Appendix 9, *Radiological Risk Review*, page 3. Section I additionally states that "Any unused phosphogypsum will be returned to the stack."

• *Description of the effectiveness and benefit of the proposed use.*

The stated purpose of the study is that it will establish whether phosphogypsum road construction can meet performance requirements regulated by FDOT: "The purpose of the small-scale pilot is to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge construction." (Mosaic 2022a, p. 4)

• *Description of any other Federal, state, and/or local requirements affected by the proposed use and how they will be satisfied.*

Beneficial use of phosphogypsum is currently regulated under the Florida Solid Waste Management Act, and approval will be required from the Florida Department of Environmental Protection for the pilot project to proceed. . (Mosaic 2022a, Section 9, p. 17, *Florida Beneficial Use Requirements*). This requirement may change due to the passage of Florida's H.R. 1191. Mosaic (2023) describes the changes as follows: "Under Florida's H.R. 1191, FDOT will determine whether PG is suitable for use in road construction aggregate. If that determination is made, by law, PG would be exempt from state regulation as a solid waste and would no longer require FDEP approval under the beneficial use regulations as explained in Section 9 and 10 of Mosaic's March 31, 2022 Petition. Under that scenario, PG would be allowed to be used as road construction aggregate consistent with applicable federal and other state regulations."

Mosaic has entered into a consent decree with the Florida Department of Environmental Protection and the U.S. EPA under the Resource Conservation and Recovery Act, which places additional requirements on the management, use, removal, placement and reuse of phosphogypsum in and from the New Wales stacks. The permissibility of removing phosphogypsum for the purposes of this pilot project under the consent order is technically and legally distinct from consideration of the request under 40 CFR Part 61 Subpart R, and is overseen by FDEP and the EPA Office of Enforcement and Compliance Assurance. Mosaic has informed EPA that it is seeking approval under the Subpart R NESHAP before seeking additional approvals (Mosaic 2022b).

• *Correspondence with Federal, State, County or municipal authorities charged with administering those requirements.*

Response to EPA September 9, 2022, Request for Information, Introduction (p. 1) describes preliminary interactions with FDEP regarding Mosaic's eventual request for regulatory approval.

• *Description of any recordkeeping and reporting procedures, including the certification requirements, and how they will be met.*

Basic recordkeeping requirements are described in §61.206(d). Record keeping and reporting requirements will be specified as conditions of EPA's approval, as deemed necessary.

• *Each request shall be signed and dated by a corporate officer or public official in charge of the facility.*

A signature page is included in the March 2022 Mosaic request (Mosaic 2022a) and in the 2023 revised request (Mosaic 2023). Both are signed by Patrick Kane, Vice President, Operations Services, North America.

Based on the results of this completeness review, EPA transmitted an updated[1] completeness determination to Mosaic on May 20, 2024.

[1] Based on a review of the request on March 31, 2022 (Mosaic, 2022a), and additional information provided on December 22, 2022 in response to EPA's questions (*Response to EPA September 9, 2022, Request for Information*), EPA transmitted a completeness determination to Mosaic on March 17, 2023 (EPA 2023).

VI. Results of EPA's Technical Review:

§61.206(b)(8) of Subpart R requires that any request include "An estimate of the maximum individual risk, risk distribution, and incidence associated with the proposed use, including the ultimate disposition of the phosphogypsum or any product in which the phosphogypsum is incorporated." The purpose of this risk assessment is to evaluate the request according to the legal threshold for potential approval: "The Assistant Administrator for Air and Radiation may decide to grant a request that EPA approve distribution and/or use of phosphogypsum if he determines that the proposed distribution and/or use is at leas[t] as protective of public health, in both the short term and the long term, as disposal of phosphogypsum in a stack or a mine." (40 CFR 61.206(c)) Risk, in this context, means the additional total risk of contracting a fatal cancer due to an individual's exposure to a carcinogen, in this case, radionuclides. This is additional, incremental risk beyond the risk due to background and other exposures. In the Federal Register notice associated with amendments to Subpart R, EPA interpreted an individual lifetime risk of fatal cancer risk of approximately 3×10^{-4} as a threshold for approving other uses of phosphogypsum. (57 FR 23311-23312, June 3, 1992). This means that if risk assessments show that a proposed use of phosphogypsum will not increase the fatal radiogenic cancer risk of any individual by more than 3 in ten thousand, or .03%, it meets regulatory requirements and may be approved.

As discussed above, the risk assessment and technical review are presented in terms of total risk of fatal radiogenic cancer. The general method for radiological risk assessment is to multiply the rate of exposure by the time of exposure, and then to multiply the total exposure by the risk per unit of exposure. Mosaic developed its risk assessment by adapting generic risk assessment scenarios for road use prepared by TFI to the proposed pilot project[2, 3]. As stated in the Mosaic request, "The risk assessment for this 2022 Mosaic Petition calculates the risk of the small-scale pilot road study by adjusting the risk determined in the TFI risk assessments to account for the shorter duration of exposure and smaller size of the pilot study (Mosaic 2022a, p. 5)." Mosaic informed EPA of its intention to use this approach prior to submitting this request, and EPA agrees with its fundamental validity; it is permissible to use conservative bounding calculations to demonstrate compliance with a risk threshold.

EPA has reviewed the technical materials submitted by Mosaic for completeness and for technical accuracy. EPA evaluated the risk assessment materials submitted in support of this request in a manner that is consistent with risk assessments previously performed in support of 40 CFR part 61, and with the EPA's established practices for radiological risk assessment. Although EPA conducted a detailed

[2] The original risk assessments may be found in "Radiological Risk Assessment in Support of Petition for Beneficial Use of Phosphogypsum," prepared by Arcadis, submitted as Appendix 2 to the TFI October 2019 request, and retained as Appendix 2 to TFI's April 2020 revised request (TFI, 2020).

[3] Although approval of the TFI request was rescinded, this decision was made on procedural and legal grounds: " …EPA decides that it was premature for the Agency to approve the proposed use without all of the information specified as constituting a proper request under § 61.206(b). …This decision is without prejudice to a subsequent or further proper request under § 61.206 for approval of the use of phosphogypsum for other purposes that contains the information required by § 61.206(b) 86 FR 35795."

review of TFI's generic risk assessment calculations for phosphogypsum in road construction[4], it did not "approve" them per se, but directly compared TFI's risk assessment results to risk assessments of road use scenarios developed by the EPA's 1992 Background Information Document (BID) for the final rule and drew conclusions for each exposure scenario. (EPA 2020). This review also compares the results from independent modeling approaches for applicable exposure scenarios to draw conclusions about the radiological risks from the use of phosphogypsum in the proposed pilot project.

Discussion of Parameters:

For the purposes of these risk assessment intercomparisons, several things should be noted:

Total risk: Stochastic risks from low levels of ionizing radiation are assumed to be directly proportional to dose, independent of dose rate. Total risks are developed first by calculating a rate of exposure risk per unit time of exposure, and then multiplying this by the duration of exposure. Throughout this report, risk estimates developed for an annual or lifetime exposure are scaled to reflect the actual exposure times that are expected to result from this pilot project. This is consistent with previous risk assessments for uses of phosphogypsum.

Road design: The dose rates in each exposure scenario depend on the geometry of the source. The road design proposed for this project is smaller than both of the road designs used to develop previous risk assessments (see Table 1 for project comparison). Road dimensions for the small-scale pilot project are described in Appendix 9 of the Mosaic request (Mosaic 2022a), and in Section 2.2 of Townsend et al. (2024).

Four test mixtures for road base will be evaluated. Per the original application, "In Mix design 1, PG will be blended with limerock (LR) sourced from an FDOT approved aggregate supplier (for B01 aggregate). In Mix design 2, PG will be blended with recycled concrete aggregate (RCA) sourced from a FDOT approved aggregate supplier (for B12 aggregate). The sources of the LR and RCA aggregates will be aggregate suppliers in the Tampa, Florida area….Mix design 3 will include PG (no more than 50%), sand, and Type I portland cement" (Mosaic 2022, Appendix 9). Mosaic revised its request to add an additional test section, in which the road base will be composed of no more than 50% PG mixed with reclaimed asphalt pavement (RAP) (Mosaic 2023).

The test sections of road will be 7.3 meters (24 feet) in width and 152.5 meters (500 feet) in length (see Figure 2). The road base containing phosphogypsum will be 25.4 centimeters (10 inches) in thickness, with a density ranging from 1.8-2.0 g/cm^3 (115- 126 lb/ft^3). 10 centimeters (4 inches) of asphalt pavement will not contain PG. The total amount of PG to be used is approximately 1200 tons (Mosaic 2023).

The road modeled in the 1992 BID included a road base that was 9.15 meters (30 feet) wide and 25 centimeters (9.8 inches) thick and a road surface 7.32 meters (24 feet) wide and 12 cm (4.9 inches) thick. In the BID, the road surface was assumed to be either concrete containing 15% phosphogypsum by weight, or asphalt containing no phosphogypsum, and the road base was assumed to be composed

[4] At that time, a technical contractor performed a detailed review of the dose and risk modeling performed, including parametrization, model calculations, and exploration of additional exposure scenarios (SC&A 2020).

of one part phosphogypsum by wieght and two parts of either sand or clay. The density of the road surface and road base were both assumed to be 2.25 g/cm^3.

The road modeled in the 2019 TFI request was a four-lane road with a road base and road surface both 15.24 meters (50 feet) wide. The thickness of the road base and road surface in the TFI request were 25 and 12 centimeters thick, respectively. The road surface was assumed to be concrete with 2.25% phosphogypsum by weight, and the road base was assumed to be composed of equal parts phosphogypsum and soil by weight. The density of the road surface and road base were both assumed to be 2.25 g/cm^3. The thicknesses and densities were the same as those in the 1992 BID.

While the BID and TFI risk assessments assume the presence of phosphogypsum in the concrete pavement, Mosaic's request indicates that phosphogypsum will not be incorporated into the asphalt pavement of the test project. Because the road proposed for the Mosaic pilot project is narrower, shorter, and contains no phosphogypsum in its pavement, the radiological exposures and risk calculations described in the following sections overestimate the actual risks associated with this pilot project to some degree.

Table 1: Variations in Road Designs between the 1992 BID, TFI Request, and Mosaic Request

Road Parameter	BID	TFI	Mosaic
Road Width	9.15 m (30 ft)	15.24 m (50 ft)	7.3 m (24 ft)
Base thickness	25 cm (9.8 in)	25 cm (9.8 in)	25.4 cm (10 in)
Base Density	2.25 g/cm^3	2.25 g/cm^3	1.85-2.02 g/cm^3
Surface Thickness	12 cm (4.9 in)	12 cm (4.9 in)	10 cm (4 in)
Composition	PG in base and surface	PG in base and surface	PG in base only
Percent PG by weight	15% in road surface, 33% in road base	2.25% in road surface, 50% in road base	Up to 50% in road base

Concentration of Ra-226: For these risk assessment scenarios, dose rates and risk may be scaled linearly based on the concentration of Ra-226 in the phosphogypsum used. The TFI risk assessment was based on an activity of 1 Bq/g (27 pCi/g), and Mosaic carried that assumption forward into its current request. EPA based its 2020 analyses on a Ra-226 concentration of 1.3 Bq/g (35 pCi/g), to be certain that the generic risk assessments would be inclusive of all domestic sources of phosphogypsum. In this document, the EPA also scaled each risk calculation to the higher concentration (i.e., 1.3 Bq/g) as the basis for the detailed discussion of each scenario. Mosaic's submission reports that the mean

concentration of Ra-226 in samples taken from its New Wales stack is .56 Bq/g (15.1 pCi/g) (Mosaic 2022a, Attachment 12), which will be confirmed by detailed analyses required by §61.207 should the project be approved. Because the risk assessments assume higher Ra-226 concentrations than the phosphogypsum proposed for use in the small-scale pilot project, the risk assessments contained in this document likely overestimate the actual risks associated with this pilot project.

Table 2, below, summarizes the risk ranges for the scenarios discussed above as calculated by both EPA and TFI:

Table 2: Total Risks from the Proposed Pilot Project

Scenarios (Exposure Duration)	Total Risk
Road Construction Worker	$< 2.0\times10^{-6}$
Truck Driver Transporting PG	2.7×10^{-7}
Road User (site employee)	$< 1.0\times10^{-6}$
Nearby Resident	$<1.0\times10^{-6}$

The Mosaic request quantitatively modeled exposure scenarios for a truck driver transporting phosphogypsum from the stack to the construction site and a road construction worker building the pilot project and qualitatively discussed the risk to a utility worker, a road user, the resident nearest the road, and a reclaimer (Appendix 9, Table 3). Each scenario is discussed below:

Truck Driver:

In Table 3 (Appendix 9, p. 8) Mosaic reports a 0.016 mSv (1.6 mrem) potential dose to a truck driver transporting phosphogypsum from the stack to the location of the pilot project. The basis of this estimate was scaling this scenario as presented in the 2019 TFI risk assessment from a five-year exposure to a one-month exposure; that is, a reduction in the total dose by a factor of 60.

A truck driver was not modeled in EPA's 1992 BID. The 2019 TFI risk assessment estimated the dose and risk to a truck driver transporting phosphogypsum to the road construction site by using MicroShield® to model direct exposure to a dose point one meter from the center of the front face (where the driver would be sitting), using a rectangular volume of the dimensions of the standard roll-off (5.2 meters long, 1.4 meters high and 2.1 meters wide), typical for a 20-ton dump truck. The volume was assumed to be filled with uncompacted phosphogypsum with a density of 1.12 g/cm^3 and a Ra-226 concentration of 1.0 Bq/g (27 pCi/g), in secular equilibrium with its decay products. The driver works for 2000 hours per year, with the truck full for half of that time (1000 hr). Shielding effects from the truck cab were not considered. The calculated dose to the driver was 0.186 mSv/yr (18.6 mrem/yr) for the one month of exposure during project construction assuming a Ra-226 concentration of 1.0 Bq/g (27 pCi/g), or a risk of 2.0×10^{-6} per year.

One month of exposure would result in a total risk of 2.1×10^{-7}. This is a conservative estimate, because shielding from the truck and cab is not taken into account. The total risk to a truck driver hauling

phosphogypsum for the purposes of constructing the small-scale pilot project is likely to be less than 2.1×10^{-7}, or three orders of magnitude below the acceptable risk threshold of 3×10^{-4}.

Construction Worker

In Table 3 (Appendix 9, p. 8) Mosaic reports a 0.018 mSv (1.8 mrem) potential dose to a worker constructing the pilot project. The basis of this estimate was scaling this scenario as presented in the 2019 TFI risk assessment from a five-year exposure to a one-month exposure; that is a reduction in the total dose by a factor of 60.

The 2019 TFI risk assessment estimated the dose to a road construction worker to be 11 microrem per hour (μrem/hr), assuming a Ra-226 concentration of 1.0 Bq/g (27 pCi/g). The doses are from direct exposure from gamma emission from PG, as well as inhalation and ingestion from potential dust emission during construction. The road construction worker moves around the surface of the road and the direct dose was calculated as the average of the dose at the road center and at the edge of the road. The risk estimate calculated in the TFI risk assessment was 5.5×10^{-5} for a five-year exposure, or an annual risk of 1.1×10^{-5}. The total risk for working one month to construct the pilot project, according to the TFI risk assessment, would be 9.2×10^{-7}.

The 1992 BID evaluated the dose and risk to a construction worker building the road from direct gamma exposure, and dust inhalation. The construction worker is assumed to work 2,000 hours per year. Scaled to 1.3 Bq/g (35 pCi/g), the direct external dose rate given by the 1992 BID for a construction worker would be .056 mGy/yr (56 mrem/yr), and the risk per year is estimated to be 2.0×10^{-5}. The contribution due to dust inhalation was considerably lower: scaled to 1.3 Bq/g (35 pCi/g), the risk per year of exposure from dust inhalation for humid and dry sites, respectively, was 1.1×10^{-7} and 3.0×10^{-7}. Assuming a dry site, for which the dust exposure would be greatest, the total combined risk for one month of work is 1.7×10^{-6}.

As described in the introduction to this section, these calculations likely overestimate risk from the proposed pilot project because they model a higher concentration of Ra-226 in road base than is proposed, the inclusion of phosphogypsum in the road surface, and a larger road footprint than the proposed pilot project. The total risk to a road construction worker constructing the small-scale pilot project will be less than 2×10^{-6}, two orders of magnitude below the acceptable risk of 3×10^{-4}.

Road User

Mosaic did not quantify the exposure to a road user. “Given the test road is on the Mosaic site, no public use or exposures are expected… consideration of other road users such as Mosaic workers traveling on the road is possible but would result in dose and exposures much less than those estimated in the 2019 risk assessment considering the PG containing portion of the road would be narrower and shorter than the road assessed in the 2019 risk assessment.” EPA concurs that the risk of public exposure to the road is low, but additionally reviewed risk assessments previously performed for road users.

The 1992 BID evaluated direct gamma exposure for a person regularly driving on the road constructed with phosphogypsum. Assuming that the automobile in which this person travels would provide some

shielding from direct gamma radiation, a shielding coefficient of 0.6 was applied. The 1992 BID estimated the external dose rate to be 0.026 0.0098 mGy/yr (2.6 and 0.98 mrem/yr) for Ra-226 concentrations of .96 and .37 Bq/g (26 and 10 pCi/g) in phosphogypsum, respectively, based on 250 hours of travel per year. Scaling these results to 1.3 Bq/g (35 pCi/g), the external dose rate inside the vehicle would be .035mGy/yr (3.5 mrem/yr). The 1992 BID estimated the risk per year from .96 and .37 Bq/g (26 and 10 pCi/g) in phosphogypsum, to be 9.6×10^{-7} and 3.7×10^{-7}, respectively. In EPA's 2020 review, lifetime risk for 30 years of exposure was reported as 3.9×10^{-5} (0.39 in 10,000).

The 2019 TFI risk assessment estimated the dose and risk to a road user (motorist or bicyclist) to be 1.1 mrem/yr assuming a Ra-226 concentration of 1 Bq/g (27 pCi/g). No shielding to the road user was assumed. The estimated risk for 26 years of exposure was 1.0×10^{-5}.

To quantify the difference in exposure times, traversing 2000 feet of road at twenty-five miles per hour takes 54 seconds (0.015 hours). To do so at ten miles per hour takes 136 seconds (.038 hours). To reach 250 hours of exposure would require 16,667 trips over the pilot project at 25 miles per hour, or 6,579 trips at 10 miles per hour - more than three trips per hour for the entirety of a 2,000-hour work year. Even if a worker was to traverse the pilot project several hundred times in the course of a year's work, her or his exposure and risk would be more than an order of magnitude less than was modeled in either the TFI or EPA risk assessments, that is, on the order of 1×10^{-6} or less.

Nearby Resident (Member of Critical Population Group)

The nearest resident is located 3.9 km (2.4 miles) from the road project and .805 km (.55mi) from an existing phosphogypsum stack (Mosaic 2024b).

The 1992 BID evaluated risks to a member of the critical population group (CPG), defined as a person living in a house located 100 or 1,000 meters from the road. Exposure pathways evaluated for the CPG included direct gamma exposure, ingestion of drinking water from a contaminated well, and ingestion of foodstuffs contaminated by well water. According to the modeling results in the 1992 BID, no radionuclides were calculated to reach an on-site well via the groundwater pathway for almost 10,000 years, so the risks from pathways other than direct gamma exposure were negligible.

The 1992 BID estimated the external dose rates to be 0.50 and 0.19 mrem/yr for Ra-226 concentrations of .96 and .37 Bq/g (26 and 10 pCi/g) in phosphogypsum, respectively. Scaling these results to 1.3 Bq/g (35 pCi/g), the external dose rate to the CPG member would be 0.67 mrem/yr. The 1992 BID estimated the risk per year from .96 and .37 Bq/g (26 and 10 pCi/g) in phosphogypsum, to be 1.6×10^{-8} and 6.2×10^{-9}, respectively. Scaling these results to 1.3 Bq/g (35 pCi/g), the risk per year to a nearby resident is estimated to be 2.2×10^{-8}. The lifetime risk for 30 years of exposure would be 6.6×10^{-7} (0.0067 in 10,000).

The 2019 TFI risk assessment estimated the dose and risk to a nearby resident for a time duration of 26 years to be 72.8 and 20.0 mrem for residents living 6.1 meters and 15.2 meters (20 feet and 50 feet), respectively, from the road. These doses correspond to total risks of approximately 5.0×10^{-5} (0.5 in 10,000) and 1.0×10^{-5} (0.1 in 10,000).

Risk estimates for the nearby resident are driven by direct exposure to gamma radiation. As distance to the source increases, dose to the receptor is reduced at an exponential rate according to the inverse square law. The nearest resident is 3.9 km (2.4 miles) from the road project and members of the public do not access the facility. TFI calculated the lifetime risk of a resident living 6 meters from a road containing phosphogypsum to be 5.0×10^{-5}. EPA estimated the lifetime risk for someone living 100 meters from a road containing phosphpgypsum as 6.6×10^{-7}. Provided that the pilot project is constructed as described, the lifetime risk to the nearest resident due to the pilot project would be several orders of magnitude less than either of these estimates. Any risk to the nearest resident from phosphogypsum would be caused primarily by the volume of phosphogypsum remaining on the stack, supporting the concept that inclusion of phosphogypsum in the pilot project is "at least as protective" as maintaining it in the nearby stack.

Scenario 4: Reclaimer

The future resident, or reclaimer, scenario represents a worst-case environmental exposure scenario in which, at some point in the future, the road is disused, partially dismantled, and a person resides full-time on the residual phosphogypsum in a structure without controls for indoor radon.

In the 1992 BID risk assessment, a reclaimer is assumed to build a house on the roadbed at some future time after the road is closed and the road surface has crumbled and been removed, and the potential risk to a future resident was calculated to be significantly above the acceptable risk of 3×10^{-4}. TFI presented an alternate scenario in which construction techniques, favorable radon transport conditions, and a lower residence time on the site resulted in a lower lifetime cancer risk to the reclaimer, 4.0×10^{-5} (0.4 in 10,000) for an exposure time of 26 years, compared to the 1992 BID estimate of 3.5×10^{-3} (35 in 10,000) for an exposure time of 30 years. In reviewing the TFI risk assessment, the Agency determined that the scenario modeled by TFI did demonstrate that the risk to a future member of the public depends on the methods used to construct the house and might be less than estimated in the 1992 BID, but found that more pessimistic scenarios are also possible. Because the future reclaimer scenario could potentially still present lifetime risks above the Agency's defined threshold of 3×10^{-4}, EPA concludes that it cannot be dismissed out of hand. "To ensure that the risk to members of the public in the future is not above the acceptable risk, the redevelopment of any abandoned roads as anything other than a road constructed in accordance with this risk assessment should not be undertaken until an additional site-specific risk assessment demonstrates that risks to members of the public are acceptable." (EPA 2020)

Mosaic declined to evaluate the reclaimer scenario, because "Given the size of the proposed test road and the observation that the test road will be constructed on Mosaic property, a reclaimer scenario is not reasonably plausible." EPA agrees that the location of the pilot project changes the consideration of the reclaimer scenario. The pilot project is proposed to be located on a large, privately-owned industrial site, on land which has been mined for phosphate ore and reclaimed. The pilot project site is located in the immediate proximity (.805 km) of an existing phosphogypsum stack. Should the site ever be developed for a different use, radiological risk due to the presence of phosphate ore, phosphogypsum, and other phosphate production residuals will have to be carefully considered, along with other risks inherent to any former industrial site. Removing the proposed quantity of phosphogypsum from the stack and using it in the proposed pilot project on the same site would not

significantly change site characteristics or create additional risk to a future trespasser, reclaimer, or other member of the public.

Although EPA finds the proposed pilot project is permissible under §61.206, this does not imply any conclusions about the risks to future reclaimers at other sites, which may be further from phosphogypsum stacks and may lack the institutional controls present at the Mosaic facility. EPA will consider these scenarios as part of any subsequent request for any use proposed to take place outside the Mosaic property.

VII. Other Considerations

Water Pathway

In its 2020 review of the TFI risk assessments, the EPA noted that although "potential radiological risks due to leaching and water transport are [generally] low, compared to the risks posed by direct gamma exposure and the inhalation of radon gas … water transport is an area of considerable uncertainty. The mobility of metals and radionuclides will likely depend on many site-specific factors, such as the sorption properties of local soils, the amount of precipitation that occurs in an area, and the depth to groundwater. The presence of karst aquifers or the formation of colloids could lead to enhanced transport, and microbes and other biota have the potential to alter radionuclide mobility." In other words, although generic modeling results performed for the 1992 BID[5] and during the review of TFI's submission[6] (SC&A 2020, Section 5.3) do not identify a scenario in which phosphogypsum road construction is expected to result in significant impacts to surface or groundwater, site-specific conditions must always be considered.

In the case of this proposed pilot project, placement of the phosphogypsum would be within an area subject to permitted groundwater protection and monitoring requirements. The facility will need to remain in compliance with those permit requirements.

At the request of EPA, the facility provided additional details on the hydrogeology of the site (Mosaic, 2022b) and the groundwater monitoring to be performed (Townsend et al. 2024). A minimum of eighteen months of groundwater monitoring is proposed, with quarterly sampling for pH, specific conductance, total dissolved solids, calcium, sodium, sulfate, and gross alpha. If an increase is noted in

[5] The 1992 BID estimated the committed dose rate from ingestion of river water contaminated by surface runoff to be 0.020 and 0.0076 mrem/yr for Ra-226 concentrations of 0.96 and 0.37 Bq/g (26 and 10 pCi/g) in phosphogypsum, respectively. Scaling these results to 1.3 Bq/g (35 pCi/g), the committed dose rate from ingestion of foodstuffs grown onsite would be 0.027 mrem/yr. The 1992 BID estimated the risk per year from ingestion of foodstuffs grown onsite from 0.96 and 0.37 Bq/g (26 and 10 pCi/g) in phosphogypsum, to be 1.5×10^{-9} and 5.9×10^{-10}, respectively. Scaling these results to 1.3 Bq/g (35 pCi/g), the risk per year is estimated to be 2.0×10^{-9}. The lifetime risk from external radiation for 30 years of exposure would be 6.0×10^{-8}. According to the 1992 BID, no radionuclides were calculated to reach an on-site well via the groundwater pathway for almost 10,000 years.

[6] In this analysis, SC&A assumed that the road base was not covered by pavement and therefore was open to infiltration for the duration of the modeling. The analysis varied the distance from the road to the well from 15.2 m to 100 m and used multiple sets of distribution coefficients for the radionuclides of concern – conservative defaults found in the code, average values, and values itended to reflect sandy soil. None of these cases resulted in a total risk in excess of 3×10^{-4} for a 26-year exposure.

any of these parameters, analysis will be performed for radium, uranium, arsenic, cadmium, chromium, and lead. EPA agrees that this environmental sampling program, if performed correctly, may increase the understanding of the mobility of both radiological and non-radiological components of phosphogypsum. However, EPA also notes that any conclusions drawn based on this groundwater monitoring would be limited to the timeframe over which the monitoring is conducted. Thus, the eighteen-month sampling duration proposed by Mosaic may not neccessarily be sufficient to support conclusions about longer term use in a full-scale project.

Non-radiological Solid Waste Considerations:

Under Subtitle D of the Resource Conservation and Recovery Act (RCRA), states have the primary authority to implement and enforce standards for management of non-hazardous industrial solid wastes, including whether or not to allow a proposed beneficial use. The request submitted by Mosaic was described as seeking separate approval of the small-scale pilot project by the Florida Department of Environmental Protection (FDEP) following EPA's review under the Subpart R NESHAP. On May 1, 2022, the Florida legislature passed a bill, HB 1191. The bill directs FDOT to study the use of phosphogypsum in roads, and exempts uses of phosphogypsum from review by FDEP. The FDEP regulates beneficial use under Florida Administrative Code (FAC) 62-701 and Part IV of Chapter 403 Florida Statutes, Solid Waste Management Act. Industrial by-products are regulated as solid waste unless otherwise exempted.: "Phosphogypsum …used in accordance with … an express United States Environmental Protection Agency approval for the specific use is not solid waste as defined in s.403.703 and shall be an allowed use in this state." However, review by FDEP is still required until FDOT issues a determination that phosphogypsum is suitable for use in road construction.

EPA developed both the the "Methodology for Evaluating the Beneficial Use of Industrial Non-Hazardous Secondary Materials" (EPA 2016a) and "Beneficial Use Compendium: A Collection of Resources and Tools to Support Beneficial Use Evaluations" (EPA 2016b) to aid states and others in making beneficial use decisions. As part of that document, EPA defined beneficial use as the substitution of a non-hazardous industrial material, either as generated or following additional processing, for some or all of the virgin, raw materials in a natural or commercial product in a way that provides a functional benefit, meets relevant product specifications, and does not pose concerns to human health or the environment. (Note that the "non-hazardous" designation is based on a material's regulatory status. Non-hazardous materials may still pose risk). Uses that do not meet these criteria may be considered improper disposal of a solid waste under federal law, and federal action could be taken if there were a finding of imminent or substantial endangerment, even in cases where the state has determined the material to not be subject to state regulation. A radiological risk assessment is not a substitute for a complete consideration of environmental health and safety.

The current proposed pilot project takes place on an existing industrial facility. It is of small scale and occurs at a significant distance from members of the public and is under environmental regulatory oversight at the facility. Mosaic committed in its request to conduct environmental sampling and study of both radiological and non-radiological parameters as part of the pilot project.

VIII. Summary and Conclusions

The purpose of this review was to evaluate, via the process identified in 40 CFR §61.206, whether the request and risk analysis submitted by Mosaic were sufficient to demonstrate that the project as

proposed fell below risk thresholds previously defined by EPA for approval of other uses of phosphogypsum. Review of the Mosaic request was performed by a technical team led by the Radiation Protection Division in consultation with other EPA program offices.

The Agency's review found that Mosaic's request is complete, that its risk assessment was technically acceptable, and that potential risks from the proposed project fall within the regulatory requirements of 40 CFR §61.206. Numerical estimates of the total lifetime risks indicate that the additional risk of fatal cancer to workers moving phosphogypsum and constructing the road will be less than 2×10^{-6} (2 in 1,000,000, or .0002%) and risk to the nearest members of the public from the project are lower than 1×10^{-6} (1 in 1,000,000, or .0001%) provided that the project is constructed as described in Mosaic's request. Therefore, the small-scale pilot project may be approved by the Agency per 40 CFR §61.206. An approval by the Assistant Administrator of Air and Radiation applies to this specific pilot project, and indicates only that the project meets the requirements of the Subpart R NESHAP. Approval does not relieve Mosaic from responsibility to comply with other applicable laws and regulations.

IX. References

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Appendix A:

Summary of Generic Risk Assessments: Parameters and Results

Tables 1 and 2 summarize annual risks calculated by TFI in its risk assessment, and by EPA in its 1992 BID, respectively, for various scenarios associated with use of phosphogypsum in road construction. The lifetime risk of fatal cancer associated with the exposure is listed in the rightmost column. A value of 3×10^{-4} would be denoted as 3.0 in the "Lifetime Risk" column of these tables.

Table A-1: Summary Table of Results for the 2019 TFI Risk Assessment

2019 TFI Scenarios[1] for 1.0 Bq/g (27 pCi/g)[2]	Lifetime Risk per Year of Exposure[3]	Years of Exposure	Lifetime Risk[4] (x 10^{-4})
Road Construction Worker	1.0E-05	5 to 20	0.5 to 2.0
Truck Driver	1.0E-05	5 to 20	0.5 to 2.0
Road User (Motorist/Bicyclist)	3.8E-07	26 to 70	0.1 to 0.3
Nearby Resident	3.1E-07	26 to 70	0.08 to 0.22
Utility Worker	4.0E-07	1 to 5	0.0 to 0.02
Reclaimer	1.5E-06	26 to 70	0.4 to 1.1

[1] See "Radiological Risk Assessment in Support of Petition for Beneficial Use of Phosphogypsum, Prepared for The Fertilizer Institute," October 2019 (Arcadis, 2019).
[2] Average concentration of Ra-226 in the phosphogypsum prior to its use
[3]Estimated from the reported risk and exposure time in the risk assessment
[4]Number of estimated fatal cancers if 10,000 people were exposed to this scenario. The lifetime risk per year of exposure multiplied by the years of exposure produce the lifetime risk for each scenario.

Table A-2: Summary Table of Results for the 1992 EPA BID

1992 BID Scenarios[1] for 0.96 Bq/g (26 pCi/g)[2]	Lifetime Risk per Year of Exposure	Years of Exposure	Lifetime Risk (x 10^{-4})
Construction Worker - No Shielding - Direct Gamma	1.5E-05	5 to 20	0.75 to 3.00
Construction Worker - With Shielding - Direct Gamma	9.0E-06	5 to 20	0.45 to 1.80
Construction Worker - Humid Site - Dust Inhalation	8.4E-08	5 to 20	0.00 to 0.02
Construction Worker - Dry Site - Dust Inhalation	2.2E-07	5 to 20	0.01 to 0.04
Person Driving on Road - Direct Gamma	8.2E-08	26 to 70	0.02 to 0.06
Member of CPG[3] - Direct Gamma	1.6E-08	26 to 70	0.00 to 0.01
Reclaimer - Direct Gamma	2.6E-05	26 to 70	6.8 to 18.2
Reclaimer - Humid Site[4] - Indoor Rn	5.9E-05	26 to 70	15.3 to 41.3

1992 BID Scenarios[1] for 0.96 Bq/g (26 pCi/g)[2]	Lifetime Risk per Year of Exposure	Years of Exposure	Lifetime Risk (x 10^{-4})
Reclaimer - Dry Site[5] - Indoor Rn	6.2E-05	26 to 70	16.1 to 43.4

[1]See EPA 402-R-92-002, *Potential Uses of Phosphogypsum and Associated Risks, Background Information Document*, Tables 4-15 and 4-16
[2]Concentration of Ra-226 in the phosphogypsum prior to its use
[3]Critical Population Group (Nearby Resident)
[4]Typical of a site in the southeastern United States
[5]Typical of a site in the southwestern United States

A summary of the scenarios included in the 1992 BID is provided in Table 3.

Table A-3: Summary of Scenarios Included in the 1992 EPA BID

	1992 BID Scenario	Scenario Description
1	Construction Worker	The construction worker is assumed to be engaged eight hours per day for 250 days per year in constructing a 16-kilometer section of road. Gamma exposures are calculated for a worker who is employed directly on the road surface and a worker who uses equipment such as a bulldozer or road grader which provides some shielding from shielding from gamma radiation. The shielding coefficient is 0.6.
2	Person Driving on Road	The person driving on the road is assumed to use the road from home to work, and return. This person travels the road one hour per day for 250 trips per year. The automobile in which this person rides provides some shielding from direct gamma radiation. The shielding coefficient is 0.6.
3	Member of the CPG (aka Nearby Resident)	The member of the CPG is assumed to live in a house located 100 or 1,000 meters from the road. Potential doses to a member of the CPG could result from direct gamma exposure or from the use of contaminated well water.
4	Reclaimer	The reclaimer is assumed to build a house on the roadbed at some future time after the road is closed and the road surface has crumbled and been removed. In addition to living in a house at the site, the reclaimer drills a well for water and plants a vegetable garden in the contaminated soil. The vegetable garden provides 50 percent of the reclaimer's foodstuffs.

A summary of the scenarios included in the 2019 TFI risk assessment is provided in Table 4.

Table A-4: Summary of Scenarios Included in the TFI Risk Assessment

TFI Scenario	Scenario Description
Road Construction Worker	This scenario assumes a road construction worker works directly on the surface of the road as it is being constructed, 2,000 hours/year for 5 years. Although some road construction workers are on equipment during the workday which would provide shielding from external gamma exposure, shielding has not been included in the calculations. The doses are from direct exposure from gamma emission from PG, and inhalation and ingestion from potential dust emission during construction. In all three conceptual site models (CSMs) the active road area is 100 m long by 15 m wide, while thicknesses vary with the CSM. As the model used was RESRAD, the exposure point is at one meter above the surface, the RESRAD default. In addition, it was assumed the road construction worker moves around the surface of the road and the direct dose was calculated as the average of the dose at the road center and at the edge of the road.
Road User (Motorist/Bicyclist)	Two road users were considered for this scenario, a driver and a bicyclist. In both instances they were assumed to travel on a final constructed road with PG in the road base and the paving. No reduction was provided to the driver as the floor and auto body shielding are assumed negligible given the current materials used thin plastic/metal.
Truck Driver	Another receptor is the truck driver who transports PG from the PG stack to the site of the road construction. The truck is assumed to be a standard dump truck. The dose to the truck driver was calculated using MicroShield®. The geometry selected was a rectangular volume, with the dimensions of the roll-off portion being 5.2 m long, 1.4 m high and 2.1 m wide which is the average for a 20-ton dump truck. The dose point was one meter from the center of the roll-off front face, where the driver would be sitting. The truck was assumed to be filled with phosphogypsum with a density of 1.12 grams per cubic centimeter (g/cm^3) which is somewhat lighter than soil. The isotopes in the PG were Ra-226 in secular equilibrium with the daughters. The activity was assumed 1.0 Bq/g (27 pCi/g) as the PG was not yet mixed with road surface material. No credit or reduction was taken for the shielding effects of the truck cab.

TFI Scenario	Scenario Description
Nearby Resident	This scenario assumes that a resident lives close to the site of the road as it is being constructed and after construction. In the first case, no shielding (road shoulders, etc.) was assumed during construction. After construction, a shoulder was established. During construction MicroShield® was used to determine the doses at various distances from the road. A rectangular volume was assumed, 15 m wide, 100 m long and 0.25 m thick. The contribution to the receptor is from the 25 cm thickness, 100 m long side face during construction and the 15m wide, 100m long surface of the road following construction. Doses were determined at 6.1 m and 15.2 m from the edge of the road at a receptor height of 1 meter above the road surface. The distance of 6.1 m is considered representative of urban settings with houses at a minimum separation from the road edge (urban setting may also have more shielding). The distance of 15.2 m is representative of more suburban setting where separation distances between roads and homes are expected to be greater.
Utility Worker	It was assumed that a trench was cut across the road. The utility worker was assumed to work in the middle of the trench about one meter from the face of the road. The dose point was 7.5 m from the road edge, 51 m from the road end and 0.25 m high. The isotopes in the PG were Ra-226 in secular equilibrium with the daughters. The activity was taken as 0.50 Bq/g (13.5 pCi/g) as the PG was mixed with road surface material at a 1:1 ratio. The direct exposure dose to the utility worker was calculated assuming the utility worker spends 160 hours per year in the PG road.
Reclaimer	The reclaimer scenario assumes that the home is a bungalow constructed slab on grade with a 16.2 cm underlying slab and a 16.2 cm gravel base underlying the slab. The basic scenario takes credit for a vapor barrier but takes no credit for any radon mitigation that might be required by local building codes. As with the case of the nearby resident, the house is presumed to be occupied for 26 years. In broad terms, the reclaimer scenario assumes the following: • Exposure to the reclaimer would be through gamma radiation and the inhalation of Radon (Rn-222) and progeny. • The reclaimer is assumed to be exposed for 26 years with approximately 75% of his/her time onsite and indoors.

TFI Scenario	Scenario Description
	The key assumptions are as follows: • The road surface has crumbled and has been removed as part of site preparation (50 years after closure also as assumed by the EPA in their 1992 BID). • Site grading for construction will almost certainly reduce the thickness of the layer containing PG; however, for present purposes, we have assumed that site preparation will reduce the PG layer to about 10 cm in thickness and the concentration of Ra-226 in the remaining layer to about .37 Bq/g (10 pCi/g). • Radon flux is reduced due to a 6-millimeter (mm) poly layer as a moisture barrier currently common in building codes. Such a layer would be expected to reduce the radon flux by at least a factor of 10.