UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 19, 2021

Mr. John Sauger
General Manager
Zion Restoration Project
Zion*Solutions*, LLC
101 Shiloh Boulevard
Zion, IL 60099-2797

SUBJECT: ZION NUCLEAR POWER STATION, UNITS 1 AND 2 - REQUEST FOR ADDITIONAL INFORMATION RELATED TO PARTIAL SITE RELEASE AND RECENT SITE SURVEY ACTIVITIES (EPID L-2020-DSR-0000)

Dear Mr. Sauger:

Beginning in November 2018, Zion*Solutions*, LLC (ZS, the licensee), requested U.S. Nuclear Regulatory Commission (NRC) review of the Final Status Survey Report (FSSR) for the Zion Nuclear Power Station, Units 1 and 2 (ZNPS, also referred to as Zion), by letters dated:

- November 1, 2018 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML18331A016);
- June 21, 2019 (ADAMS Accession No. ML19178A109);
- March 11, 2019 (ADAMS Accession No. ML19077A095);
- September 30, 2019 (ADAMS Accession No. ML19295G627);
- November 25, 2019 (ADAMS Accession No. ML19338B809);
- December 30, 2019 (ADAMS Accession No. ML20009E643);
- April 30, 2020 (ADAMS Accession No. ML20147A092); and
- May 1, 2020 (ADAMS Accession No. ML20133J976).

These requests were supplemented by letters dated:

- May 15, 2020 (ADAMS Accession No. ML20147A128);
- June 4, 2020 (ADAMS Accession No. ML20167A280);
- November 11, 2020 (ADAMS Accession No. ML20351A154);
- February 10, 2021 (ADAMS Accession No. ML21067A225);
- April 2, 2021 (ADAMS Accession No. ML21103A229);
- April 15, 2021 (ADAMS Accession No. ML21112A166); and
- May 11, 2021 (ADAMS Accession No. ML21131A072).

These submittals support the ZNPS partial site release request received on June 5, 2020 (ADAMS Accession No. ML20164A096), which would remove a 112-acre portion of the site from ZNPS License Nos. DPR-39 and DPR-48. These licenses were issued pursuant to Part 50, "Domestic Licensing of Production and Utilization Facilities," of Title 10 of the *Code of Federal Regulations* (10 CFR). The proposed action would effectively terminate the ZNPS 10 CFR Part 50 licenses outside the footprint for the remaining onsite Independent Spent Fuel Storage Installation (ISFSI), which encompasses approximately 5 acres.

Specifically, ZS intends to remove an area consisting of 7 basement survey units and 116 land survey units (including 3 below grade excavation survey units), and 5 buried piping survey units. This action will represent the completion of decommissioning activities at the ZNPS site, until such time as the ISFSI is no longer needed for the storage of spent fuel and subsequently decommissioned. The FSSR is the documentation that demonstrates completion of the activities described in the License Termination Plan (LTP), which was submitted by letter dated December 19, 2014 (ADAMS Accession No. ML15005A336), as supplemented by letters dated:

- February 26, 2015 (ADAMS Accession No. ML15061A281);
- November 12, 2015 (ADAMS Accession No. ML15344A344);
- March 8, 2016 (ADAMS Accession No. ML17129A311);
- July 20, 2016 (ADAMS Accession No. ML16211A200);
- February 27, 2017 (ADAMS Accession No. ML17208A121);
- July 20, 2017 (ADAMS Accession No. ML17215A095);
- February 7, 2018 (ADAMS Accession Nos. ML18052A529 and ML18052A851);
- April 10, 2018 (ADAMS Accession No. ML18103A016); and
- August 28, 2018 (ADAMS Accession No. ML18242A082).

The Zion LTP was approved by the NRC on September 28, 2018 (ADAMS Accession No. ML18163A223). The LTP provided the details of the plan for characterizing, identifying, and remediating the remaining residual radioactivity at the ZNPS site to a level that will allow the site to be released for unrestricted use. The LTP also described how the licensee will confirm the extent and success of remediation through radiological surveys, as captured in the FSSR, provide financial assurance to complete decommissioning, and ensure the environmental impacts of the decommissioning activities are within the scope originally envisioned in the associated environmental documents. The NRC staff is reviewing the FSSR and the associated partial site release to ensure that the removal of these 128 survey units from the 10 CFR Part 50 license demonstrates the ability of the site, in aggregate, to meet the criteria for unrestricted release contained in Subpart E, "Radiological Criteria for License Termination," of 10 CFR Part 20, "Standards for Protection Against Radiation."

The NRC staff has reviewed the subject submittals and determined that additional information is needed to complete its review, as described in the enclosed Requests for Additional Information (RAIs). The requested information was discussed with ZS during a teleconference with the NRC staff on August 5, 2021. In order to continue the review of the ZNPS FSSR and partial site release, please respond to this request for additional information in a timely fashion. Please note that RAI-10 is still under development and will be provided in both draft and final form to the licensee under separate correspondence.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of ADAMS. ADAMS is accessible from the NRC Web site at https://www.nrc.gov/reading-rm/adams.html.

If you have any questions regarding this request or the ongoing partial site release review, please contact me at (301) 415-3178 or via e-mail at Marlayna.Doell@nrc.gov.

Sincerely,

Signed by Doell, Marlayna
on 08/19/21

Marlayna V. Doell, Project Manager
Reactor Decommissioning Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket Nos. 50-295 and 50-304
License Nos. DPR-39 and DPR-48

Enclosure: Request for Additional Information

cc w/enclosure: Zion Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO THE ZION*SOLUTIONS*, LLC

PARTIAL SITE RELEASE REQUEST AND RECENT SITE SURVEY ACTIVITIES

ZION NUCLEAR POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-295 AND 50-304

The NRC staff is reviewing the Zion FSSR and the associated partial site release request to ensure that the proposed removal of 128 survey units from the ZNPS 10 CFR Part 50 licenses demonstrates the ability of the site to meet the criteria for unrestricted release contained in Subpart E of 10 CFR Part 20. The NRC staff has reviewed the FSSR submittals and supplements provided to date, as well as the results from the April 2021 inspection survey, and determined that additional information related to current radiological conditions at the site is needed to complete its review, as described in the following RAIs. The information gathered in response to these RAIs will be used, in part, by the NRC staff to perform additional risk assessments and/or dose calculations to obtain reasonable assurance that the Zion site meets the assumptions outlined in the Zion LTP and may be released from the ZNPS 10 CFR Part 50 licenses without undue risk to public health and safety, or impact on the environment.

1. Origin and Extent of Radioactive Particle Contamination at the Zion Site

Comment: The NRC staff and its contractor, the Oak Ridge Institute of Science and Energy (ORISE), retrieved several discrete radioactive particles during an April 2021 limited scope inspection survey activity at the ZNPS site. Furthermore, on June 30, 2021, the licensee recovered an additional piece of radioactive material while performing supplementary surveys. More information on the origin of this material and why it is present at the site after completion of final status surveys (FSS) is necessary in order for the NRC staff to reach a determination that the site meets the radiological release criteria of 10 CFR Part 20.

Basis: In April 2021, the NRC staff along with staff from ORISE, conducted a limited scope supplementary inspection survey to obtain independent quantitative radiological data for the NRC's use in evaluating final radiological conditions at the Zion facility. Informed by information provided by the licensee in response to previous RAIs on the Zion FSSR, the surveys focused on the radiological status of locations where: (1) radioactive particles may reside, and (2) concrete debris was stored on survey units that previously received FSS.

Specifically, ZNPS site records indicate that during decommissioning activities, radioactive particles were released and distributed on land areas by atmospheric dispersion and deposition, as well as during certain waste loading activities. These two sources of particles at the site are summarized in two licensee condition reports (CRs) (CR-2014-001074 and

CR-2015-000324) and ZS RAI responses dated February 10, 2021 (ADAMS Accession No. ML21067A225). Given the location of some of the particles retrieved, particles may have been transported across the site due to local flooding events and site activities (e.g., land grading, vehicle traffic, and personnel transit).

In addition, radioactive particles were identified by the licensee during FSS, and by ORISE staff during previous confirmatory surveys at the ZNPS site. The licensee performed FSS and remedial action (RA) support surveys using a traditional approach based on the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). In response to previous RAIs on the Zion FSSR, the licensee also stated that a modified survey procedure (ZS-RP-JA-011, "Use of the M3-44-10 Gamma Detector for Discrete Radioactive Particles," Revision 4) was applied during open air demolition of ZNPS structures by the ZS Radiological Operations personnel to increase the probability of particle identification in site locations where radioactive particles may reside.

At the time of the April 2021 inspection survey, radioactive particles were not expected to be identified in land areas that were previously scanned by the licensee. However, given that particles had been found during ORISE confirmatory surveys in various areas across the site, the NRC staff was concerned that remaining radioactive particles may be sufficient in number to be of regulatory concern for license termination. Specifically, the NRC staff was concerned that the licensee's FSS survey design did not account for the potential presence of particles, especially in light of the fact that ORISE identified radioactive particles during certain confirmatory surveys after FSS had been completed by ZS. Furthermore, certain Class 3 areas of the site had limited areas scanned (e.g., switchyard and the beach) and the NRC staff were concerned that particles may have been transported to those areas.

As informed by previous RAI responses, the NRC staff expected that only particles containing cobalt-60 (Co-60) within a certain activity range might remain at the site surface in certain locations. However, during the April 2021 inspection survey not only particles containing Co-60 were found, but also particles containing mixtures of radionuclides that were not expected to be present in the ZNPS surface soil. Furthermore, in some instances Co-60 particles were identified in unexpected locations at the site. The results of the April 2021 inspection survey are documented in a draft ORISE report (5271-09), which is in the process of being finalized and made publicly available in support of the current RAIs. Table 1 and Table 2 below are taken from the draft report and summarize the suspected and confirmed radioactive particles that were retrieved during the inspection survey, as well as their radionuclide activities. The radionuclide concentrations of the soil surrounding the particles is presented in Table 3. Due to the limited sample size of these particles, the radioanalytical procedures were limited in scope and therefore the results in these tables may not reflect the full spectrum of radionuclides present in these particles. The information in these tables will be updated, if necessary, once the ORISE report is finalized.

Some of the April 2021 inspection survey observations (for example: Samples S0124, S0203, S0126, S0120, and S0204AEu) may indicate to ensure that the scan sensitivity implemented during FSS was inadequate to detect certain radionuclides that are present at the ZNPS site. It was also determined that the licensee had not sampled and analyzed for certain hard-to-detect radionuclides (i.e., americium-241 (Am-241) and other transuranic radionuclides collected at the land surface). Without knowing the specific radionuclides that were present on the land surface, the licensee could not design a survey program that could adequately detect and quantify the radioactivity in the ZNPS land areas.

Table 1 – Field and Particle Collection Conditions

Sample ID	CSU	FSS Survey Unit	Approximate Depth (cm)	Sample Collection Notes
S0112A	2	10209E	<15	Sample was relatively easy to collect. Submitted to ORISE Radiological and Environmental Analytical Laboratory (REAL) for further analysis.
S0116	2	10220I	Surface	Sample required effort to isolate and collect. Submitted to REAL for analysis.
S0120	2	12203D	Surface	Sample was easy to collect, technican was able to scoop material with hand trowel. Submitted to REAL for further analysis.
S0124[a]	1	12201B	30	Sodium iodide (NaI) detector response was near backgound levels, sample was difficult to isolate and collect. Technican used a shovel to remove soil approximately 50 centimeters (cm) in diameter. Submitted to REAL for further analysis.
S0126[a]	2	12203A	Surface	Sample was easy to collect, technican was able to scoop material with hand trowel. Submitted to REAL for further analysis.
S0203[a,b]	2	10204B	<15	Sample was relatively easy to isoloate and collect. Submitted to RESL for analysis.
S0204[a,b]	1	12201B	<15	Sample required effort to isolate and collect. Submitted to RESL for analysis.

[a] Suspect particle was not collected from a confirmatory survey unit (CSU) grid cell.
[b] Sample collected by NRC staff.

Table 2 – Summary of Particle Total Activities (pCi)[a]

Sample	Am -241	Ba -133	Cm -244	Co-60	Cs -134	Cs -137	Eu-152	Eu-154	Eu -155	Np-237	Pu-238	Pu-239	Sr-90
S0112A	0.040	10	0.000	**48400**	36	-27	-20	-40	27	0.000	0.000	0.059	-0.21
S0116	0.019	-8	0.038	**18400**	22	-4	-28	0	48	0.00	0.000	0.041	-0.34
S0124	0.12	-300	0.06	**1508000**	1200	1000	-500	2000	-10	0.020	**0.14**	**0.079**	0.49
S0126	**79900**	-11	**14800**	62	12	**98900**	-70	**2920**	**838**	**3.9**	**26188**	**7540**	**157043**
S0204AEu	0.028	**1520**	-	**30000**	-	-	**344000**	**16200**	-	-0.028	-0.028	**16.6**	0.8

[a] Bolded values indicate the 95 percent (%) uncertainty interval did not include zero.

Table 3 – Radionuclide Concentrations in Soil Surrounding Particles (pCi/g)[a]

Soil Sample	Particle Sample	Am-241	Ba-133	Cm-244	Co-60	Cs-134	Cs-137	Eu-152	Eu-154	Eu-155	Np-237	Pu-238	Pu-239	Sr-90
S0112	S0112A	0.003	-0.228	-0.0016	**0.039**	**0.025**	**0.134**	0.009	0.000	0.023	0.0000	0.0031	0.0031	-0.02
S0116A	S0116	0.0016		-0.0016							0.0015	0.0030	0.0046	-0.01
S0120	-	0.0024	**0.80**[b,c]	0.0008	**27.4**[b,c]	0.80[b]	0.04	**1449**[b,c]	**79.5**[b,c]	0.9[b]	-0.0008	0.0031	**0.0046**	0.06
S0121	S0120	-0.0089	-0.056	0.0015	0.008	0.010	**0.0499**	0.013	-0.014	0.008	-0.0014	0.0000	0.0029	0.06
S0124A	S0124	0.0000		0.0000							0.0000	0.0032	0.0049	**0.17**
S0125	S0126	0.0016	-0.017	0.0000	0.001	-0.0010	**0.038**	0.000	0.012	0.033	0.0000	0.0015	0.0030	0.12
S0203	S203A	0.010	0.02		0.007	0.003	0.03	0.009	1	1	0.01			
S0204	S0204AEu		0.04		**0.020**	0.04	**0.024**	**0.089**	0.003	0.03	0.012		-0.0016	0.6
S0204A	S0204AEu		0.013		**0.094**	0.0000	**0.051**	**0.60**	0.020	0.02	0.021		0.003	0.1

[a] Bolded values indicate the 95% uncertainty interval did not include zero.
[b] Value for S0120 is approximated; the sample volume did not fill the calibrated geometry.
[c] Bolded values for S0120 are based on review of gamma spectrum and not the uncertainty.

Note that sample S0203 contained elevated concentrations of thorium-232 (Th-232), thorium-238 (Th-228), and radium-228 (Ra-228) at 1,050 picocuries per gram (pCi/g), 1,550 pCi/g, and 2,400 pCi/g, respectively. Elevated concentrations of uranium-238 (U-238) and uranium-234 (U-234) at approximately 150 pCi/g were also reported in this sample.

For ease of reference, Figure A.8 and Figure A.9 from the ORISE report are reproduced below to show the locations of the suspected and confirmed particles within the ZNPS survey units (SUs), as well as the judgmental soil sample locations from the April 2021 inspection survey.

Figure 1 - Suspected Particle Locations (Figure A.8 in ORISE Report)

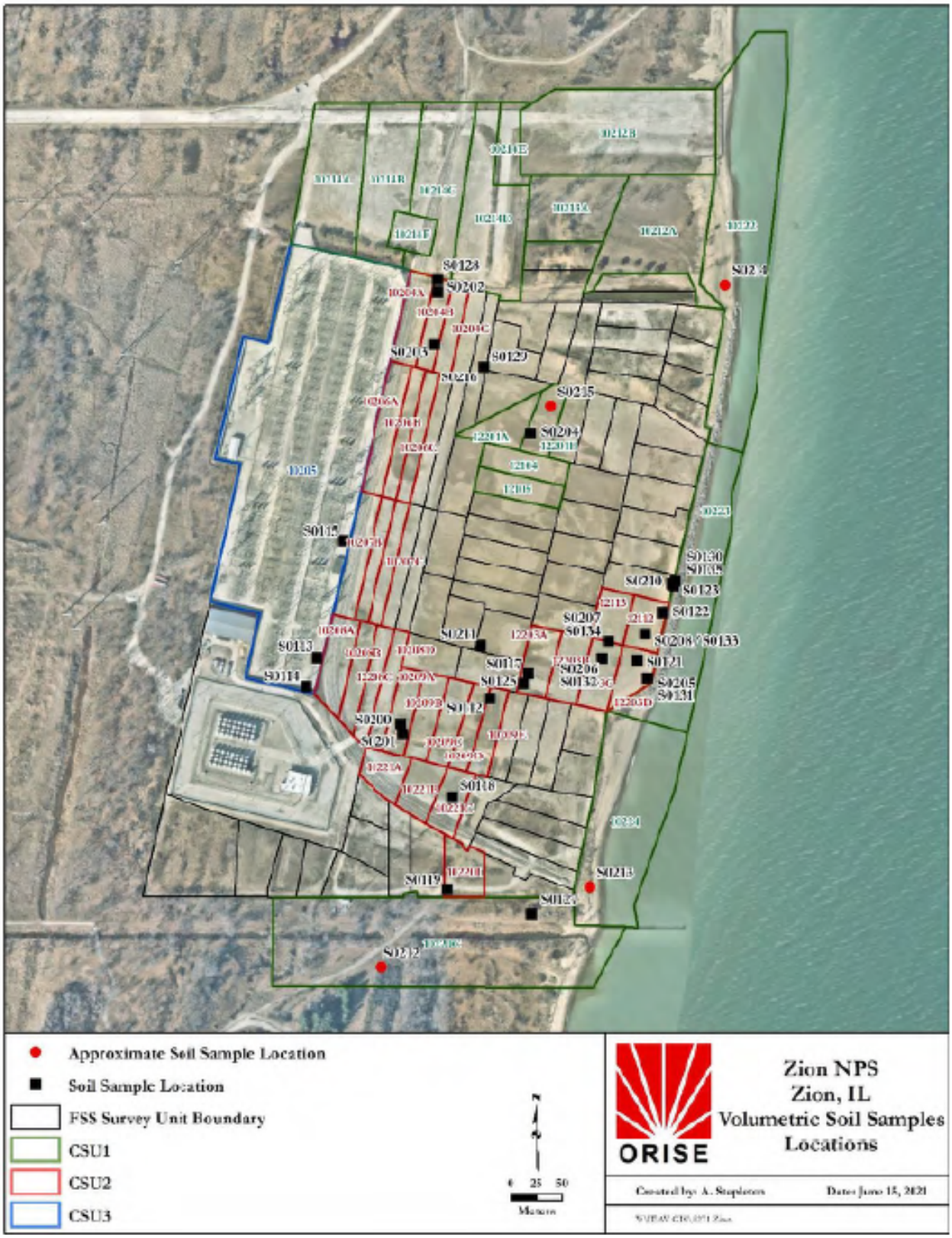

Figure 2 – Judgmental Volumetric Soil Sample Locations (Figure A.9 in ORISE Report)

Particle S0112A in SU 10209E and Particle S0116 in SU 10220I

During the April 2021 inspection survey, three of the five confirmed particles (Samples S0112A, S0116, and S0124) contained predominantly Co-60, which is consistent with previously identified particles at the Zion site during decommissioning activities. Two of these (Samples S0112A and S0116) were found toward the southern part of the site.

Sample S0112A is a particle containing 0.05 microCi of Co-60, which was found in SU 10209E. Survey Unit 10209, Restricted Area South of the Gate House, was originally classified as a Class 3 SU in the Zion LTP. However, the licensee reclassified this area from Class 3 to Class 1 in 2016 "due to changing radiological and operational conditions brought about by site decommissioning activities inside or adjacent to this area." Specifically, "survey unit 10209 was divided into three complete survey units: 10209C, 10209D,10209E; and one partial survey unit: 10209B, to comply with the survey unit size recommendations from MARSSIM Section 4.6. The west portion of 10209B and a fifth survey unit, 10209A, were incorporated into the area from survey unit 10208."

Survey Unit 10209E was part of Phase 3 of the Zion FSSR submittal. FSS activities took place from May to October 2019 for this SU. The licensee's release record for SU 10209E describes how a radioactive particle was discovered below the surface during FSS activities, after a subsurface investigational sample was triggered based on the surface scan. However, the release record does not describe the origin of the particle or how it came to be present in the subsurface. The release record for SU 10209E states:

> An investigation was performed following a scan alarm in row No. 83 on May 17, 2019. An initial reading of 9,281 counts per minute (cpm) was recorded at a point approximately four meters from the west end of the row. The activity was found to be a small radioactive particle located four inches below the surface. When the particle was uncovered, a second reading of 35,412 cpm was recorded and the particle was captured.

It is unclear whether the source of the radioactive particle identified in Sample S0112A in April 2021 is the same as the source of the particle found in the subsurface during the licensee's FSS activities in May 2019. However, information provided by the licensee in the February 2021 RAI response indicates that a primary source for particles located in SU 10209 was likely due to a waste package liner loading event (8-120 liner event) in 2014.

Furthermore, additional radioactive particles were identified in other survey units that were part of Phase 3 of the Zion FSSR. The Phase 3 FSS report specifically describes how, in seven of 41 survey units, subsurface investigational samples were triggered by surface scans, some of which resulted in the discovery of particles:

> Surface soil samples were collected to a depth of 0.15 meters below the topsoil surface. Leaves, rocks, roots, and other objects were excluded as much as possible from the sample. In Class 1 open land survey units, subsurface soil samples (soil from a depth of greater than 0.15 meters) are collected as part of the survey design. In accordance with Section 5.7.1.6.2 of the LTP, a subsurface soil sample is required at 10% of the systematic surface soil sample locations in a Class 1 survey unit with the location(s) selected at random. In addition, if during the performance of FSS, the analysis of a surface soil sample, or the results of a

> surface gamma scan indicated the potential presence of residual radioactivity at a concentration of 75% of the subsurface soil [operational derived concentration guideline level], then a biased subsurface soil sample(s) would be required to the appropriate depth within the area of concern as part of the investigation. This occurred in seven (7) of the forty-one (41) survey units in this Phase 3 FSSR (survey units 10202B, 10203E, 10209A, 10209D, 10209E, 10221B, and 12112).

The information provided in the licensee's release records for these seven survey units indicate the presence of radioactive particles (either on the surface or subsurface) in several of the survey units. For example, in SU 10202B, two Co-60 particles were detected and remediated during FSS as a result of scan investigation samples being triggered. In SU 10209A, a Co-60 particle was discovered during the FSS scan. In SU 12112, a particle was suspected in one of the split samples shared with ORISE during a confirmatory survey. These examples, as well as other examples documented in the licensee's previous FSSR RAI responses, release records, or ORISE confirmatory reports, indicate the presence of Co-60 particles remaining at the Zion site during the FSS or confirmatory survey stage. In some cases, the origin of the radioactive particles can be attributed to the 8-120 liner event. In other cases, these particles were in areas that the licensee stated were not impacted by the 8-120 liner event; therefore the potential origin of the particles is less clear.

A particle containing 0.02 microCi of Co-60 was found in SU 10220I during the April 2021 inspection survey. Survey Unit 10220A, Southeast Corner of the Exclusion Area – Lakeshore, was originally classified as a Class 3 SU in the Zion LTP. SU 10220A was subsequently reclassified to Class 2 because the survey unit to the north was reclassified to Class 1. In May 2019, during performance of the FSS for the Class 2 SU 10220A, a 90,000 cpm radioactive particle was found in the area. Survey Unit 10220A was therefore reclassified to a Class 1 SU and divided into four survey units: 10220A, 10220H, 10220I, and 10220J. Survey Unit 10220I was part of Phase 4 of the Zion FSSR submittal, and ORISE identified an area of elevated radioactivity during a confirmatory survey of SU 10220I, which the licensee subsequently investigated. As described by the licensee in an associated FSSR RAI response (February 2021), "based on the gamma spectroscopy results, it was concluded that the elevated scans observed in survey unit 10220I were due to the presence of naturally occurring radioactive materials (NORM)." However, the licensee's release record for SU 10220I does not indicate the origin or potential origin of the radioactive particle that was discovered in the original 10220A survey unit.

The RAI response from February 2021 also explains how several survey units to the southern and western portion of the ZNPS site were impacted by the 8-120 liner contamination event from September 2014. However, the impacted survey units do not include those from the SU 10220 group above. Furthermore, the RAI response states that all contamination was remediated following the 8-120 liner contamination event:

> [Discrete Radioactive Particles] DRPs were identified in survey unit 10221, where the loading took place, across survey units 10208, 10207, 10206, 10204, 10203, and then in 10202, where the liner and trailer were staged temporarily for shipping survey. Over 100 DRPs ranging from 0.001 microCi to 3 microCi were identified and remediated after this event. Surveys were performed of walking areas adjacent to the travel path of the liner, parking areas inside and outside of the Radiologically Restricted Area, and the main access road entering the Radiologically Restricted Area. No DRPs were identified in these areas. No

> surveys were performed of areas inside the Security Restricted Area, as they were not considered impacted by this event. The cause of the spread of contamination was corrected, and all contamination was remediated following this event. The corrective action documentation and surveys are supplied in the enclosure to this response.

The RAI response further states:

> Based upon the identification of multiple DRPs in areas outside of structures in October of 2014, following the event identified in CR-2014-001074, the 8-120 liner storage area present within portions of survey units 10208, 10209, and 10221, was deemed an elevated risk for DRPs.

However, even considering the large area and number of survey units the February 2021 RAI response describes as being impacted by the liner contamination event, the SU 10220 group is not included within that scope. Therefore, one cannot readily attribute the particle identified in SU 10220I to this event. The other source of particles described in the RAI response are the particles that were released out of the containment structures during demolition activities and dispersed via the wind into outside locations. However, given the distance of SU 10220I from the containment buildings, attributing the origin of the particle to that source would imply that the particles were carried a far distance from the containment source. Depending on the origin of the particle and the mechanism for how it came to be in SU 10220I, other survey units equally as far could also have been impacted. For example, the origin of the particle could call into question whether SU 10220C, which is a Class 3 survey unit adjacent to the south of SU 10220I, should have been reclassified to Class 1.

In summary, while the radioactive characteristics (Co-60) of the particles contained in Sample S0112A and Sample S0116 from the April 2021 inspection survey are consistent with particles that have been previously identified throughout the Zion site, the information provided by the licensee to date related to the radioactive particles found in SU 10209E and SU 10220I is insufficient to understand the origin of this contamination, how it came to be present in those locations, and the extent to which similar particles may be present in other potentially impacted survey units.

Suspected Particle S0120 in SU 12203D

During the April 2021 inspection survey, the suspected particle in Sample S0120, which was found in SU 12203D on the eastern part of the ZNPS site near the beach, was determined to be volumetric contamination upon analysis. It contained Co-60, europium-152 (Eu-152), and europium-154 (Eu-154) (see Table 3 above). As described in the ORISE report:

> After the particle separation process performed by REAL staff, outlined in Section 4.1.2, it was determined that sample S0120 did not contain a particle. Rather, sample S0120 was found to exhibit uniform levels of elevated direct gamma radiation consistent with volumetric contamination; the sample matrix was a mixture of rocks (possibly containing concrete), soil, and sand.
>
> The sample had a relatively large concentration, compared to other volumetric samples, of europium — specifically Eu-152 with a lower concentration of Eu-154. Plutonium-239/240 (Pu-239/240) was a statistical detect in

sample S0120. A re-count of this sample with a longer count time confirmed that Pu-239/240 was a statistical detect. Sample S0120 shares similar radiological characteristics with sample S0204A and most likely originated from neutron activation of the reactor bioshield.

The NRC staff notes that the licensee did not define europium isotopes as radionuclides of concern (ROCs) for soil in the Zion LTP because europium was only expected to be present in specific parts of the concrete surrounding the reactor in the containment buildings. As part of the technical basis for the LTP, the licensee did, however, calculate a concentration (if present across the site) equivalent to 25 millirem per year (mrem/yr) for the europium isotopes in soil (note that those concentrations are not applicable to particles and only apply to volumetric soil contamination). These radionuclide concentrations are listed in Table 28 of ZNPS Technical Support Document (TSD) 14-019, "Radionuclides of Concern for Soil and Basement Fill Model Source Terms," Revision 2 (ADAMS Accession No. ML17208A117), and are repeated below in Table 4, along with the ORISE analysis results for the radionuclide concentrations present in Sample S0120.

Table 4 – Concentrations in Table 28 of TSD 14-019 Compared to Concentrations in S0120

Radionuclide	Soil Activity Equivalent to 25 mrem/yr (pCi/g)	Sample S0120 Activity (pCi/g)
Co-60	4.73	27.4
Eu-152	10.7	1449
Eu-154	9.97	79.5

The licensee also assumed that soil as a media would occupy 25.6% of the 25 mrem/yr unrestricted release dose criteria for Zion (see TSD 17-004, "Operational Derived Concentration Guideline Levels for Final Status Survey," Revision 3 (ADAMS Accession No. ML18052A539)), which is how the licensee derived the operational derived concentration guideline level (OpDCGL) levels for the defined ROCs listed in the Zion LTP.

Based on a review of the above information and ORISE sample results, the NRC staff notes that the europium concentrations in Sample S0120 are greater than the concentrations that are equivalent to 25 mrem/yr for the surface soil across the Zion site as assumed in the associated ZNPS TSD, although the TSD concentrations assume contamination across the entire site as opposed to only in an elevated area. For soil, the Zion LTP allows elevated areas to remain that are above the site wide DCGL ($DCGL_W$) but below the DCGL for areas of uniform elevated concentration ($DCGL_{EMC}$); and Section 5.2.15 of the LTP lists the area factors that are approved to be used for the ROCs in any such elevated area. However, since europium isotopes were not defined as ROCs, there are no approved area factors for Eu-152 or Eu-154; and, as stipulated in Section 5.1 the Zion LTP, the concentration is to be compared to the values in Table 28 of TSD 17-004 to assess the potential insignificant radionuclide contribution, and potentially trigger additional evaluation by the licensee.

The NRC staff also notes that Survey Unit 12203 was originally classified as a Class 2 SU in the Zion LTP. However, the licensee reclassified this area from Class 2 to Class 1 in 2016 "due to changing radiological and operational conditions brought about by site decommissioning activities inside or adjacent to this area." Specifically, SU 12203 was

divided into four separate survey units. In response to previous RAIs related to this and associated survey units, the licensee indicated that survey units 12112, 12113, 12203A, 12203B, 12203C, and 12203D had concrete debris temporarily placed in them, or transported through them, after FSS of the survey units was completed. However, as discussed in the February 2021 RAI response, the licensee contends that the concrete debris was free of residual radioactivity; and specifically, the release record for SU 12203D does not describe a history of contamination or remediation performed in this survey unit.

In summary, there is not enough information on the origin of the volumetric contamination in Sample S0120, how it became present in SU 12203D, and what other survey units may be impacted by similar contamination. Furthermore, given that volumetric contamination by europium isotopes was not expected in surface soil at the site, and therefore europium isotopes were not defined as ROCs for soil in the Zion LTP, there is not an approved method in the LTP for determining compliance with the radiological release criteria using a comparison to a $DCGL_{EMC}$ for this soil sample. Therefore, more information is requested to understand the potential extent of condition and the impact on compliance with the 10 CFR Part 20 release criterion.

Suspected Particle S0203 in SU 10204B

During the April 2021 inspection survey, the suspected particle in Sample S0203, which was found in SU 10204B on the northern part of the ZNPS site in the North Gate Area, was determined, upon further investigation by the Radiological and Environmental Science Laboratory (RESL), to contain a chunk of material that had a uniform distribution of radioactive material rather than a particle. As described in the ORISE report:

> Sample S0203A was also collected based on the suspicion of a particle; however, laboratory analysis revealed that this sample is unlike any of the other samples collected during this confirmatory survey. This sample contained elevated concentrations of Th-232, Th-228, and Ra-228 at 1,050 pCi/g, 1,550 pCi/g, and 2,400 pCi/g, respectively. Elevated conventions of U-238 and U-234 at approximately 150 pCi/g were also reported in this sample. These results are reported as sample S203ATh in Table B.4. The elevated Ra-228 concentration relative to Th-232 indicates that the material within the sample is not natural and the material has received some form of processing. The origin of this sample could not be determined based on the available data but are not produced in commercial light-water reactors and are, therefore, not plant-derived.

Survey Unit 10204, North Gate Area, was originally classified as a Class 3 SU in the Zion LTP. However, the licensee reclassified this area from Class 3 to Class 1 in 2017 “due to changing radiological and operational conditions brought about by site decommissioning activities inside or adjacent to this area.” Specifically, SU 10204 was separated into four survey units, and the associated release record describes how a radioactive particle was discovered during a surface scan for FSS and removed from one of these divided survey units (SU 10204D). However, the release record does not give the detailed radiological characteristics of the particle identified during FSS, so a comparison to the radiological characteristics of S0203 are not possible.

Specifically, the release record for SU 10204D provides limited information, stating:

> A 1 square foot elevated area was observed toward the western edge of the row. A scan measurement of 11,600 cpm was observed. The activity was found to be from a small radioactive particle reading 20,000 cpm located approximately 2 inches below the surface.

In summary, the radionuclide mixture within Sample S0203 appears to be consistent with enhanced thorium material. The licensee should attempt to determine the origin of this contamination, or provide reasonable assumptions regarding the potential origin of this material. For instance, the licensee should state whether the thorium material is likely a result of decommissioning operations, such as cutting or welding metal components; whether it was inadvertently imported as part of the clean fill for final site grading, or some other origin. The licensee should also clarify if the material is similar in characteristics to the particle removed from SU 10204D during FSS.

Particle S0126 in SU 12203A

During the April 2021 inspection survey, the particle in Sample S0126, which was located in SU 12203A, was determined to have a radionuclide mixture of: transuranics (Am-241, curium-241 (Cm-241), plutonium-238 (Pu-238), neptunium-237 (Np-237), and Pu-239/240)); and fission products (cesium-137 (Cs-137), strontium-90 (Sr-90), europium-154 (Eu-154), and europium-155 (Eu-155)). This mixture was characterized in the ORISE report as most likely coming from reactor fuel. However, it is unclear what transport mechanisms during the Zion decommissioning process led to the presence of this particle on the soil surface.

Survey Unit 12203 was originally classified as a Class 2 SU in the Zion LTP. However, the licensee reclassified this area from Class 2 to Class 1 in 2016 “due to changing radiological and operational conditions brought about by site decommissioning activities inside or adjacent to this area.” Specifically, SU 12203 was divided into four separate survey units.

In the survey unit where Sample S0126 was found (SU 12203A), concrete debris from the ZNPS Unit 1 and Unit 2 containment exterior was stored during decommissioning. Additionally, in survey units 12205A-E, concrete debris was stored, removed, and then an FSS was re-performed on those survey units. In response to associated RAIs on this topic from February 2021 (ADAMS Accession No. ML21067A225), the licensee indicated that survey units 12112, 12113, 12203A, 12203B, 12203C, and 12203D had concrete debris temporarily placed in them, or transported through them, after FSS was completed. The licensee stated that the debris that was temporarily placed in survey units 12112, 12113, 12203A, 12203B, 12203C, and 12203D was comprised of concrete originating from the exterior of the Zion containment buildings and was therefore considered low-risk.

However, as documented in the NRC’s 2020 first quarterly inspection report (ADAMS Accession No. ML20080J249), NRC inspectors identified a Severity Level (SL) IV, Non-Cited Violation (NCV) of ZNPS License Condition 2.C.(17) for failing to implement and maintain in effect all provisions of the approved LTP. Specifically, the licensee placed contaminated concrete debris in an area under FSS controls, which is inconsistent with the intent of LTP Section 5.6.3 to implement contamination controls throughout FSS activities until there is no risk of recontamination from decommissioning, or until the survey area has been released from the 10 CFR Part 50 license. As indicated in the NRC inspection report,

the concrete debris was subsequently removed from the impacted survey units and shipped for disposal as low-level radioactive waste. Once the concrete debris was removed, the February 2021 RAI response indicates that the two impacted areas underwent additional surveillances, and some degree of re-survey and contamination controls were implemented to confirm radiological conditions and preclude re-contaminating these areas.

The licensee further contends that the concrete debris was not a source of discrete radioactive particles. In the February 2021 RAI response, the licensee states that:

> Concrete debris generated during all radiological structural demolition was never a source of DRPs on-site. The majority of all DRPs identified outside of structures throughout the project are conducive with the radiological, metallurgical, and dimensional characteristics representative of reactor internals segmentation tailings.

In addition to the concrete debris, other information provided by the licensee points to an additional type of breakdown in isolation and control of SU 12203A after FSS, which may be relevant to the identification of the particle in Sample S0126. Specifically, as an enclosure to the February 2021 RAI response, the licensee provided CR ES-ZION-CR-2019-0066, which was initiated on May 13, 2019. This CR describes how a snow removal pile was identified as straddling SU 12203A after FSS had been completed in January-February 2019. The recommended action in the CR was to perform a special surveillance in accordance with ZS-LT-300-001-003 to assess any impact to the FSS of SU 12203A.

In summary, the information provided to date regarding to the particle found in SU 12203A is insufficient to understand the origin of this contamination and the extent to which similar particles (reactor fuel particles) may be present in other potentially impacted survey units. A potential origin of the particle could be the stored concrete debris. However, the licensee contends that the concrete debris was not a source of particle contamination. Another potential origin may be the snow removal pile, but no information other than the referenced CR regarding the snow pile was provided. Therefore, more information is requested to understand the potential origin and extent of condition of this particle.

Particles S0124 and S0204AEu in SU 12201B

During the April 2021 inspection survey, ORISE identified a 1.5 microCi Co-60 particle in Sample S0124, located in SU 12201B, which is north of the Zion Unit 2 containment building. An additional particle found in SU 12201B, Sample S0204AEu, contained Eu-152, Eu-154, and barium-133 (Ba-133), which are neutron activation products typically found within the bioshield surrounding the reactor pressure vessel. Furthermore, uranium-233 (U-233) was also identified in Sample S0204AEu, which results from activation of natural Th-232 contained in concrete. As a result, this particle (Sample S0204AEu) was characterized in the ORISE report as likely coming from the reactor bioshield concrete.

Survey Unit 12201, North Protected Area Yard, was originally classified as a Class 2 SU in the Zion LTP, but was subsequently reclassified to a Class 1 area in 2016 and divided into five separate survey units (survey units 12201A-E), which were part of Phase 4 of the Zion FSSR submittal. The North Protected Area Yard is contained in what is referred to as the “Power Block” area, which is the soil around the footprints of the Zion Unit 1 and Unit 2

containment structures. The Power Block consists of nineteen Class 1 open land survey units: the southern half of 10203A, 10203F, 12201A, B and C, 12202A, B, C, D, E and F, 12104, 12105, 12106, 12107, 12108, 12109, 12110, and 12111.

Phase 4 of the Zion FSSR describes how, after realizing that the soils surrounding the Zion containment structures were contaminated, the licensee applied a sacrificial layer of soil around the Power Block and then removed the sacrificial soil after demolition of the containment buildings was completed. As further described in the February 2021 RAI response, there was known particle contamination in the Power Block prior to when the sacrificial soil was placed in this area, and additional remediation occurred after the sacrificial soil was removed. The licensee subsequently remediated the indigenous soils prior to backfilling the area with 3 additional feet of clean soil. The indigenous soil of most of the Power Block was approximately at the 588-foot elevation.

Phase 4 of the Zion FSSR (ADAMS Accession No. ML20133J976) specifically indicates:

> From February 26, 2019, through June 18, 2019, scanning and remediation commenced south of Unit 1 and progressed to the north and west of the Containment footprints (see Figure 3-5). Large areas of elevated activity were identified by scan and verified by soil sample analysis and subsequently marked.

In May 2019, during the "Results of Re-Survey of 'Power Block' Area and Readiness for ORISE Confirmatory Surveys" campaign performed by the licensee, significant remediation was performed in SU 12201B. Additionally, as stated in the enclosure to the February 2021 RAI responses with the same name:

> Remediation was performed to recover discovered discrete particles in survey units 12104, 12106, 12107, 12109, 12201B, 12201C, and 12202D or, to reduce detected volumetric contamination in soil in survey units 12104, 12105, 12106, 12107, 12108, 12109, 12110, 12111, 12201A, 12201B, 12201C, 12202C, 12202E, and 12202F.

Despite these indications and the need to perform additional remediation activities, the Power Block Readiness Report does not discuss the origin or potential cause of the contamination, nor is the particle contamination or remediation performed prior to FSS described or otherwise addressed in the licensee's associated release records. For example, the release record for Survey Unit 12201B attributes the change in classification of the survey unit as being "due to changing radiological and operational conditions brought about by site decommissioning activities inside or adjacent to this area." The release record indicates that FSS took place in September 2019, and that no remediation was performed.

In summary, the likely source of the particle identified in Sample S0124, as discussed by the licensee in previous submittals including the Zion Final Status Survey Due Diligence Plan dated July 16, 2021, was from the reactor vessel internal segmentation activities that released particles from containment to nearby areas prior to the sacrificial soil being emplaced and removed from the Power Block. However, the location of the particle within approximately one foot of the surface appears to contradict the statements in Phase 4 of the Zion FSSR about three feet of clean soil subsequently being emplaced in this area. Furthermore, the radionuclide profile of the particle found adjacent to Sample S0124 (Sample S0204AEu) indicates the source

of that particle is distinct and from the reactor bioshield. Therefore, the information provided to date is insufficient to explain the origin of the particle contamination, and the extent to which similar particles (Co-60 particles, particles from reactor bioshield concrete, or irradiated fuel fragments) may be present in other affected survey units.

Path Forward:

For each particle or sample identified during the April 2021 inspection survey and described above, please explain to the extent possible:

a. The likely origin of the particle or material identified in the sample (e.g., activated metal, bioshield concrete, irradiated fuel fragments, etc.) from decommissioning operations, including the hypothetical radionuclide mix for each type of particle based on the reactor operational history of both units (e.g., fuel burnup and activation).

b. The size range of particles expected to be produced by decommissioning operations for the three types of particles identified (i.e., Co-60 metal, possible activated bioshield concrete, possible activated fuel fragment). Specifically, for the types of cutting operations above and below water and demolition activities that were performed at Zion, the range of expected particle sizes should be identified, along with technical references for the expected size range where available.

c. A description of how the particle or material transported from the contamination source to where it was found during the April 2021 inspection survey, as well as the potential timing or time range of when the particle was transported to that location.

As an example to address the above, for several years discrete particles of Co-60 were released to the atmosphere during the Zion containment structure demolition activities due to wind entrainment. The licensee should provide an analysis that explains the range of particle sizes that could be transported and deposited onsite based on these demolition activities and local wind conditions during the release period. In addition, the licensee should provide an explanation of the activated concrete found in two distinct site areas (SU 12201B north of containment and SU 12203D on the eastern portion of the site by the beach) and the presumed irradiated fuel fragment.

d. The most likely cause for why the particle or material was not found in licensee surveys.

e. Whether these areas received an ORISE confirmatory survey in their final condition.

f. If the area received a confirmatory survey in its final condition, provide an estimate of whether the particles were present and missed during the confirmatory survey or were transported to the area after the confirmatory survey due to other site activities.

g. Given the observations in the survey units listed above, as well as any additional observations resulting from ongoing licensee activities under the Final Status Survey Due Diligence Plan, provide an explanation for why the licensee surveys are adequate.

h. Given that the licensee's FSS and other survey activities did not identify these particles or other radiological material, provide a discussion to support reasonable assurance that there are not similar particles in other areas at a concentration level or to an extent that might challenge the unrestricted release criterion of 10 CFR Part 20.

In addition, to aid the NRC staff's understanding of the potential origin of this contaminated material, why it is presently at the Zion land surface or within one foot of the surface, and whether similar contaminated material could have been transported to other locations not surveyed in April 2021 due to resuspension from normal site winds, resuspension during site grading operations, open air demolition, etc., please provide additional information to the extent available on the following timeline considerations:

i. When clean fill was placed over and surrounding the basement substructures in the Zion Power Block area.

j. When final grading of the site commenced and was completed.

k. When final grading occurred for the area where concrete debris was stored.

l. When the final cover of seed bed (i.e., grass) on the final site grade was placed.

m. When ZNPS waste handling activities occurred in each of the locations where the particles and radiological material "chunks" were found (south of the railroad track, south of the Auxiliary Building, southeastern portion of the site near the beach, etc.).

n. Timing of any other operational events that could explain the origin or presence of the particles and radiological material "chunks" of contaminated debris at the site.

2. <u>Evaluating the Zion LTP Change Review Process</u>

Comment: The approved Zion LTP contains mechanisms for evaluating the need for potential changes to the assumptions made in the LTP, which form the criteria used to develop the FSS plans and conclude that the site may be released. Given the current information on final site radiological status, more information is necessary in order for the NRC staff to reach a determination that the Zion site meets the LTP bounding assumptions.

Basis: The Zion LTP was submitted as a supplement to the ZNPS defueled safety analysis report, and was accompanied by a proposed license amendment (in the form of a license condition) that establishes the criteria for when changes to the Zion LTP require prior NRC approval. Information from previous RAI responses related to the Zion FSSR, in addition to the April 2021 inspection survey results, potentially indicate a radiological condition of the site that was not accounted for in the approved LTP.

ZNPS License Condition 2.C.17 establishes the criteria (A) thru (M) under which Zion*Solutions* would need prior approval from the NRC to make changes to the Zion LTP. The following are examples of the LTP change criteria that should be evaluated throughout the decommissioning process based on the radiological status of the site:

Zion*Solutions* may make changes to the LTP without prior approval provided the proposed changes do not meet any of the following criteria:

(E) Increase the derived concentration guideline levels and related minimum detectable concentrations (for both scan and fixed measurement methods).

(F) Increase the radioactivity level, relative to the applicable DCGL, at which an investigation occurs.

(I) Change the approach used to demonstrate compliance with the dose criteria (e.g., change from demonstrating compliance using derived concentration levels to demonstrating compliance using a dose assessment that is based on final concentration data).

(J) Change parameter values or pathway dose conversions used to calculate the dose such that the resultant dose is lower than that in the approved LTP and if a dose assessment is being used to demonstrate compliance with the dose criteria.

(L) Assign a dose for reuse concrete other than the dose values provided along with the LTP (as shown in Table 6-53 (Revision 2) of the LTP) and documented in Section 8 and Table 33 of TSD 14-010, "RESRAD Dose Modeling for Basement Fill Model and Soil DCGL and Calculation of Basement Fill Model Dose Factors and DCGLs," Revision 6.

Path Forward:

a. Please explain the process the licensee underwent to determine whether or not the information available since approval of the Zion LTP has triggered an evaluation of the LTP change criteria. Information potentially impacting the Zion LTP licensing basis is included in: an RAI response submitted in February 2021 (draft form in November 2020) related to dose from potential radioactive particles left on the Zion site, the April 2021 inspection survey results, and the Zion Final Status Survey Due Diligence Plan.

b. Please discuss the results of the evaluation as they impact the ZNPS licensing basis. If an outcome of the process was that the licensing basis is not impacted, please justify why this is the case when considering the information available.

3. <u>Background Values for Transuranic Radionuclides</u>

Comment: Several soil samples collected during the April 2021 inspection survey were analyzed for the presence of transuranic radionuclides. The results of the radioanalytical tests indicate that some samples include low levels of Am-241 and Pu-239, such as Sample S0120 and Sample S0127. It appears that the Zion LTP does not address these radionuclides. Therefore, more information is needed by the NRC staff to adequately assess the impact of these radionuclides on the Zion final site status.

Basis: Soil samples collected during the April 2021 inspection survey were found to contain low levels of Am-241 and Pu-239. There are several technical support documents on local background activity levels for the Zion site, including: (1) ZS-2013-004, "Examination of

Cs-137 Global Fallout in Soils at Zion Station;" (2) "Determination of Radionuclide Activity Concentrations In Soils In Non-Impacted Soils Adjacent to the Zion Nuclear Station," (see Enclosure 2 to ADAMS Accession No. ML16028A192); and (3) CS-RS-PN-028, "Background Reference Area Report Zion Nuclear Power Station, Zion, IL," (see ADAMS Accession No. ML15188A111; Package Accession No. ML15188A105).

However, these documents do not contain an assessment of Am-241 and Pu-239 in local soils, and instead provide information on Cs-137, Co-60, Sr-90, and naturally-occurring radioactive materials in local soils. Therefore, the technical support documents do not state whether low levels of Am-241 and Pu-239 in the soil is most likely attributable to licensed operations or background radiation. Additional information is needed on local background levels of Am-241 and Pu-239 to determine whether the presence of those radionuclides in Sample S0120 and Sample S0127, collected during the April 2021 inspection survey, are from licensed operations or from another source, such as background radiation.

Path Forward:

a. Please explain whether the Zion LTP considered or addressed these radionuclides.

b. Please provide additional information on the background levels of Am-241 and Pu-239 that might be attributable to fallout in the local area surrounding the Zion site. Alternatively, please provide an explanation for the presence of Am-241 and Pu-239 in the soils if these radionuclides are not attributable to fallout in the local area.

c. Compare background radiation levels to the levels that were identified in the soil samples collected during the April 2021 inspection survey, and provide an explanation of whether the Am-241 and Pu-239 identified in these samples is the result of licensed material or background radioactivity from fallout.

4. <u>Particle Releases as They Relate to Site Characterization in the LTP</u>

Comment: More information is needed by the NRC staff on the process used by the licensee to determine whether the releases of radioactive particles that occurred during decommissioning activities at the Zion site were documented in the site characterization within the LTP as it relates to spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site during decommissioning.

Basis: Radioactive particles were identified during the April 2021 inspection survey which indicate that contamination remained at the Zion site from prior release(s) after cleanup and remediation activities were completed by the licensee.

In accordance with 10 CFR 50.82(a)(9)(i), the LTP must be a supplement to the updated final safety analysis report, or equivalent. Per 10 CFR 50.82(a)(9)(ii), the LTP must include:

(A) A site characterization;

(B) Identification of remaining dismantlement activities;

(C) Plans for site remediation;

(D) Detailed plans for the final radiation survey;

(E) A description of the end use of the site, if restricted;

(F) An updated site-specific estimate of remaining decommissioning costs;

(G) A supplement to the environmental report, pursuant to 10 CFR 51.53, describing any new information or significant environmental change associated with the licensee's proposed termination activities; and

(H) Identification of parts, if any, of the facility or site that were released for use before approval of the license termination plan.

Site characterization is informed through surveys as well as document reviews, including records of spills or releases or contamination. In accordance with 10 CFR 50.75(g), spills or unusual occurrences involving the spread of contamination at a site that may result in significant contamination remaining after cleanup are required to be documented until the license is terminated. The purpose of the records in the '10 CFR 50.75(g) file' is to inform the Historical Site Assessment (HSA), and ultimately the site characterization in the LTP to help define the appropriate radiological release surveys planned for the site.

The requirement at 10 CFR 50.75(g) states, in part:

(g) Each licensee shall keep records of information important to the safe and effective decommissioning of the facility in an identified location until the license is terminated by the Commission. If records of relevant information are kept for other purposes, reference to these records and their locations may be used. Information the Commission considers important to decommissioning consists of —

(1) Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site. These records may be limited to instances when significant contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete.

The Zion HSA and associated site characterization, how the 10 CFR 50.75(g) file informs this site characterization, and how site characterization shapes the adequate planning of remediation activities during the decommissioning process are assessed in the safety evaluation for the Zion LTP as follows:

Licensees conduct site characterization surveys to determine the nature and extent of radioactive contamination in buildings, plant systems and components, site grounds, and surface and groundwater. The major objectives of characterization activities are to permit the planning and conduct of radiological remediation activities; confirm the effectiveness of radiological remediation methods; provide information to develop specifications for final status surveys; define site and building areas as survey units and assign survey unit classifications; and provide information for dose modeling.

> The licensee conducted radiological site characterization activities that included a historical site assessment (ADAMS Accession No. ML15342A281), scoping surveys, and a characterization survey. The HSA included a review of records maintained to satisfy the requirements of 10 CFR 50.75(g)(1)(requiring the licensee to keep "[r]ecords of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site"), as well as environmental reports, Radiological Environmental Monitoring Reports, Radioactive Effluent Release Reports, Licensee Event Reports, Plant Operating Reports, Plant Safety Analyses, Radiological Surveys, and Plant Operating Logs. Additionally, personal interviews of current and former ZNPS site personnel and reviewed collections of photographs were performed for the HSA.

In addition, as described in the Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans (NUREG-1700, Revision 2):

> The licensee should use the site characterization information to develop input for use in the dose modeling such as ROCs. As part of the review, the NRC staff should review the licensee's site characterization plans and site records (required under 10 CFR 50.75(g)). The purpose of this review is twofold. First, the NRC staff seeks to ensure that the site characterization presented in the LTP is complete. Second, the NRC staff verifies that the licensee obtained the data using sufficiently sensitive instruments and proper quality assurance procedures to obtain reliable data that are relevant to determining whether the site will meet the decommissioning limits if characterization data is used as final survey data.

Furthermore, the acceptance criteria for site characterization listed in NUREG-1700, Revision 2, include:

- The LTP identifies all locations, both inside and outside the facility, where radiological spills, disposals, operational activities, or other radiological accidents and or incidents occurred and could have resulted in contamination.

- The LTP describes, in summary form, the original shutdown, and current radiological and non-radiological status of the site.

- The LTP site characterization is sufficiently detailed to allow the NRC staff to determine the extent and range of radiological contamination of structures, systems (including sewer systems and waste management systems), floor drains, ventilation ducts, piping and embedded piping, rubble, ground water and surface water, components, residues, and environment, including maximum and average contamination levels and ambient exposure rate measurements of all relevant areas (structures, equipment, and soils) of the site (including contamination on and beneath paved parking lots).

- The LTP describes in detail the areas and equipment that need further remediation to allow the reviewer to estimate the radiological conditions that will be encountered during remediation of equipment, components, structures, and outdoor areas.

Section 2.5 of the Zion LTP as it relates to continuing characterization states the following:

> The survey of many inaccessible or not readily accessible subsurface soils or surfaces has been deferred. All continuing Characterization Plans will be provided to the NRC for information and all continuing Characterization Reports will be provided to the NRC for evaluation.
>
> All surface soil at ZNPS has been adequately characterized and additional characterization of surface soil is not anticipated during continuing characterization. Radiological Assessment (RA) surveys will be performed in currently inaccessible soil areas that are exposed after removal of asphalt or concrete roadways and parking lots, rail lines, or building foundation pads (slab on grade).

According to the RAI response from February 2021 (ADAMS Accession No. ML21067A225), radioactive particles were released at the Zion site beginning in 2012 as a result of ongoing decommissioning activities. The licensee undertook multiple significant particle retrieval and remediation efforts, beginning as early as 2012, and continuing through when the Zion LTP was approved in September 2018. Particles continued to be found throughout FSS and ORISE confirmatory survey activities. Addressing this type of radioactive particle contamination is important for informing site characterization activities, as well as the radiological status of the site at the time of submission of the LTP. Although the Zion LTP was approved after these particle releases and many remediation efforts occurred, the LTP contains no mention of radioactive particle releases or the associated remediation efforts.

Along with the February 2021 RAI responses, Zion condition reports regarding particle releases identified in 2014 and 2015 were provided to the NRC staff. Specifically:

- ZNPS CR-2014-001074 describes a contamination event involving particles when a waste liner was loaded onto a shipping cask in the South Yard.

- ZNPS CR-2015-000324 describes particle contamination identified on the ground on the north side of the Zion Unit 2 containment structure.

Both of these ZNPS CRs contain a field called “50.75(g) Issue,” and a “yes” is denoted under this field, indicating that these events were potentially intended to become part of the site characterization supporting documentation. However, it is unclear what process was applied to decide whether these particle release events would be addressed or included in the site characterization details in the Zion LTP.

Path Forward:

a. The ZNPS CRs indicated a “yes” under the “50.75(g) Issue” field. Please describe the factors that go into deciding whether an event is added to the Zion 10 CFR 50.75(g) file if it is indicated with a “yes” in an associated condition report. Please describe the factors that go into deciding whether contamination events are discussed in the site characterization portion of the LTP, and/or subsequently used to update survey plans.

b. Considering that the majority of the site characterization activities took place prior to 2014, discuss why the site characterization discussion in the Zion LTP was not revised by the licensee to reflect the change in radiological conditions at the site that was determined in 2016, prior to the Zion LTP being approved in 2018.

5. <u>Radionuclide Surrogate Ratio Assumptions</u>

Comment: The relative ratio of Sr-90 to Cs-137 in a particle collected during the April 2021 inspection survey is significantly different than the surrogate ratio for soil that was assumed in the Zion LTP. Information is needed by the NRC staff to assess the impact of this result on the overarching soil surrogate ratio assumptions used during Zion FSS development.

Basis: The Zion LTP lays out an approach for applying a surrogate ratio to account for the Hard-to-Detect (HTD) ROCs. A surrogate ratio for Sr-90 is necessary because the survey techniques used in the licensee's FSS measure for gamma emitting radionuclides and Sr-90 emits only beta particles, which cannot be detected with the survey instruments used by the licensee. In the LTP, the Sr-90 to Cs-137 surrogate ratio assumed for soil was 0.002 (see Zion LTP Table 5-15). (Note that in the LTP, the Auxiliary Building ratios are assumed for soil because of the lack of positive Sr-90 indications in the soil characterization samples.)

Sr-90 was not expected to be present in the soil at the Zion site. This radionuclide was not detected in the soil samples presented in Chapter 2 of the Zion LTP, which discusses site characterization. Specifically, Section 2.3.5.1 and Section 2.3.5.2 of the Zion LTP summarize the site characterization of soil samples that were sent to an offsite lab and analyzed for radionuclides such as tritium (H-3), carbon-14 (C-14), technetium-99 (Tc-99), nickel-63 (Ni-63), Sr-90, and alpha emitters. No plant-derived radionuclides were identified besides Cs-137 and Co-60. The characterization of the Zion site soil was conducted between 2011 and 2013, which was prior to the majority of the licensee identified decommissioning activities that resulted in the spread of radioactive particles.

Sr-90 was also not detected in site soil during continuing characterization activities after the Zion LTP was approved. The licensee's response to RAIs on Phase 4 of the Zion FSSR, dated June 5, 2020 (ADAMS Accession No. ML20164A096), summarizes the continuing characterization samples taken from the foundation soil beneath each Zion containment structure and the Auxiliary Building basement floor slab. Sr-90 was not detected in these samples during the continuing characterization activities. In addition, as documented in an ORISE confirmatory survey report summarizing surveys conducted in April and July 2019 of the Zion soil land areas (5271-SR-07 Zion Sacrificial Sub-Soil), Sr-90 was also not detected in any of the samples ORISE analyzed for HTDs. Furthermore, ORISE did not detect any Sr-90 in the samples analyzed for HTDs during a subsequent confirmatory survey in December 2019 through January 2020 (5271-SR-08 Remaining Land Areas).

However, even though Sr-90 was not expected to be present in the Zion surface soils in any detectable amount, a particle containing Sr-90 in a greater relative amount to Cs-137 was identified during the April 2021 inspection survey. Specifically, the ratio of Sr-90 to Cs-137 in Sample S0126 collected in SU 12203A is 1.58 (1.57×10^5 pCi / 9.9×10^4 pCi).

The licensee's FSS of SU 12203A was conducted in January and February 2019. In accordance with the Zion LTP, 10% of the FSS samples (15 samples) were analyzed for the HTD ROCs Sr-90 and Ni-63. Sr-90 was not detected in any of the FSS samples. After FSS,

concrete debris was stored on SU 12203A (and adjacent survey units) for several months. As stated in the RAI response from February 2021 (ADAMS Accession No. ML21067A225), the licensee contends that the concrete debris stored in SU 12203A post FSS was clean and was not a source of radioactive contamination or radioactive particles. The RAI response states that the "concrete debris generated during all radiological structural demolition was never a source of DRPs on-site. The majority of all DRPs identified outside of structures throughout the project are conducive with the radiological, metallurgical, and dimensional characteristics representative of reactor internals segmentation tailings."

The NRC staff notes that Sample S0126 is identified as a discrete radioactive particle, and it is therefore technically inappropriate to compare its activity level to that of the DCGL for Sr-90, the derivation of which assumes that soil contamination is relatively homogeneously spread throughout the soil, as opposed to being concentrated in a miniscule particle. Nonetheless the presence of this particle on the soil surface calls into question the validity of the assumptions surrounding the presence of Sr-90 in the Zion soils and the surrogate ratio applied. Given that the licensee's FSS and other survey scans and sampling (except for the 10% analyzed for Sr-90) could not detect Sr-90, it is important that the surrogate ratios applied and assumed in the Zion LTP (and therefore used to inform the FSS methods and survey design implemented across the site) be defensible and supported.

The topic of surrogate ratios and insignificant radionuclides was raised during the NRC staff's review and approval of the Zion LTP. Specifically, in a response to RAIs related to the Zion LTP submitted on March 8, 2016 (ADAMS Accession No. ML16081A010), the licensee defended their method for determining surrogate ratios by stating that "there is no credible mechanism that would cause the HTD mixture percentage to increase with decreasing Cs-137 activity." The RAI response further states that "…there is no credible mechanism for increasing the relative concentrations of insignificant radionuclides during decommissioning. The remediation would either isolate or remove the contaminated material which has been evaluated in the insignificant radionuclide calculation or result in inadvertent mixing with adjacent clean material. Neither of these processes would concentrate one radionuclide preferentially versus another." The NRC staff needs additional information to evaluate whether these statements are still accurate given the results from Sample S0126 in regard to the relative ratio of Sr-90 to Cs-137.

The NRC staff also notes that the Zion LTP includes an option to use a survey unit-specific surrogate ratio. Specifically, Section 5.1 of the LTP states that "survey unit-specific surrogate ratios, in lieu of the maximum ratios from section 5.2.11 Table 5-15, may be used for compliance if sufficient radiological data exists to demonstrate that a different ratio is representative for the given survey unit," and that "in these cases, the survey unit-specific radiological data and the derived surrogate ratios will be submitted to the NRC for approval."

As an example of this process, the licensee applied a survey unit-specific surrogate ratio to the under-vessel area in the Zion Unit 1 containment building (see ADAMS Accession No. ML18103A016). The survey unit-specific ratio approach requires sufficient data to support the alternative surrogate ratio, including a rationale as to why the ratio is different for a given survey unit when compared to the remainder of the site. Given the lack of clarity surrounding the origin of Sample S0126, how it was transported to SU 12203A, and why it was not previously identified, as well as the lack of other radiological data to help define a survey unit-specific surrogate ratio, it may be challenging to support such a specific ratio.

Path Forward:

a. If not previously discussed in response to RAI-1, please provide information that explains the source of this particle and how it came to be present in SU 12203A.

b. Explain why the particle not being found during the licensee's FSS of SU 12203A does not indicate overall quality issues with the Zion FSS methodology, given that the particle contained gamma emitting radionuclides at levels that were within the scope and detection capabilities of the Zion FSS design.

c. Explain why the surrogate ratio for Sr-90/Cs-137 is different for this particle than that which was assumed for soils across the site, and as described in the Zion LTP.

d. Evaluate the potential impact on the Sr-90 surrogate ratio assumed for SU 12203A due to the presence of this particle. Assess whether, in accordance with the Zion LTP, a survey unit-specific surrogate ratio should be applied to this survey unit.

e. Evaluate the potential impact on the Sr-90 surrogate ratio assumed for other Zion survey units that may contain similar particles, and explain why the surrogate ratio applied to these other survey units is still valid. Provide a discussion to support reasonable assurance that particles containing a similar ratio of Sr-90 to Cs-137 do not exist in locations outside of what the license considers to be the affected area.

f. Provide the potential overall or compliance dose consequences of assuming a different Sr-90 to Cs-137 surrogate ratio within what ZS considers to be the affected area.

6. <u>Evaluation of "Insignificant Radionuclides"</u>

Comment: The relative activity ratios of the "insignificant" radionuclides in samples that were identified during the April 2021 inspection survey are significantly different in some cases than what was assumed in the Zion LTP. Also, at least one of the radionuclides observed in one of the particles was not on the original "initial suite list" for the site (Ba-133). Given that the LTP does not address this mix of radionuclides, information is needed to assess the impact on the overarching radionuclide assumptions used for FSS development.

Basis: Section 5.1 of the Zion LTP describes that the licensee assigns 10% of the total dose for unrestricted site release (2.5 mrem/yr) to account for the "insignificant" radionuclides present in soil. This approach follows the guidance in Volume 2, "Characterization, Survey, and Determination of Radiological Criteria," of NUREG-1757, "Consolidated Decommissioning Guidance," Revision 1; specifically Section 3.3, which states that radionuclides and exposure pathways that contribute no greater than 10% of the dose criteria may be considered as insignificant contributors, and that the sum of the dose contributions from all radionuclides and pathways considered insignificant should be no greater than 10% of the dose criteria for site release.

The radiological composition of several of the particles identified during the April 2021 inspection survey is unexpected in terms of the presence and relative activity of the "insignificant" radionuclides. For example, Sample S0126 contained Co-60, Cs-137, Eu-154, Eu-155, Am-241, curium-244 (Cm-244), Np-237, Pu-238, Pu-239, and Sr-90. Sample S0120 contained Co-60, Eu-152, Eu-154, Ba-133, and Pu-239. Sample S0204AEu

contained Co-60, Eu-152, Eu-154, Ba-133, and Pu-239. Refer to RAI-1 for the radionuclide activity associated with each of these samples. As discussed previously, transuranic radionuclides (Am-241, Cm-244, Np-237, Pu-238, Pu-239, etc.) were not expected in the Zion site soils. Europium was also not expected in the surface soils and was only defined as an ROC for the concrete in the Zion containment buildings.

In Chapter 6 of the Zion LTP, as well as in response to RAIs related to the Zion LTP submitted on March 8 2016 (ADAMS Accession No. ML17129A311), the licensee describes that europium isotopes are not ROCs for soil because they were activation products and only expected to be in certain parts of the Zion containment concrete. In response to these same RAIs, the licensee describes how characterization surveys identified concrete with activated Eu-152 and Eu-154 within the reactor bioshield but not outside the reactor bioshield. Specifically, the RAI response states:

> During characterization, concrete core samples were taken from the Unit 1 Bio-Shield and from the 541 foot elevation floor of each unit to assess the activation radionuclide profile at depth. The Bio-Shield core sample was used to quantify the potential depth of neutron activation of the structural concrete surrounding the reactor, assuming that the maximum neutron flux occurred at the reactor centerline (elevation 572 foot 9-inches). A 6 foot core was obtained from the outer surface of the Unit 1 Bio-Shield inward toward the core center line.
>
> Analysis of the core indicates that Eu-152 and Eu-154, which are indicators of the neutron activation of concrete, were not detected in concentrations greater than their respective [minimum detectable concentration] MDC until a depth of 47.5 inches (from the exterior of the Bio-Shield inward toward the core center line). The concrete core samples taken from the 541 foot elevation floor of each unit were taken to a depth of 18 inches. Analysis of the 541 foot elevation cores indicates minimal concentrations of Eu-152 and Eu-154 detected at depth.
>
> These characterization results support the conclusion that neutrons were successfully attenuated by the shielding around the reactors and consequently, there is minimal potential for the activation of concrete in areas outside the Bio-Shield or below the 3 feet of concrete above the liner. Consequently, it is highly unlikely that the concrete under the liner is activated.

Based on these statements, the NRC staff believes that the relative ratio of “insignificant” radionuclides in comparison to Cs-137 identified is several of the samples collected during the April 2021 inspection survey was not expected by the licensee, and the subsequent FSS were not designed considering the potential for these relative amounts of alpha emitters to gamma emitting radionuclides. Section 5.1 of the Zion LTP does however describe the commitments surrounding evaluation of insignificant contributor radionuclides during continuing characterization. To summarize, if the insignificant contributor dose from each individual sample is less than the insignificant contributor dose assigned for planning purposes, then no further adjustments for insignificant contributor dose were warranted. If the insignificant contributor dose from the characterization sample is greater than the insignificant contributor dose assigned for planning purposes, then an investigation will be conducted and the insignificant contributor dose will be revised as described in Section 5.1 of the LTP. Furthermore, if the data indicate different ROCs for the given survey area, a specific ROC list will be applied to the area. The Zion LTP also states that “the actual

insignificant contributor dose will be calculated for each individual sample result using the DCGLs from TSD 14-019 Table 27 for structures and Table 28 for soils." Table 28 from TSD 14-019, Revision 2, is reproduced below for reference.

Radionuclide	Soil (pCi/g)
H-3	4.58E+03
C-14	8.96E+01
Fe-55	3.37E+04
Ni-59	1.09E+04
Co-60	4.73E+00
Ni-63	3.97E+03
Sr-90	1.34E+01
Nb-94	7.51E+00
Tc-99	1.28E+02
Ag-108m	7.40E+00
Sb-125	3.36E+01
Cs-134	7.52E+00
Cs-137	1.58E+01
Pm-147	1.20E+05
Eu-152	1.07E+01
Eu-154	9.97E+00
Eu-155	3.91E+02
Np-237	8.01E-01
Pu-238	1.62E+02
Pu-239/240	1.46E+02
Pu-241	6.52E+03
Am-241	1.34E+02
Am-243	4.98E+01
Cm-243/244	7.61E+01

Figure 3 - DCGLs for Soil (Figure 28 in TSD 14-019, Revision 2)

Given that the concentration of Eu-152 and Eu-154 in the soil for Sample S0120 exceed the concentrations from Table 28 in TSD 14-019, the assumed insignificant contributor dose contribution has been exceeded for that sample. For Sample S0204AEu, the Eu-152 concentration is 6% of the Table 28 value, which is over half of the 10% dose contribution assigned to all the insignificant radionuclides. (Note that the use of area factors and a $DCGL_{EMC}$ was approved for only the ROCs (not the insignificant radionuclides) in the Zion LTP.) Comparing the dose contribution of the insignificant radionuclides for the particle in Sample S0126 is less straightforward because the activity levels are reported in pCi as compared to pCi/g. However, the relative activity level of the insignificant radionuclides when compared to Cs-137 or Co-60 is higher than expected based on-site characterization. Given this information, the potential impact of these sample results on the relative activity ratios of the "insignificant" radionuclides assumed in the Zion LTP needs to be addressed.

Path Forward:

a. Evaluate the potential dose contributions from the radionuclides that were defined as "insignificant" radionuclides in the Zion LTP, using the range of ratios/radionuclides observed in the samples collected during the April 2021 inspection survey.

b. Evaluate the ability of the survey methods used during the Zion FSS activities to detect the potentially significant radionuclides identified during the April 2021 inspection survey that were not on the original ROC list for the Zion site.

c. Evaluate whether the observed conditions are within the bounds of what was assumed in the Zion LTP (i.e., 10% of the dose is from insignificant radionuclides) and what potential actions are needed (e.g., a license amendment to change the list of ROCs) if the final site conditions do not fall within the original assumptions used in the LTP.

7. Concrete Debris Information

Comment: During the April 2021 inspection survey, the NRC staff observed debris (e.g., electrical wiring, protruding metal rods, and what appeared to be concrete debris) on the soil surface in various areas of the Zion site. Given that the Zion LTP assumes that most of the site will be covered with clean fill material, information is needed for the NRC staff to assess the potential impact on the final radiological site status.

Basis: In accordance with Section 2.4 of the Zion LTP, only concrete that meets the licensee's non-radiological definition for demolition debris, and where radiological surveys demonstrate that the concrete meets the criteria for unconditional release, was to be used for backfill on the site. Per NRC safety evaluation associated with the Zion LTP, no demolition debris was supposed to be left on the Zion site other than as backfill in the basements. Additionally, as per the LTP, the Zion basement structures were expected to be covered with a minimum of three feet of clean cover material (i.e., soil).

Section 2.4 of the Zion LTP states that "in accordance with Section 3.160(b) of the Illinois Environmental Protection Act, [Clean Concrete Demolition Debris] CCDD is defined as uncontaminated broken concrete without protruding metal bars, bricks, rock, stone, reclaimed or other asphalt pavement or soil generated from construction or demolition activities. Only concrete debris that meets the definition of CCDD will be considered for use as clean hard fill and only when surveys have demonstrated that the concrete is free of detectable residual radioactivity. Concrete debris that is surveyed and found contaminated with detectable residual radioactivity will be disposed of as low-level radioactive waste."

Subsequent to a teleconference with the NRC staff on May 20, 2021, the licensee submitted the following in response to the question of whether what the NRC observed on the Zion surface soil during the April 2021 inspection survey was concrete debris:

> At any decommissioning site, it is possible for small amounts of demolition debris to remain on the surface. Final site grading, in addition to the rise of solid materials due to freeze-thaw cycles, could contribute to the amount of concrete or larger solid materials that are at the surface. Additionally, one type of fill brought on-site for construction purposes was gravel, typically sandstone, from the Franklin Quarry (in Franklin, WI) owned by Vulcan Materials. Some of this gravel was light in color and could be mistaken for crushed concrete. Note that for the Power Block area a finer sand fill material was used to build up to the final elevation – therefore minimizing the chance that concrete debris from this area could migrate to the surface. Zion*Solutions* contends that every effort was put forth toward cleaning up as much concrete debris at the site as reasonable.

The NRC staff notes that this response could be interpreted to mean that potentially contaminated concrete debris was not fully removed from the site per the corrective action associated with a violation included in the NRC inspection report dated March 18, 2020 (ADAMS Accession No. ML20080J249). In this violation, NRC inspectors identified a

Severity Level IV violation of ZNPS License Condition 2.C.(17) for failing to implement and maintain in effect all provisions of the approved Zion LTP, which did not allow for concrete debris to remain onsite other than as backfill in the basements. The response also seems to imply that freeze-thaw cycles could effectively bring pieces of the basement fill material through the clean cover to the surface, which was not evaluated as part of the Zion basement fill model (BFM). Therefore, clarity is needed surrounding the origin of the material that was observed at the surface of the Zion site and its regulatory significance.

Path Forward:

a. Indicate how the current site conditions are consistent with the commitments in the Zion LTP given the surface materials noted during the NRC's April 2021 inspection survey.

b. Provide information on whether the material on the Zion site surface is demolition debris that should have been removed during decommissioning, offsite gravel that was used for grading, or some other explanation for its presence, such as basement fill that has been disturbed by action of weather (e.g., erosion, freeze-thaw cycles) or site operations.

8. <u>Information on Clean Cover Material</u>

Comment: Observations from the April 2021 inspection survey are indicative that the thickness of clean cover in certain areas of the site are not consistent with the Zion LTP commitments, the assumptions for deriving the basement DCGLs, and the description of the end state of the site included in Phase 4 of the Zion FSSR. Information is needed by the NRC staff to verify that the cover material is consistent with the assumptions included in the Zion LTP and the final site description in Phase 4 of the Zion FSSR.

Basis: Both the Zion LTP and Phase 4 of the Zion FSSR describe the use of clean soil cover over parts of the ZNPS site. Furthermore, the BFM conceptual site model assumes a certain thickness of clean cover over the Zion basement structures. Contrary to these descriptions, the NRC staff identified a 1.5 microCi Co-60 particle within approximately one foot of the surface in SU 12201B north of the Zion Unit 2 containment structure, where the site was expected to have three feet of clean fill material. In another area where clean fill material was expected (the survey units where the Crib House had been), samples near the surface were found that contained europium, which was unexpected (see RAI-6). The survey unit over the Crib House also had a documented erosion issue.

In Phase 4 of the Zion FSSR, the licensee describes how a 1.5 foot layer of clean sacrificial soil brought from offsite was placed over the 588-foot grade surface soils surrounding the two Zion containment buildings prior to demolishing the containment domes. This was done because the 588-foot grade soils were identified as contaminated by the licensee, and the intention at that time was to reuse the containment concrete as basement fill material. In order to avoid contaminating this concrete with the surface soil during containment building demolition, the sacrificial layer of clean soil was necessary. Subsequently, after removal of the sacrificial soil layer, the exposed 588-foot soils were scanned.

During this scanning process, large areas of elevated activity were identified by the licensee, and soil identified as exceeding the OpDCGLs for subsurface soil was excavated and disposed of as radioactive waste. Post-remediation surveys were then performed by scan and media sampling. ORISE also performed confirmatory surveys of the exposed

subsurface soils surrounding the former Zion containment buildings in July and August of 2019. The Phase 4 FSSR describes how “three small particles of radioactive material were identified by the ORISE survey. The particles were captured and removed. Shortly thereafter, clean fill was acquired from an off-site source and used to increase the grade of all survey units surrounding any end-state basement to the 591-foot elevation.” Therefore, as described in the Phase 4 FSSR, the layer of soil from the 588-foot elevation to the 591-foot elevation for the portion of the Zion site referred to as the “power block” is expected to contain three feet of clean fill material from an offsite source in the end state.

Figure 4 below, reproduced from the ORISE Survey Report (5271-SR-07 Zion Sacrificial Sub-Soil), shows the SUs with 588-foot indigenous soils that received confirmatory survey in August 2019. Note that SU 12201B is located directly north of the Zion Unit 2 containment.

Figure 4 - SUs Associated with the Power Block Subject to Confirmatory Surveys (Figure 3.1 in ORISE Survey Report 5271-SR-07)

Separate from the description of the sacrificial soil layer areas contained in Phase 4 of the Zion FSSR, the Zion LTP contains requirements about certain areas receiving a clean cover of material. In accordance with the LTP, the Zion end state basements were to be covered

by a minimum of three feet of clean soil and physically altered to a condition which would not realistically allow the remaining structures, if excavated, to be occupied. Furthermore, the conceptual BFM, which was used to derive the DCGLs for the basement surfaces, assumed a 3 meter thick clean cover over the backfilled basements.

Specifically, Chapter 5 of the Zion LTP, Revision 2, states:

> The structural surfaces that will remain at ZNPS following the termination of the license are constructed of solid steel and concrete which will be covered by at least three feet of soil and physically altered to a condition which would not allow the remaining structural surfaces, if excavated, to be realistically occupied.

In addition, Section 6.5.4 of the Zion LTP, Revision 2, states:

> The BFM applies to the backfilled basements which will have a minimum of three feet of cover and approximately 3 meters of clean fill above the potential source term zone as defined by the equilibrium water level in the backfilled basements. The equilibrium water level is conservatively assumed to be at the natural water table elevation of 579 foot. Therefore, the dose from the water-independent exposure pathways is negligible.

This LTP assumption is modeled in RESRAD by assigning a value of 3 meters to the clean cover depth parameter. Of note, the erosion rate parameter in RESRAD (and that used for Zion) is defined as 0.0015 meters per year (m/yr). At a rate of 0.0015 m/yr, it would take approximately 2000 years to erode away the 3-meter clean cover material at Zion before the basement fill material was exposed. This period of time exceeds the 1000 year time period established for decommissioning compliance.

The RESRAD assumptions regarding clean cover combined with erosion rate affect the importance of the water-independent dose pathways used to determine compliance with the dose criteria for unrestricted site release (25 mrem/yr). A thinner clean cover and/or higher erosion rate also influences the DCGL values for the basement surfaces because the water-independent dose pathways would have become more important with an assumption of less or no cover material, or which could have eroded over the compliance period.

Information provided to the NRC staff as part of previous RAI responses related to the Zion FSSR may indicate that the erosion rate at the Zion site is higher than what was assumed in the Zion LTP for use in the BFM conceptual model. Specifically, a ZNPS CR from January 2020 provided with the RAI responses dated February 10, 2021 (ADAMS Accession No. ML21067A225) described erosion across SU 12204C, which includes the former Forebay and Crib House. CR ES-ZION-CR-2020-0001 states the following:

> When performing [Radiological Environmental Monitoring Program Thermoluminescent dosimeter] REMP TLD change on 12/29/19 noted erosion in two areas 200-300 yards south of the old Forebay in [SU] 12204C. See two attached pictures. One picture shows approximate 2 foot deep crevice with over 8 foot uncovered timber. Second area near timber is another crevice with large exposed boulder, 2 inch pipe and rebar sticking up from eroded area.

The licensee action associated with this CR was:

> Project Management to assess future erosion concerns and what (if any) actions are necessary to prevent or mitigate those concerns. Potentially look at adding this to the surveillance schedule.

The result for this licensee action from the CR was:

> The area was resurveyed to validate FSS status had not changed. Survey showed no change to FSS. The normal surveillance of FSS areas added observing areas for any erosion issues. The areas identified in this CR are scheduled to be backfilled during final site grading. This issue can be closed.

Further observations and samples collected during the April 2021 inspection survey also call into question the thickness of the clean cover material in the final Zion site configuration. For example, limited samples were collected in April 2021 from the area where erosion was documented in the referenced CR, but some samples that were collected in SU 12204C near the border with SU 12204B and SU 10223 (beach area) contained unexpected radionuclides. Specifically, Sample S0135 and Sample S0130 contained Eu-155. It is unclear why europium is present in this area, as europium indicates activated concrete and is not expected in the Zion soil. It is also unclear if the samples represent backfill material or material that was placed on top of the clean fill material that was used for final site grading.

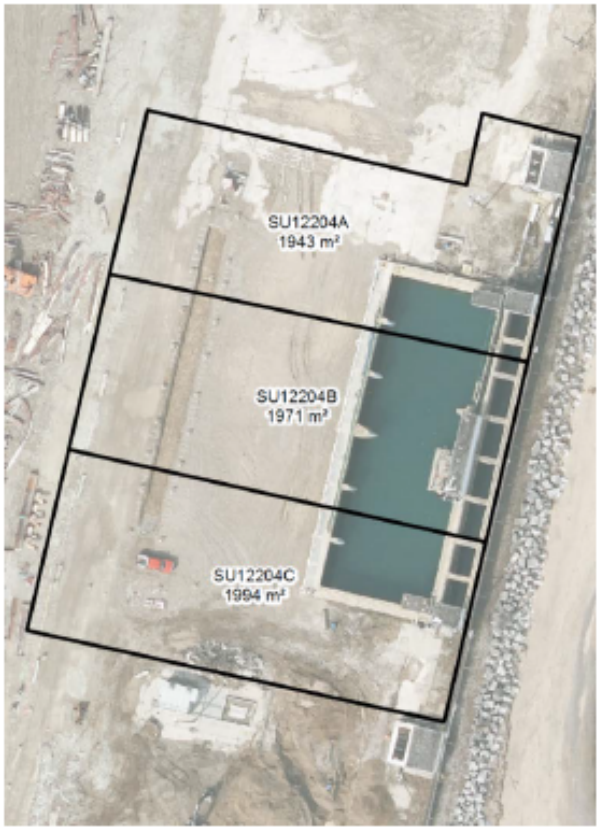

Figure 5 – The Three Class 1 Open Land Survey Units Created from Class 2 Survey Unit 12204 (Figure 2 in the FSS Release Record for SU 12204C in the Phase 3 FSSR)

The NRC staff discussed preliminary results from the April 2021 inspection survey with the licensee on May 20, 2021. In response to why a particle was found within approximately one foot of the Zion soil surface, the licensee provided the following statement:

> The origin of the discovered particle is the events from 2014 and 2015 that saw the spread of particles to a number of survey units within the [radiologically restricted area]. This particular particle was not captured during cleanup efforts or subsequent surveys. When the Unit 2 containment tent was removed, along with its asphalt foundation, a one to two-foot depression was created. The depression was filled with the soil that was used as the sacrificial layer to support Containment demolition. The hypothesis is that the particle was in the depression prior to the depression being backfilled with the sacrificial soil.

In addition, in response to why the NRC staff identified samples containing elevated amounts of radioactivity at or near the surface in SU 12201A and SU 12201B, following the May 20, 2021, teleconference the licensee stated:

> As stated…above, the site was not covered with three feet of clean fill, and elevated scan measurements at the surface of a Class 1 survey unit are expected.

These preliminary responses are not adequate for the NRC staff to verify that the cover material is consistent with the assumptions included in the Zion LTP and the final site description in Phase 4 of the Zion FSSR. As the staff understands it, the licensee's general explanation is that particles remain in the soil that was beneath the sacrificial soil layer even after that sacrificial layer was removed; and, contrary to what is described in the Phase 4 FSSR, the area that received sacrificial soil was not then covered with three feet of clean soil. Therefore, more information is needed to provide clarity on the final site configuration.

Path Forward:

a. Discuss the final site configuration for the Zion site areas that received a sacrificial layer of soil that was subsequently removed and remediated, and over which clean fill material was emplaced. Specify the thickness of the clean cover material intended for the end state over these areas, and from where the clean cover material was sourced. Indicate the survey units where this final site configuration exists.

b. For the areas of the site directly above backfilled basement structures (including the ZNPS Crib House basement in SU 12204), verify that the thickness of the clean cover material between the land surface and the upper level of the basement fill material is consistent with the Zion LTP commitments and the description of the site end state in Phase 4 of the Zion FSSR.

c. Justify how current site conditions are consistent with Zion LTP. If the Zion site conditions are not consistent, discuss the intended path forward (e.g., a license amendment to revise the assumptions in the Zion LTP) to resolve the inconsistency.

d. If the thickness of the clean cover material is less than that assumed in the Zion LTP, or the erosion rate is greater than what was assumed in the RESRAD dose modeling for the Zion site, provide an evaluation of the dose resulting from the material in the Zion basements structures with the lower amount of shielding/dilution.

9. Reuse of Excavated Soil

Comment: The Zion LTP commitments indicate that excavated soil will not be reused at the site except for under limited specific circumstances. Information is needed by the NRC staff to verify that the LTP assumptions on soil reuse remain valid.

Basis: According to Section 5.7.1.1 of the Zion LTP, large-scale soil reuse is not permitted at the site. The LTP does allow for excavation of overburden soil to remove a buried pipe or conduit, but the license must then put the overburden soil back in the same place from which it originated. However, recent statements made by the licensee may indicate that there was more mixing and reuse of excavated soils than what is allowed under the LTP.

Section 5.7.1.7, "Reuse of Excavated Soils," of the Zion LTP states:

> ZS will not stockpile and store excavated soil for reuse as backfill in basements. However, overburden soils will be created to expose buried components (e.g. concrete pads, buried pipe, buried conduit, etc.) that will be removed and disposed of as waste, or to install a new buried system. In these cases, the overburden soil will be removed, the component will be removed or installed, and the overburden soil will be replaced back into the excavation.

As part of the Zion LTP review, the NRC staff asked RAIs related to the licensee's commitments for excavated soil reuse because the plans for soil reuse were not clear in the original LTP submittal. In response to RAIs associated with the Zion LTP review dated February 27, 2017 (ADAMS Accession No. ML17208A121), the licensee states:

> ZS will commit to not stockpile excavated soil for re-use onsite as backfill for basement voids. However, there are excavations that have occurred and will occur in the future to remove piping or equipment, or in some cases to install piping or equipment. In these cases, after the activity is completed, the overburden soil is replaced into the hole that it was removed from. This overburden soil is not "stockpiled" for use as backfill at other site locations as the soil must return to the excavation where it came from. ZS proposes the following approach for the survey of overburden soils prior to re-introduction of the soil into the excavation from where it originated. ZS will use the same instrumentation as specified in LTP Revision 1, Chapter 5, Table 5-20, and instrument quality as specified in the [Quality Assurance Program Plan] QAPP.
>
> - Perform a pre-excavation gamma scan over excavation footprint and the proposed area where the excavated soil will be temporarily staged. The scan coverage will be in accordance with survey unit classification where excavation occurred. Appropriate scanning speed and scanning distance will be implemented to ensure that an MDC of 50% of the applicable soil DCGL will be achieved.
>
> - Soils sample(s) or portable multichannel analyzer measurement(s) will be obtained at any area identified as elevated during surface scan. If plant-derived residual radioactivity is positively identified in the soil, then the soil will not be returned to the excavation and will be dispositioned as radioactive waste.

- Intermittent gamma scans will be performed of the exposed subsurface soil in the excavation as the excavation progresses. Soils sample(s) or portable multichannel analyzer measurement(s) will be obtained at any area identified as elevated during scan of the exposed subsurface soils during excavation or the walls and floor of the excavation. If plant-derived residual radioactivity is positively identified in any excavated soil, or identified in the walls or floor of the excavation, then excavation will continue to remove the contaminated soil and the identified contaminated soil will be disposed of as radioactive waste.

The NRC staff discussed preliminary results from the April 2021 inspection survey with the licensee on May 20, 2021. In response to a question regarding the soil remaining in the final site condition, the licensee stated that the soil across the top of the Zion site in the Power Block is a "mixture of native soil, excavated and re-used soil, and clean fill from offsite." In addition, in response when asked to verify that there is 3 feet of clean fill in the Power Block area of the site, the licensee stated the following:

> In accordance with the LTP, remaining structural surfaces were covered by at least three feet of soil and physically altered to a condition which would not allow the structure, if excavated, to be realistically occupied. In some instances, excavated soils were re-used given the subsurface soil OpDCGLs were not exceeded (i.e., the top 3-foot stratum of soil at the site is a mixture of native soil, excavated and re-used soil, and clean fill from offsite). Further, site basements were filled at different times during decommissioning, and decommissioning activities occurred over the top of filled basements throughout the remainder of decommissioning. The LTP requirement for three feet of soil was only applicable to the footprint of backfilled structures. It was not an LTP requirement to place three feet of clean fill over the entire site.

These preliminary responses are not adequate for the NRC staff to verify that the reuse of excavated soil at the site is consistent with the commitments included in the Zion LTP. As the staff understands it, the licensee's general explanation is that some excavated soils were reused if they did not exceed the OpDCGLs, and that some parts of the 3 foot clean cover material may consist of reused soil along with native and offsite material. Therefore, more information is needed to provide clarity on the final site configuration and use of soil.

Path Forward:

a. Describe how soil reuse throughout the decommissioning process aligns with the commitments in the Zion LTP.

b. Provide justification and documentation of the process used to determine soil reuse as appropriate, including radiological scans for any soils that were reused from other parts of the Zion site and describe how the process aligns with what was discussed in the RAI response associated with the Zion LTP review dated February 27, 2017 (ADAMS Accession No. ML17208A121).

10. <u>Information on Licensee Surveys and Dose Assessment for Particles</u>

This RAI will be provided in under separate correspondence.

11. Remediation of Contamination on Containment Building Exterior Concrete Previously Determined To Meet "Free Release" Criteria

Comment: The survey data from the 2018 Unconditional Release Surveys (URS) for the Zion containment building exterior concrete (provided as an attachment to the February 2021 RAI response package) indicates that plant-derived radioactivity was detected and remediated. This information is inconsistent with the text included in the February 2021 RAI response (ADAMS Accession No. ML21067A225), in which the licensee states that this concrete met the "free release" criteria. This data is also inconsistent with previous surveys of that concrete, which is unexpected given that the concrete has been under isolation and control procedures since the surveys. Justification is needed to assess the adequacy of previous URS surveys and the isolation and control measures, and the potential impact of any inadequacies on the Zion final site status.

Basis: The February 2021 RAI response indicated that the concrete material from the Zion containment structures which was placed on survey units that had already undergone FSS (i.e. SUs 12112, 12113, 12203A, 12203B, 12203C, and 12203D) met the criteria for unconditional release (i.e., no detection of plant-related activity above background) prior to being placed on those survey units. The RAI response specifically stated that "all CCDD was surveyed in accordance with approved MARSAME-based URS procedures to meet requirements for unconditional release." The RAI response further indicated that two URS surveys were performed for the Zion Unit 1 and Unit 2 containment building exterior surfaces, one in July 2016 and one in March and May 2018. The NRC previously received the results of the July 2016 survey, and the results of the 2018 URS surveys for the concrete exterior were provided as an attachment to the RAI response titled "2018 Unit 1 and Unit 2 Containment Exterior URS." This attachment included information such as field logs, scan results, and smear sample data, but does not provide a detailed narrative description of the process used for the 2018 URS that could provide context for the results.

Based on the NRC staff's review of the 2018 URS data, it appears that plant-derived radioactivity above background was found during these surveys. The NRC staff is basing this conclusion on the reported scan alarms, smear samples greater than the minimum detectable activity (MDA), and the remediation of areas of the Zion containment structure concrete performed by the licensee as a result of the 2018 URS survey results.

The 2018 URS survey information also indicates that remediation of the containment concrete was performed in certain areas, such as in grids 13, 58, and 59 of the Zion Unit 1 containment building. However, it is not clear if remediation was also performed in other areas. It is also not clear from the information provided if all of the areas in which detectable radioactivity was identified were remediated. It is further unclear what process was used to determine which concrete could be categorized as "free release material." For example, it is not clear how wide of an area around the detectable radioactivity was removed. Finally, the URS field logs for the post-remediation surveys are included in 2018-URS-0-009. Some of the pages of this document are included in the attachment, but it is not clear if all were provided, and it is not clear which data correspond to the post-remediation measurements.

The measurement of radioactivity above background in the 2018 URS survey appears to be inconsistent with the text in in the February 2021 RAI response (i.e., that the 2018 survey confirmed previous measurements). The RAI response also indicated that isolation and control measures were put in place for the containment structure concrete prior to the time

period for 2016 URS survey, and that these controls remained in place. In addition, the RAI response indicated that the concrete debris from the outside of containment was considered low-risk with respect to plant-originated contamination. Given that the exterior containment concrete was previously surveyed, that isolation and control measures were in place, and that the material was considered to be low-risk for contamination, it is not clear why radioactivity appears to have been detected during the 2018 URS surveys (i.e., was the initial survey inadequate, or was there a breakdown in isolation and control measures?).

The text of the February 2021 RAI response also indicates that in the 2018 URS surveys the survey design called for a 100% scan below 3 meters and in areas within the containment tent enclosures, and a 10% scan above 3 meters. Based on this scan coverage, more information is needed to understand how it is known, or was concluded by the licensee, that the concrete above 3 meters does not contain any plant-derived residual radioactivity.

Additional justification is also needed that the process used for analyzing the smear samples from the outside of containment is adequate based on the information recently provided on the 2018 URS survey. The URS data tables reported alpha and beta measurements (in disintegrations per minute), as well as columns labeled “Unc” and MDA, for both the alpha and beta measurements. In many cases, it appears that any measurement above the “Unc” value was flagged for reanalysis, but it is unclear what the “Unc” term represents. It is also unclear whether the “Unc” or the MDA value was used as the basis for determining whether plant-derived radioactivity was present above background. Smear samples that had a measurement above “Unc” or the MDA also appear to have been recounted many times. In some cases, the sample appears to have been recounted until the measured value was below the “Unc” or MDA threshold. Based on this discussion, more information is needed on the process used to determine if a sample should be recounted, as well as the process for using the data from multiple counts to determine whether radioactivity above background was present. For example, it is not clear if all of the sample data was included in the background radioactivity determination, or if the determination was based only on the final measurement. In some cases, it appears that some of the samples had many measurements above the “Unc” or MDA threshold and only one below, such that the final value might not be representative of the level of radioactivity in the sample.

Based on this discussion, additional information is needed to understand the final radiological conditions of the Zion site and how they compare to the requirements of the Zion LTP and the unrestricted site release criteria. The concrete evaluated in these URS surveys was moved into areas of the site that had already undergone FSS, and could have been a potential source of the radiological contamination identified in those areas during subsequent confirmatory surveys, including the NRC’s April 2021 inspection survey. Additional information is also needed to understand URS survey data that appears to be inconsistent with the February 2021 RAI response provided by the licensee.

Path Forward:

Please provide the following information:

a. Justification that the licensee statement that the 2018 URS surveys confirmed that the concrete on the outside of containment meets the “free release” criteria given the reported remediation and detections of contamination recently provided to the NRC. This justification should address remediation that appears to have been performed on

the containment building exterior concrete in 2018 and scan alarms and smear measurements that appear to be above the MDA in the 2018 URS survey results for the containment building exterior concrete. This justification should also include an evaluation of how the 2018 URS results compared to the 2016 URS results.

b. A description of the extent of contamination observed on the exterior containment building concrete after that area was put under isolation and control (i.e., 2016). This description should include:
   - summary of the areas identified as potentially above background from scan alarms or smear sample measurements in the 2018 URS survey, including the measured activity and the approximate location (e.g., elevation [less than 3 meters or above 3 meters], the proximity of the location to key features [such as equipment hatches, tent enclosures], and whether the area was located on the Zion Unit 1 or Unit 2 containment building);
   - summary of the areas of the containment building exterior concrete remediated during or after the 2018 URS surveys;
   - post-remediation data for the Zion containment building concrete that has not already been provided and/or a description of where the post-remediation data is located if it has been provided (e.g., which pages of the "2018 Unit 1 and Unit 2 Containment Exterior URS" attachment contain the post-remediation data).

c. Justification that the process used for the URS surveys and the determination that material met the "free release criteria" is consistent with commitments in the LTP:
   - a description of the process used to determine which areas to remediate and how large of an area to remediate (i.e., once radioactivity was detected, how large of an area around the detection point was remediated and/or excluded from being part of the "free release" concrete material);
   - an evaluation of whether the process for including or excluding concrete from being considered as "free release material" is consistent with the LTP conditions on URS.

d. Justification that the URS Surveys were performed adequately, including
   - a description of the process used to analyze the smear sample results, including: the method for determining if radioactivity above background was found in the sample (i.e., whether "Unc", the MDA, or some other criteria was used and a description of what "Unc" represents if "Unc" was used as the basis), a description of the process for determining whether smear samples were recounted, a description of which data was used in the evaluation of whether radioactivity above background was present when a sample was counted multiple times, and a justification for excluding data from the evaluation if any data was excluded.
   - justification that concrete that had been located above 3 meters on the containment building exterior does not contain any residual contamination given the survey scan coverage of 10%.

e. Evaluation of whether the containment building exterior concrete contamination (and/or the processes responsible for the contamination) could be a source of particles observed by the NRC, its contractor ORISE, and the licensee on the Zion site. This evaluation should include:
   - an evaluation of the root cause for radioactivity being detected in 2018 but not 2016 (i.e., was the initial survey inadequate, or was there a breakdown in isolation and control measures?);

- a description of the containment structure concrete, if any, from an area with detectable radioactivity above background that was included in the “free release material” (i.e., CCDD) that was disposed of on-site or that was moved through areas of the site post FSS;
- an evaluation of whether the factors that led to the detection of contamination on the Zion containment building concrete could have led to similar problems elsewhere on the site and, if so, a description of corrective actions that were taken or will be taken by the licensee to address the problem.

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