DOE/EIS-0387-SA-04
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FINAL SUPPLEMENT ANALYSIS FOR THE FINAL SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE Y-12 NATIONAL SECURITY COMPLEX, EARTHQUAKE ACCIDENT ANALYSIS

National Nuclear Security Administration

EXECUTIVE SUMMARY

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the U.S. Department of Energy (DOE), is responsible for meeting the national security requirements established by the Congress and the President and has a statutory mission to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile (50 U.S. Code (U.S.C.) § 2401(b)). The Y-12 National Security Complex (Y-12) is the primary site of uranium operations for NNSA, and it provides manufacturing facilities for maintaining the U.S. nuclear weapons stockpile.

In March 2011, NNSA prepared the Final Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 National Security Complex (Y-12 SWEIS; DOE/EIS-0387) (NNSA 2011), which analyzed the potential environmental impacts of ongoing and future operations and activities at Y-12. In July 2017, a federal lawsuit was filed by four individuals and three nonprofit organizations asserting that NNSA had violated the *National Environmental Policy Act of 1969*, as amended (NEPA) (42 U.S. C. § 4321 et seq.), by failing to prepare a supplement to the Y-12 SWEIS. Among other things, the plaintiffs argued that NNSA should prepare a new or supplemental SWEIS due to new circumstances concerning the decision to construct a smaller-scale Uranium Processing Facility (UPF) and significant new information that came to light after the publication of the 2011 SWEIS. On the latter point, plaintiffs asserted that the seismic risk in East Tennessee had increased as evidenced by seismic hazard maps published in 2014 by the U.S. Geological Survey (USGS).

On September 24, 2019, a Memorandum Opinion and Order was issued by the U.S. District Court of the Eastern District of Tennessee as a result of the July 2017 federal lawsuit. While the Court ruled that NNSA is not required to prepare a new or supplemental SWEIS based upon changes to the UPF, the Court also ruled that “new information revealed since the 2011 SWEIS requires further analysis.” The Court ordered that NNSA “shall conduct further NEPA analysis-- including at a minimum, a supplement analysis-- that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporated the 2014 USGS map.”

In accordance with the Court Order, this Supplement Analysis (SA) presents an accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that have incorporated the 2014 USGS seismic hazard/maps. The purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS.

As shown in Section 3.0 of this SA, the potential impacts associated with an earthquake accident at Y-12 would not be significantly different than the impacts presented in the Y-12 SWEIS. Based on the results of this Final SA, NNSA has determined that: (1) the earthquake consequences and risks do not constitute a substantial change; (2) there are no significant new circumstances or information relevant to environmental concerns; and (3) no additional NEPA documentation is required at this time.

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ACRONYMS AND ABBREVIATIONS

ARF	airborne release fraction
AROD	amended ROD
ASCE	American Society of Civil Engineers
CEQ	Council on Environmental Quality
CEUS SSC	Central and Eastern United States Seismic Source Characterization for Nuclear Facilities
CFR	*Code of Federal Regulations*
CNS	Consolidated Nuclear Security, LLC
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DR	damage ratio
DU	depleted uranium
EIS	Environmental Impact Statement
ELP	Extended Life Program
EPRI	Electric Power Research Institute
EU	enriched uranium
FR	*Federal Register*
HEU	highly enriched uranium
HEUMF	Highly Enriched Uranium Materials Facility
IBC	International Building Code
ICRP	International Commission on Radiation Protection
IFDP	Integrated Facilities Disposition Program
LCF	latent cancer fatality
LPF	leak path factor
MACCS	MELCOR Accident Consequence Code Systems
MAR	material-at-risk
MEI	maximally exposed individual
NEHRP	National Earthquake Hazards Reduction Program
NEPA	*National Environmental Policy Act of 1969*
NGA-East	Next Generation Attenuation-East
NNSA	National Nuclear Security Administration
NPR	Nuclear Posture Review
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PAC	Protective Action Criteria
PEER	Pacific Earthquake Engineering Research Center
PGA	Peak Ground Acceleration
PSHA	Probabilistic Seismic Hazard Analysis
RF	respirable fraction
ROD	Record of Decision
SA	Supplement Analysis
SDC	seismic design categories
SDRS	Safety Detection and Response System
SSMP	Stockpile Stewardship and Management Plan
SWEIS	Site-Wide Environmental Impact Statement

UPF	Uranium Processing Facility
USC	U.S. Code
USGS	U.S. Geological Survey
Y-12	Y-12 National Security Complex

1.0 INTRODUCTION

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the U.S. Department of Energy (DOE), is responsible for meeting the national security requirements established by the Congress and the President and has a statutory mission to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile (50 U.S.C. § 2401(b)). The Y-12 National Security Complex (Y-12) is the primary site of uranium operations for NNSA, and it provides manufacturing facilities for maintaining the U.S. nuclear weapons stockpile. Y-12 is unique in that it is the only source of secondaries, cases, and other nuclear weapons components for the NNSA nuclear security mission. Uranium materials, including enriched uranium (EU), and manufacturing capabilities are essential to the missions of NNSA's national security programs.

As explained in Section 1.1, NNSA has prepared this Supplement Analysis (SA) to evaluate the potential impacts of an earthquake accident at Y-12, based on updated seismic hazard information. This SA was prepared in accordance with the DOE procedures implementing the *National Environmental Policy Act of 1969*, as amended (NEPA; 42 U.S. Code (USC) § 4321 et seq.), that require that "[when] it is unclear whether or not an Environmental Impact Statement (EIS) supplement is required, DOE shall prepare a Supplement Analysis [that] shall discuss the circumstances that are pertinent to deciding whether to prepare a supplemental EIS pursuant to 40 CFR 1502.9(c)" (10 *Code of Federal Regulations* [CFR] 1021.314). An SA may also be prepared at any time, as appropriate, to further the purposes of NEPA.

1.1 Background

In March 2011, NNSA prepared the Final Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 National Security Complex (Y-12 SWEIS; DOE/EIS-0387) (NNSA 2011), which analyzed the potential environmental impacts of ongoing and future operations and activities at Y-12. Five alternatives were analyzed in the Y-12 SWEIS: (1) No-Action Alternative (maintain the status quo), (2) Uranium Processing Facility (UPF) Alternative, (3) Upgrade in-Place Alternative, (4) Capability-sized UPF Alternative, and (5) No Net Production/Capability-sized UPF Alternative. In the Record of Decision (ROD) dated July 20, 2011 (76 *Federal Register* [FR] 43319), NNSA decided to construct and operate a Capability-sized UPF at Y-12 as a replacement for certain EU processing facilities. With regard to other missions at Y-12, NNSA decided to continue those missions in existing facilities with no changes.

In 2016, as a result of concerns about UPF cost and schedule growth, NNSA prepared an SA to the Y-12 SWEIS (2016 SA; DOE/EIS-0387-SA-01) (NNSA 2016a), which evaluated a proposed action to meet EU requirements using a hybrid approach of upgrading existing EU facilities (hereafter, these facilities are referred to as the "Extended Life Program [ELP] facilities") and constructing multiple new buildings (e.g., UPF complex). That proposed action combined elements of two proposed alternatives from the Y-12 SWEIS (called the hybrid approach), which differed from the selected alternative in the ROD. The analysis in the 2016 SA indicated that the identified and projected environmental impacts of the proposed action would not be significantly different from those in the Y-12 SWEIS, and on July 12, 2016, NNSA issued an amended ROD (AROD) to implement the hybrid approach (81 FR 45138) (2016 Amended ROD).

In July 2017, a federal lawsuit was filed by four individuals and three nonprofit organizations asserting that NNSA had violated NEPA by failing to prepare a supplemental SWEIS. Among other things, the plaintiffs argued that NNSA should prepare a supplemental SWEIS due to significant new information that came to light after the publication of the 2011 SWEIS. More specifically, plaintiffs asserted that the seismic risk in East Tennessee had increased as evidenced by seismic hazard maps published in 2014 by the U.S. Geological Survey (USGS).

In August 2018, NNSA prepared another SA to the Y-12 SWEIS (2018 SA; DOE/EIS-0387-SA-03) (NNSA 2018), which evaluated the environmental impacts of continuing site operations against the existing Y-12 SWEIS to determine if significant changes or new information warranted a supplemental or new SWEIS. In the 2018 SA, NNSA determined that Y-12 continuing operations were not significantly different than those evaluated in the 2011 SWEIS.

On September 24, 2019, a Memorandum Opinion and Order was issued by the U.S. District Court for the Eastern District of Tennessee as a result of the July 2017 federal lawsuit (USDC 2019). The Court ruled that NNSA is not required to prepare a new or supplemental SWEIS due to the decision to construct a smaller-scale UPF project and continue some EU operations in the ELP facilities. However, the Court also ruled that "new information revealed since the 2011 SWEIS requires further analysis," and consistent with that ruling, the Court vacated the 2016 SA, the 2016 amended ROD, and the 2018 SA. Further, the Court ordered that NNSA "shall conduct further NEPA analysis-- including at a minimum, a supplement analysis-- that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporated the 2014 USGS map."[1]

On October 4, 2019, NNSA amended its July 2011 ROD for the Y-12 SWEIS to reflect its decision to continue to implement, on an interim basis, the hybrid approach previously approved in the vacated 2016 AROD. As the Court previously ruled in its Order, that hybrid approach, which combined elements of the two alternatives previously analyzed in the Y-12 SWEIS, was adequately analyzed within the range of alternatives considered in the Y-12 SWEIS. The 2019 AROD enables NNSA to conduct the required additional NEPA documentation which is contained in this SA, while continuing to implement safety improvements previously approved in the 2016 AROD, pending the completion of the additional analysis ordered by the Court. Once this process is completed, NNSA plans to issue a new AROD describing what, if any, changes it has decided to make in light of that analysis.

1.2 Purpose and Need for this Supplement Analysis

In accordance with the Court Order, this SA presents an unbounded[2] accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses or conservative application of the 2014 USGS hazard/maps in conjunction with information

[1] The Court also ruled that 69 categorical exclusion determinations were in violation of NEPA and ordered that "the relevant exclusions should be prepared in a manner consistent with the letter of the relevant DOE regulations." Consistent with the Court Order, DOE/NNSA has appropriately revised those 14 categorical exclusion determinations for projects that were still ongoing at the time of the Court's Order. Those categorical exclusions are not included in the scope of this SA.

[2] The Y-12 SWEIS did not present a specific and detailed assessment of earthquake accidents because the source terms (i.e., hazards) from earthquake accidents were less than or equal to (i.e., "bounded by") other accidents (*see* Table D.9.3-1 of NNSA 2011). By presenting a specific and detailed assessment of earthquake accidents, this SA "unbounds" the earthquake accidents from other accidents, and the results stand on their own.

determined through site specific testing and previous analyses. The analysis in this SA is intended to ensure informed decision-making by NNSA and disclose to the public: (1) the differences in earthquake hazards among the various facilities at Y-12 that NNSA will use to conduct the ongoing EU mission in accordance with the 2019 AROD; and (2) the differences in the earthquake hazards among previously-reviewed alternatives. The purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. Based on the SA, NNSA will determine whether the Y-12 SWEIS should be supplemented, a new SWEIS is warranted, or no further NEPA documentation is required.

1.3 Organization of this Supplement Analysis

This SA is organized as follows:

- Section 1.0 contains the introduction and background information;
- Section 2.0 provides seismic and facility information relevant to the analysis in this SA;
- Section 3.0 presents the accident analysis of earthquake consequences at the Y-12 site, and contains the comparative environmental impact analysis;
- Section 4.0 contains the conclusion and determination; and
- Section 5.0 identifies references used in this SA.

1.4 Relevant NEPA Documents and other Documents

This SA tiers from the Y-12 SWEIS and incorporates the analysis from other documents to succinctly present the analysis. Information from these documents provides a context for understanding the current status of NEPA compliance, which forms the foundation for preparing the analysis in this SA.

Y-12 SWEIS (NNSA 2011). See description in Section 1.1. The Y-12 SWEIS is the most current site-wide NEPA documentation for Y-12 and provides information about Y-12 site operations, baseline environmental conditions, and ongoing environmental impacts relevant to this SA.

***Seismic Analysis and Consequences of a Seismically-Initiated Accident* (CNS 2020a).** In March 2020, Consolidated Nuclear Security, LLC (CNS), the management and operating contractor for Y-12, prepared a technical document (hereafter, CNS 2020 Seismic Report) to address issues discussed by the U.S. District Court in the Memorandum Opinion and Order. The CNS 2020 Seismic Report (*see* Appendix B) provides supporting information for this SA and is incorporated by reference, as appropriate. Among other things, that document: (1) discusses the 2014 USGS seismic hazard/maps and the process DOE/NNSA uses to develop a more detailed, multi-parameter site-specific Probabilistic Seismic Hazard Analysis (PSHA) as part of a seismic risk assessment for sites that house nuclear facilities (*see* Sections 2.1.1 and 2.1.2); (2) identifies the site-specific PSHAs that have been developed for Y-12 and the Y-12 nuclear facilities addressed in this SA (*see* Section 2.2); (3) explains how the UPF design requirements account for the 2014

USGS seismic hazard/maps (*see* Section 2.2.1); and (4) explains the process NNSA is employing to account for the 2014 USGS seismic hazard/maps in the site-specific PSHA for the ELP facilities (*see* Section 2.2.2).

1.5 Public Process

Although publication of a Draft SA is not required, NNSA made the Draft SA available for public review and comment on the NNSA NEPA web page (https://www.energy.gov/nnsa/nnsa-nepa-reading-room) on April 9, 2020. As shown in Table 1-1, NNSA announced the availability of the Draft SA in local newspapers and initially provided an approximately 30-day comment period (April 9, 2020 – May 11, 2020). In response to public requests, NNSA extended the comment period by 15 days, until May 26, 2020.

Table 1-1. Newspaper Notices for the Draft SA

NEWSPAPER	MEDIA	PUBLICATION DATE
Knox News-Sentinel	Print/Web	Thursday, April 9
The Oak Ridger	Print	Thursday, April 9
Roane County News	Print	Friday, April 10
Oak Ridge Today	Web	Thursday, April 9 - Thursday, April 16

NNSA received 142 comment documents on the Draft SA. Comments on the Draft SA, as well as NNSA's corresponding responses to those comments, are presented in Appendix C of this SA. All comment documents received are included in the Administrative Record for this SA. The major topic areas of the comments received on the Draft SA can be summarized as follows:

- NNSA should prepare a new SWEIS;
- NNSA should extend the comment period on the SA, particularly in the midst of a pandemic;
- NNSA should hold public hearings on the SA;
- Construction at Y-12 should be halted until all relevant seismic information has been gathered;
- Operations at Y-12 are not needed and violate the Nuclear Nonproliferation Treaty;
- National spending priorities should be to protect people, create safe jobs, and restore the environment;
- Impacts from earthquakes will be greater than previously analyzed and will adversely affect the health of workers and the public;
- The Draft SA does not evaluate new information that has come to light since 2011;
- The SA analysis should address earthquakes at all Y-12 facilities;
- The SA analysis should address both radioactive and hazardous, non-radioactive constituents released in an earthquake;

- The SA does not adequately assess impacts to minorities and low-income populations, particularly those at the Scarboro and Woodlawn communities; and
- The analysis in the SA does not include an updated probabilistic seismic hazard analysis (PSHA) for ELP facilities; thus, it has not complied with the Court's order to prepare an updated seismic hazard analysis.

In the process of preparing this Final SA, NNSA reviewed and considered all comments received on the Draft SA, including comments received after the comment period closed. In response to comments, NNSA has made revisions throughout the SA, as appropriate. The Final SA and determination are available to the public on the NNSA NEPA Reading Room website (https://www.energy.gov/nnsa/nnsa-nepa-reading-room).

2.0 INFORMATION RELEVANT TO THIS SUPPLEMENT ANALYSIS

2.1 Seismic Risk Assessment and Seismic Hazard Analysis

Seismic hazard analysis is an analysis of the impacts of possible future earthquakes based on study and understanding of the geology in a region. In evaluating the risks posed by existing or planned buildings that will hold nuclear materials, NNSA always considers seismic events in the design of facilities and the potential for such events to cause a release of nuclear material into the environment. Based on this potential for release of radioactive materials, the seismic design requirements are defined by DOE requirements and/or consensus engineering codes and standards, as described in this section. In order to do this, NNSA must first consider the material-at-risk (MAR), which is the amount and character of nuclear materials present, and the source term, which is the amount of nuclear material that may be released to the environment in the event of an accident, such as an earthquake. Based on the potential consequences, using extremely conservative methods to maximize consequences, seismic design criteria are determined. The criteria can be summarized as follows: effectively, the greater the hazard the more stringent the structural and confinement design requirements for the facility. These requirements are also used to evaluate existing facilities constructed prior to current requirements. Effectively, the seismic requirements increase based on the magnitude of the event by assuming a greater return interval event (a more severe earthquake).

The potential for seismic events at a site is often defined in terms of probabilistic ground motion. Ground motion means the motion of the ground that is caused by an earthquake. The USGS missions include monitoring and reporting on earthquakes, assessing earthquake impacts and hazards, and conducting targeted research on the causes and effects of earthquakes. As part of that mission, the USGS provides periodic updates to estimates of probabilistic ground motion. The USGS updates to probabilistic ground motion are used by model building codes, such as the International Building Code (IBC) (a consensus standard). NNSA uses IBC standards for non-nuclear facilities. However, NNSA requires a more detailed, multi-parameter site-specific PSHA as part of a seismic risk assessment for sites that house nuclear facilities (*see* Sections 2.1.2 and 2.1.3).

As explained in Section 2.1.2, a PSHA considers a range of site-specific information and data to develop the design response spectra (*see* definition in Section 2.2.1) for all frequencies of ground motion. However, in evaluating the degree to which updated USGS data may affect an existing PSHA, it is useful to pick a data point, such as Peak Ground Acceleration (PGA) in order to conduct an "apples-to-apples" comparison, even though such data are only part of the suite of data that will be used.[3]

Common Seismic Terms used in this SA

Peak Ground Acceleration (**PGA**) refers to the maximum ground acceleration that occurs during earthquake shaking at a given location.

Probabilistic Seismic Hazard Analysis (PSHA) is a method used to estimate the level of ground motion with a specified probability of exceedance. Earthquakes from all possible regional seismic sources, each with a given probability of occurrence, are taken into account in this type of analysis.

[3] PGA is frequently used for discussion and comparison because it is provided in most PSHAs. PGA also provides a relatively easy comparison of seismic hazard at different sites.

This allows an assessment as to whether the predicted ground motion is more or less severe than that previously predicted, and if it is more severe, whether there is sufficient margin in the design to cover the predicted increase. One public source of information that allows this type of comparison using the PGA is the USGS on-line maps and calculation tools (*see* Section 2.1.1).

2.1.1 USGS Seismic Hazard Analysis Tools

In 2014, the USGS issued a report, *Documentation for the 2014 Update of the United States National Seismic Hazards Maps* (USGS 2014), which provides generalized seismic hazard maps by geographic area for the entire country. The USGS provides an on-line tool (*see* footnote 6 below) where specific geographic coordinates (latitude/longitude) can be entered to obtain various parameters that help identify potential seismic hazards in a geographic area.[4]

The USGS seismic hazard maps and earthquake ground motion parameters are updated approximately every six years[5] to account for new data and incorporate recently published findings on earthquake ground shaking, faults, seismicity, and geology. The USGS 2014 Report is the successor to the USGS 2008 Report (USGS 2008). The USGS 2014 Report provides comparative maps that depict the change in seismic hazards since the publication of the USGS 2008 Report (*see* Figure 2-1).

To determine if the earthquake ground motion hazard, as depicted in the USGS 2014 Report, has changed since the issuance of the USGS 2008 Report, NNSA used the USGS on-line tool to compute the earthquake ground motions for rock and the ground motions for the soil conditions at the specific locations of the facilities at Y-12.[6] The earthquake ground motions for the specific soil conditions are calculated to account for local soil amplification. The USGS on-line tool defines the earthquake ground motions for a range of site conditions from hard rock to soft soil and for a range of Risk Categories. The Risk Categories range from Risk Category I to IV as defined in IBC, Table 1604.5. Risk Category IV facilities are those facilities designated as essential facilities and requires the most stringent earthquake design for the facilities. The UPF nuclear related facilities and the ELP facilities are classified as Risk Category IV. The site conditions are classified in the IBC Section 1613.2.2 as Site Class A, B, C D, E and F. The ground motions increase as the Site Class changes from A through F. Based on the specific rock and soil

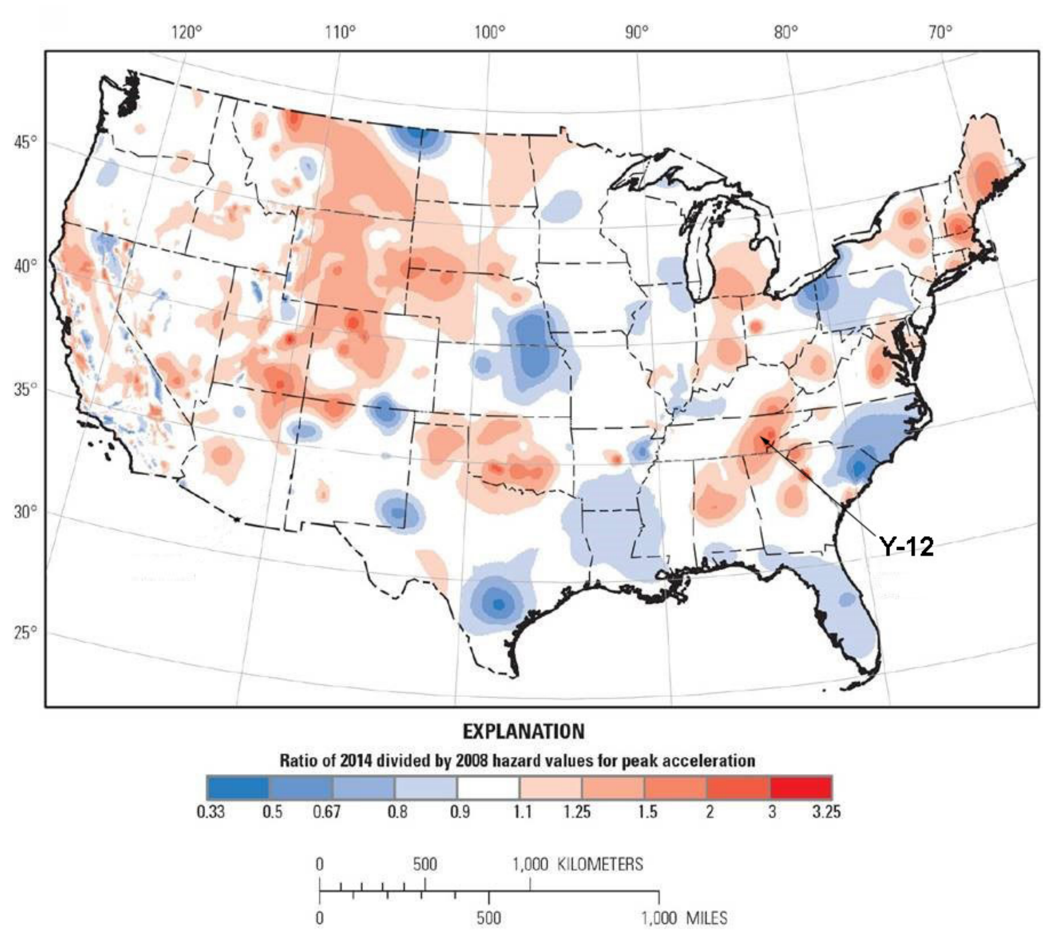
[4] For any given site on the map, the computer calculates earthquake ground motion (peak acceleration) for all the earthquake locations and magnitudes believed possible in the vicinity of the site. Each of these magnitude-location pairs is believed to happen at some average probability per year. Small ground motions are relatively likely, large ground motions are very unlikely. Beginning with the largest ground motions and proceeding to smaller, probabilities are added for the total probability in a particular period of time. The corresponding ground motion (peak acceleration) is said to have a probability of exceedance in time (years). The map contours represent the ground motions corresponding to this probability at all the sites in a grid covering the U.S. Thus, the maps are not actually probability maps, but rather ground motion hazard maps at a given level of probability.

[5] Although USGS has not announced a publication date, an update to the USGS 2014 Report is expected in 2020. NNSA also notes that the USGS has a 2018 hazard update report available on their website (see https://www.usgs.gov/natural-hazards/earthquake-hazards/seismic-hazard-maps-and-site-specific-data). That update shows a slight reduction in the seismic hazard for the Oak Ridge area. The 2018 update will be incorporated into the next editions of the American Society of Civil Engineers (ASCE) 7 standard and the International Building Code (IBC). The information in the USGS 2018 update is being considered in the Y-12 seismic hazard update, and NNSA will continue to monitor USGS publications and consider any new information, as appropriate.

[6] Access to the USGS design ground motion values for a particular latitude, longitude, risk category, and site class, may be obtained at https://earthquake.usgs.gov/ws/designmaps/ (Accessed here on February 24, 2020). The ground motion values for the 2008 National Hazards Maps may be obtained either by using the 2009 NEHRP Standard, or 2010 ASCE 7 Standard. The values for the 2014 National Hazards Maps may be obtained using either the 2015 NEHRP Standard, or the 2016 ASCE 7 Standard.

conditions at the ELP and UPF facilities, Site Classes B and C are used to define the ground motions for design and evaluation.

At Y-12, the coordinates of the UPF and ELP facilities (35.99 N, 84.26 W) were entered into the USGS on-line tool to calculate an estimate of the PGA at firm rock with 2-percent probability of exceedance in 50 years for both the USGS 2008 Report and the USGS 2014 Report. The USGS on-line tool calculated that the PGA at the surface, corrected for site class C, with 2 percent probability of exceedance in 50 years, changed from approximately 0.22g in 2008 to approximately 0.34g in 2014. The change represents an increase in predicted ground motion of approximately 56 percent. Such an increase, in and of itself, does not mean that the earthquake risk at Y-12 has increased significantly or constitutes significant new circumstances or information relevant to environmental concerns. To make such a determination, NNSA must consider this new information within the framework of the PSHAs that govern the design, construction, and operation of the UPF and ELP facilities, as well as the earthquake accident analysis. Sections 2.1.2 and 2.2 of this SA discuss the relationship between the USGS seismic hazard maps (including the increased PGA from the USGS 2014 Report) and the PSHAs for the UPF and ELP facilities. Section 3 of this SA provides the quantitative analysis of an earthquake accident for the UPF and ELP facilities with consideration of the information from the USGS 2014 Report.



Source: USGS 2014.

Figure 2-1. USGS Map Comparing Change in Peak Ground Acceleration

The seismic hazard maps provided by the USGS are integrated into the National Earthquake Hazards Reduction Program (NEHRP). The NEHRP is tasked with reducing the risks to life and property from earthquakes through the development and implementation of hazard reduction measures. One of these measures is the publication of the "Recommended Seismic Provisions for New Buildings and Other Structures" (NEHRP 2015). The publication provides recommendations for standards in the structural designs to withstand seismic hazards. These recommendations, along with the ASCE standards and IBC, are adopted by many states and local building departments into law (ASCE 2016; ICC 2014).

2.1.2 NNSA Seismic Hazard Analysis at Y-12

NNSA uses the IBC and hence the USGS ground motion values in the seismic design of low-risk facilities. However, in accordance with DOE Order 420.1C (Facility Safety), NNSA requires a site-specific PSHA to define the seismic ground motion for the design of critical facilities, including high-risk structures. As discussed below, the site-specific PSHA considers a range of regional and site-specific information.

The hazard analysis provided by and periodically updated by the USGS is one of several sources of the relevant seismic information included in a site-specific PSHA. Other available information, such as nuclear industry and Nuclear Regulatory Commission (NRC)-generated analyses, is also included. The site-specific PSHA also requires the incorporation of local geologic data to better characterize local seismic sources and establish facility site conditions affecting ground motion. The incorporation of other available seismic data and site-specific geologic studies in a PSHA can increase or decrease design ground motions as compared to using only the USGS National Seismic Hazards Maps and provides greater detail and understanding of the site (CNS 2020a).

For facilities at Y-12, hazard analyses from a project sponsored by the NRC, DOE, and the Electric Power Research Institute (EPRI) have been incorporated into PSHAs. This project is known as the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) and it was initiated in 2008. This project was commissioned specifically to characterize seismic sources that can affect nuclear facilities. The CEUS SSC project was completed in 2012 and published by the NRC as NUREG-2115, *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities* (NRC 2012).

A second joint project by the NRC, DOE, and EPRI is known as the Next Generation Attenuation-East (NGA-East) project. The NGA-East study was completed in December 2018 and was published in the Pacific Earthquake Engineering Research Center (PEER) Report No. 2018/08, *Central and Eastern North America Ground-Motion Characterization– NGA East Final Report* (PEER 2018).

A full-scale PSHA also involves extensive field work including geologic mapping, fault excavation, geophysics, geologic age dating, evaluation of seismic (vibratory ground motion) wave propagation through rock and soil layers, expert elicitation/judgement, and peer reviews, which has been done at the Y-12 site. Many parameters for a specific site or facility location are evaluated, including PGA and ground velocity and displacement, to define the potential hazard. These parameters and the models based on them are affected by local variables such as bedrock type, depth to bedrock, and local soil thickness and properties (CNS 2020a).

2.2 Y-12 Facilities and Site-Specific Probabilistic Seismic Hazard Analysis

This SA includes the evaluation of the potential impacts associated with the operation of three nuclear facilities at Y-12. The first is the UPF, which is being designed and constructed at Y-12 to replace an existing nuclear facility, the 9212 Complex. Evaluation of the risk of a seismically-initiated accident is an important consideration in this activity, because the UPF is designed to protect workers, the public, and the environment against such risks. Accordingly, it is important to assure the public that the UPF has been designed and is being constructed appropriately.

The other facilities involved are the two existing ELP facilities-- the 9215 Complex and the 9204-2E Facility. Nuclear operations are planned to continue in these facilities for potentially two or more decades under the current hybrid approach. NNSA has extensively evaluated the existing facilities, identified and analyzed the hazards, and implemented controls (such as administrative controls that limit MAR) through formal safety analysis and authorization processes as defined in DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* (DOE 2006). To ensure those future operations are conducted safely, the ELP extends the life of these facilities through refurbishments which reduce risk and ensure the continued reliability of operations in the future. Risk of a seismically-initiated accident is also an important factor in these facilities, but consideration of that risk is different than that for UPF since the facility structures already exist. For the ELP facilities, it is important to not only determine the amount of seismic risk and the feasibility of upgrades, but to also explore risk reduction methods beyond structural upgrades. Ongoing efforts to reduce the inventory of nuclear materials at these facilities by transferring them to other locations, as appropriate, and to upgrade the facilities and processing equipment also reduce nuclear safety risk (CNS 2020a).

There are two site-specific PSHAs (BWXT 2003, B&W 2012a) currently in effect that are applicable to the facilities at Y-12: one is for UPF and the other is for the balance of the facilities at Y-12, including the ELP facilities. These PSHAs were issued in 2015 (UPF) and 2003 (ELP facilities) based on the latest seismic information available at that time. For the ELP facilities, the PHSA was reviewed against updated seismic information in 2012 (*see* Sections 2.2.1 and 2.2.2 below). Each PSHA considers the USGS seismic hazard, as incorporated into codes and standards; nuclear industry data, specifically the CEUS SSC analysis; and the local geologic data. The primary output from the PSHA is site-specific seismic response spectra that provide ground motions over frequency ranges that are key inputs into structural designs for new facilities (UPF) and for evaluations of the performance of existing facilities (ELP facilities). The site-specific seismic response spectra depend on the type of rock, type of soil, and the depth of the soil overburden on the rock at the specific building structure location at Y-12 (CNS 2020a).

USGS seismic hazard analyses are also used to update various codes and standards. Of interest is the ASCE 7, Minimum Design Loads for Buildings and Other Structures, and the IBC, which are among the many requirements for facilities at Y-12. The 2014 USGS study was incorporated into ASCE 7 in 2016 (referred to as ASCE 7-16) and was incorporated in the IBC in 2018 (CNS 2020a).

2.2.1 UPF Seismic Analysis

As discussed in CNS 2020a, the UPF project established its site-specific PSHA, site-specific seismic response spectra, and UPF design-basis earthquake spectra in 2015 in the following documents:

- Summary of the UPF Design-Basis Earthquake Response Spectra Development (RP-ES-801768-A040) (CNS 2015a).
- Development of Horizontal Hard Rock Response Spectra and Fine-Spaced Rock Hazard Curves for the Development of the SDC-1, SDC-2, and SDC-3 Design Response Spectra (DAC-ES-801768-A244) (CNS 2015b).
- UPF Horizontal and Vertical Design-Basis Earthquake Spectra (DAC-ES-801768-A330) (CNS 2015c).

Seismic Response Spectra and Design-Basis Earthquake Spectra

Earthquake ground motions from the PSHA are defined as "**seismic response spectra**" for the different annual probabilities of occurrence. The seismic response spectra are a plot of accelerations versus frequency. The range of frequencies used to determine the seismic response spectra covers the range of natural frequencies for a building. (Note: natural frequency refers to the frequency that a building sways in when it is returning to its original position after it has been excited).

The "**design-basis earthquake spectra**" is used to determine the earthquake response of a building. For example, when the natural frequencies of a building are determined, the building earthquake accelerations can be determined, and from the accelerations the building earthquake forces can be determined and used to design the building.

The seismic design response spectra were based on both ASCE 7 and the CEUS SSC data, and site-specific geologic information, as discussed in Section 2.1.2. The most recent seismic information available at the time was used and is reflected in the UPF Code of Record (CNS 2020a). UPF used the 2010 version of ASCE 7 (which incorporated the 2008 USGS data) and the 2012 CEUS SSC report. UPF established its design-basis earthquake spectra conservatively, and in particular, did not use reductions in the spectra allowable per ASCE 7 which would normally be taken when a site-specific seismic response spectra are available.[7] This conservative approach was taken, in part, to provide margin for new seismic information that would be forthcoming in future years (CNS 2020a).

As discussed in Section 2.1.1, USGS published new seismic hazard maps in 2014 which were later incorporated into ASCE 7 in 2016 (ASCE 7-2016). In 2017, the UPF project reviewed the impact of the changes in the ASCE 7-2016 spectra. The ASCE 7-2016 response spectra (using the 2014 USGS seismic hazard/maps), with allowable reductions for site-specific analysis (*see* footnote 7), was compared to the UPF design-basis earthquake spectra. For frequencies between 5 Hertz and 15 Hertz, the difference was negligible (approximately 1.5 percent). For frequencies above and below that range, the UPF design-basis earthquake spectra is actually more conservative (i.e., greater) than the ASCE 7-2016 spectra, which incorporated the 2014 USGS seismic hazard/maps.

[7] Per ASCE 7-16, Section 21.3, when a site-specific PSHA is performed to determine the design spectral response accelerations, the accelerations at any frequency cannot be less than 80 percent of the more generalized spectral response accelerations obtained from the USGS hazard maps.

These favorable results are directly attributable to the decision to establish the UPF design-basis earthquake response spectra conservatively back in 2015 (CNS 2020a). Consequently, NNSA is confident the UPF design conservatively accounts for the 2014 USGS seismic hazard/maps, and that the UPF would therefore withstand the increased magnitude seismic event that is possible under the 2014 USGS seismic hazard/maps.

It should also be noted that the seismic response spectra are an input to the UPF structural design. The UPF structural design was also established conservatively, with adequate design margins, such that the design would perform its required functions even for some increases in the seismic response spectra. To minimize the amplification effects of the earthquake ground motion from the existing soil, a few of the features of the UPF Main Process Building structural design include:

- Excavation of 15 feet of soil to the underlying bedrock.
- Backfill of the excavated soil with engineered mass fill concrete.
- 9-foot-thick reinforced concrete foundation on top of the mass fill concrete.
- Reinforced concrete shear wall system to resist seismic loads with a composite elevated slab system consisting of reinforced concrete slabs and supporting steel beams (CNS 2020a).

In summary, consistent with prior NEPA analysis, UPF has a robust building design that will perform all of its required functions even after a design-basis earthquake (CNS 2020a). This conclusion has not changed as a result of the 2014 USGS seismic hazard/maps.

2.2.2 Existing ELP Facilities Seismic Analysis

The relevant ELP facilities consist of the 9215 Complex and the 9204-2E Facility. The 9215 Complex was built in the mid-1950s and the 9204-2E Facility was completed in 1971. They are both industrial facilities that were designed and constructed to the standards that existed at the time they were constructed. Expectations for nuclear facilities have significantly changed since their construction, including seismic design requirements. NNSA requires periodic review of seismic hazard analyses for its existing nuclear facilities. The ELP facilities at Y-12 have been reviewed in the past and updated seismic evaluations have been and continue to be performed (CNS 2020a).

The site-specific PSHA for existing facilities at Y-12 (*Update of the Seismic Hazard at the Department of Energy National Security Administration Y-12 National Security Complex* [RT-ST 921200-A001]) (NNSA 2003), including the ELP facilities, was performed in 2003 with participation from USGS and several industry experts. That approved analysis was used to perform seismic facility evaluations for the ELP facilities in the 2003–2005 timeframe (CNS 2020a).

USGS issued updated seismic hazard maps in 2008 and the CEUS SSC study was published in 2012. Consistent with DOE's requirement for a ten-year review, the PSHA for existing facilities at Y-12 was formally reviewed against this updated information in 2012 (*Update of the Seismic Hazard at the Department of Energy National Nuclear Security Administration Y-12 National Security Complex* [RP-900000-0029]) (NNSA 2012). That review showed that both the 2008 USGS hazard map and the 2012 CEUS SSC study resulted in a decrease in the seismic hazard when compared to the Y-12 2003 site-specific PSHA. Based on the comparison, and to be conservative, Y-12 decided to continue to use the more conservative 2003 site-specific seismic hazard (CNS 2020a).[8]

As discussed in Section 2.1.1, USGS published updated seismic hazard maps in 2014 which showed an increase in the seismic hazard at Y-12 compared to the 2008 USGS hazard maps. As noted above, the Y-12 2003 site-specific seismic hazard is also greater than the 2008 USGS seismic hazard. Accordingly, the difference between the 2014 USGS seismic hazard/maps and the Y-12 2003 site-specific seismic hazard is less significant than the difference between the 2014 and 2008 USGS seismic hazards. As discussed in Section 2.1.3.1, the 2014 USGS seismic hazard/maps were incorporated into ASCE 7 in 2016. Subsequently, an informal comparison of the ASCE 7-2016 seismic hazard with the Y-12 2003 site-specific seismic hazard shows that the Y-12 2003 site-specific seismic response spectrum is more conservative in some frequency ranges, while the ASCE 7-2016 seismic response spectrum is more conservative in others. These differences merit more formal review, which is currently underway, and described below (CNS 2020a).

The ELP includes a commitment to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities. That work is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021. The updated PSHA will incorporate the 2014 USGS seismic hazard/maps, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East) (CNS 2020a).

With regard to the ELP facilities, the PSHA is used to evaluate the performance of those facilities under seismic hazard conditions. Among other things, the PSHA aids in understanding and defining the severity (and hence, the probability) of an earthquake capable of causing release of radioactive material. The ELP facilities (the 9215 Complex and the 9204-2E Facility) were designed and constructed before the establishment of modern nuclear safety standards. Some portions of the facilities meet such standards and other portions do not. The new seismic facility evaluations will provide an up-to-date evaluation of any remaining weaknesses and the potential for upgrades will be addressed. Upgrading both structures to fully meet modern seismic standards for new facilities may not be feasible or practical. However, the potential for structural upgrades will also be informed by an independent expert panel review that Y-12 contracted for in 2016 (*Recommendations of the Seismic Expert Panel Review of Buildings 9204-2E and 9215* [RP 900000-0182]) (NNSA 2016b), which provided suggestions for practical approaches to structural upgrade initiatives in these two facilities (CNS 2020a).

It is important to recognize that the planned updated studies are intended to answer in more detail the capacity of the existing structures based on advanced analytical techniques (i.e., accounting for non-linear effects which typically demonstrate additional capacity to resist earthquake ground motion) not previously used. As a result, the potential for improvements will be better understood while reconciling the differences between the USGS data and the other relevant studies discussed earlier. The existing seismic studies for the ELP facilities, however, do provide a solid technical basis on which to judge the effects of the 2014 USGS seismic hazard/maps in support of determining potential consequences to the public.

[8] NNSA is required to periodically update its seismic hazards to consider new information. The 2012 update (NNSA 2012) did that, specifically considering the 2008 USGS information and the CEUS SSC study.

3.0 POTENTIAL ACCIDENT IMPACTS OF AN EARTHQUAKE AT Y-12

3.1 Introduction and Technical Approach

This section presents the potential accident impacts of an earthquake at Y-12 and evaluates whether those impacts would be considered significant in the context of NEPA (40 CFR 1508.27) when compared to the analysis in the Y-12 SWEIS. The technical approach for performing this analysis is summarized below. A more detailed description of the technical approach is presented in Appendix A.

In preparing this analysis, NNSA identified the current documentation describing and quantifying the hazards associated with the operation of the UPF and ELP facilities. Some of those safety-basis documents are either classified or contain Unclassified Controlled Nuclear Information and are not releasable to the general public. The following safety-basis documents were reviewed to develop the unclassified input data for the earthquake accident analysis:

- "Preliminary Documented Safety Analysis for the Uranium Processing Facility" (RP-EF-801768-A191) (CNS 2017a);
- "UPF Calculation Cover Sheet: Evaluation of Radiological and Toxicological Exposure for the Uranium Processing Facility" (DAC-EF-801768-A084) (CNS 2017b);
- "Safety Analysis Report for the 9215 Complex" (Y/MA-7886, Rev. 10, DCN-03) (CNS 2015d); and
- "Safety Analysis Report for the 9204-2E Facility" (Y/SAR-003, Rev. 11) (CNS 2015e).

In addition, NNSA utilized subject-matter experts at Y-12 to develop input data for the analysis in this SA. Those data are documented in a Data Call reference document (CNS 2020b). This SA uses unclassified and publicly-releasable data derived from the safety-basis documents and the Data Call reference document to define the earthquake accident scenarios and input parameters for the analysis in this SA. As previously documented in the 2001 SWEIS and the 2011 SWEIS, NNSA has determined that hazardous chemicals released in accidents would not result in irreversible or other serious health effects (*see* also Appendix C, comment-response 27). Consequently, the analysis in this SA focus on the potential impacts associated with radiological releases.

The potential impacts of accidental radiological releases associated with the earthquake accident scenarios were determined using the MELCOR Accident Consequence Code Systems (MACCS) computer code. MACCS is a DOE/NRC sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and NEPA documentation for facilities throughout the DOE complex. MACCS models the consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accidental release occur, the radioactive gases and aerosols in the plume would be transported by the prevailing wind at the time of release while dispersing in the atmosphere. MACCS allows up to a year of meteorological conditions to be evaluated based on meteorological data measurements, and the plume is released into each set of sampled weather conditions (i.e., wind speed, wind direction, atmospheric stability, and precipitation rate), creating a statistical distribution of results. The environment would be contaminated by radioactive materials deposited from the plume, and workers and the population would be exposed to radiation. The objectives of a MACCS calculation are to estimate the range and probability of the health impacts induced by the radiation exposures.

The most important inputs to the code were the source terms (i.e., the amount of radioactive material released). Section 3.2 explains how the source terms for the earthquake scenarios were determined. The results obtained by the MACCS model include doses due to inhalation of airborne material as well as external exposure to the passing plume. This represents the major portion of the dose that an individual would receive from a facility accident.

For this analysis, NNSA estimated the potential radiological impacts for three receptors: (1) the maximally exposed individual (MEI)[9] at the Y-12 boundary; (2) the offsite population within 50 miles of the UPF and ELP facilities; and (3) a noninvolved worker at both 100 meters and 1,000 meters[10] from the accident location. The doses were converted to latent cancer fatalities (LCFs)[11] using the factor of 0.0006 LCF per person-rem for both members of the public and workers; if applicable, calculated LCFs were doubled for individual doses greater than 20 rem (NCRP 1993). The MEI, 50-mile offsite population, and noninvolved worker are assumed to be exposed for the duration of the release; they or NNSA would take protective or mitigative actions thereafter if required by the size of the release.

3.2 Potential Environmental Impacts and Comparisons

Seismic events have the potential to: (1) produce explosions, induce spills of oxide and aqueous radioactive materials, and cause localized fires which may release radioactive materials to the environment; (2) cause a criticality accident which could produce a direct radiation dose and release radioactive materials to the environment; and (3) cause failures of safety- and non-safety-related structures and systems which are intended to mitigate the effects of an accident.

Criticality Accident

A criticality accident is an uncontrolled nuclear fission chain reaction (but not a nuclear detonation). Criticality accidents can release radioactivity to the environment and produce potentially fatal direct radiation doses.

UPF. For the UPF, this SA evaluates two scenarios: (1) a beyond design-basis earthquake accident in which engineered safety systems and controls do not prevent/mitigate the accident; and (2) a design-basis earthquake accident in which safety systems and controls mitigate the impacts of the accident. By analyzing a spectrum of earthquake accidents, NNSA and the public are better able to understand the range of accident impacts-- the most likely impacts (based on the design-basis mitigated scenario) and the highest potential impacts (based on the beyond design-basis unmitigated scenario). Based on the safety-basis documents identified in Section 3.1 of this SA, NNSA determined that a beyond design-basis earthquake accident that released radioactive materials through induced explosions, spills of oxide and aqueous radioactive materials, and localized fires is the appropriate earthquake accident scenario to analyze for the UPF (CNS 2020b).

9 The MEI is a hypothetical individual located offsite who could potentially receive the maximum dose of radiation.

10 The Y-12 SWEIS presented dose results for the noninvolved worker at 1,000 meters from the accident location. Consequently, this SA provides results for both distances to support comparisons in Section 3.3 of this SA.

11 In this SA, LCF refers to a fatality associated with acute and chronic exposure to radiation.

With regard to accident probabilities, because the UPF is being designed and constructed to conservatively meet modern nuclear safety and seismic standards (*see* Section 2.2.1), the design-basis earthquake accident probability is estimated to be 4×10^{-4} per year, which equates to the occurrence of such an accident once every 2,500 years. The beyond design-basis earthquake accident probability is estimated to be a maximum of $1\text{x}10^{-6}$, which equates to the occurrence of such an accident once every million years (CNS 2020b). These probabilities take into account the probability of the initiating event (i.e., earthquake) and the probability of following events that influence the impacts of the accident (e.g., subsequent explosions, spills, localized fires, and the failure of safety systems and controls designed to prevent these events, as well as failure of mitigating safety systems [e.g., ventilation system with High Efficiency Particulate Air filters]).

ELP Facilities. For the 9215 Complex and 9204-2E Facility, based on the safety-basis documents identified in Section 3.1 of this SA, NNSA determined that a seismic-induced criticality event with small localized fires is the appropriate scenario to analyze. A review of the safety-basis documents for the 9215 Complex and 9204-2E Facility indicated that the source term associated with a seismic-induced criticality event at these facilities would be significantly greater than the source term associated with seismic-induced localized fires (CNS 2020b).

For the ELP facilities, which were designed and constructed before the establishment of modern nuclear safety and seismic standards, the accident probability is estimated to be 2×10^{-3} per year, which equates to the occurrence of such an accident once every 500 years (CNS 2020b).[12] This takes into account the probability of the initiating event (i.e., earthquake) and the probability of a criticality event with a subsequent direct radiation dose and the release of radioactive materials. As discussed in Section 2.2, the earthquake probabilities for both the UPF and ELP facilities account for the 2014 USGS seismic hazard/maps (CNS 2020b).

The source terms shown in Table 3-1 and 3-2 provide the estimated quantity of radioactive material released to the environment for the earthquake accidents at the UPF, 9215 Complex, and the 9204-2E Facility. The source terms are calculated by the equation:

$$\text{Source Term} = \text{MAR} \times \text{ARF} \times \text{RF} \times \text{DR} \times \text{LPF}$$

where:

MAR= The amount and form of radioactive material at risk of being released to the environment under accident conditions.
ARF = The airborne release fraction reflecting the fraction of damaged MAR that becomes airborne as a result of the accident.
RF = The respirable fraction reflecting the fraction of airborne radioactive material that is small enough to be inhaled by a human.
DR = The damage ratio reflecting the fraction of MAR that is damaged in the accident and available for release to the environment.
LPF = The leak path factor reflecting the fraction of respirable radioactive material that has a pathway out of the facility for dispersal in the environment.

[12] Earthquakes with a probability of 2×10^{-3} or less are assumed to result in a seismic-induced criticality event; consequently, for the ELP facilities, this SA evaluates an earthquake with a probability of $2\text{x}10^{-3}$.

Table 3-1. Postulated Earthquake Accident Parameters—UPF

Accident	Source Term			
	Event	**Material**	**Source Term for Beyond Design-Basis Earthquake (kg)**	**Source Term for Design-Basis Earthquake (kg)**
Earthquake that causes explosions, radioactive material spills, and localized fires at UPF	Explosion	EU Aqueous	6×10^{-6}	0
		EU Oxide	0.4515	0
		EU Contaminated Combustibles	0.008	0
		Filters (EU Oxide)	1.19	0
		Furnace (EU Oxide)	1.355	0
		Calciner	2.818	0
	Spills	Depleted Uranium (DU) Aqueous	0.235	0
		EU Aqueous	3.744	0.0432
		EU Organic	0.0138	0.00264
		EU Oxide (spilled from 3 meters)	5.39	0.0374
		EU Oxide (spilled from 1 meter)	0.377	0
		DU Oxide (spilled from 3 meters)	0.13	0
		DU Oxide (spilled from 1 meter)	0.009	0
	Fires	EU Aqueous	0.02	0.02
		EU Chip	0.06	0.06
		EU Alloy (not in racks)	0.005	0.005
		EU Slurry	0.17	0.17
		EU Slurry	0.2	0.2
		EU Contaminated Combustibles	0.0125	0.0125
		EU Crystals	0.3	0.3

Source: CNS 2017b, CNS 2020b.

Table 3-2. Postulated Earthquake Accident Parameters—ELP Facilities

Accident	Source Term		
	Radionuclide	Half Life	Curies released
Earthquake that causes criticality event at either the 9215 Complex or the 9204-2E Facility	Kr-83m	1.8 hr	8.0
	Kr-85m	4.5 yr	7.5
	Kr-85	1.7 yr	8.00×10^{-5}
	Kr-87	76.3 min	49.5
	Kr-88	2.8 hr	32.5
	Kr-89	3.2 min	0.0021
	Xe-131m	11.9 day	0.004
	Xe-133m	2.0 day	0.09
	Xe-133	5.2 day	1.35
	Xe-135m	15.6 min	110
	Xe-135	9.1 hr	18
	Xe-137	3.8 min	2,450
	Xe-138	14.2 min	650
	I-131	8.1 day	0.0435
	I-132	2.3 hr	5.5
	I-133	0.8 hr	0.8
	I-134	52.6 min	22.5
	I-135	6.6 hr	2.35

Note 1: Kr = Krypton; Xe = Xenon; I = Iodine.
Note 2: Uranium metal criticality is assumed to have 1×10^{18} total fissions.
Source: CNS 2020b.

In preparing this earthquake accident analysis, NNSA has made conservative assumptions related to facility damage and radioactive material release (CNS 2020b). NNSA also assumed that no special actions (i.e., emergency response) would be taken to avoid or mitigate exposure to the general population following an accidental release of radioactive material. Doses were also calculated using conservative assumptions, such as the wind blowing toward the MEI and locating the receptor along the plume centerline, where potential impacts would be maximized. For the beyond design-basis UPF earthquake accident and the earthquake accidents involving the ELP facilities, no credit is taken for the preventive or mitigating effects of active safety systems (i.e., systems designed to perform automatic actions based on some input parameter) or fire suppression efforts and equipment.

3.2.1 Consequences

Consequence analysis is independent of the probability that an earthquake accident would occur (i.e., the consequence analysis assumes the earthquake accident will occur). As a result of that analytical construct, seismic hazard probability is not a factor in determining the potential consequences that may result from an earthquake. Consequently, even if the probability of the earthquake accident analyzed in this SA were to change (regardless of the reason for that change), the consequences presented in this SA would not change. Based on that rationale, the 2014 USGS seismic hazard/maps would not constitute significant new circumstances or information relevant to environmental consequences compared to the consequence analysis in the Y-12 SWEIS.

Consequence, Probability, and Risk

This SA presents both the consequences and risks of a seismic accident (*see* Tables 3-3 and 3-4).

- "Consequence" refers to the results of an accident without consideration of the probability of the accident (i.e., accident consequences are independent of probability).
- "Probability" refers to the likelihood of an accident occurring. The probability of occurrence is expressed as a number between 0 (no chance of occurring) and 1 (certain to occur). Alternatively, instead of probability of occurrence, one can specify the frequency of occurrence (i.e., once in 2,500 years, which also can be expressed as 0.0004 times per year).
- "Risk" is the chance, high or low, that an accident will cause the consequences. Risk is determined by multiplying the consequences and the probability.

As shown in Table 3-3, the UPF beyond design-basis earthquake accident was determined to have the highest potential consequences to the MEI, offsite population, and noninvolved worker. For the UPF beyond design-basis earthquake accident, a dose of 424 person-rem (which equates to less than one [approximately 0.25] LCFs) in the offsite population could result in the absence of mitigation (i.e., under the worst case scenario of all alternatives previously reviewed in the Y-12 SWEIS, as well as in this SA, less than one LCF would be expected to occur in the offsite population). An offsite MEI would receive a dose of approximately 0.484 rem. Statistically, the MEI would have a 0.00029 chance, or about 1 in 3,500, of developing an LCF. A noninvolved worker, located 1,000 meters from the accident, would receive a dose of approximately 1.4 rem. Statistically, the noninvolved worker would have a 0.00086 chance, or about 1 in 1,200, of developing an LCF. As shown in Table 3-3, the UPF design-basis earthquake accident and a seismic-induced criticality event in either the 9215 Complex or 9204-2E Facility would have virtually no likely impacts to the offsite population and noninvolved worker. Under the worst case scenario of a beyond design-basis earthquake at the UPF, consequences of less than 1 LCF (0.25 LCF) would be expected.

Radiation Dose Measurement

In this SA, radiation doses are measured in units of either "person-rem" or "rem."

Person-rem is used to measure the total collective radiation dose for a group of people. To determine the population dose, this SA sums up the individual dose of every person within a 50-mile radius of Y-12. Statistically, approximately 1,667 person-rem would result in one LCF.

Rem is used to measure the radiation dose for a single individual. Individual doses are converted to LCFs by multiplying the dose by 0.0006. For example, an individual who receives a dose of 1.5 rem would have a 0.0009 chance of developing an LCF.

Table 3-3. Radiological Consequences for Earthquake Accident

Accident	Maximally Exposed Individual[a,d]		Offsite Population[b]		Noninvolved Worker[c,d]	
	Dose (rem)	Latent Cancer Fatality	Dose (Person-rem)	Latent Cancer Fatality	Dose (rem)	Latent Cancer Fatality
Beyond design-basis earthquake that causes explosions, radioactive material spills, and localized fires at UPF	0.48	0 (0.0003)	424	0.25	17 - 48[e] (100 meters)	0 (0.01-0.06)
					1.4 (1,000 meters)	0 (8.6x10^{-4})
Design-basis earthquake that causes radioactive material spills and localized fires at UPF	0.0296	0 (1.8x10^{-5})	24.9	0 (0.015)	2.93 (100 meters)	0 (1.8x10^{-3})
					0.088 (1,000 meters)	0 (5.3x10^{-5})
Earthquake that causes criticality event at either the 9215 Complex or 9204-2E Facility	0.0021	0 (1.3x10^{-6})	0.76	0 (4.5x10^{-4})	5.8[f] (100 meters)	0 (0.0035)
					0.007[f] (1,000 meters)	0 (4.2x10^{-6})

a. At site boundary, approximately 1.2 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. This SA presents dose results for the noninvolved worker at 100 and 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
e. For the beyond design-basis UPF earthquake accident in this SA, the noninvolved worker dose of 48 rem at 100 meters is based on a ground-level release of radioactive material. A ground-level release generally maximizes the dose to the noninvolved worker. At close distances, where a noninvolved worker is assumed to be located, an elevated release generally results in a reduced dose because more of the radioactive plume passes overhead and there is less inhalation. For the beyond design-basis UPF earthquake accident in this SA, NNSA also performed a sensitivity analysis to determine the dose to the noninvolved worker from an elevated release. Based on that revised assumption, the noninvolved worker dose at 100 meters would be approximately 17 rem (NuScale 2020).
f. Includes a direct radiation dose of 5.7 rem at 100 meters or 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

3.2.2 Risks

While risk analysis also incorporates the same conservative assumptions relating to radioactive material release, the results are determined by multiplying the accident consequences and the earthquake probability. Such an approach accounts for differences in the vulnerability of facilities to seismic hazards. For example, as discussed in Section 3.2, the probability of an earthquake accident (with resultant release of radioactive material) associated with the ELP facilities is estimated to be greater than the probabilities for the UPF earthquake accidents. This is due to the fact that the ELP facilities, while safe, do not meet modern codes and standards for new facilities (CNS 2020a). As a result, radioactive material release could occur in the ELP facilities in the event of a less severe, more probable earthquake.

As shown in Table 3-4, when probabilities are taken into account, all of the earthquake accident scenarios were determined to have virtually zero risks to the MEI, offsite population, and noninvolved worker. As shown in Table 3-4, the maximum risk to the MEI is 0 (7.0x10^{-9} per year, or approximately one statistical fatality in 143 million years); the maximum risk to the population is 0 (6.0×10^{-6} per year, or approximately one statistical fatality in 167,000 years); and the maximum risk to the noninvolved worker at 100 meters is 0 (7.0×10^{-6} per year, or approximately one statistical fatality in 140,000 years).

Table 3-4. Radiological Risks for Earthquake Accident

Accident	Probability	Maximally Exposed Individual[a] (LCFs)	Offsite Population[b] (LCFs)	Noninvolved Worker[c] (LCFs)
Beyond design-basis earthquake that causes explosions, radioactive material spills, and localized fires at UPF	1×10^{-6}	0 (3.0×10^{-10})	0 (2.5×10^{-7})	0 ($1.0\text{x}10^{-8}$ – 6.0×10^{-8}) (100 meters)
				0 (8.6×10^{-10}) (1,000 meters)
Design-basis earthquake that causes radioactive material spills and localized fires at UPF	4×10^{-4}	0 (7.0×10^{-9})	0 (6.0×10^{-6})	0 (7.2×10^{-7}) (100 meters)
				0 (2.1×10^{-8}) (1,000 meters)
Earthquake that causes criticality event at either the 9215 Complex or 9204-2E Facility	2×10^{-3}	0 ($2.6\text{x}10^{-9}$)	0 ($9.0\text{x}10^{-7}$)	0 ($7.0\text{x}10^{-6}$)[d] (100 meters)
				0 ($8.4\text{x}10^{-9}$)[d] (1,000 meters)

a. At site boundary, approximately 1.2 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.
c. This SA presents risk results for the noninvolved worker at 100 and 1,000 meters from the accident location. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
d. Includes LCFs from a direct radiation dose of 5.7 rem at 100 meters and 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

As discussed in Section 2.2.1, the UPF design accounts for the 2014 USGS seismic hazard/maps. With regard to the ELP facilities, as discussed in Section 2.2.2, NNSA is currently in the process of updating the PSHA, which is anticipated by the end of 2020. The updated PSHA will incorporate the 2014 USGS seismic hazard/maps, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East) (CNS 2020a). In preparing this SA, NNSA has evaluated the 2014 USGS seismic hazard/maps and conservatively estimated the probability of the earthquake accident for the ELP facilities. Based on existing structural analyses, NNSA is confident that the updated PSHA would not increase the earthquake probability used in this SA (CNS 2020b). Consequently, the risks would be no greater than the risks presented in this SA.

3.2.3 Involved Workers

For each of the earthquake accidents evaluated, there is a potential for injury or death to involved workers in the vicinity of the accident. Estimation of potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the worker decreases because the exposure cannot be adequately established with respect to the presence of shielding and other protective features. The worker also may be acutely injured or killed by physical effects of the accident. An earthquake accident with subsequent fire could have substantial consequences, ranging from workers being killed by debris from explosions to high radiation exposure.

Because the design of UPF would meet modern codes and standards, the areas containing the equipment which could cause explosions, spills, or localized fires are normally unoccupied enclosures. UPF is designed with a Safety Detection and Response System (SDRS) which alerts personnel to evacuate the facility prior to spills or localized fires being able to overcome the initial/closest barrier. The SDRS also isolates potential accident initiators to further minimize impacts to personnel and to protect property (e.g., from explosions). As a result of the SDRS and the UPF facility layout, which places potential spill locations away from main egress paths, only a fraction of the design occupant load would be exposed. Consequently, it is likely that no workers would be exposed to seismic-induced explosions and no more than 100 workers would be exposed to spills and local fires, which could lead to injuries or deaths (CNS 2020b).

With regard to a criticality event in the 9215 Complex or 9204-2E Facility, in addition to the potential for injury or death from the physical effects of the accident, severe worker exposures could also occur inside the facility. Depending on distance and the amount of intervening shielding material, lethal doses composed of radiation could occur. NNSA estimates that less than 100 workers would be in either the 9215 Complex or 9204-2E Facility. NNSA further estimates that the direct radiation doses of a nuclear criticality event, if one occurred, would likely not extend beyond the building boundary, and that distance and shielding (e.g., containers, process equipment, and the walls of the facility) would make the likely effects of direct radiation at the site boundary negligible (CNS 2020a).[13] With a seismically-qualified system, a criticality would be detected by the criticality alarm system, and an evacuation alarm would be sounded. All personnel would immediately evacuate the building. The existing criticality alarm systems in the 9215 Complex and 9204-2E Facility are not seismically-qualified. A current project under the ELP is underway, however, to install a modern, seismically-qualified criticality alarm system in the 9204-2E Facility. A similar project is planned for the 9215 Complex in the near future. Both projects are expected to be completed and operational before approximately 2026. The current system and the new system will alarm in time to allow complete evacuation during a criticality event. The current system was installed in the 1980's and has operated for decades. The addition of a new system is primarily to enhance confidence as NNSA extends the life of the facilities.

Immediate emergency response actions could reduce the potential for injuries and deaths for workers near the accident. Established emergency management programs would be activated in the event of an accident. Following initiation of accident/site emergency alarms, workers would evacuate the area in accordance with site emergency operating procedures.

Section 3.3.1 provides comparisons of the potential impacts to involved workers from accidents involving the smaller-scale UPF and the ELP facilities against the facility accidents analyzed in the Y-12 SWEIS.

[13] With regard to the potential impacts to the public, direct radiation from a potential criticality accident, with no shielding, is provided in footnote "f" of Table 3-3 and footnote "d" of Table 3-4. The unshielded direct radiation dose would be 0.0011 rem at 1,000 meters from an accident. At 500 meters, which is the approximate distance to the top of Pine Ridge, the unshielded direct radiation dose would be 0.036 rem. At a distance of approximately 650 meters, which is the approximate distance to the DOE fence line near Scarboro Road, the unshielded direct radiation dose would be 0.011 rem (*see* Table D.9.3-4 of NNSA 2011). Statistically, each of these doses would result in 0 LCFs.

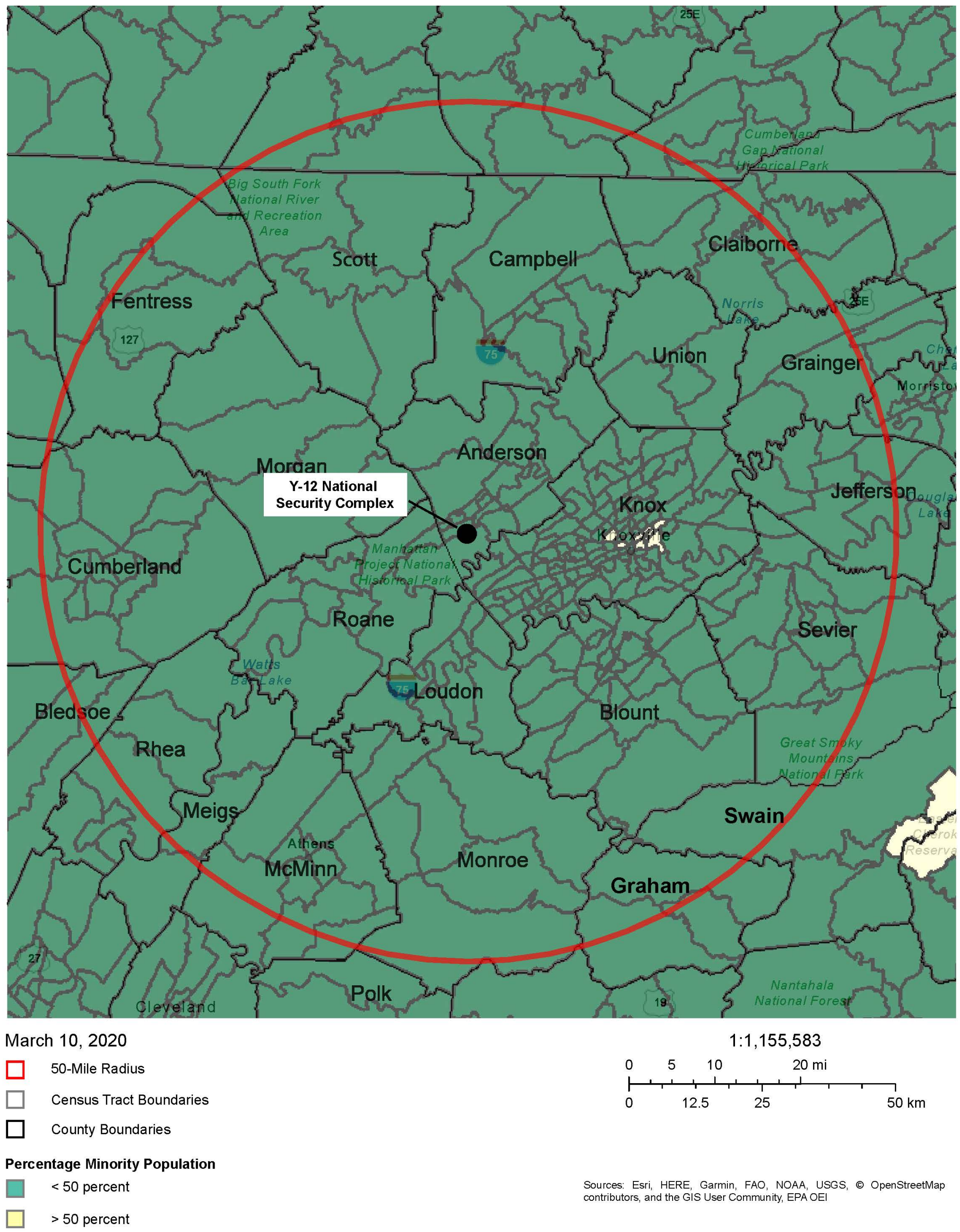
3.2.4 Environmental Justice Impacts

Under Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," Federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. Minority populations refer to persons of any race self-designated as Asian, Black, Native American, or Hispanic. Low-income populations refer to households with incomes below the Federal poverty thresholds. Environmental justice concerns the environmental impacts that proposed actions may have on minority and low-income populations, and whether such impacts are disproportionate to those on the population as a whole in the potentially affected area.

For this SA, the threshold used for identifying minority and low-income communities surrounding specific sites were developed consistent with Council on Environmental Quality (CEQ) guidance (CEQ 1997, p. 25) for identifying minority populations using either the 50-percent threshold or a "meaningfully greater" percentage of minority or low-income individuals in the general population. For this SA, "meaningfully greater" is defined as 20 percentage points above the population percentage in the general population. The potentially affected area considered is the area within a 50-mile radius of Y-12. Figures 3-1 and 3-2 show the geographic distribution of minority and low-income populations near Y-12.

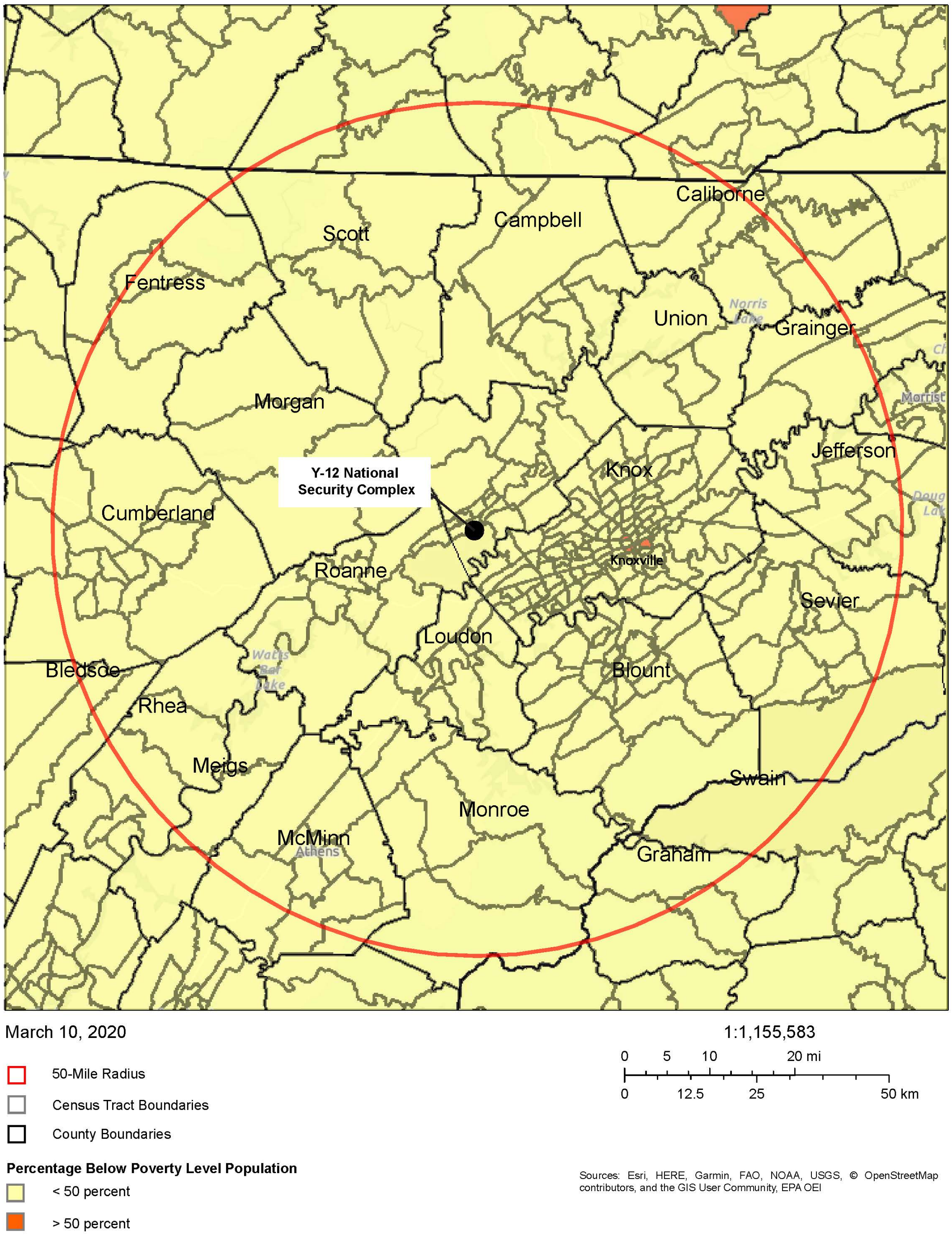
As shown in Table 3-3, an offsite MEI would receive a dose of approximately 0.484 rem. Statistically, the MEI would have a 0.00029 chance of developing an LCF, or about 1 in 3,500. The impacts to the MEI, who is assumed to be located at the site boundary approximately 1.2 miles from the release, would be small. Because the nearest minority populations and low-income populations are located approximately 15 miles east of Y-12 (*see* Figures 3-1 and 3-2), potential accidental doses at those locations would be even less than the MEI dose. Based on modelling results, a person located approximately 15 miles east of Y-12 would receive a maximum dose of approximately 3.9×10^{-4} rem from an earthquake accident at Y-12. Statistically, this person would have a 2.4×10^{-7} chance of developing an LCF, or about 1 in 4.2 million. Consequently, NNSA has concluded that there would be no disproportionately high and adverse human health impacts on minority populations and low-income populations from an earthquake accident at the UPF, 9215 Complex, or the 9204-2E Facility.

While NNSA acknowledges the existence of low-income and minority populations in the Scarboro and Woodlawn communities, the low-income and minority populations in those census tracts do not exceed the thresholds used by NNSA to be classified as low-income or minority populations for the purpose of Environmental Justice analysis. However, even if those census tracts were specifically analyzed for Environmental Justice impacts, as shown in Table 3-3, any impacts would be small to the Scarboro and Woodlawn communities, as well as to all other members of the population; consequently, there would be no disproportionately high and adverse human health impacts on minority populations and low-income populations from an earthquake accident at the UPF, 9215 Complex, or the 9204-2E Facility. For additional information on Environmental Justice issues regarding the Scarboro and Woodlawn communities, please see Appendix C, comment-responses 15-17.



Source: EJSCREEN 2020.

Figure 3-1. Minority Population – Census Tracts with More than 50 Percent Minority Population or a Meaningfully Greater Percentage of Minority Individuals in the General Population in a 50-Mile Radius of Y-12.



Source: EJSCREEN 2020.

Figure 3-2. Low-Income Population – Census Tracts with More than 50 Percent Low-Income Population or a Meaningfully Greater Percentage of Low-Income Individuals in the General Population in a 50-Mile Radius of Y-12.

3.2.5 Secondary Impacts

DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011), requires radiological activities that have the potential to impact the environment to be conducted in a manner that protects populations of aquatic animals, terrestrial plants, and terrestrial animals in local ecosystems from adverse effects due to radiation and radioactive material released from DOE operations. This SA focuses on potential impacts to humans, based on the concept endorsed by the International Commission on Radiation Protection (ICRP), which states, "if man is adequately protected then other living things are also likely to be sufficiently protected" (ICRP 1991). Such an approach uses human protection to infer environmental protection from the effects of ionizing radiation. Based on the analysis in this SA, potential impacts to humans would be small, and no further evaluations of other biota are necessary to demonstrate protection.

In addition, DOE Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2019) (DOE 2019), provides dose evaluation methods that can be used to demonstrate protection of biota in accordance with DOE Order 458.1. Per that technical standard, biota dose rates below 1 rad/day (for aquatic animals and terrestrial plants), and below 0.1 rad/day (for riparian animals and terrestrial animals), are demonstrative that populations of plants and animals are adequately protected from the effects of ionizing radiation.[14] As shown in Table 3-3, the design-basis earthquake that causes radioactive material spills and localized fires at UPF would result in a dose to the MEI of 0.0296 rem, which is demonstrative that populations of plants and animals would be adequately protected from the effects of ionizing radiation. Similarly, an earthquake that causes a criticality event at either the 9215 Complex or the 9204-2E Facility would result in a dose to the MEI of 0.0021 rem, which is demonstrative that populations of plants and animals would be adequately protected from the effects of ionizing radiation.[15]

As discussed in Appendix A, the analysis in this SA conservatively assumes that radioactive material would remain airborne and be inhaled, rather than deposited on surfaces. By assuming that radioactive materials are not deposited on surfaces, inhalation doses to humans are maximized. Consequently, the SA analysis conservatively estimates human exposures. NNSA has previously estimated contamination that could occur if radioactive material deposition were assumed to occur (note: under that assumption, the human doses would be minimized). For the design-basis UPF earthquake accident analyzed in this SA, contamination levels requiring remediation would be limited to the immediate area surrounding the UPF, within the Y-12 site boundary. For a beyond design-basis UPF earthquake accident, contamination levels requiring remediation could extend approximately 0.3-1.5 miles from the UPF (*see* also Section D.9.6 of NNSA 2011). As discussed in Section 3.2, the design-basis earthquake accident probability is estimated to be 4×10^{-4} per year, which equates to the occurrence of such an accident once every 2,500 years. The beyond design-basis earthquake accident probability is estimated to be a maximum of $1x10^{-6}$, which equates to the occurrence of such an accident once every million years (CNS 2020b).

[14] The difference between a "rad" and "rem" is that the rad is a measurement of the radiation absorbed by the material or tissue, whereas the rem is a measurement of the biological effect of that absorbed radiation. For general purposes most physicists agree that rad and rem may be considered equivalent (DOE 2019).

[15] As shown on Table 3-3, the beyond design-basis earthquake would result in a dose to the MEI of 0.48 rem. Per DOE 2019, such a dose is below the protection standard of 1 rad/day (for aquatic animals and terrestrial plants). Although the 0.48 rem dose is above the daily protection standard of 0.1 rad/day (for riparian animals and terrestrial animals), over the course of five days, the accident dose would be less than the protection standard.

3.3 Comparison of Impacts

Section 3.2 presents the earthquake impacts for the UPF and ELP facilities based upon seismic hazard information and analyses that account for the 2014 USGS seismic hazard/maps. Using the information in Sections 3.2, this section compares and contrasts those impacts with impacts from the Y-12 SWEIS accident analysis. Two types of impact comparisons are presented: (1) facility-to-facility (*see* Section 3.3.1); and (2) alternative-to-alternative (*see* Section 3.3.2). These comparisons are intended to support conclusions/determinations as to whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns; or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. To aid in understanding the comparisons in this section, a brief discussion of the Y-12 SWEIS accident analysis is provided.

Y-12 SWEIS Accident Analysis. The approach to the accident analysis for the Y-12 SWEIS is described in Section D.9.1 of the Y-12 SWEIS and summarized as follows:

1. NNSA screened out buildings without radioactive materials or with low-hazard rankings;

2. For high-hazard facilities such as the 9215 Complex, 9204-2E Facility, and Building 9212,[16] NNSA reviewed relevant safety-basis documents specific to each building and its operations. Through those reviews, NNSA identified potential accident scenarios and source terms (release rates and probabilities) associated with those facilities. Table D.9.3-1 of the Y-12 SWEIS shows the accidents considered for the nine high-hazard facilities. As shown in that table, a total of 56 accidents were considered. Earthquake accidents were considered for seven of the nine facilities.[17]

3. Based on the potential accident scenarios and source terms, NNSA identified the highest consequence accident for five high-hazard facilities, including the 9215 Complex, 9204-2E Facility, and Building 9212. For each of these facilities, consequences from earthquakes were determined to be equal to, or less than, consequences from other accidents such as fires, explosions, and airplane crashes. Consequently, the impacts of earthquake accidents were not carried forward for detailed analysis in the SWEIS.

4. Detailed analyses were conducted for the highest consequence accidents for each of the five high-hazard facilities. Those impacts are presented in Table D.9.4-1 (consequences) and Table D.9.4-2 (risks) of the Y-12 SWEIS.

5. With regard to the UPF, because detailed design descriptions of the UPF were not available, NNSA used the accident analyses of the 9215 Complex, 9204-2E Facility, and Building 9212 as surrogates to conservatively represent the UPF accidents.[18] Such an approach was conservative because it did not take into account the robust design and construction features of the UPF (*see* Section 2.2.1 of this SA) that would reduce accident

[16] The smaller-scale UPF would replace a majority of the EU operations located in Building 9212.
[17] The Analytical Laboratory and Machine Shop Special Materials were exceptions. Because these two facilities were not among the five highest hazard facilities at Y-12, accidents from these two facilities were not among the accidents analyzed in detail.
[18] The UPF evaluated in the SWEIS was intended to replace the operations in Building 9212, the 9215 Complex, and 9204-2E.

impacts compared to the existing facilities analyzed in detail in the Y-12 SWEIS. Although NNSA acknowledged that "new facilities such as the UPF would be constructed to current building design standards and would be designed and built to withstand higher seismic accelerations and thus would be more resistant to earthquake damage," the SWEIS accident analysis took no credit for these advancements over existing facilities. Based on the conservative approach, NNSA concluded that the risks presented for the current Y-12 facilities (both individually and additive) would be bounding for the UPF (NNSA 2011).

3.3.1 Facility-to-Facility Comparisons

To aid in understanding the facility-to-facility comparisons that will be presented in this section, Figure 3-3 identifies the three relevant high-hazard facilities/missions that were originally intended to be replaced by the UPF. Figure 3-3 also shows the differences between the 2011 ROD and the 2019 AROD. As shown in Figure 3-3, the following generalities can be made: (1) the smaller-scale UPF is essentially a replacement for the operations in Building 9212; and (2) operations in the 9215 Complex and the 9204-2E Facility will continue in upgraded facilities.

EXISTING FACILITIES	Y-12 SWEIS ROD (2011) "UPF Alternative"	Amended ROD (2019) "Hybrid Alternative"
Building 9212 (EU Operations)	**UPF** • EU Operations • EU Metal Fabrication • Assembly	**Smaller-scale UPF** • EU Operations
9215 Complex (EU Metal Fabrication)		**9215 Complex Upgrade** (EU Metal Fabrication)
9204-2E (Assembly)		**9204-2E Upgrade** (Assembly)

Note: borders/shadings/hashmarks are used to show the relationship of existing facilities to the Hybrid Alternative.

Figure 3-3. Relationship of Facilities to 2011 ROD and 2019 AROD

Table 3-5 provides the rationale for the facility-to-facility comparisons in this SA. (Note: comparisons of the earthquake accidents in this SA cannot be made against earthquake accidents in the Y-12 SWEIS. The earthquake accidents were not analyzed in detail in the 2011 SWEIS because an earthquake accident was not the highest consequence accident for any of the high-hazard facilities). Sub-sections that follow provide the impact comparisons for each facility pairing.

Table 3-5. Rationale for Facility Pairings/Comparisons

Facility/Accident Analyzed in this SA	Facility/Accident Analyzed in Y-12 SWEIS	Rationale
UPF/Design-Basis Earthquake that causes radioactive material spills and localized fires	9212 Facility/ Aircraft Crash and Fire	• Smaller-scale UPF would replace 9212 Facility; • Similar operations (EU operations) and types of MAR; • Similar accident probabilities ➢ UPF earthquake: $4x10^{-4}$ ➢ Aircraft crash in 9212 Facility: $1x10^{-4}$ (highest in range)[a]
9215 Complex/ Earthquake that causes criticality event	9215 Complex/ Major fire	• Same facility evaluated in both SA and Y-12 SWEIS; • Similar operations (EU Metal Fabrication) and types of MAR; • Similar accident probabilities ➢ Earthquake: $2x10^{-3}$ ➢ Major fire: $1x10^{-2}$ (highest in range)[a]
9204-2E Facility/ Earthquake that causes criticality event	9204-2E/ Explosion	• Same facility evaluated in both SA and Y-12 SWEIS; • Similar operations (Assembly) and types of MAR; • Similar accident probabilities ➢ Earthquake: $2x10^{-3}$ ➢ Explosion: $1x10^{-4}$ (highest in range)[a]

a. Table 5.14.1-1 of the Y-12 SWEIS shows the ranges of probabilities estimated for an airplane crash, major fire, and explosion. The term "highest in range" refers to the highest probability in each range.

3.3.1.1 UPF and Building 9212 Comparison

Tables 3-6 and 3-7 show the impact comparisons for the UPF earthquake accident analyzed in this SA and the most applicable 9212 Facility accident analyzed in the Y-12 SWEIS. As shown in those tables, the consequences and risks associated with a UPF design-basis earthquake accident would be significantly less than those for the 9212 Facility accident analyzed in the Y-12 SWEIS. With regard to involved workers, the modern design and construction features of the smaller-scale UPF would reduce risks to involved workers compared to workers in the 9212 Building. Depending on the accident, there are approximately 100-400 involved workers in the 9212 Building who would be at risk from an accident. For the smaller-scale UPF, it is likely that no workers would be exposed to seismic-induced explosions and no more than 100 workers would be exposed to spills and local fires which could lead to injury or death (CNS 2020b).

Table 3-6. Radiological Consequence Comparison for UPF and 9212 Facility

Accident	Maximally Exposed Individual[a,d]		Offsite Population[b]		Noninvolved Worker[c,d]	
	Dose (rem)	Latent Cancer Fatality	Dose (Person-rem)	Latent Cancer Fatality	Dose (rem)	Latent Cancer Fatality
SA: Design-basis earthquake that causes radioactive material spills and localized fires at UPF	0.0296	0 ($1.8x10^{-5}$)	24.9	0 (0.015)	0.088	0 ($5.3x10^{-5}$)
Y-12 SWEIS: Aircraft Crash in 9212 Facility	0.3	0 ($2.0x10^{-4}$)	665	0.4	0.388	0 ($2.3x10^{-4}$)

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
Source: CNS 2020b, NNSA 2011, NuScale 2020.

Table 3-7. Radiological Risk Comparison for UPF and 9212 Facility

Accident	Probability	Maximally Exposed Individual[a] (LCFs)	Offsite Population[b] (LCFs)	Noninvolved Worker[c] (LCFs)
SA: Design-basis earthquake that causes radioactive material spills and localized fires at UPF	4×10^{-4}	0 (7.0×10^{-9})	0 (6.0×10^{-6})	0 (2.1×10^{-8})
Y-12 SWEIS: Aircraft Crash in 9212 Facility	1×10^{-4}	0 (2.0×10^{-8})	0 (4.0×10^{-5})	0 (2.3×10^{-8})

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
Source: CNS 2020b, NNSA 2011, NuScale 2020.

3.3.1.2 9215 Complex Comparison

Tables 3-8 and 3-9 show the impact comparisons for the 9215 Complex earthquake accident analyzed in this SA and the most applicable 9215 Complex accident analyzed in the Y-12 SWEIS. As shown in those tables, the consequences and risks associated with an earthquake accident in the 9215 Complex would be significantly less than those for the 9215 Complex accident analyzed in the Y-12 SWEIS. For involved workers, the number of workers in the 9215 Complex would be no different than the number of involved workers estimated in that facility when the Y-12 SWEIS was prepared. Consequently, potential accident impacts from an accident, whether a criticality event or another type of accident, would not change: no more than 100 workers in the 9215 Complex would be at risk of injury or death (CNS 2020b).

Table 3-8. Radiological Consequence Comparison for 9215 Complex

Accident	Maximally Exposed Individual[a,d]		Offsite Population[b]		Noninvolved Worker[c,d]	
	Dose (rem)	Latent Cancer Fatality	Dose (Person-rem)	Latent Cancer Fatality	Dose (rem)	Latent Cancer Fatality
SA: Earthquake that causes criticality event in 9215 Complex	0.0021	0 ($1.3\text{x}10^{-6}$)	0.76	0 ($4.5\text{x}10^{-4}$)	0.007[e]	0 ($4.2\text{x}10^{-6}$)
Y-12 SWEIS: Major fire in 9215 Complex	0.59	0 ($3.6\text{x}10^{-4}$)	520	0.31	16.3	0 ($9.8\text{x}10^{-3}$)

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
e. Includes a direct radiation dose of 0.0011 rem at 1,000 meters (see Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

Table 3-9. Radiological Risk Comparison for 9215 Complex

Accident	Probability	Maximally Exposed Individual[a] (LCFs)	Offsite Population[b] (LCFs)	Noninvolved Worker[c] (LCFs)
SA: Earthquake that causes criticality event in 9215 Complex	2×10^{-3}	0 (2.6×10^{-9})	0 (9.0×10^{-7})	0 (8.4×10^{-9})[d]
Y-12 SWEIS: Major fire in 9215 Complex	1×10^{-4}	0 (3.6×10^{-8})	0 (3.1×10^{-5})	0 (9.8×10^{-7})

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. Includes LCFs from a direct radiation dose of 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

3.3.1.3 9204-2E Facility Comparison

Tables 3-10 and 3-11 show the impact comparisons for the 9204-2E Facility earthquake accident analyzed in this SA and the most applicable 9204-2E Facility accident analyzed in the Y-12 SWEIS. As shown in Tables 3-10 and 3-11, the consequences and risks associated with an earthquake accident in the 9204-2E Facility would be significantly less than those for the 9204-2E Facility accident analyzed in the Y-12 SWEIS. For involved workers, the number of workers in the 9204-2E Facility would be no different than the number of involved workers estimated in that facility when the Y-12 SWEIS was prepared. Consequently, potential accident impacts from an accident, whether a criticality event or another type of accident, would not change: no more than 100 workers in the 9204-2E Facility would be at risk of injury or death (CNS 2020b).

Table 3-10. Radiological Consequence Comparison for 9204-2E Facility

Accident	Maximally Exposed Individual[a,d]		Offsite Population[b]		Noninvolved Worker[c,d]	
	Dose (rem)	Latent Cancer Fatality	Dose (Person-rem)	Latent Cancer Fatality	Dose (rem)	Latent Cancer Fatality
SA: Earthquake that causes criticality event in 9204-2E Facility	0.0021	0 (1.3×10^{-6})	0.76	0 (4.5×10^{-4})	0.007[e]	0 (4.2×10^{-6})
Y-12 SWEIS: Explosion in 9204-2E Facility	0.058	0 (3.5×10^{-5})	51.2	0.031	1.18	0 (7.1×10^{-4})

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
e. Includes a direct radiation dose of 0.0011 rem at 1,000 meters (see Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

Table 3-11. Radiological Risk Comparison for 9204-2E Facility

Accident	Probability	Maximally Exposed Individual[a] (LCFs)	Offsite Population[b] (LCFs)	Noninvolved Worker[c] (LCFs)
SA: Earthquake that causes criticality event in 9204-2E Facility	2×10^{-3}	0 ($2.6x10^{-9}$)	0 ($9.0x10^{-7}$)	0 ($8.4x10^{-9}$)[d]
Y-12 SWEIS: Explosion in 9204-2E Facility	1×10^{-4}	0 (3.5×10^{-9})	0 (3.1×10^{-6})	0 (7.1×10^{-7})

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. Includes LCFs from a direct radiation dose of 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

3.3.2 Alternative-to-Alternative Comparisons

Section 3.2 presents the potential impacts associated with an earthquake accident at each of three facilities (smaller-scale UPF, 9215 Complex, and the 9204-2E Facility). Taken together, those three facilities reflect the "Hybrid Alternative." This section compares the accident impacts of the Hybrid Alternative against the Y-12 SWEIS alternatives. These alternative-to-alternative comparisons are based on the potential consequences of site-wide accidents that cause a simultaneous release of radioactive material for the Hybrid Alternative, the Y-12 SWEIS Capability-sized UPF Alternative,[19] and the No-Action Alternative.

For the Hybrid Alternative, two site-wide accident scenarios are presented: (1) a design-basis earthquake that causes radioactive material spills and localized fires in the UPF, and simultaneous criticality events in the 9215 Complex and 9204-2E Facility; and (2) worst-case design-basis accidents that occur simultaneously as follows: a design-basis earthquake accident in the smaller-size UPF; a large fire in the 9215 Complex; and an explosion in the 9204-2E Facility.

For the Capability-sized UPF Alternative, NNSA utilized the *Preliminary Safety Design Report for the Uranium Processing Facility* (B&W 2012b) to develop the input data needed for the accident analysis of the full-size (single building) UPF. Using that data, NNSA developed the source term data for a design-basis earthquake that causes localized process area fires in a single building UPF that was intended to house EU operations, EU metal fabrication, and assembly operations.[20]

For the No-Action Alternative, the Y-12 SWEIS presents the following accident consequences: (1) a fire from an airplane crash into Building 9212, which houses EU operations; (2) a major fire in the 9215 Facility, which houses EU metal fabrication; and (3) an explosion in the 9204-2E Facility, which houses assembly operations. As discussed in Section 3.3.1, operations in those three facilities are similar and comparable to operations that would be conducted in the facilities that comprise the Hybrid Alternative or the single building UPF.

[19] The Capability-sized UPF Alternative was the preferred alternative in the Y-12 SWEIS.
[20] The *Preliminary Safety Design Report for the Uranium Processing Facility* (B&W 2012b) is classified. However, NNSA developed unclassified data for this SA. That data is contained in the Data Call reference document (CNS 2020b). The source term associated with spills was insignificant compared to the source term for localized fires.

The Y-12 SWEIS does not identify and analyze a single accident, such as a site-wide earthquake accident, that could simultaneously release radioactive materials from multiple facilities. As such, a direct comparison of accident risk (which requires a consideration of the accident probability associated with the accident) between the Y-12 SWEIS and this SA is not applicable. However, for the No-Action Alternative, the Y-12 SWEIS presents the consequences of accidents in multiple facilities, and those additive consequences can be compared against the simultaneous accident consequences presented in this SA. (Note: a comparison of consequences does not require consideration of the initiating event or the probability of an accident).

Table 3-12 presents the potential consequences of site-wide accidents for the Hybrid Alternative and the Y-12 SWEIS alternatives. As shown in Table 3-12, the No-Action Alternative, which would continue operations in existing facilities, would have the highest consequences compared to the Hybrid Alternative and the Capability-sized UPF Alternative. That conclusion is consistent with the conclusions presented in the Y-12 SWEIS (*see* Section 5.14.3 of NNSA 2011). Although the consequences would be highest for the No-Action Alternative, those consequences would be small (i.e., a total dose of 1,236 person-rem, which equates to less than one [approximately 0.72] LCF in the offsite population).

As shown in Table 3-12, the consequences for the worst-case design basis accident for the Hybrid Alternative would be much smaller than the No-Action Alternative. That reduction would largely be the result of transferring Building 9212 operations to a modern UPF and reducing MAR in the 9215 Complex. As noted in Section 3.3.1.1, Table 3-6, consequences associated with the smaller-scale UPF are dramatically lower than in 9212. Furthermore, as noted in footnote “f” of Table 3-12, the consequences of a large fire in the 9215 Complex for the Hybrid Alternative would be: 274 person-rem to the population; 0.327 rem to the MEI; and 0.97 rem to the noninvolved worker (*see* NuScale 2020). To put these consequences into perspective, the Y-12 SWEIS estimated the consequences of a large fire in the 9215 Complex as: 520 person-rem to the population; 0.59 rem to the MEI; and 16.3 rem to the noninvolved worker (*see* Table 5.14.1-1 of NNSA 2011). The MAR reductions in the 9215 Complex have resulted in an approximately 45-47 percentage reduction in offsite consequences for the worst-case design-basis accident in that facility.

As shown in Table 3-12, the consequences of an accident involving the Capability-sized UPF Alternative (row 2) are the smallest of the worst-case accidents. New nuclear facilities should have the smallest accident consequences due to meeting modern nuclear safety requirements. Comparing worst-case accidents in all three alternatives show that the Capability-sized UPF (row 2) has the lowest consequences, the Hybrid Alternative (row 3) has higher consequences, but those consequences are still significantly lower than the No-Action Alternative (row 4).

Finally, if one compares only the design-basis earthquake accidents for the Hybrid Alternative (row 1) and the Capability-sized UPF alternative (row 2), the consequences are similar. This is largely due to the consolidation of EU operations from the older nuclear facilities into a modern UPF. For either alternative, the offsite consequences would be very small (i.e., a total dose of 26.4-29.6 person-rem, which equates to less than one [approximately 0.016-0.018] LCF in the offsite population).

Table 3-12. Consequence Comparison: Hybrid Alternative and Y-12 SWEIS Alternatives

Row	Accident[a]	Maximally Exposed Individual[b,e]		Offsite Population[c]		Noninvolved Worker[d,e]	
		Dose (rem)	Latent Cancer Fatality	Dose (Person-rem)	Latent Cancer Fatality	Dose (rem)	Latent Cancer Fatality[d]
1	**Hybrid Alternative (smaller-scale UPF, 9215, 9204-2E)** Scenario 1: Design-basis earthquake causes the following simultaneous events: Smaller-scale UPF: radioactive material spills and localized fires; 9215: criticality event; 9204-2E: criticality event.	0.034	0 (2.0×10^{-5})	26.4	0 (0.016)	0.10 (1,000 meters)	0 (6.1×10^{-5})
2	**Y-12 SWEIS Capability-sized UPF Alternative** Design-basis earthquake (which is also the worst-case design-basis accident) causes radioactive material spills and localized fires in full-size (single building) UPF that was intended to house EU operations, EU metal fabrication, and assembly	0.0352	0 (2.1×10^{-5})	29.6	0 (0.018)	0.104 (1,000 meters)	0 (6.2×10^{-5})
3	**Hybrid Alternative (smaller-scale UPF, 9215, 9204-2E)** Scenario 2: Worst-case design-basis accidents occur simultaneously: Smaller-scale UPF: design-basis earthquake accident; 9215: large fire;[f] 9204-2E: explosion.	0.415	0 (0.0025)	350.1	0.21	2.24 (1,000 meters)	0 (0.0013)
4	**Y-12 SWEIS No-Action Alternative** Worst-case design-basis accidents occur simultaneously in existing EU facilities: 9212: airplane crash; 9215: major fire; 9204-2E: explosion	0.948	0 (0.00059)	1,236	0.74	17.9 (1,000 meters)	0 (0.011)

a. Each alternative includes the potential impacts associated with a design-basis earthquake at the Highly Enriched Uranium Materials Facility (HEUMF) and other EU support facilities at Y-12. A design-basis earthquake at HEUMF would not release any radioactive material to the environment. A design-basis earthquake at other EU support facilities would release insignificant quantities of radioactive material to the environment compared to the source terms associated with the UPF, 9215 Complex, and Building 9204-2E (CNS 2020b).
b. At site boundary, approximately 1.2 to 1.3 miles from release.
c. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
d. Based on a noninvolved worker assumed to be 1,000 meters from the accident locations.
e. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed.
f. Source term for large fire in 9215 Complex revised from data in Y-12 SWEIS to account for reductions in MAR (*see* CNS 2020b). The facility-specific consequences of a large fire in the 9215 Complex would be: 274 person-rem to the population; 0.327 rem to the MEI; and 0.97 rem to the noninvolved worker (*see* NuScale 2020).

Source: NNSA 2011, CNS 2020b, NuScale 2020.

3.4 Cumulative Impacts

The Council of Environmental Quality regulations (40 CFR § 1508.7) define cumulative impacts as "the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." The analysis in Section 3.3.2 addresses site-wide accidents/simultaneous accidents in multiple facilities, including the HEUMF and other EU support facilities at Y-12. That analysis provides cumulative impacts information regarding site-wide accidents.

4.0 CONCLUSION AND DETERMINATION

NNSA has prepared this SA to evaluate the potential impacts of an earthquake accident at Y-12, based on updated seismic hazard information. This SA was prepared in accordance with the DOE procedures implementing NEPA (10 CFR 1021) that require that "[when] it is unclear whether or not an Environmental Impact Statement (EIS) supplement is required, DOE shall prepare a Supplement Analysis [that] shall discuss the circumstances that are pertinent to deciding whether to prepare a supplemental EIS pursuant to 40 CFR 1502.9(c)" (10 CFR 1021.314). An SA may also be prepared at any time, as appropriate, to further the purposes of NEPA.

As shown in Section 3.0, the potential impacts associated with an earthquake accident at Y-12 would not be significantly different than impacts presented in the Y-12 SWEIS. Based on the results of this Final SA, NNSA has determined that: (1) the earthquake consequences and risks do not constitute a substantial change; (2) there are no significant new circumstances or information relevant to environmental concerns; and (3) no additional NEPA documentation is required at this time.

Based on my review of the information in this SA and pursuant to NNSA's administrative procedures and DOE's NEPA implementing procedures (10 CFR 1021.314(c)), I have determined, with the concurrence of the NNSA Production Office Counsel, that no further NEPA documentation is required at this time. However, NNSA will continue to evaluate new seismic information as it is developed, including upon the completion of the updated PSHA that is anticipated to be issued by the end of 2020 and the updated facility evaluations that are anticipated to be completed by the end of 2021.

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APPENDIX A

Technical Approach for the Earthquake Accident Analysis

Consequences of accidental radiological releases were determined using the MELCOR Accident Consequence Code System (MACCS) computer code. MACCS is a DOE/NRC sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and NEPA documentation for facilities throughout the DOE complex. A detailed description of the MACCS model is available in a technical report: Code Manual for MELCOR Accident Consequence Code System2 (MACCS) (NUREG/CR-6613 (NRC 1998).

MACCS estimates the radiological doses, health effects, and economic consequences that could result from postulated accidental releases of radioactive materials to the atmosphere. The release of radioactive materials to the environment is commonly referred to as a source term. MACCS simulates the atmospheric transport and dispersion of the source term as a plume (or series of plumes) and estimates the health and economic consequences due to radioactive contamination from the plume(s) during transport. MACCS calculations are divided into 3 primary modules: ATMOS, EARLY, and CHRONC.

ATMOS performs the calculations related to atmospheric transport, dispersion, deposition, and the radioactive decay of materials prior to release and during the release and transport in the atmosphere. The user defines the initial inventory of radionuclides available for release: each individual nuclide and their initial inventory of activity. The plume release can be divided into multiple plume segments to match the temporal resolution of the meteorological data file. To model a radionuclide release, a user provides MACCS with the characteristics of each plume segment:

- time between the accident occurring and the plume releasing to the environment;
- duration of the plume segment release;
- plume release height;
- plume dimensions at the time of release;
- plume buoyancy;
- particle size distribution of any aerosols in the plume; and
- fraction of the initial nuclide inventory for each radionuclide that is released to the environment in the plume segment.

The plume is released into all meteorological conditions sampled by MACCS. Each plume segment travels in the wind direction and at the wind speed that is present at the time of that plume segment’s release. MACCS employs a straight-line Gaussian plume model, meaning that each plume segment travels in a straight line and does not change directions following its release to the environment. Modeling multiple plume segments in a release allows MACCS to more realistically evaluate the consequences of shifting wind conditions during long releases. As each plume segment travels downwind, the plume expands in the vertical and lateral directions based on its current distance from the release point of the plume, and the atmospheric stability at that time. The plume can become depleted due to dry deposition (fallout), wet deposition (washout, i.e. knockout due to rain), and radioactive decay of the materials in the plume. After the ground level airborne and deposited radionuclide concentrations have been calculated in ATMOS, this information is passed to EARLY.

EARLY estimates the dose consequences and health effects due to radiation exposure during the emergency phase. The emergency phase begins when the first plume segment of a release arrives in a grid element, and can last up to 40 days. There are five dose pathways considered in EARLY: cloudshine (submersion in the plume), groundshine (exposure to radionuclides deposited during plume transport), inhalation of the passing plume, inhalation of resuspended radionuclides that were once deposited on the ground, and dose due to exposure from radionuclides deposited on the skin. Dose exposures can be calculated to a variety of organs in the body, as well as a total effective dose equivalent. The EARLY module can model protective actions to reduce radiation exposure including sheltering in place, ordered evacuation through a predetermined route, ad-hoc relocation of individuals in high exposure areas, and potassium iodide prophylaxis. Multiple portions of the population, referred to as cohorts, can be modeled independently and take different protective actions than other cohorts or perform protective actions at different times. Actions following the emergency phase are handled by the CHRONC module.

CHRONC performs all of the calculations related to the intermediate and long-term phases. The intermediate phase begins immediately at the conclusion of the emergency phase, and can last up to 1 year. The intermediate phase is not required to be modeled, and can have zero duration. Only groundshine and resuspension inhalation are considered during this phase. If individuals incur doses over a user-defined threshold, they are relocated for the duration of this phase. The long-term phase begins immediately after the intermediate phase. Exposure pathways resulting from ground-deposited material are considered in the long-term phase: groundshine, resuspension inhalation, and food and water ingestion. Various long-term protective actions can be modeled, including decontamination, interdiction, and condemnation of property, as well as food and crop disposal. These actions are considered separately depending on non-farm and farm land usage.

Due to two conservative assumptions made in this analysis-- deposition of radionuclides is prohibited and protective actions are not considered-- not all aspects of the MACCS code are used. Without ground contamination to consider, the CHRONC module is unnecessary. Additionally, without protective actions, the evacuation, sheltering, relocation, and prophylaxis measures that can be credited by MACCS during the emergency phase to reduce dose consequences are unused.

As implemented, the MACCS2 model evaluates doses due to inhalation of airborne material, as well as external exposure to the passing plume. This represents the major portion of the dose that an individual would receive because of a facility accident. The longer-term effects of radioactive material deposited on the ground after a postulated accident, including the resuspension and subsequent inhalation of radioactive material and the ingestion of contaminated crops, were not modeled for this SA because these pathways have been studied and found to contribute less significantly to the dosage than the inhalation of radioactive material in the passing plume; they are also controllable through interdiction. Instead, the deposition velocity of the radioactive material was set to zero, so that material that might otherwise be deposited on surfaces remained airborne and available for inhalation. This assumption is conservative for the postulated UPF uranium release and realistic for the postulated 9215 and 9204-2E criticality releases. The uranium isotopes released from a UPF accident would be alpha particle emitters that primarily contribute to inhalation dose, as alpha particles do not penetrate skin. Prohibiting deposition maximizes the uranium available for inhalation. The criticality release is comprised of noble gases and vapors, which are nonreactive and do not deposit in the environment.

The source terms were handled by the code by considering the MAR as the inventory. The release fraction of each scenario was then the product of the various factors (DR, ARF, RF, and LPF) that describe the material available to actually impact a receptor.

Meteorological data for Y-12 is taken from 10 meter elevation measurements at weather Tower W of Oak Ridge National Laboratory (ORNL). The meteorological data contains hourly wind speed, wind direction in 16 compass sectors, atmospheric stability, and precipitation rate. Tower W is the meteorological tower nearest the Y-12 site, with a latitude and longitude of 35.98 N, 84.27 W. Hourly wind speed, wind direction, and atmospheric stability is provided in MACCS format by ORNL for 2015 through 2019. Hourly precipitation data is provided by ORNL for 2001 through 2019. Data provided by ORNL for these years is complete and quality assured; therefore, no modifications were made to these data in this analysis. Each hour of the annual meteorological site specific data set for each site was sampled, assuring a complete representation of the entire meteorological data set. The results from each of these samples were then ranked and combined (according to their frequency of occurrence) and a distribution of results is presented by the code. This distribution includes statistics such as 95th percentile, 50th percentile, and mean dose. The latter is presented in this SA.

It was conservatively assumed that no special actions would be taken to avoid or mitigate exposure to the general population following an accidental release of radionuclides. For example, there would be no evacuation or protection of the surrounding population. Potential protective actions are not modeled. All individuals, both workers and members of the public, are assumed to be standing outside, unprotected, for the duration of the hypothetical release. This is a conservative assumption because neglecting protective actions maximizes the potential dose consequences.

The spatial grid at the Y-12 site is set up with radial distances that capture the MEI and worker dose at 100 meters, 1,000 meters, 1.24 miles, 15 miles due east, and the total population dose within 50 miles. Consistent with the resolution of meteorological data available from ORNL, the spatial grid has 16 compass sectors. Dose receptors were at 100 meters, 1,000 meters, 1.24 miles, and due east at 15 miles. The cumulative population dose is based on the total population within 50 miles of the release. These distances are consistent with co-located workers at Y-12 and the area of the affected environment surrounding Y-12. The Y-12 site boundary distance is shown to be 1.3 miles in the 2011 SWEIS, and modeling the closest member of the public at 1.24 miles adds slight conservatism to the dose estimate. The nearest environmental justice population to Y-12 is shown to be about 15 miles due east; therefore, this location is evaluated for environmental justice purposes. Population and individual doses were statistically sampled by assuming an equally likely accident start time during any hour of the year. All hours were sampled. The results from each of these samples were then sorted to obtain a distribution of results (radiation dose).

MEI and noninvolved worker doses were calculated using conservative assumptions, such as the wind blowing toward the MEI and locating the receptor along the plume centerline. The doses were converted to LCFs using the factor of 0.0006 LCF per person-rem for both members of the public and workers; if applicable, calculated LCFs were doubled for individual doses greater than 20 rem (NCRP 1993). The MEI and noninvolved worker are assumed to be exposed for the duration of the release; they or DOE would take protective or mitigative actions thereafter if required by the size of the release.

Plumes are assumed to release at ground level. This assumption is conservative and consistent with the postulated release height for a hypothetical EU Warehouse earthquake release. A ground level release maximizes the radionuclide concentration at ground level, which then maximizes the absorbed dose to the ground level receptor. A sensitivity case is evaluated at an 8 meter release height to confirm that a ground level release is conservative.

Neutrally buoyant plumes (i.e., plumes that do not rise nor fall during transport) are modeled, using the heat buoyancy model and a plume heat content of 0 watts. This assumption is conservative and consistent with the Y-12 safety analysis of the UPF. Neglecting plume rise is a bounding assumption that maximizes the plume centerline relative radionuclide concentration at ground level at all radial distances when radionuclide deposition is also prohibited. The plume radionuclide concentration is largest at the plume centerline, and neglecting plume rise prohibits the plume centerline from rising above dose receptors.

The analysis of accidents is based on calculations relevant to hypothetical sequences of events and models of their potential impacts. The models provide estimates of the frequencies, source terms, pathways for dispersion, exposures, and the effects on human health and the environment as realistic as possible within the scope of the analysis. In many cases, the scarcity of experience with the postulated accidents leads to uncertainty in the calculation of the consequences and frequencies. This fact has promoted the use of models or input values that yield conservative estimates of consequences and frequency. Additionally, since no credit is taken for safety systems that may function during an event, these events do not represent expected conditions within the facility at any point in its lifetime.

Due to the layers of conservatism built into the accident analysis for the spectrum of postulated accidents, the estimated consequences and risks to the public represent the upper limit for the individual classes of accidents. A conservative approach is appropriate and standard practice for analyses of this type, which involve high degrees of uncertainty associated with analytical factors such as accident frequency, MAR, and LPF.

More details regarding the MACCS modeling that was conducted for this SA can be found in "Dose Consequence Modeling Results for the Y-12 Earthquake Accident Supplement Analysis" (NuScale 2020).

APPENDIX B

Seismic Analysis and Consequences of a Seismically-Initiated Accident

RP YAREA-F-1709 000 01

Seismic Analysis and Consequences of a Seismically-Initiated Accident

March 2020

Seismic Analysis and Consequences of a Seismically-Initiated Accident

March 2020

Prepared by
Consolidated Nuclear Security, LLC
Management & Operating Contractor
for the
Pantex Plant and Y-12 National Security Complex
under Contract No. DE-NA0001942
with the
U.S. Department of Energy
National Nuclear Security Administration

APPROVALS

Signature on File

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Date

REVISION LOG

Revision No.	Date	Description	Pages Affected
0	January 17, 2020	Initial issue.	All
1	March 26, 2020	Revised to clarify worst-case accident consequences in Sect. 4.2	14

CONTENTS

ABBREVIATIONS

ASCE	American Society of Civil Engineers
CEUS SSC	Central and Eastern United States Seismic Source Characterization for Nuclear Facilities
DOE	U.S. Department of Energy
ELP	Extended Life Program
EPRI	Electric Power Research Institute
HEPA	high-efficiency particulate air
IBC	International Building Code
MAR	material at risk
NEPA	National Environment Policy Act
NGA-East	Next Generation Attenuation-East
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
PEER	Pacific Earthquake Engineering Research Center
PDSA	Preliminary Documented Safety Analysis
PSHA	Probabilistic Seismic Hazard Analysis
SA	Supplement Analysis
SWEIS	Site-Wide Environmental Impact Statement
UPF	Uranium Processing Facility
USGS	United States Geological Survey
Y-12	Y-12 National Security Complex

1. INTRODUCTION

This report is intended to address issues that were raised by the U.S. District Court in the Memorandum Opinion and Order (Case 3:18-cv-00150-PLR-DCP Document 63) filed September 24, 2019. This report is also intended to support future supplement analysis.

In evaluating the risks posed by existing or planned buildings that will hold nuclear materials, the National Nuclear Security Administration (NNSA) considers the risk that impacts from seismic events may affect facilities and cause a release of nuclear material into the environment. In order to do this, NNSA must consider a number of variables, each one of which may influence the results of the risk analysis. These include such things as the design of the facility; the material at risk (MAR), which is the amount and character of nuclear materials present; the likelihood and severity of a seismic event (seismic hazard); and the impact of the event on the structure.

Seismic analysis and accident analysis are specialty technical fields that involve in-depth technical analyses and technical terminology. This report attempts to respond to the issues raised by the court by summarizing the technical analyses in a manner that the public can understand.

The issues that are addressed involve multiple nuclear facilities at the Y-12 National Security Complex (Y-12). The first is the Uranium Processing Facility (UPF), which is being designed and constructed at Y-12 to replace an existing nuclear facility, the 9212 Complex. Risk of a seismically-initiated accident is an important consideration in this activity, since UPF is designed to protect workers, the public, and the environment against such risks. Accordingly, it is important to address the issues that have been raised, and to reassure the public that UPF has been designed and is being constructed appropriately.

The other facilities involved are the existing nuclear facilities, the 9215 Complex and the 9204-2E Facility. Nuclear operations are planned to continue in these facilities for more than two decades under the current strategy. To ensure those future operations are conducted safely, an Extended Life Program (ELP) is being implemented to reduce the risk in these facilities and refurbish the facilities to ensure their continued reliability in the future. These facilities are referred to as the ELP facilities. Risk of a seismically-initiated accident is also important in these facilities, but the consideration of that risk is different than that for UPF since the facility structures already exist and upgrades to meet modern seismic structural standards for new facilities may not be feasible or practical. For the ELP facilities, it is important to not only determine the amount of seismic risk and the feasibility of upgrades, but to also explore ways beyond structural upgrades to reduce risk.

This report provides background information on the court request, seismic analysis, and accident analysis, then addresses UPF seismic analysis and accident analysis, followed by seismic analysis and accident analysis of ELP facilities, and concludes with clarifying information about nuclear criticality safety.

It is also important to recognize that a report of this nature unavoidably focuses on weaknesses in existing facilities that are aging, particularly in the 9212 Complex, the 9215 Complex, and the 9204-2E Facility. These weaknesses can and will be addressed for future operations through replacement (UPF) or upgrades (ELP facilities). These weaknesses should not, however, be mistaken to imply that the ELP facilities are unsafe for current operations. To the contrary, the existing facilities have been extensively evaluated, hazards have been identified and analyzed, and controls are implemented through formal safety analysis and authorization processes as defined in DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. Administrative controls are relied on in some cases where engineered controls do not exist or are of questionable reliability. In all cases, safety controls are implemented and routine assessments ensure that safety controls are effective. Ongoing efforts to remove unnecessary nuclear materials and to upgrade the facilities and processing equipment also reduce nuclear safety risk.

2. BACKGROUND

2.1 COURT REQUEST

The court order states that NNSA "shall conduct further NEPA [National Environment Policy Act] analysis – including at a minimum, a supplement analysis – that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporate the 2014 USGS [United States Geological Survey] seismic hazard map."

There are several underlying issues that were explained in the memorandum opinion. They are summarized here:

- 2014 USGS seismic hazard maps showed an increase in the hazard for East Tennessee compared to the earlier 2008 USGS seismic maps. While NNSA explained the impact of this new information in the 2016 Supplement Analysis (DOE/EIS-0387-SA-01, *Supplement Analysis for Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2016 SA) and the 2018 Supplement Analysis (DOE/EIS-0387-SA-03, *Supplement Analysis for the Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2018 SA), the court questioned perceived discrepancies between the 2016 SA explanation for UPF and the response to an internal UPF project peer review.
- For ELP facilities, the 2018 SA discussed a 2003 site-specific seismic hazard analysis that is not discussed in the 2011 Site-Wide Environmental Impact Statement (DOE/EIS-0387, *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2011 SWEIS) nor in the 2016 SA. Furthermore, the impact of the 2014 USGS data on ELP facilities is not clear. Finally, none of these documents explain the fact that there are two separate site-specific seismic hazard analyses, one for UPF and a separate one for all other facilities at Y-12.
- The court criticized the use of bounding analysis to compare accident consequences impact in the 2011 SWEIS since the only comparison was to the no action alternative. That bounding comparison was subsequently continued in the 2016 SA and the 2018 SA. The result is that the public cannot reasonably compare the differences between alternatives other than with the no action alternative, and cannot discern any differences with the current strategy, which is a combination of the capability-sized UPF and upgrade-in-place alternatives.
- Furthermore, due to the less mature nature of UPF design and safety analysis at that time, there could be no specific comparisons made to UPF accident consequences in the 2011 SWEIS, but that design and safety analysis has been completed since then.
- NNSA did not make "explicit reference" to methodologies or studies it relied upon, specifically not referencing Y-12 site-specific seismic hazard analyses in either the 2011 SWEIS nor the 2016 SA.
- The court expressed concerns about the impact of a seismically-initiated nuclear criticality accident—the potential of a "nuclear explosion"—based on a November 2016 Defense Nuclear Facilities Safety Board on-site review. Based on this concern raised by the court, the consequences of a potential nuclear criticality accident merit discussion.

2.2 SEISMIC INFORMATION AND ITS USE IN SEISMIC ANALYSIS

For the design of nuclear facilities, DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, requires the development of a site-specific Probabilistic Seismic Hazard Analysis (PSHA) that considers a range of regional and site-specific information. The hazard analysis provided by and periodically updated by the USGS is some, but not all, of the relevant seismic information included in a site-specific PSHA. Other available information, such as nuclear industry and Nuclear Regulatory Commission (NRC)-generated analyses, is also included. The site-specific PSHA also requires the incorporation of local geologic data to better characterize local seismic sources and establish facility site conditions affecting ground motion. The incorporation of other available seismic data and site-specific geologic studies in a PSHA can increase or decrease design ground motions as compared to using only the USGS hazard map.

Hazard analyses from a project sponsored by the NRC, U.S. Department of Energy (DOE), and the Electric Power Research Institute (EPRI) were incorporated into both the UPF and Y-12 PSHAs. This project is known as the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) and it was initiated in 2008. This project was commissioned specifically to characterize seismic sources that can affect nuclear facilities. The CEUS SSC project was completed in 2012 and published by the NRC as NUREG-2115, *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*.

A second joint project by the NRC, DOE, and EPRI is known as the Next Generation Attenuation-East (NGA-East) project. The NGA-East study was completed in December 2018 and was published in the Pacific Earthquake Engineering Research Center (PEER) Report No. 2018/08, *Central and Eastern North America Ground-Motion Characterization– NGA East Final Report*.

There are two site-specific PSHAs applicable to the facilities at Y-12. One is for UPF and the other is for the balance of the facilities at Y-12. These are discussed separately in this report. However, each PSHA considers the USGS seismic hazard, as incorporated into codes and standards; nuclear industry data, specifically the CEUS SSC analysis; and the local geologic data. The primary output from the PSHA is site-specific seismic response spectra that provides ground motions over frequency ranges that are key inputs into structural designs for new facilities (UPF) and for evaluations of the performance of existing facilities (ELP facilities). The site-specific seismic response spectra depends on the type of rock, type of soil, and the depth of the soil overburden on the rock at the specific building structure location at Y-12.

USGS seismic hazard analyses are also used to update various codes and standards. Of interest is the American Society of Civil Engineers (ASCE) ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, and the *International Building Code* (IBC), which are among the many requirements for facilities at Y-12. The 2014 USGS study was incorporated into ASCE 7 in 2016 (referred to as ASCE 7-16) and was incorporated in the IBC in 2018.

2.3 "UNBOUNDED" CONSEQUENCE ANALYSIS

The court order requested "unbounded accident analysis of earthquake consequences," consistent with its criticism of bounding analysis, as described in Sect. 2.1. To address this topic, this report compares facility-specific earthquake consequences between specific relevant facilities/alternatives. This comparison was accomplished by comparing the consequences that are reported in the respective facility safety basis documents.

The UPF safety basis document was approved in July 2017 (and updated in 2019), which enables comparisons that were previously not possible. In the current strategy, UPF replaces the 9212 Complex at Y-12. Accordingly, UPF consequences, as defined in its 2017 safety basis, are compared to consequences for the 9212 Complex, as defined in the safety basis that was in effect at the time of the 2011 SWEIS (Sect. D.9.1.2). This comparison is essentially the UPF alternative versus the no-action alternative for the facility being replaced by UPF.

ELP facilities represent the upgrade-in-place alternative for those facilities. New safety basis documents are planned for these facilities in 2025. However, updates have been made since 2011 to implement changes associated with ongoing MAR inventory reductions, specifically in the 9215 Complex. Accordingly, current consequences are compared with those that were defined in safety basis documents referenced in the 2011 SWEIS (Sect. D.9.1.2), which essentially provides a comparison between the upgrade-in-place and no-action alternatives for the ELP facilities.

There is no mature safety basis documentation for the replacement (original UPF concept) of the ELP facilities, so a quantitative comparison of consequences cannot be made. Replacement of these facilities was included with the UPF alternative as discussed in the 2011 SWEIS and the 2016 SA, and consequences were compared qualitatively, but bounded by the no-action alternative. For this report, a qualitative comparison of consequences is made between a potential replacement (original UPF concept) for the ELP facilities and the upgrade-in-place alternative, but not bounded by the consequences associated with the site-wide no-action alternative.

Accident consequences defined in the relevant safety basis documents do not take credit for any mitigation from facility design features. The accident consequence analysis in the 2011 SWEIS does take credit for some facility design features, including seismic qualification and air filtration. For this report, the consequences as reported in the safety basis documents are compared directly, and that is followed by a qualitative discussion of mitigation from design features. However, the comparisons presented here are still valid. In fact, the benefits of new facilities and upgraded facilities will be even more pronounced when mitigation is taken into account.

3. UPF

3.1 UPF SEISMIC ANALYSIS

The UPF project established its site-specific PSHA, site-specific seismic response spectra, and UPF design basis earthquake spectra in 2015 in the following documents:

- RP-ES-801768-A040, *Summary of the UPF Design Basis Earthquake Response Spectra Development*, dated September 2015
- DAC-ES-801768-A244, *Development of Horizontal Hard Rock Response Spectra and Fine-Spaced Rock Hazard Curves for the Development of the SDC-1, SDC-2, and SDC-3 Design Response Spectra*, dated June 18, 2015
- DAC-ES-801768-A330, *UPF Horizontal and Vertical DBE [Design Basis Earthquake] Spectra*, dated September 17, 2015

The seismic design response spectra were based on both ASCE 7 and the CEUS SSC data, and site-specific geologic information, as discussed in Sect. 2.2. The most recent seismic information available at the time was used and is reflected in the UPF Code of Record. UPF used the 2010 version of ASCE 7 (which incorporated the 2008 USGS data) and the 2012 CEUS SSC report. UPF established its design basis earthquake spectra conservatively, and in particular, did not use reductions in the spectra allowable per ASCE 7 which would normally be taken when a site-specific seismic response spectra are available. This conservative approach was taken, in part, to provide margin for new seismic information that would be forthcoming in future years.

A new USGS seismic hazard analysis was published in 2014, and that was later incorporated into ASCE 7 in 2016 (ASCE 7-2016). In 2017, the UPF project reviewed the impact of the changes in the ASCE 7-2016 spectra. The ASCE 7-2016 response spectra (using the USGS 2014 hazard map), with allowable reductions for site-specific analysis, was compared to the UPF design basis earthquake spectra. For frequencies between 5 Hz and 15 Hz, the difference was negligible. For frequencies above and below that range, the UPF design basis earthquake spectra is actually more conservative than the ASCE 7-2016 (USGS 2014) data. These favorable results are directly attributable to the decision to establish the UPF design basis earthquake response spectra conservatively back in 2015.

It should also be noted that the seismic response spectra are an input to the UPF structural design. The UPF structural design was also established conservatively, with adequate design margins, such that the design would perform its required functions even for some increases in the seismic response spectra. For context, just a few of the robust features of the UPF Main Process Building structural design include:

- Excavation of 15 ft of soil to the underlying bedrock.
- Backfill of the excavated soil with engineered mass fill concrete.
- 9-ft-thick reinforced concrete foundation on top of the mass fill concrete.
- Reinforced concrete shear wall system to resist seismic loads with a composite elevated slab system consisting of reinforced concrete slabs and supporting steel beams.

UPF has a robust building design that will perform all of its required functions even after a design basis earthquake.

Finally, the court perceived a discrepancy between two statements about the impact of the USGS 2014 hazard on UPF seismic analysis. Those statements are both true and are not discrepant, but their context, including time and audience, need to be more fully explained. One of these statements was the response in March 2016 to a project seismic peer review recommendation from late 2015. The recommendation was that the project needed to develop a formal position regarding the new, increased hazard from the USGS 2014 map. In the response, UPF cited the lack of maturity of the USGS 2014 data, the fact that it had not yet been adopted into codes that UPF was required to follow (ASCE 7), and acknowledged that it may have to incorporate the data once the data were more mature, incorporated into ASCE 7, and evaluated. For purposes of managing design requirements that statement was true, and reflected formal management practices for design requirements. As noted above, the new data was subsequently incorporated into ASCE 7 and was then compared with the UPF design basis earthquake spectra. The second statement, made in the public 2016 SA, stated the following:

> Although different, the new USGS seismic hazard map does not change the site-specific seismic data at Y-12 which is used to determine facility design and construction requirements. The site-specific design-basis earthquake spectra that would be factored into the requirements for any new UPF buildings has been conservatively developed, and contains margin to address both current requirements and possible future modification of the spectra input, such as the input from the recent USGS seismic hazard changes.

This statement is also true. When looking at the USGS 2014 study that was available at the time, it was apparent that the USGS results would not change the UPF design basis earthquake spectra since UPF had chosen to incorporate the unreduced ASCE 7-2010 (USGS 2008) response spectra back in 2015 to address anticipated changes. This result was later confirmed in the UPF 2017 review of the impact of the changes in the ASCE 7-2016 spectra, described in this section.

For completeness, the 2018 SA addressed this same topic, consistent with the evolution of available information, as follows:

> For the UPF specifically, the seismic forces used for the design are based upon values developed prior to the 2014 USGS maps being accepted into industry codes. The design of the UPF is conservative, in that the design accounts for earthquakes as if they had magnitudes greater than what the codes had defined at the time. The earthquake forces utilized in the UPF design are not significantly different than the 2014 USGS map data. Coupling this with other conservative aspects of the structural design, there is high confidence that the 2014 USGS results do not pose an issue for the UPF.

3.2 UPF – CONSEQUENCES OF A SEISMICALLY-INITIATED ACCIDENT

In the 2011 SWEIS, UPF had not yet established an approved formal safety analysis. Since then, in July 2017, the UPF Preliminary Documented Safety Analysis (PDSA) (RP-EF-801768-A191, *Preliminary Documented Safety Analysis for the Uranium Processing Facility*) was approved. The PDSA evaluates many potential accidents, including seismically-initiated ones, which facilitates comparisons with other Y-12 facilities.

The planned operations for UPF are comparable to the current operations in Building 9212. Consequences of the worst-case, seismically-initiated facility accident for UPF are about 80% lower than the equivalent accident in the 9212 Complex, the facility that it replaces, as defined in the 2011 SWEIS. This result is essentially a comparison between the UPF alternative and the no-action alternative for the 9212 Complex only, and is not bounded by the site-wide consequences of the no-action alternative.

That consequence comparison does not, however, take credit for nuclear safety controls and design features. In reality, the worst-case consequence analyzed in the UPF PDSA will likely never occur. UPF was designed and is being constructed to modern nuclear safety and nuclear security standards that make it nearly impossible to ever experience those consequences. Design features that prevent or mitigate such an accident include:

- The seismically-qualified structure will be intact and structurally stable even after an earthquake, providing a robust platform for other safety equipment.
- Seismic equipment qualifications enable confinement of nuclear materials and enable safety systems to perform their safety function even after an earthquake.
- Nuclear-grade high-efficiency particulate air (HEPA) filters, provided as part of a multi-tiered confinement ventilation system, filter any potential hazardous material releases prior to exiting the building via the exhaust stack.
- Modern fire suppression systems (sprinklers) will operate before, during, and after an earthquake, and are fed by an independent, seismically-qualified water tank.

In contrast, the facility UPF replaces, the 9212 Complex, is not seismically qualified, has less comprehensive ventilation filtration, and older, less robust fire protection systems.

It should be noted that NNSA has continued efforts to improve the safety posture of the 9212 Complex in parallel with UPF design and construction. In particular, nuclear material reduction efforts have reduced the consequences of a worst-case accident by 40% since the 2011 SWEIS, and new limits have been established to keep the nuclear inventory low. NNSA has also invested $76M in a Nuclear Facilities Risk Reduction project that upgraded aging electrical and ventilation systems in the 9212 Complex in order to ensure its reliability until UPF is completed.

4. EXTENDED LIFE PROGRAM FACILITIES

4.1 ELP FACILITIES SEISMIC ANALYSIS

The ELP facilities consist of the 9215 Complex and the 9204-2E Facility. The 9215 Complex was built in the mid-1950s and the 9204-2E Facility was completed in 1971. They are both significant industrial facilities that were designed and constructed to the standards that existed at the time they were constructed. They are facilities that have served their missions well and they provide a stable home for the nuclear operations that they support. Based on the amount and forms of nuclear material processed, the nuclear operations in these facilities have less nuclear safety risk than those in the 9212 Complex.

The ELP facilities have aged and many of their mechanical and electrical systems are in need of refurbishment. Expectations for nuclear facilities have also significantly increased since their construction. Seismic design requirements are one area that has significantly changed. DOE requires periodic review of seismic hazard analyses for its existing nuclear facilities. The ELP facilities at Y-12 have been reviewed in the past and updated seismic evaluations are currently being performed.

The site-specific PSHA for existing facilities at Y-12 (RT-ST 921200-A001, *Update of the Seismic Hazard at the Department of Energy National Security Administration Y-12 National Security Complex*), including the ELP facilities, was performed in 2003 with participation from USGS and several industry experts. That approved analysis was used to perform seismic facility evaluations for the ELP facilities in the 2003–2005 timeframe.

USGS issued a new seismic hazard map in 2008 and the CEUS SSC study was published in 2012. The PSHA for existing facilities at Y-12 was formally reviewed against this new information in 2012 (RP-900000-0029, *Update of the Seismic Hazard at the Department of Energy National Nuclear Security Administration Y-12 National Security Complex*). That review showed that both the 2008 USGS hazard map and the 2012 CEUS SSC study resulted in a decrease in the seismic hazard when compared to the Y-12 2003 site-specific PSHA. Based on the comparison, and to be conservative, Y-12 decided to continue to use the more conservative 2003 site-specific seismic hazard.

In 2014, USGS published an updated national seismic hazard map. That map showed an increase in the seismic hazard, when compared to the 2008 USGS hazard map. As noted above, the Y-12 2003 site-specific seismic hazard is also greater than the 2008 USGS hazard. Accordingly, the difference between the 2014 USGS hazard and the Y-12 2003 site-specific hazard is less significant than the difference between the 2014 and 2008 USGS hazards. The 2014 USGS hazard was incorporated into ASCE 7 in 2016. Subsequently, an informal comparison of the ASCE 7-2016 seismic hazard with the Y-12 2003 site-specific seismic hazard shows that the Y-12 2003 site-specific seismic response spectrum is more conservative in some frequency ranges, while the ASCE 7-2016 (based on the 2014 USGS map) seismic response spectrum is more conservative in others. These differences merit more formal review, which is currently underway, and described below.

The ELP was established in 2016 (RP YAREA-F-0602 000 00, *Extended Life Program, Buildings 9204-2E and 9215*, January 2016), which includes a commitment to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities. That work is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021. The updated PSHA will incorporate the USGS 2014 hazard, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East).

The ELP facilities (the 9215 Complex and the 9204-2E Facility) were designed and constructed before the establishment of modern nuclear safety standards. Previous facility evaluations have shown some seismic deficiencies of these facilities when evaluated against modern standards for new facilities. Some portions of the facilities meet such standards and other portions do not. The new seismic facility evaluations will provide an up-to-date evaluation of any remaining weaknesses and the potential for upgrades will be addressed. Upgrading both structures to fully meet modern seismic standards for new facilities may not be feasible or practical. However, the potential for structural upgrades will also be informed by an independent expert panel review that Y-12 contracted for in 2016 (RP 900000-0182, *Recommendations of the Seismic Expert Panel Review of Buildings 9204-2E and 9215*, September 2016), which provided suggestions for practical approaches to structural upgrade initiatives in these two facilities.

As discussed earlier, the ELP facilities were designed to the structural codes in place at the time of their construction, not to the seismic requirements for a new facility today. These facilities are considered acceptable today through the safety analysis and safety controls that are implemented in the approved safety basis documents. Any upgrades accomplished by the ELP will improve upon that safety posture, even if it is not feasible to fully meet the requirements for new facilities.

4.2 ELP FACILITIES – CONSEQUENCES OF A SEISMICALLY-INITIATED ACCIDENT

As part of the ELP, it was recognized that it may not be feasible or practical to make all upgrades to meet modern nuclear safety standards for new facilities, and that even when upgrades are made, they take significant time to complete. This is particularly true of structural upgrades to meet seismic requirements.

At the same time, the ELP also recognized that a faster way to reduce the consequences of potential facility accidents, including seismically-initiated accidents, is to reduce the amount of nuclear material that could be involved in such an accident. That material is called MAR. Accordingly, an aggressive MAR reduction program was planned and initiated, reducing in-process inventories to the minimum needed for efficient operations, and moving the rest to storage in the Highly Enriched Uranium Materials Facility, a facility that was designed and constructed to modern nuclear standards.

The reduction of worst-case consequences has been significant. Consequences of the worst-case facility accident in the ELP facilities, as defined in the facility safety analysis documents, have been reduced by 50% since the SWEIS was issued in 2011 as a direct result of the MAR reductions. Furthermore, the reductions have been codified in the formal safety analysis documents (DCN-03 to Y/MA-7886, Rev. 10, *Safety Analysis Report for the 9215 Complex*, and DCN-02 to Y/MA-7887, Rev. 10, *Technical Safety Requirements for the 9215 Complex*), which provide the limits for operations (like a nuclear license), so that these lower inventory levels will be maintained.

In the ELP facilities, a seismic accident is not the worst-case accident. A seismic accident is analyzed to include a criticality and small, localized fires. MAR reductions reduce the risk of such events but not as significantly as in the worst-case accident because not all facility inventory is involved.

Additional MAR reductions will be made in the future, as process changes are implemented, that will reduce worst-case accident consequences even more. Accordingly, the consequence comparison above is essentially a comparison of the upgrade-in-place alternative (but with more improvement to go) with the no-action alternative.

ELP investments are reducing the probability of some accidents and improving the safety systems that prevent or mitigate other accidents. One example is the electrical refurbishments that replace aging equipment and bring it up to modern codes, which reduces the likelihood of an electrically initiated fire. Refurbishments of ventilation systems and fire protection systems improves the ability to prevent or mitigate accidents. Furthermore, any structural/seismic improvements that may be initiated after the new facility evaluations would reduce the probability and consequence of seismically-initiated accidents even more. The mitigation of consequences for the upgrade-in-place alternative (ELP) will be better than the mitigation for the no-action alternative because of the upgrades described above.

Another comparison to be made is that of the upgrade-in-place alternative for the ELP facilities with a potential new replacement for the ELP facilities, which would have happened if the original UPF concept, as described in the 2011 SWEIS, had been pursued. Consequences of the worst-case seismically-initiated accident for the ELP facilities as defined in their safety basis documentation would likely be similar to the consequences in a replacement facility (original UPF concept), for the similar operations, because the new facility would be designed as a low-MAR facility and because the safety basis documents do not take credit for mitigation from facility design features.

When considering mitigation from facility design features, a new facility would provide more mitigation than the upgrade-in-place facility. New facilities would be constructed to modern seismic requirements and designed and built to withstand anticipated seismic accelerations, which would prevent any significant damage from the design basis earthquake. The upgrade-in-place alternative would also decrease the seismic accident risks, but not to the extent of a new facility. The upgrades would meet modern nuclear requirements to the extent possible, but some systems—even with refurbishment—will not be as reliable as new replacements. The upgrade-in-place alternative is still be significantly better than the no-action alternative, as previously described.

Finally, it is important to note that the Y-12 safety posture has already been improved by the ELP. Some upgrades, like sprinkler head replacements, have already been completed and most of the highest priority electrical upgrades are complete. The ELP upgrades are broken into small projects and incremental benefits are achieved as each project is completed.

5. CONSEQUENCES – NUCLEAR CRITICALITY

A nuclear criticality accident can contribute indirectly to the worst-case consequence, and those impacts were included in Sects. 3.2 and 4.2, above. However, in order to have a complete discussion of consequences of seismic accidents at Y-12, the direct impacts of a nuclear criticality accident must be considered. Prevention of a nuclear criticality accident is extremely important for ensuring safety of Y-12 workers; however, a nuclear criticality accident at Y-12 would not significantly impact the public.

A nuclear criticality accident can cause significant impact in the local area of the event, including large radiation doses and energy releases. This is a significant hazard to the direct workers involved and to other workers in the immediate vicinity. Because of these impacts, NNSA has a robust program to prevent such accidents, including engineered features, administrative controls, and training. Nuclear criticality safety is a dominant consideration in existing, upgraded, and new nuclear facilities at Y-12.

However, the impacts of a nuclear criticality accident, if one occurred, would likely not extend beyond the building boundary. Distance and shielding (e.g., containers, process equipment, and the walls of the facility) make the likely effects at the site boundary negligible.

Finally, designs for upgraded and new facilities attempt to eliminate or minimize nuclear criticality risk. The highest risk of nuclear criticality is associated with processing of highly concentrated high-equity solutions of enriched uranium, like those in the 9212 Complex. The design and construction of UPF, combined with new technologies in the ELP facilities, eliminate seismic concerns associated with these processes. UPF is seismically qualified and the ELP facilities are focused on enriched uranium metal, which has a much lower risk of seismically-initiated nuclear criticality.

REFERENCES

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International Building Code, International Code Council

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Y/MA-7887, Rev. 10, DNC-02, *Technical Safety Requirements for the 9215 Complex*, Dec. 22, 2015

APPENDIX C

Comments and Responses on the Y-12 SWEIS Earthquake Accident Draft SA

C.1 Introduction

Although publication of a Draft SA is not required, NNSA made the Draft SA available for public review and comment on the NNSA NEPA web page (https://www.energy.gov/nnsa/nnsa-nepa-reading-room) on April 9, 2020. NNSA announced the availability of the Draft SA in local newspapers (*see* Table 1-1) and initially provided an approximately 30-day public comment period (April 9, 2020 – May 11, 2020). In response to public requests, NNSA extended the comment period by 15 days, until May 26, 2020.

NNSA received 142 comment documents on the Draft SA. Table C-1 provides a list of the commenters who submitted one or more comment documents on the Draft SA. A summary of the comments relevant to the Draft SA, as well as NNSA's corresponding responses to those summary comments, are provided in Section C.2. All comment documents received are included in the Administrative Record for this SA.

Table C-1. Index of Commenters

Adams, Mary	Allen, Jim
Alwin, Rebecca	Andersen, William J.
Anderson, Glen	Archiniega, Lupe, Loretto Motherhouse
Arends, Joni, Concerned Citizens for Nuclear Security	B., Angela, Loretto Motherhouse
B., Jane, Loretto Motherhouse	Baker, Scott
Barfield, Ellen	Barrett, Christopher
Bergier, Kim Joy	Bern, Sue
Birchem, Regina	Boertje-Obed, Greg
Bol, Scot	Boone, William
Brannan, Mary Kay, Loretto Motherhouse	Brian, Johanna, Loretto Motherhouse
Bryan, Mary	Charmky, Susan, Loretto Motherhouse
Clark, Brita Larsen	Clark, Donald B., Network for Environmental & Economic Responsibility, United Church of Christ
Clark, Terrence, Western North Carolina Chapter Physicians for Social Responsibility	Clemens, Steve
Clements, Tom, Savannah River Site Watch	Cliffood, Devin, Loretto Motherhouse
Coghlan, Jay, Nuclear Watch New Mexico	Coleman, Betty
Colley, Vina, Portsmouth Piketon, Residents for Environmental Safety and Security (PRESS), Co-Founder National Nuclear Workers for Justice (NNWJ)	Collins, Jessie Pauline
Collins, Judy	Collins, Kevin, Oak Ridge Environmental Peace Alliance
Cowan, Margaret Parks	Delastrada, Bob
Donn, Marjory M.	Doyle, Antoinette, Loretto Motherhouse
D'Souza, Neville	Dufour, Joanne
Dyvine, Padma	Ewald, Linda

Fenoglio, Ella Joan	Fisher, Stephen
Fitzgerald, Amy S., City of Oak Ridge	Fleming, Mark
Fruer, Pat, Loretto Motherhouse	Gamble, Doug
Garvey, Lydia	Gray, Nancy Adadow
Green, Carol	Gregg, Nina
Hawkins, Janice, Des Moines WILPF	Henighan, Richard
Hickey, Bill and Billie	Hindle, Pamela F.
Hogan, Barbara, Loretto Motherhouse	Hormel, Jay
Hutchison, Ralph, Oak Ridge Environmental Peace Alliance	Illegible 1, Loretto Motherhouse
Illegible 2, Loretto Motherhouse	Jacobs, B., Loretto Motherhouse
Johnson, Elizabeth B.	Johnson, Libby
Kahle, Joyce	Kahn, Henry
Kamps, Kevin, Beyond Nuclear	Kelley, Marylia, Tri-Valley CAREs
Laffan, Denise	Lawton, Nick, Eubanks & Associates LLC on behalf of the Natural Resources Defense Council, the Oak Ridge Environmental Peace Alliance, and Nuclear Watch New Mexico
Lechner, Judith V.	Lentsch, Mary Dennis
Linge, David	Livermore, Phyllis
Lloyd, Robin	Lovelace, Claire
Macks, Victor and Gail	Malley, Keith
Mares	Mattingly, Donna, Loretto Motherhouse
McGlinn, Jim	McHugh, MaryAnn
Medeiros, Bunny	Metz, John
Mills, Roger	Minkler, Joyce, Loretto Motherhouse
Mohling, Judith, Nuclear Nexus Program, Rocky Mountain Peace and Justice Center	Morgan, Thomas, Alworth Center for the Study of Peace & Justice
Morris Jr., Joel V.	Myers, William Franklin
Nickle, Carol	Oleshansky, David
Olsen, Nancy	Osborne, Guy Larry
Patrie, Lewis	Peacock, Rich
Pino, Paul	Preheim, Nina
Presbey, Gail	Ramirez, A., Loretto Motherhouse
Rickenbach, Nancy	Riegle, Rosalie G.
Ritter, Dorothy	Robinson, Jean
Rodriguez, Teresa	Rogers, Talbot
Rovetti, Corinne	Rumschlag, Catherine
S., Barbara, Loretto Motherhouse	S., Marie L., Loretto Motherhouse
Santoyo, Marlena	Sauer, Jen
Schutt, Donna	Schwarzenberger, Francine
Shelton, Tina	Skees, Ciciliana, Loretto Motherhouse
Snider, Hideko Tamura, One Sunny Day Initiatives	Sprinkle, James
Steckler, Marie L., Loretto Motherhouse	Stein, Cletus

Stevens, Jean	Strasser, Emily
Swain, Mary, Loretto Motherhouse	Taylor, Matt, Tennessee Department of Environment & Conservation, Office of Policy and Sustainable Practices
Traynor, Betty	Turk, Margaret
Ullrich, Jim	Ulmer, Barby
V.K., Loretto Motherhouse	Virse, Maria, Loretto Motherhouse
Watchempino, Laura	Way, Ineke
Webber, Bob	Weehler, Cynthia
Weiner, Alan	Weiner, Judy
Welburn, Billye	Wingeier, Douglas E.
Witters, Nancy, Loretto Motherhouse	Wohlgemuth, James, Veterans for Peace Chapter 089
Wolden, D.	Wright, Jim
Zalph, Ruth	Zorbanos, Beth K.

C.2 Summary Comments and Responses

NNSA reviewed every comment document received, summarized those comments, and prepared responses to address those comments. The comment summaries and NNSA's corresponding responses are shown below. Where applicable, the comment response indicates the section(s) of the SA that were modified.

1. *Commenters state that a new SWEIS is needed because of the higher likelihood of a major seismic event and greater impacts than reflected in the 2011 SWEIS.*

Response: Section 1.1 of this SA describes the events that led to the preparation of this SA and the definition of the SA scope. As discussed in Section 1.2, the purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. As discussed in Sections 2.1 and 2.2, the SA considers the relevant new information regarding seismic risks related to the Y-12 facilities. Based on the analysis in Section 3, this SA verifies that the potential environmental impacts would not be significantly different or outside the range of the impacts presented in the Y-12 SWEIS. Based on the results of this SA, NNSA has determined that: (1) the earthquake consequences and risks do not constitute a substantial change; (2) there are no significant new circumstances or information relevant to environmental concerns; and (3) no additional NEPA documentation is required at this time.

2. *Commenters request that the public comment period be extended. Many commenters cite leaders in both houses of Congress who called for all comment periods to be extended indefinitely during the national COVID-19 emergency. In addition, commenters request that public hearings be held for the SA.*

Response: Although DOE procedures implementing NEPA (10 CFR 1021) do not require public comment on an SA, NNSA decided, in its discretion, that public comment in this instance would be helpful and issued the Draft SA for public review and comment for an approximately 30-day period. Based on public comments requesting an extension of the comment period, NNSA extended the comment period on the Draft SA by 15 days. NNSA considered all late comments received. NNSA declined to hold a public hearing on the Draft SA, which is not required for documents such as this SA and Environmental Assessments. NNSA also declined to grant a further extension of the comment period, given that it was unable to negotiate a withdrawal of a pending motion to enforce the Court's judgment in litigation challenging the 2016 SA.

3. *Commenters express opposition to continued operations at Y-12, including proceeding with the UPF, for a variety of reasons, including risks from seismic accidents.*

Response: The commenters' opposition to continued operations at Y-12 and the decision to proceed with the UPF is noted. Section 3 of the SA presents the health and environmental risks associated with seismic accidents.

4. *Commenter states that no additional analysis or evaluation is necessary for the Y-12 site and DOE programs.*

Response: The commenter's opinion is noted.

5. *Commenters state that the United States has more than enough nuclear weapons and the national posture has been out of compliance with the Nuclear Nonproliferation Treaty. In addition, building new facilities to manufacture new nuclear weapons directly violates the Nuclear Nonproliferation Treaty.*

Response: This comment addresses policy questions that are beyond the scope of NEPA review. NNSA is responsible for meeting the national security requirements established by the Congress and the President and has a statutory mission to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile (50 U.S.C. § 2401(b)). The Nuclear Nonproliferation Treaty was ratified by the Senate in 1969 and officially entered into force as a Treaty of the United States in 1970. Today, the U.S. continues to view the Nuclear Nonproliferation Treaty as the cornerstone of the nuclear non-proliferation regime (DoD 2018, p. 70). Article VI of the Nuclear Nonproliferation Treaty obligates the parties "to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control." The U.S. has taken this obligation seriously and has emphasized both the long-term goal of eliminating nuclear weapons and the requirement that the U.S. have modern, flexible, and resilient nuclear capabilities that are safe and secure until such a time as nuclear weapons can prudently be eliminated from the world. It should be noted that the Nuclear Nonproliferation Treaty, however, does not provide any specific date for achieving the ultimate goal of nuclear disarmament, nor does it require the elimination of the current stockpile of nuclear weapons. Continued operations at Y-12, including proceeding with the construction and operation of the UPF, enables NNSA to maintain the safety, reliability, and performance of the U.S. nuclear weapons stockpile until the ultimate goals of the Nuclear Nonproliferation Treaty are attained. That strategy is consistent with the Nuclear Nonproliferation Treaty.

6. *Commenters state concern that the current COVID-19 pandemic crisis requires a reconsideration of spending priorities that protect people, create safe jobs, and restore the environment. Commenters added that funding must be prioritized to actually make us safer—investments in medical research, infrastructure, technology, materials and equipment, and direct care services, not investments in weapons of mass destruction to threaten other nations. Commenters state that nuclear weapons and massive military expenditures do not effectively contribute to American national security.*

Response: Congress and the President determine federal budget requirements and priorities. It is beyond the scope of the SA to address federal budget authorizations/appropriations.

7. *Some commenters state that the accident impacts for the Hybrid Alternative would be 10 times greater than the 2011 Y-12 SWEIS estimates. Other commenters state that the accident impacts for the Hybrid Alternative would be 10 times greater than the estimates for the alternative of using a single new facility.*

Response: Accident impacts (i.e., consequences) for the Hybrid Alternative would not be 10 times greater than the 2011 Y-12 SWEIS estimates. As shown in Table 3-12 of this SA, the accident impacts for the Hybrid Alternative (rows 1 and 3) are much less than the accident impacts presented in the 2011 Y-12 SWEIS (row 4). In fact, the most relevant and directly applicable comparison is shown in rows 3 and 4 of Table 3-12 (note: that comparison is considered "most relevant and directly applicable" because it is compares "worst-case design-basis accidents" for both the Hybrid Alternative and the 2011 Y-12 SWEIS accidents). That comparison shows that the worst-case design-basis accident impacts for the Hybrid Alternative (row 3) would be 56-72 percent smaller than the worst-case design-basis accident impacts presented in the 2011 Y-12 SWEIS (row 4).

With regard to the comment that accident impacts for the Hybrid Alternative would be 10 times greater than the accident impacts of using a single new facility, rows 2 and 3 of Table 3-12 confirm that conclusion. That conclusion demonstrates an advantage of consolidating EU operations from older nuclear facilities into modern facilities. However, that conclusion must also be put into perspective. As shown by rows 2 and 3 of Table 3-12, the accident impacts would be very small for either the Hybrid Alternative or the Y-12 SWEIS Capability-sized UPF Alternative. Specifically, the dose to the MEI for either alternative would be less than approximately 0.415 rem (which corresponds to an LCF risk of 0 [0.0025]). Additionally, the population dose for either alternative would be less than approximately 350 person-rem (which corresponds to approximately 0.21 LCFs). Consequently, the analysis in both the 2011 Y-12 SWEIS and this SA indicate that 0 LCFs would be expected in the 50-mile population surrounding Y-12 from any accident involving existing or new facilities, including either the smaller-scale UPF or the full-size (single building) UPF.

8. *Commenters express concern about the safety of the workers as well as citizens in the vicinity of Y-12.*

Response: Section 3 of this SA presents the potential impacts to workers and the public from seismic accidents at Y-12. As shown in that section, potential impacts from seismic accidents would be small to the public and noninvolved workers (see Table 3-3 of this SA). With regard to involved workers, as discussed in Section 3.2.3 of this SA, those workers may be acutely injured or killed by physical effects of the accident. An earthquake accident with subsequent fire could have substantial consequences, ranging from involved workers being killed by debris from explosions to high radiation exposure.

9. *Commenters question the severity of earthquakes needed to release radioactive materials from the Y-12 facilities. Commenters state that there is no reference in the SA or the appended documents to a specific size earthquake which makes it hard to calculate the site-wide impacts of the design-basis event. Commenters state that the Draft SA fails to candidly or accurately describe the "catastrophic consequences" that would result from a strong earthquake striking the Y-12 Complex.*

Response: This SA presents the impacts of seismic accidents at Y-12 for both new and existing facilities associated with the 2011 SWEIS action alternatives. As discussed in Section 3 of this SA, NNSA has made conservative assumptions related to facility damage and radioactive material release from such accidents. For the UPF, the design-basis earthquake accident probability is estimated to be 4×10^{-4} per year, which equates to the occurrence of such an accident once every 2,500 years. The beyond design-basis earthquake accident probability is estimated to be a maximum of $1x10^{-6}$, which equates to the occurrence of such an accident once every million years. For the ELP facilities, which were designed and constructed before the establishment of modern nuclear safety and seismic standards, the accident probability is estimated to be 2×10^{-3} per year, which equates to the occurrence of such an accident once every 500 years. The earthquakes analyzed in the SA are in the 6.0 magnitude range (*see* also comment-response 28).

10. *Commenters state that an unbounded accident analysis of earthquake consequences at Y-12 must consider the whole environment (i.e., animals, plants, ecosystems, and the food web), not just humans.*

Response: Section 3.2.5 has been added to the Final SA to further address this issue. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011), requires radiological activities that have the potential to impact the environment to be conducted in a manner that protects populations of aquatic animals, terrestrial plants, and terrestrial animals in local ecosystems from adverse effects due to radiation and radioactive material released from DOE operations. This SA focuses on potential impacts to humans, based on the concept endorsed by the International Commission on Radiation Protection (ICRP), which states, "if man is adequately protected then other living things are also likely to be sufficiently protected" (ICRP 1991). Such an approach uses human protection to infer environmental protection from the effects of ionizing radiation. Based on the analysis in this SA, potential impacts to noninvolved workers and the offsite public would be small, and no further evaluations of other biota are necessary to demonstrate protection.

In addition, DOE Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2019) (DOE 2019), provides dose evaluation methods that can be used to demonstrate protection of biota in accordance with DOE Order 458.1. Per that technical standard, biota dose rates below 1 rad/day (for aquatic animals and terrestrial plants), and below

0.1 rad/day (for riparian animals and terrestrial animals), are demonstrative that populations of plants and animals are adequately protected from the effects of ionizing radiation.[21] As shown in Table 3-3, the design-basis earthquake that causes radioactive material spills and localized fires at UPF would result in a dose to the MEI of 0.0296 rem, which is demonstrative that populations of plants and animals would be adequately protected from the effects of ionizing radiation. Similarly, an earthquake that causes a criticality event at either the 9215 Complex or the 9204-2E Facility would result in a dose to the MEI of 0.0021 rem, which is demonstrative that populations of plants and animals would be adequately protected from the effects of ionizing radiation.

As discussed in Appendix A, the analysis in this SA conservatively assumes that radioactive material would remain airborne and be inhaled, rather than deposited on surfaces. Prohibiting deposition maximizes the inhalation dose to humans. Consequently, the SA analysis conservatively estimates human exposures. NNSA has previously estimated contamination that could occur if radioactive material deposition were assumed to occur (note: under that assumption, the human doses would be minimized). For the design-basis UPF earthquake accident analyzed in this SA, contamination levels requiring remediation would be limited to the immediate area surrounding the UPF, within the Y-12 site boundary. For a beyond design-basis UPF earthquake accident, contamination levels requiring remediation could extend approximately 0.3-1.5 miles from the UPF (*see* Section D.9.6 of NNSA 2011).

11. *Commenters state that in the 2011 SWEIS, NNSA said it could fulfill its mission— stockpile stewardship and maintenance— with a throughput capacity of less than 10 secondaries and cases per year. Commenters question why NNSA is spending billions and billions of dollars on a plan to produce 80 secondaries and cases per year?*

Response: The 2011 Y-12 SWEIS evaluated a No Net Production/Capability-sized UPF Alternative that would have supported surveillance and dismantlement operations and a limited LEP workload; however, that alternative would not have supported adding replacement or an increased number of secondaries and cases to the stockpile (NNSA 2011, Section 3.2.5). In the 2011 ROD and the 2019 AROD, NNSA did not select that alternative. Current national security requirements (*see* the 2018 Nuclear Posture Review [NPR] [DoD 2018] and the Fiscal Year 2020 Stockpile Stewardship and Management Plan [SSMP] [NNSA 2019]), cannot be met with a throughput capacity of 10 secondaries and cases per year. In addition, both the 2018 NPR and the SSMP endorse the need for the UPF.

12. *Commenters state that access to the site from the northeast could easily be limited or prohibited outright by the destruction of roadbeds and bridges in the event of a seismic occurrence. Commenters also state that the collapse of Y-12 facilities can create conditions that block first responders and their vehicles from reaching injured workers or extinguishing fires. Commenters question impacts to first responders and state that they must be included in the analysis.*

[21] The difference between a "rad" and "rem" is that the rad is a measurement of the radiation absorbed by the material or tissue, whereas the rem is a measurement of the biological effect of that absorbed radiation. For general purposes most physicists agree that rad and rem may be considered equivalent (DOE 2019).

Response: NNSA's first responders are located at the Y-12 site and there are multiple access points/means of reaching any facilities on site, even for any supporting responders from offsite. In addition, site emergency response plans address such scenarios and first responders are trained to handle such events. First responders are also trained to respond to situations involving collapsed structures. First responders would also wear personal protective equipment to minimize inhalation of radioactive/hazardous materials. Because inhalation of radioactive/hazardous materials is the primary pathway for exposure, doses to first responders would be kept as low as reasonably achievable. NNSA acknowledges that first responders face similar risks as involved workers—they could be acutely injured or killed by physical effects of the accident and could be exposed to high doses of radiation.

13. *Commenters state that a major task of the Y-12 complex will be creating plutonium for weapons, and that plutonium is extremely dangerous to humans and other living organisms. Commenters add that the plutonium in our thousands of current weapons has been shown to be sufficiently stable to keep our warheads and bombs functional for decades.*

Response: Y-12 operations do not create/produce plutonium, nor involve plutonium.

14. *Commenters state that studies of how the buildings will hold up during an earthquake will not be completed until the end of next year. Commenters state that construction of the UPF should be halted until all relevant information has been gathered.*

Response: As discussed in Section 2.2.2, the existing seismic studies for the ELP facilities provide a solid technical basis on which to judge the effects of the 2014 USGS seismic hazard/maps in support of determining potential consequences to the public. As the analysis in this SA shows, once operational, the smaller-scale UPF will reduce potential accident impacts at Y-12 (*see* Table 3-12). Consequently, NNSA has determined that halting construction is not in the best interest of worker safety and the public.

15. *Commenters disagree that there are no low-income communities or communities of color that would be disproportionately affected by a seismic accident at Y-12. Commenters state that the Scarboro and Woodlawn communities are within a mile of the site, and these communities consist largely of low-income persons and minorities.*

Response: The analysis in this SA demonstrates that seismic accident doses to the MEI and surrounding 50-mile population would be very small (*see* Table 3-3 of this SA). The MEI is a hypothetical offsite individual who could potentially receive the maximum dose of radiation; consequently, doses to other offsite individuals would be less than the MEI dose. While NNSA acknowledges the existence of low-income and minority populations in the Scarboro and Woodlawn communities, the low-income and minority populations in those census tracts do not exceed the thresholds used by NNSA to be classified as low-income or minority populations for the purpose of Environmental Justice analysis (*see* comment response 17 below). However, even if those census tracts were to exceed the 50 percent threshold, as shown in Table 3-3, any impacts would be small to all members of the population; consequently, there would be no disproportionately high and adverse human health impacts on minority populations and low-income populations from an earthquake accident at the UPF, 9215 Complex, or the 9204-2E Facility.

16. *Commenters state that actual wind speeds and directions may vary over time, which would drive radioactive plume transport, as well as the degree of dispersion and the locations of deposition within the community. These factors would directly affect the distance and exposure of the MEI and possible disproportionate effects on minority and low-income population. Commenters encourage NNSA to clarify the meteorological approach used by NNSA to analyze impacts, and explain the possibility that wind might blow in directions other than the prevailing direction during and immediately after an accidental release.*

Response: The SA uses meteorological data taken from 10 meter elevation measurements at weather Tower W at Y-12, which is the nearest meteorological tower to the facilities addressed in the SA. The meteorological data contains hourly wind speed, wind direction in 16 compass sectors, atmospheric stability, and precipitation rate. In the MACCS analysis, the radionuclide release is simulated as beginning at every hour of the year. Therefore, the plume experiences all potential meteorological conditions throughout that year in 8,760 weather trials. Dose results from each weather trial are averaged throughout the entire year (NuScale 2020).

The plume is released into meteorological conditions identified in the meteorological data file. Each plume segment travels in the wind direction and at the wind speed that is present at the time of that plume segment's release. MACCS employs a straight-line Gaussian plume model, meaning that each plume segment travels in a straight line and does not change directions following its release to the environment. Modeling multiple plume segments in a release allows MACCS to more realistically evaluate the consequences of shifting wind conditions during long releases. As each plume segment travels downwind, the plume expands in the vertical and lateral directions based on its current distance from the release point of the plume, and the atmospheric stability at that time (NuScale 2020).

The approach used in the SA is consistent with generally-accepted scientific approaches used in MACCS modelling and provides the most realistic evaluation. The approach is also consistent with the approach used in the 2011 SWEIS, which ensures that comparisons to those results are directly applicable.

In preparing the analysis, NNSA could have disregarded actual meteorological data, and instead assumed meteorological conditions to maximize impacts to a receptor at any assumed location. For example, NNSA could have assumed that the meteorological conditions resulted in a predominant wind direction (and plume) directed at the Scarboro community. If NNSA had made those assumptions, the analysis would have shown a maximum dose to the nearest residence in the Scarboro community (who would be approximately 1,000 meters north of the UPF) as 1.4 rem for a beyond design-basis UPF earthquake, and 0.088 rem for a design-basis UPF earthquake. Statistically, the number of LCFs from either of those accidents would have been 0. Consequently, even in such a conservative analytical approach, there would have been no disproportionately high and adverse human health effects on those populations.

17. *Commenters state that the evaluation of potential dose to minority and low-income populations may be biased low by evaluating communities in downtown Knoxville, 15 miles east of Y-12, instead of the adjacent Scarboro community. Instead of the criterion used by NNSA to evaluate census tracts with more than 50-percent minority populations, commenters suggested that NNSA use a different criterion in which "the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population." Commenters encourage NNSA to clarify in the SA how it is evaluating the possible dose to Oak Ridge residents in the Scarboro community.*

Response: While the titles of Figures 3-1 and 3-2 in the Draft SA only indicated census tracts with more than 50-percent minority and low-income populations, a "meaningfully greater" threshold was also considered in the analysis for this SA. For the Y-12 SA, the threshold used for identifying minority and low-income communities surrounding specific sites were developed consistent with CEQ guidance (CEQ 1997, p. 25) for identifying minority populations using either the 50-percent threshold or a "meaningfully greater" percentage of minority or low-income individuals in the general population. For this SA, meaningfully greater is defined as 20 percentage points above the population percentage in the general population. The potentially affected area considered is the area within a 50-mile radius of Y-12. The State of Tennessee was used as the reference community to determine "meaningfully greater" thresholds. The average minority population percentage of Tennessee is 26 percent and the average low-income percentage is 16.7 percent (USCB 2020a). The thresholds for minority and low-income populations are presented below:

Population	Meaningfully Greater Threshold
Minority Population	46%
Low-Income Population	36.7%

While using this threshold it was determined that the nearest minority and low-income populations that exceeded these thresholds were located approximately 15 miles east of Y-12 (EJSCREEN 2020). The titles of Figures 3-1 and 3-2 have been revised to accurately reflect the census tracts with more than 50-percent minority and low-income populations, as well as a meaningfully greater threshold.

The Scarboro community located north of Y-12 is in Anderson County within Census Tract 202. The table below presents the demographic composition and poverty level of census tracts that include and are adjacent to the Scarboro community. While minority and low-income populations have been identified within these census tracts, none of the census tracts identified below exceed the 50-percent threshold or the "meaningfully greater" threshold used for the analysis in this SA.

	Census Tract 201	Census Tract 202.01	Census Tract 202.02	Census Tract 204	Census Tract 205	Census Tract 206
White	2,124	3,273	3,403	3,555	2,349	2,076
Hispanic or Latino (of any race)	97	94	539	147	303	261
Black or African American	659	69	87	185	487	206
American Indian and Alaska Native	0	8	0	33	35	0

Asian	141	480	114	56	37	35
Native Hawaiian and Other Pacific Islander	0	0	0	0	0	0
Some Other Race	11	0	0	0	9	3
Two or more races	127	65	22	307	307	58
Minority	1,035	716	762	728	1,178	563
Total Population	3,159	3,989	4,165	4,283	3,527	2,639
% Minority	32.8	17.9	18.3	17.0	33.4	21.3
% Below Poverty Level	27.1	4.4	8.1	31.8	29.2	9.5

Source: USCB 2020b.

As discussed in comment-response 16, even if NNSA had assumed meteorological conditions that would have maximized the dose to the Scarboro community, the analysis in the SA would have supported the conclusion that there would be no disproportionately high and adverse human health effects on those populations.

18. *Commenters state that DOE has taken credit for distance and shielding (e.g., containers, process equipment, and the walls of the facility) in analyzing the impacts of criticality accidents. Commenters state that a more conservative tact would be to assume no shielding and possibly zero distance at the DOE boundary.*

Response: The discussion in Section 3.2.3 of the SA, which focuses on potential impacts to involved workers, has been revised to include information on unshielded impacts in the event of a criticality accident. With regard to the potential impacts to the public, direct radiation from a potential criticality accident, with no shielding, is provided in footnote "f" of Table 3-3 and footnote "d" of Table 3-4. The unshielded direct radiation dose would be 0.0011 rem at 1,000 meters from an accident. At 500 meters, which is the approximate distance to the top of Pine Ridge, the unshielded direct radiation dose would be 0.036 rem. At a distance of approximately 650 meters, which is the approximate distance to the DOE fence line near Scarboro Road, the unshielded direct radiation dose would be 0.011 rem (see Table D.9.3-4 of NNSA 2011). Statistically, each of these doses would result in 0 LCFs.

19. *Commenters state that the Draft SA should have been prepared by DOE rather than Consolidated Nuclear Security (CNS), the management and operating contractor for Y-12. Commenters suggest that this creates a conflict of interest.*

Response: NNSA prepared the SA with support from an independent NEPA contractor. CNS provided technical support to NNSA and the NEPA contractor.

20. *Commenters question whether increased operations with nuclear and other materials increases seismic risk.*

Response: Potential consequences from an earthquake are a function of the MAR in the facility, as well as the structural integrity of the facilities. Because there are no proposals to increase the MAR in the Y-12 facilities, the potential consequences would not change compared to the results presented in the SA. The probability of an earthquake is independent of the operations in a given facility; consequently, risks would be no different than the results presented in the SA.

21. Commenters request that NNSA discuss the role of Y-12 in providing HEU components to the proposed plutonium pit facilities at SRS and LANL. Commenters question how seismic activity at Y-12 and UPF would impact supply of materials to SRS and LANL. Commenters state that the SA should evaluate the impacts of a disruption in Y-12 operations.

Response: The role of Y-12 within the nuclear weapons complex is discussed in the 2011 SWEIS (NNSA 2011) and the Complex Transformation Supplemental Programmatic EIS (NNSA 2008). Y-12 would provide HEU components to LANL and SRS to support pit production requirements. While it is conceivable that an earthquake could interrupt Y-12 operations, it would be unduly speculative to quantify any such impacts beyond acknowledging that such an interruption has the potential to also adversely impact operations at other NNSA sites.

22. Commenters state that NNSA should prepare a new SWEIS that considers a Maximum Risk Reduction/Mission Capacity Preservation Alternative that would prioritize safety over producing more nuclear weapons components. According to the commenters, this alternative would prioritize eliminating legacy threats to workers, the public, the environment, and even NNSA's mission capabilities by fully funding the decontamination, decommissioning, and demolition of excess (no longer used) facilities. It would prioritize high risk facilities, including those in the high security/production areas. It could be crafted to permit limited national security activities for the maintenance of a safe and secure stockpile, and if necessary, production operations would be halted and maintained in a secure standby to allow remediation to take place.

Response: NNSA is responsible for meeting the national security requirements established by the Congress and the President. Congress and the President determine federal budget requirements and priorities, and it is beyond the scope of the SA to address federal budget authorizations/appropriations. With regard to eliminating legacy threats and decontamination, decommissioning, and demolition of excess facilities, those actions are currently carried out by the DOE's Office of Environmental Management in parallel with actions associated with national security requirements. Safety is NNSA's number one priority, and NNSA does not prioritize production over safety.

23. Commenters state that NNSA should address facility construction costs in its NEPA processes, including in the Final SA.

Response: In and of themselves, construction costs are not an environmental impact and are beyond the scope of the additional analysis of seismic risks ordered by the Court. Costs are considered, as appropriate, in the NNSA decision-making process.

24. Commenters state that NNSA should complete a nation-wide programmatic environmental impact statement for nuclear weapons complex reconfiguration under the two trillion dollar nuclear weapons "modernization" program.

Response: Section 1.2 describes the purpose and need for this SA. Commenters suggestion would not meet the purpose and need and is beyond the scope of this SA.

25. *Commenters state that the Court Order does not limit the NEPA analysis exclusively to earthquakes, although updated earthquake information is central to it. Commenters state that the SA should evaluate other accidents in addition to earthquakes. Commenters also state that there are quantities of HEU at Y-12 that are unaccounted, which calls into question the validity of the SA analysis.*

Response: Section 1.2 describes the purpose and need for this SA, which defines the scope of the analysis. The Court Order specifically states that NNSA "shall conduct further NEPA analysis— including at minimum, a supplement analysis— that includes an unbounded accident analysis *of earthquake consequences at the Y-12 site*, performed using updated seismic hazard analyses that incorporate the 2014 USGS seismic hazard map" (emphasis added). Nothing in the Court Order states that the SA should evaluate the consequences of other accidents. However, it is also worth noting that the SA analyzes explosions, spills, fires, and criticality events, all of which are earthquake-induced. With regard to claims of "unaccounted HEU," the analysis in the SA is based upon conservative MAR estimates and provides a reasonable estimate of the potential impacts that could result from earthquakes at Y-12.

26. *Commenters state that the Court Order does not limit the earthquake analysis to only three facilities at the Y-12 Complex— the UPF, Building 9215, and Building 9204-2E. Commenters state that NNSA has omitted the other facilities at Y-12 which would also be affected by a design-basis earthquake. This is particularly significant given that Y-12 has five of the top twelve "NNSA's Highest-Risk Excess Facilities," including Building 9201-05. In addition, the analysis in the SA ignores completely the possible consequences from an earthquake event in the next five years, prior to occupancy of the UPF, despite the requirement that ongoing activities be considered in an environmental analysis. This is demonstrated by the lack of analysis of an earthquake involving Building 9212. Commenters also state that the SA should address the potential impacts of soil contaminants released in the event of an earthquake.*

Response: Section 1.2 describes the purpose and need for this SA, which defines the scope of the analysis. The Court specifically stated that "by using the bounding analysis, DOE avoided any comparison of the relative differences in impacts that might result *when choosing between the action alternatives*" (emphasis added). The Court explained that "differences in impacts between the UPF alternative (where all buildings would be brand-new and all older buildings would be mothballed) and the Upgrade in-Place alternative (where older buildings would be improved to the extent possible) would be completely obscured." In ordering NNSA to "unbound" its analysis of potential seismic accidents, the Court's intent was for NNSA to un-obscure and disclose the relative differences in impacts that might result when choosing between the action alternatives. The SA accomplishes that mandate.

As discussed in Section 3.3 of this SA, in preparing the 2011 Y-12 SWEIS accident analysis, NNSA considered all potential facilities at Y-12. For facilities with radioactive materials and with high-hazard rankings, NNSA reviewed relevant safety-basis documents specific to each building and its operations. As shown in Section D.9.1.2 of the 2011 Y-12 SWEIS, safety-basis documentation for Building 9201-05 was reviewed and considered in the site-wide accident analysis. Through those reviews, NNSA identified potential accident scenarios and source terms (release rates and probabilities) associated with each of those facilities. Table D.9.3-1 of the 2011 Y-12 SWEIS shows the accidents considered for the nine high-hazard facilities, which included Building 9201-05. Next, NNSA evaluated the accident scenarios and source terms and determined that five accidents (in five facilities, including the 9215 Complex, 9204-2E Facility, and Building 9212) could have the highest consequences and should be analyzed in detail. In terms of potential consequences from accidents, Building 9201-05 was not one of the five highest-hazard facilities, and was not further evaluated in the 2011 Y-12 SWEIS. Currently, Building 9201-05 no longer supports the Y-12 national security mission, has been de-inventoried of nuclear materials, and is available for deactivation and demolition (estimated to start in 2025).

With regard to Building 9212, that facility is not part of any of the action alternatives; nonetheless, as part of the No-Action Alternative, the SA includes the worst-case accident in Building 9212 as part of the accident consequence comparisons in Table 3-12. With regard to the potential impacts of soil contaminants released in the event of an earthquake, such an analysis would be beyond generally-accepted accident analysis methodology and would require undue speculation.

27. Commenters state that the Draft SA is inadequate because it limits its earthquake review to solely radioactive releases when there are likely to be both radioactive and hazardous, non-radioactive constituents released in an earthquake. Additionally, the cumulative and synergistic impacts of the totality of the contaminants that may be released in a quake must be addressed under NEPA.

Response: The previous analyses of chemical accidents presented in the 2001 Y-12 SWEIS and 2011 Y-12 SWEIS remain accurate, and include consideration of Building 9212 and the other facilities at Y-12. The chemical accidents of concern were fires and loss of confinement events. The chemical accidents selected were not limited based on seismic hazard magnitude (e.g., accidents assumed a complete release; consequently, an earthquake-induced release would not change the consequences). The fire risk of the facility is managed under the fire protection program such that when taking into account the extended life of the structures, the overall frequency and consequences of the chemical accidents analyzed in the 2001 Y-12 SWEIS and 2011 Y-12 SWEIS remain unchanged. Once operational, the UPF would eliminate the chemical accidents of concern from Building 9212 (CNS 2020b).

With regard to the UPF, in the *Preliminary Documented Safety Analysis for the Uranium Processing Facility* (RP-EF-801768-A191) (CNS 2017a), NNSA identified two chemicals (ammonium hydroxide and hydrochloric acid) that could potentially exceed Protective Action Criteria[22] (PAC)-2 to the noninvolved worker as a result of a spill and/or fire event. However, as a result of further evaluations of these two chemicals, NNSA has determined that UPF will require

[22] PACs are essential components for planning and response to uncontrolled releases of hazardous chemicals. These criteria, combined with estimates of exposure, provide the information necessary to evaluate chemical release events for the purpose of taking appropriate protective actions. During an emergency response, these criteria may be used to evaluate the severity of the event, to identify potential outcomes, and to decide what protective actions should be taken. These criteria may also be used to estimate the severity of consequences of an uncontrolled release and to plan for an effective emergency response. PAC-1 could result in mild, transient health effects; PAC-2 could result in irreversible or other serious health effects that could impair the ability to take protective action; and PAC-3 could result in life-threatening health effects (DOE 2020).

a reduced quantity of ammonium hydroxide with a lower concentration, such that an accidental release would no longer exceed PAC-2 for the noninvolved worker. The quantity of hydrochloric acid has been reduced to a point where it will no longer even screen forward for additional analysis. The UPF quantities and concentrations of nitric acid (the primary chemical hazard of concern discussed in the 2011 SWEIS) are insufficient to exceed PAC-2 to the noninvolved worker or PAC-1 to the public MEI. In summary, UPF both eliminates the Building 9212 chemical accidents of concern and does not, itself, present any non-uranium, chemical accidents of interest to the SWEIS (CNS 2020b).

28. *Commenters state that the Draft SA does not evaluate new information that has come to light since 2011. Commenters state that such new information includes reports from DOE's Inspector General, reports and weekly assessments from the Defense Nuclear Facilities Safety Board (DNFSB), and updated scientific information about seismic risks in eastern Tennessee. Commenters also stated that a focus on capable faults is inappropriate in light of recent scientific evidence showing that powerful earthquakes occur in areas with no known capable faults.*

Response: Section 1.2 describes the purpose and need for this SA, which defines the scope of the analysis. The Court Order specifically states that NNSA "shall conduct further NEPA analysis—including at minimum, a supplement analysis—that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporate the 2014 USGS seismic hazard map." The SA accomplishes that mandate. NNSA notes that there are other established mechanisms for responding to reports from organizations such as the Inspector General and DNFSB.

With regard to updated scientific information about seismic risks in eastern Tennessee, and capable faults, NNSA provides the following response:

As discussed in Section 2.2.2 of this SA, the ELP includes a commitment to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities. That work is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021. The updated PSHA will incorporate the 2014 USGS seismic hazard/maps, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East) (CNS 2020a).

With regard to the ELP facilities, the PSHA is used to evaluate the performance of those facilities under seismic hazard conditions. Among other things, the PSHA aids in understanding and defining the severity (and hence, the probability) of an earthquake capable of causing release of radioactive material. The ELP facilities (the 9215 Complex and the 9204-2E Facility) were designed and constructed before the establishment of modern nuclear safety standards. Some portions of the facilities meet such standards and other portions do not. The new seismic facility evaluations will provide an up-to-date evaluation of any remaining weaknesses and the potential for upgrades will be addressed. Upgrading both structures to fully meet modern seismic standards for new facilities may not be feasible or practical. However, the potential for structural upgrades will also be informed by an independent expert panel review that Y-12 contracted for in 2016 (Recommendations of the Seismic Expert Panel Review of Buildings 9204-2E and 9215 [RP

900000-0182]) (NNSA 2016b), which provided suggestions for practical approaches to structural upgrade initiatives in these two facilities (CNS 2020a).

It is important to recognize that the planned updated studies are intended to answer in more detail the capacity of the existing structures based on advanced analytical techniques (i.e., accounting for non-linear effects which typically demonstrate additional capacity to resist earthquake ground motion) not previously used. As a result, the potential for improvements will be better understood while reconciling the differences between the USGS data and the other relevant studies discussed earlier. The existing seismic studies for the ELP facilities, however, do provide a solid technical basis on which to judge the effects of the 2014 USGS seismic hazard/maps in support of determining potential consequences to the public.

Lettis Consultants International, Inc. (Lettis) is presently performing the updated PSHA for Y-12 as noted in Section 2.2.2. Lettis has expert geologists, geophysicists, seismologists, and earthquake engineers involved who have performed PSHAs at numerous DOE sites and commercial nuclear power plant sites. They have been involved in recent studies for the nearby Clinch River site, which is being considered as a site for a new modular nuclear reactor facility and at the Watts Bar Nuclear Reactor site (about 40 miles southwest of Y-12).

The latest NRC NUREG-2115, Central and Eastern United Sates Seismic Source Characterization for Nuclear Facilities, issued in 2012 and the PEER Report No. 2018/08, Central and Eastern North America Ground-Motion Characterization, NGA-East Final Report, issued in 2018, are being used in the PSHA study. Both of these documents were sponsored by the NRC, DOE and EPRI to be used in updating PSHAs for DOE and commercial nuclear power plant sites in the Central and Eastern United States (CEUS).

In addition to these documents, Lettis is reviewing and using any recent data since these two studies were completed. They are reviewing the papers referenced by the commenters, and they have discussed the papers with some of the key authors.

Lettis is also reviewing the latest 2018 USGS seismic hazard information, which has been published on the USGS website (https://www.usgs.gov/natural-hazards/earthquake-hazards/science/2018-united-states-lower-48-seismic-hazard-long-term?qt-science_center_objects=0#) and also in the Earthquake Engineering Research Institute Earthquake Spectra, Vol 36(1) 5-41. Figure 11 in these documents show a slight decrease in the seismic hazard for the East Tennessee area compared to the USGS 2014 seismic hazard results.

The design/evaluation basis earthquake ground motion determined from the PSHA for a specific annual probability of exceedance considers all the earthquake sources and their associated magnitudes. From the PSHA results, the magnitudes of the earthquakes that control the ground motion at the specific annual probability of exceedances can be determined from a de-aggregation of the results.

The de-aggregation of previous (pre-2014) Y-12 seismic hazard results and previous USGS seismic hazard results for the East Tennessee area, which defined the controlling earthquake moment magnitudes, were 5 to 6 occurring within 10 to 20 kilometers of the site and a moment magnitude of about 7.5 occurring at a distance of about 475 to 500 kilometers from the site for an annual probability of exceedance of $4x10^{-4}$ (return period of 2,500 years, 2 percent in 50 years). The moment magnitudes of 5 to 6 occurring within 10 to 20 kilometers of the site define the high to moderate frequencies of the design/evaluation basis earthquake ground motion, whereas the moment magnitude of about 7.5 occurring at a distance of 475 to 500 kilometers from the site defines the low frequencies of ground motion. As the annual probability of exceedance of the design basis earthquake decreases, the controlling magnitudes of the earthquakes occurring close to the site increase. The updated PSHA results are expected to define the same range of magnitudes that control the design/evaluation basis earthquake.

29. *Commenters state that the Draft SA discloses that an earthquake that would cause extremely serious consequences regarding Building 9204-2E or the 9215 Complex is more probable than purportedly comparable hazards considered in the 2011 SWEIS. For example, with regard to Building 9204-2E, the SA concedes that the probability of an earthquake that causes a criticality event in the 9204-2E facility is $2x10^{-3}$, whereas the only point of comparison identified in the 2011 SWEIS had a probability of only $1x10^{-4}$. Accordingly, the new information reveals that an earthquake is twenty times more probable than the accidents previously considered in the 2011 SWEIS.*

Response: As shown in Table D.9.3-1 of the 2011 SWEIS, NNSA estimated the frequency (i.e., probability) of an earthquake in any of the Y-12 facilities at a range of $1x10^{-2}$ to $1x10^{-4}$; likewise, NNSA estimated the probability of a criticality accident in any of the Y-12 facilities at a range of $1x10^{-2}$ to $1x10^{-4}$. The probability estimate of $2x10^{-3}$ presented in Table 3-4 of this SA is within that range.

30. *Commenters state that NNSA's decision to continue construction of the UPF and related facilities on an "interim" basis creates a heretofore nonexistent NEPA status, one that cannot be reconciled with NEPA's requirement that agencies may not undertake premature actions that prejudice or predetermine the outcome of a NEPA analysis.*

Response: The Amended ROD announced on October 4, 2019, is adequately supported by the 2011 SWEIS, is legally sufficient, and is not inconsistent with, or in violation of the Court Order. NNSA decided to continue to operate Y–12 to meet the stockpile stewardship mission critical activities assigned to the site on an interim basis, pending further review of seismic risks at Y–12. The Court did not vacate the 2011 ROD or Y-12 SWEIS or enjoin any activities at Y-12. The Court held that the NNSA's new strategy of upgrading (modernizing) existing enriched uranium buildings pursuant to the ELP and constructing UPF with multiple buildings was adequately considered as part of the 2011 SWEIS. However, the Court did require additional NEPA analysis of seismic risks at Y-12. Pending completion of that additional analysis, NNSA made the reasonable decision in the 2019 AROD to "continue to implement safety improvements under previously approved contracts," thereby enhancing safety at Y-12 in the interim, pending the issuance of "a new ROD describing, what, if any, changes it has decided to make in light of that analysis."

31. *Commenters provide the following specific seismic-related comments:*

a. *NNSA continues to offer a discussion of USGS data that is "deficient." For example, NNSA's reliance on a measure of risk in terms of a "2 percent over 50 years" standard is inappropriate in light of the age and vulnerability of the buildings at Y-12. Commenters state that this warrants more careful analysis and consideration of less frequent but much larger shaking than that reported for 2% in 50 years.*

b. *The Draft SA does not utilize modern, non-linear modeling techniques. Accounting for non-linear effects is part of what "the planned updated studies are intended to answer in more detail." NNSA's failure to consider non-linear modeling is a defect in the consideration of seismic risks.*

Response: NNSA provides the following specific responses to the comments:

a. DOE requirements for seismic analysis are consistent with industry standards and represent an appropriate evaluation basis to assure acceptable risk to the public and the environment. DOE Order 420.1C (Change 2), "Facility Safety," is the key DOE directive that is used to define the annual probability (return period) of the earthquake that should be used for the design/evaluation of DOE facilities. DOE Order 420.1C (Change 2) invokes the use of several DOE standards to provide the detail requirements. These standards are:

(1) DOE-STD- 1189-2016, "Integration of Safety into the Design Process"
(2) DOE-STD-1020-2016, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities"
(3) DOE-STD-3007-2017, "Preparing Criticality Safety Evaluations at DOE Nonreactor Nuclear Facilities"
(4) DOE-STD-3009-2014, "Preparation of Nonreactor Nuclear Facility Documented Safety Analysis"

The DOE-STD-1189, DOE-STD-3007, and the DOE-STD-3009 standards provide the criteria for performing the earthquake-induced accident analyses of the nonreactor nuclear facilities. From the earthquake-induced accident analyses, the consequences to the noninvolved worker and the public are determined.

The DOE-STD-1020 standard defines five natural phenomena seismic design categories (SDC-1, SDC-2, SDC-3, SDC-4, and SDC-5) used for the DOE nonreactor nuclear facilities. The SDC of a facility is based on the unmitigated consequences of the earthquake induced accidents in the facility.

Based on the unmitigated consequences for earthquake induced accidents in Building 9204-2E, the 9215 Complex, and UPF facilities, they are considered SDC-2 facilities. For SDC-2 facilities, the DOE-STD-1020 standard specifies that the IBC should be used to design/evaluate the facilities. The earthquake hazard defined in the IBC, which is used to determine the design/evaluation basis earthquake ground motions, is the 2 percent in 50 years seismic hazard (which equates to an annual of probability of exceedance of $4x10^{-4}$, or a return period of 2,500 years, i.e., an earthquake ground motion that might occur once in 2,500 years). The design/evaluation basis earthquake ground motions and the design criteria used for the SDC-2 facilities are equivalent to what is used for the earthquake design of hospitals, fire stations, and emergency operation centers.

The latest ASCE 43 (in publication), "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," standard also specifies the earthquake hazard to be used to determine the design/evaluation earthquake for SDC-2 facilities is 2 percent in 50 years (an annual of probability of exceedance of $4x10^{-4}$, or a return period of 2,500 years).

The DOE-STD-1020 standard also provides criteria to address potential degradation due to aging of the existing facilities. Detailed walk downs and inspections have been conducted on a regular basis to determine any aging concerns in the facilities. Any aging related degradation is mitigated to ensure the design capacities of the facilities are not impacted. In addition, the existing condition of the facilities are being considered in the ELP natural phenomena evaluations to determine if cost-beneficial upgrades can be made.

b. The existing Building 9204-2E and 9215 Complex facilities were not designed for ductile detailing requirements for reinforced concrete and steel structures that are required in today's codes and standards which allow for considerable non-linear behavior before failure during earthquakes. Based on that, the original analyses of the existing facilities conservatively did not consider any detailed non-linear seismic analyses to determine the failure modes of the facilities, thus resulting in assumed failures for lower earthquake ground motions than would be expected if detailed non-linear analyses had been performed.

The re-analyses of the facilities using the updated seismic hazard results are being performed using the recommendations from a seismic expert panel who reviewed the previous analyses and the facility drawings, along with a walk-down of the facilities. The expert panel members are internationally-recognized experts in earthquake engineering, and have many years of experience at DOE sites and at numerous commercial nuclear power plant sites. The expert panel recommended the re-analyses be performed using the ASCE 4-16, "Seismic Analysis of Safety Related Nuclear Structures," and ASCE 43 (latest version in publication), "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities." Previous versions of these two industry standards are referenced in the DOE-STD-1020-2016 standard, since it was issued prior to the latest editions of these two industry standards.

The ASCE 4 and 43 standards address the non-linear behavior of structures first by doing linear analysis using varying damping ratios, inelastic energy absorption factors, and varying Limit States.[23] If these analyses indicate significant non-linear behavior, then detailed dynamic non-linear analyses are recommended. The expert panel recognized the lack of ductile detailing in the

[23] "Damping ratio" is a dimensionless measure describing how vibrations in a structure decay during an earthquake. "Inelastic energy absorption factor" is a reduction factor to reduce the earthquake loads to account for inelastic behavior. The factor is a function of the Limit State and the structural system. "Limit State" is the limiting acceptable condition of the structure. The Limit State can be defined in terms of a maximum acceptable displacement, strain, ductility, or stress. Four Limit States are specified in the ASCE standards:
A = short of collapse, but structurally stable
B = Moderate permanent deformation
C = Limited permanent deformation
D = Essentially elastic

existing facilities and provided recommendations on how to address any limited non-linear behavior that could occur in the facilities.

32. *Commenters state that the UPF safety basis document was approved in July 2017 (and updated in 2019), which enables comparisons that were previously not possible. Commenters state that while the UPF has an operative safety basis, currently valid ones do not exist for the aged Buildings 9215 and 9204-2E.*

Response: Buildings 9215 and 9204-2E have current safety basis documents (as identified in Section 3.1 of this SA) which comply with DOE Standard 3009-94, are continuously evaluated by federal review teams, and have been approved by an NNSA Safety Basis Approval Authority.

33. *Commenters state that NNSA only promises to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities in the future, with no guarantee that it will do so. Commenters conclude that not having an updated PSHA amounts to "incomplete and unavailable information." Commenters state that the SA does not comply with NEPA's regulations on making decisions based on incomplete or unavailable information, and as such, states that the SA should "consider impacts which have catastrophic consequences, even if their probability of occurrence is low."*

Response: In preparing this SA, NNSA has evaluated the 2014 USGS seismic hazard/maps and conservatively estimated the probability of the earthquake accident for the ELP facilities and the potential consequences of such an accident. Section 2 of the SA explains the relationship between the USGS seismic hazards/maps and the site-specific PSHAs for Y-12 facilities, and Section 2.2.2 specifically addresses the ELP facilities. Based on existing structural analyses, NNSA states its confidence that "the updated PSHA would not increase the earthquake probability used in the SA."

As discussed in Section 2.2.2 of this SA, a site-specific PSHA has existed for the ELP facilities since approximately 2003. That PSHA was formally reviewed against updated seismic information in 2012 (Update of the Seismic Hazard at the Department of Energy National Nuclear Security Administration Y-12 National Security Complex [RP-900000-0029]) (NNSA 2012). That review showed that both the 2008 USGS hazard map and the 2012 CEUS SSC study resulted in a decrease in the seismic hazard when compared to the Y-12 2003 site-specific PSHA. Based on the comparison, and to be conservative, Y-12 decided to continue to use the more conservative 2003 site-specific seismic hazard (CNS 2020a).

As discussed in Section 2.1.3.1, the 2014 USGS seismic hazard/maps were incorporated into ASCE 7 in 2016. Subsequently, an informal comparison of the ASCE 7-2016 seismic hazard with the Y-12 2003 site-specific seismic hazard shows that the Y-12 2003 site-specific seismic response spectrum is more conservative in some frequency ranges, while the ASCE 7-2016 seismic response spectrum is more conservative in others. These differences merit more formal review, which is currently underway.

The issue of incomplete or unavailable information is discussed in 40 CFR § 1502.22. That section states the following: "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an *environmental impact statement* and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" (emphasis added). Subsections (a) and (b) of 40 CFR § 1502.22 state the following:

> (a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.
>
> (b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement:
>
> (1) A statement that such information is incomplete or unavailable;
> (2) A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;
> (3) A summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment, and
> (4) The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

NNSA notes that the SA is not an environmental impact statement, which calls into question the applicability of 40 CFR § 1502.22. NNSA also notes that the overall costs of obtaining the incomplete or unavailable information (i.e., the updated PSHA for the ELP facilities) are not exorbitant and the means to obtain it are known; however, obtaining such information takes time, and as NNSA states in Section 2.2.2 of this SA: "That work [the updated PSHA for the ELP facilities] is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021."

Irrespective of the foregoing discussion, this SA presents the worst-case consequences of an earthquake involving ELP facilities, and those consequences are not significant (*see* Table 3-3, which shows that 0 LCFs to the MEI, 50-mile population, and noninvolved workers would result from the worst-case earthquake involving the ELP facilities). In addition, NNSA notes that any change to the site-specific PSHA for the ELP facilities would not change the consequences presented in Table 3-3, because those consequences reflect a worst-case (catastrophic) analysis, even if their probability of occurrence is low. Consequently, while the PHSA is not yet complete, sufficient analysis exists in the SA to make the required finding as set forth in Section 4.0, Conclusion and Determination.

34. *Commenters state that the SA provides no timeline for the decontamination, decommissioning and demolition of the 9212 Complex.*

Response: The target date for the start of the deactivation of the 9212 Complex is 2035 or later. Completion of the decontamination, decommissioning, and demolition of the 9212 Complex is 2040 to 2045 (CNS 2020b). NNSA also notes that the MAR in the 9212 Complex has been and will continue to be steadily reduced between now and 2023 to a low level that will maintain operations until UPF comes online (nominally 2026-2027). To date, the MAR in the 9212 Complex has been reduced by approximately 40 percent compared to the MAR that existed in 2011. The environmental impacts associated with such future activities would be evaluated if required by subsequent applicable NEPA or CERCLA documentation.

35. *Commenters state that the cumulative impacts analysis in the SA does not address site-wide impacts from past, present, and reasonably foreseeable actions. Specifically, commenters state that site-wide earthquake impacts should be presented.*

Response: Section 1.2 describes the purpose and need for this SA, which defines the scope of the analysis. Because the scope of the SA focuses on an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporate the 2014 USGS seismic hazard map, the cumulative impact analysis (Section 3.4 of this SA) addresses site-wide accidents that could occur simultaneously. Table 3-12 of the Final SA has been revised to include consideration of seismic impacts from other facilities at Y-12, specifically the HEUMF and other EU support facilities.

36. *Commenters state that the analysis in the SA is "not unbounded" because it uses data from other analyses.*

Response: Although the commenters did not specify what "data from other analyses" were used in this SA, the earthquake analysis in this SA uses data specifically developed for evaluating the potential impacts of earthquakes at Y-12. By presenting a specific and detailed assessment of earthquake accidents, this SA "unbounds" the earthquake accidents from other accidents, and the results stand on their own.

37. *Commenters state that the updated analysis in the SA concludes that an earthquake incident at Y-12 would have virtually no impact to the offsite population. Commenters state that construction of the UPF is vital to protect the health and safety of citizens, and risks to workers, the community, and the region of "no action" far exceed the stated risks posed by a low-probability seismic event.*

Response: The commenters' opinion is noted. Table 3-12 shows that the potential consequences of the No-Action Alternative would be greater than all other alternatives. That table also supports the conclusion that consolidating EU operations from older nuclear facilities into modern facilities such as the UPF reduces potential accident consequences.

38. *Commenters state that the 2011 Y-12 SWEIS and the SA exclude cumulative site-wide impacts of ongoing activities such as the Integrated Facilities Disposition Program (IFDP).*

Commenters state that such an approach does not provide a complete representation of the site-wide impacts at Y-12. Commenters state that the SA must either examine the full slate of environmental impacts from on-going and reasonably foreseeable activities, or it must default to the preparation of a new SWEIS.

Response: As shown in Section 6.2.5 of the 2011 Y-12 SWEIS, NNSA specifically considered IFDP activities in the cumulative impact analysis. The cumulative impact analyses in Section 6.3 include IFDP impacts, as appropriate. With regard to this SA, as discussed in Section 1.2, the purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. In order to accomplish that purpose, this SA presents the potential earthquake accident impacts for the action alternatives. Other site-wide activities, such as the IFDP, which are occurring independently, are beyond the scope of this SA. Based on the results of this SA, NNSA does not think additional NEPA documentation is required at this time.