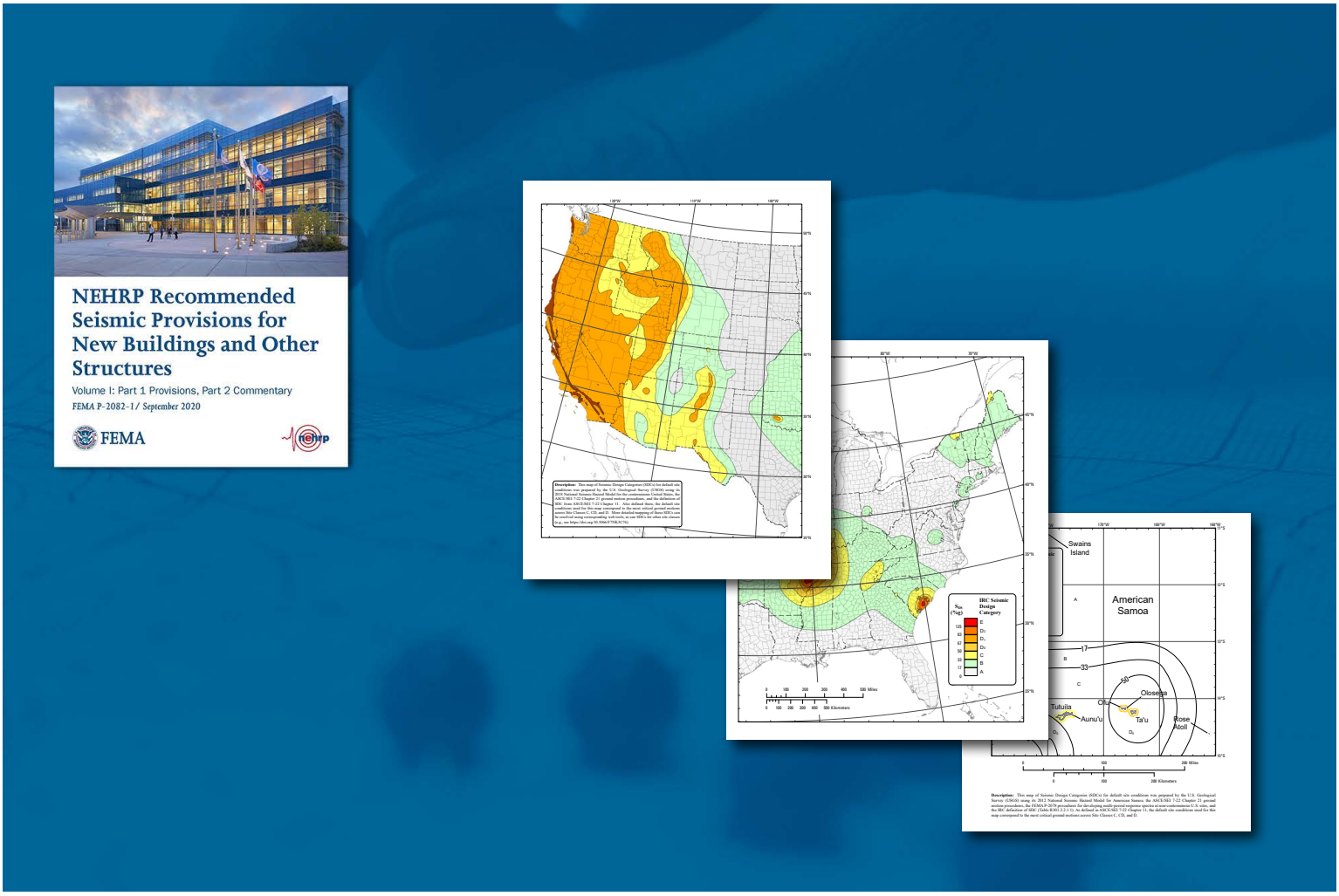

2020 NEHRP Recommended Seismic Provisions: Seismic Design Category Maps for 2024 International Residential Code (IRC) and International Building Code (IBC)

FEMA P-2192-4, April 2023

FEMA nehrp USGS science for a changing world

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Contents

Introduction to the 2024 IRC and IBC Maps

Updated seismic design maps have been adopted into the 2024 editions of the *International Residential Code* (IRC, ICC, 2024a) and the *International Building Code* (IBC, ICC, 2024b). Both map sets are based on the *2020 NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* (NEHRP Recommended Provisions, FEMA, 2020a) and the 2022 ASCE *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI 7-22, ASCE, 2022). As in past updates, the IRC and IBC maps have been developed in collaboration with the U.S. Geological Survey (USGS) and are based on their National Seismic Hazard Models (NSHMs), the site-specific ground motion procedures of the *2020 NEHRP Recommended Provisions* and ASCE/SEI 7-22, and the IRC and IBC definitions of SDC.

In the IRC, the Seismic Design Category (SDC) is mapped directly for greater ease of use. The IRC SDC maps can be conservatively used for any site, except that use of the maps is not permitted for poor soil sites as discussed in IRC Section R401. In the updated IRC SDC maps, the same choices as in prior IRC map editions have been made by the map development team. The first choice assumes that dwelling seismic demands are controlled by short-period behavior, with mapping based on only the short-period design spectral response acceleration parameter, S_{DS}. This ignores the one-second parameter, S_{D1}, which is considered in the IBC. The second choice assumes default site (soil) conditions, defined in the *2020 NEHRP Recommended Provisions* and ASCE/SEI 7-22 as the most critical of Site Classes C, CD, and D. Third, unlike the *2020 NEHRP Recommended Provisions* and ASCE/SEI 7-22, SDC E is mapped where S_{DS} exceeds 1.25 and SDC D is subdivided into D_0, D_1, and D_2. With these choices, the mapping information from the 2020 *NEHRP Recommended Provisions* and ASCE/SEI 7-22 are translated to SDC, using Table R301.2.2.1.1. The intent of adopting SDC maps is to spare the non-technical user of the IRC from having to implement the provisions of ASCE/SEI 7 Chapter 11; however, the IRC includes provisions allowing use of the IBC and ASCE/SEI 7 to determine SDC should the user elect to do so. Because the IRC maps only incorporate S_{DS} and not S_{D1}, it is possible for the IRC maps to assign a lower SDC than would be assigned using ASCE/SEI 7 in some locations. Because the IRC maps incorporate Site Classes C, CD, and D, it is possible for the IRC maps to assign a higher SDC than would be assigned using ASCE/SEI 7 when using a specific assigned site class. The IRC maps are provided in Figures 1 through 14.

In the 2018 and 2021 editions of the IRC, two separate sets of SDC maps were incorporated. These were identified as the Seismic Design Category Maps (Figures R301.2.2.1(1) through R301.2.2.1(6)) and the Alternate Seismic Design Category Maps (Figures R301.2.2.1.1(1) through R301.2.2.1.1(6)). The Seismic Design Category Maps were determined using default site conditions, defined then as the most conservative of Site Classes C and D. Because concern was expressed that use of these SDC maps would cause conservative SDC assignments in some locations relative to the use of Site Class D in previous editions of the IRC, Alternate Seismic Design Category Maps were developed based on Site Class D alone and permitted to be used where information was available to justify, to the satisfaction of the building official, that Site Classes A, B, or D could be assigned. These provided reduced SDCs in some locations. The need for an alternative SDC map set was investigated during the development of the 2024 IRC SDC maps; it was found that differences that would occur were in very few locations. As a result, the creation of a second map set was judged to be unnecessary. It is hoped that the return to a single map set will simplify use of the IRC seismic provisions.

New in the 2024 edition, IBC seismic design maps are now similarly presented as SDC maps. Designers have the choice to use the IBC SDC maps or the provisions of ASCE/SEI 7. The IBC SDC maps can be conservatively used for any site, except that use of the maps is not permitted for sites corresponding to Site Classes DE, E, or F. Like the IRC SDC maps, the IBC maps are developed based on default site (soil) conditions (most critical of Site Classes C, CD, and D). In addition, in accordance with ASCE/SEI 7 Section 11.6, SDC E or F is mapped where S_1 at Site Class BC exceeds 0.75g. The IBC SDC maps differ from the IRC SDC maps in that they have been developed considering both S_{DS} and S_{D1}, as well as S_1, per the ASCE/SEI 7 definition of SDC. Due to the consideration of S_{D1}, the IBC SDC maps are anticipated to typically generate the same or more conservative assignments of SDC than the IRC maps. Use of these IBC maps for default site conditions is anticipated to result in assignment of the same or a higher SDC than ASCE/SEI 7, except where the Site Class is DE, E, or F. The IBC includes provisions allowing use of ASCE/SEI 7 to determine SDC; it is anticipated that design professionals will often check to see if the ASCE/SEI 7 provisions will result in assignment of a lower SDC. A lower SDC might be assigned when using a specific assigned site class. The IBC maps are provided in Figures 15 through 28.

The updates to the IRC and IBC maps, like the map updates already adopted by the *2020 NEHRP Recommended Provisions* and ASCE/SEI 7-22, are based on (1) recommendations of the Project 17 collaboration between the Building Seismic Safety Council (BSSC) and the USGS (BSSC, 2019), and (2) the 2018 update of the USGS NSHM (Petersen et al., 2020) for the conterminous U.S. The Project 17 recommendations include improvements to (1) site-class effects, (2) spectral periods defining short-period and one-second ground-motion parameters, (3) deterministic caps on the otherwise probabilistic ground motions, and (4) maximum-direction scale factors. The updates in the 2018 USGS NSHM from the previous (2014) version (used in the 2018 and 2021 versions of the IRC and IBC) include incorporation of (1) new NGA-East and other ground-motion models for the central and eastern U.S., (2) deep sedimentary basin effects in the Los Angeles, Seattle, San Francisco, and Salt Lake City regions, (3) earthquakes that occurred in 2013 through 2017, and (4) updated weights for the western U.S. ground-motion models.

For the states and territories outside of the conterminous U.S., where the existing USGS NSHMs did not yet support direct development of multi-period response spectra (MPRS) needed for the above-mentioned modifications to site-class effects and spectral periods, MPRS were developed using the FEMA P-2078 “Procedures for Developing Multi-Period Response Spectra at Non-Conterminous United States Sites” (FEMA, 2020b). Via these procedures, the ground motion parameter values for default site conditions were approximated from Site Class BC values of short-period and one-second parameters, using the existing USGS seismic hazard models for Alaska (Wesson et al., 2007), Hawaii (Klein et al., 2001), Puerto Rico and the U.S. Virgin Islands (Mueller et al., 2003), Guam and the Northern Mariana Islands (Mueller et al., 2012), and American Samoa (Petersen et al., 2012). Other relatively minor updates were made to the short-period and one-second Site Class BC values for each region so that they are consistent with the risk-targeted calculations and maximum-direction scale factors used for the conterminous U.S.

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Petersen, M.D., Shumway, A.M., Powers, P.M., Mueller, C.S., Moschetti, M.P., Frankel, A.D., Rezaeian, S., McNamara, D.E., Luco, N., Boyd, O.S., Rukstales, K.S., Jaiswal, K.S., Thompson, E.M., Hoover, S.M., Clayton, B.S., Field, E.H., and Zeng, Y., 2020, "The 2018 update of the U.S. National Seismic Hazard Model: Overview of model and implications," Earthquake Spectra, 36(1), 5-41,

Wesson, R.L., Boyd, O.S., Mueller, C.S., Bufe, C.G., Frankel, A.D., & Petersen, M.D., 2007. "Revision of time-Independent probabilistic seismic hazard maps for Alaska," U.S. Geological Survey Open-File Report 2007-1043.

Seismic Design Category Maps for 2024 IRC (Color)

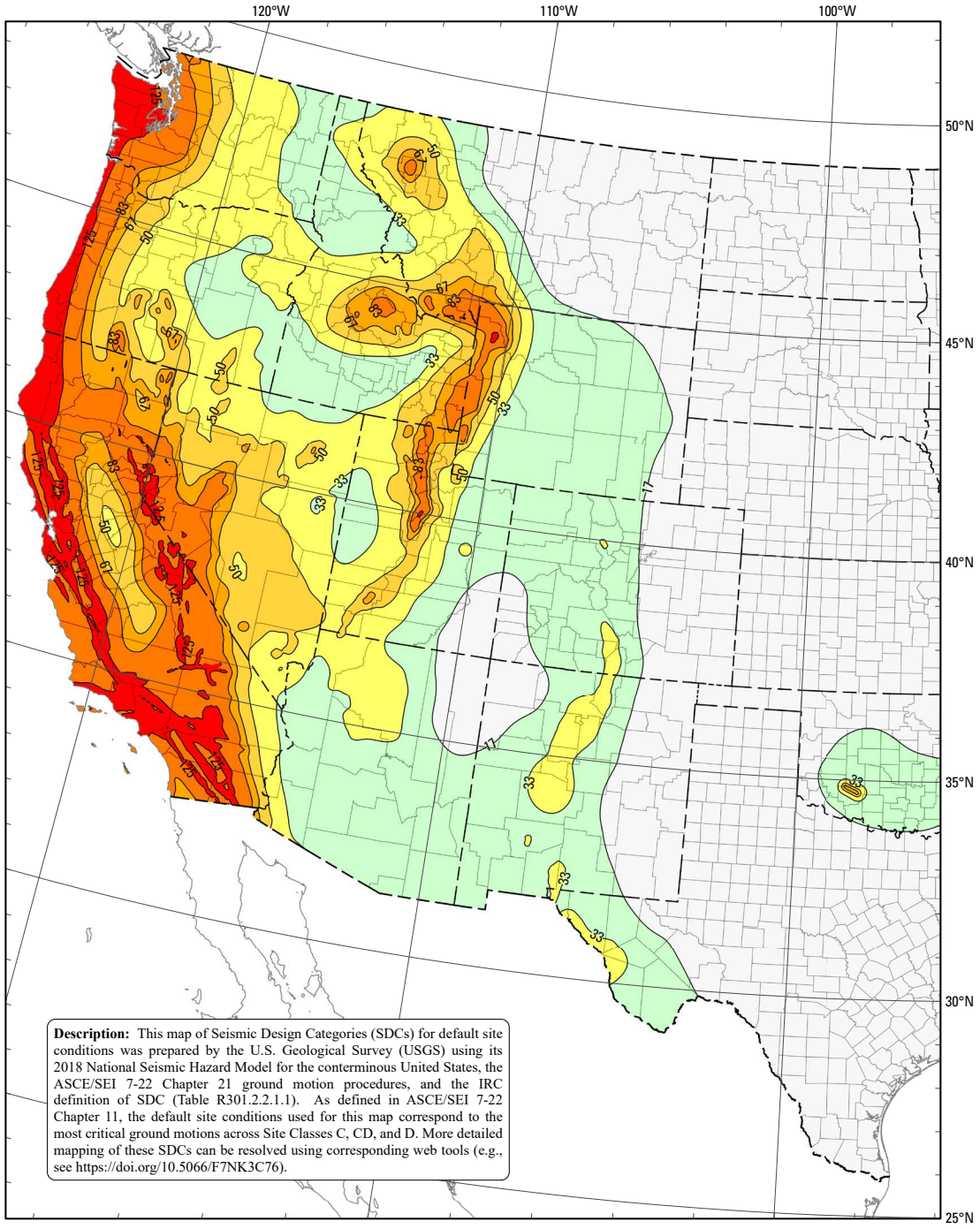


Figure 1. Seismic Design Category Map for 2024 IRC - Western U.S. (Color)

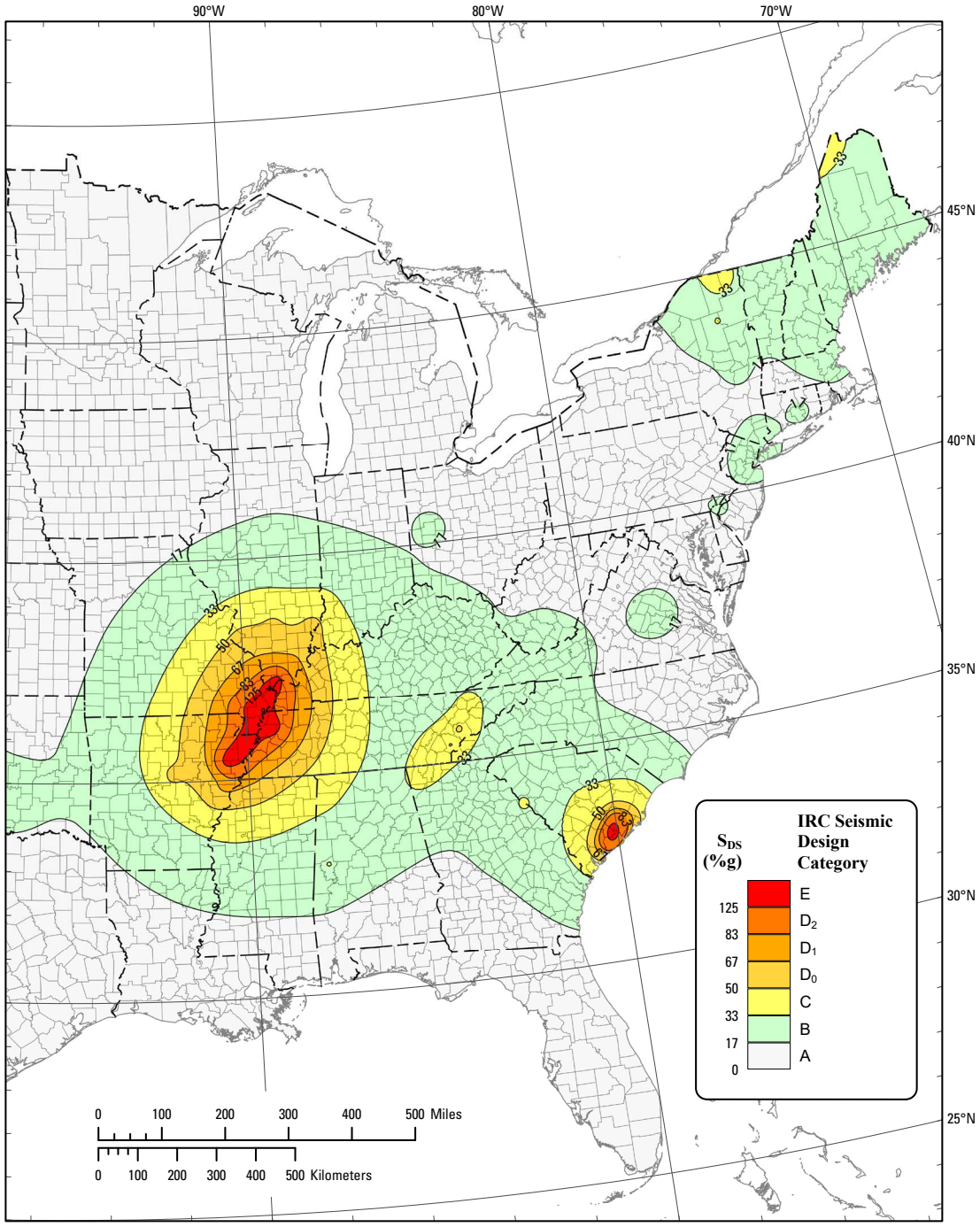
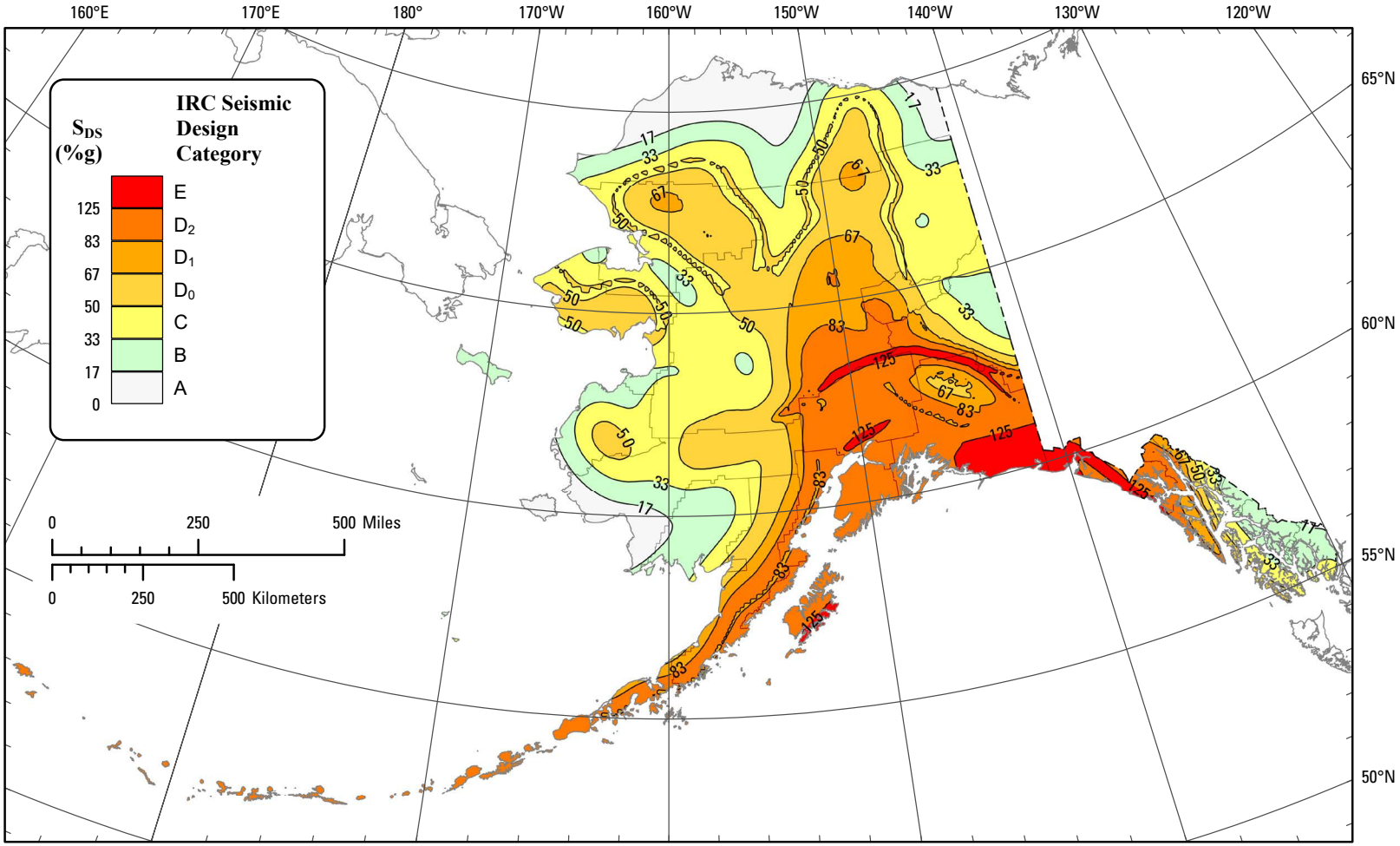


Figure 2. Seismic Design Category Map for 2024 IRC - Eastern U.S. (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2007 National Seismic Hazard Model for Alaska, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 3. Seismic Design Category Map for 2024 IRC - Alaska (Color)

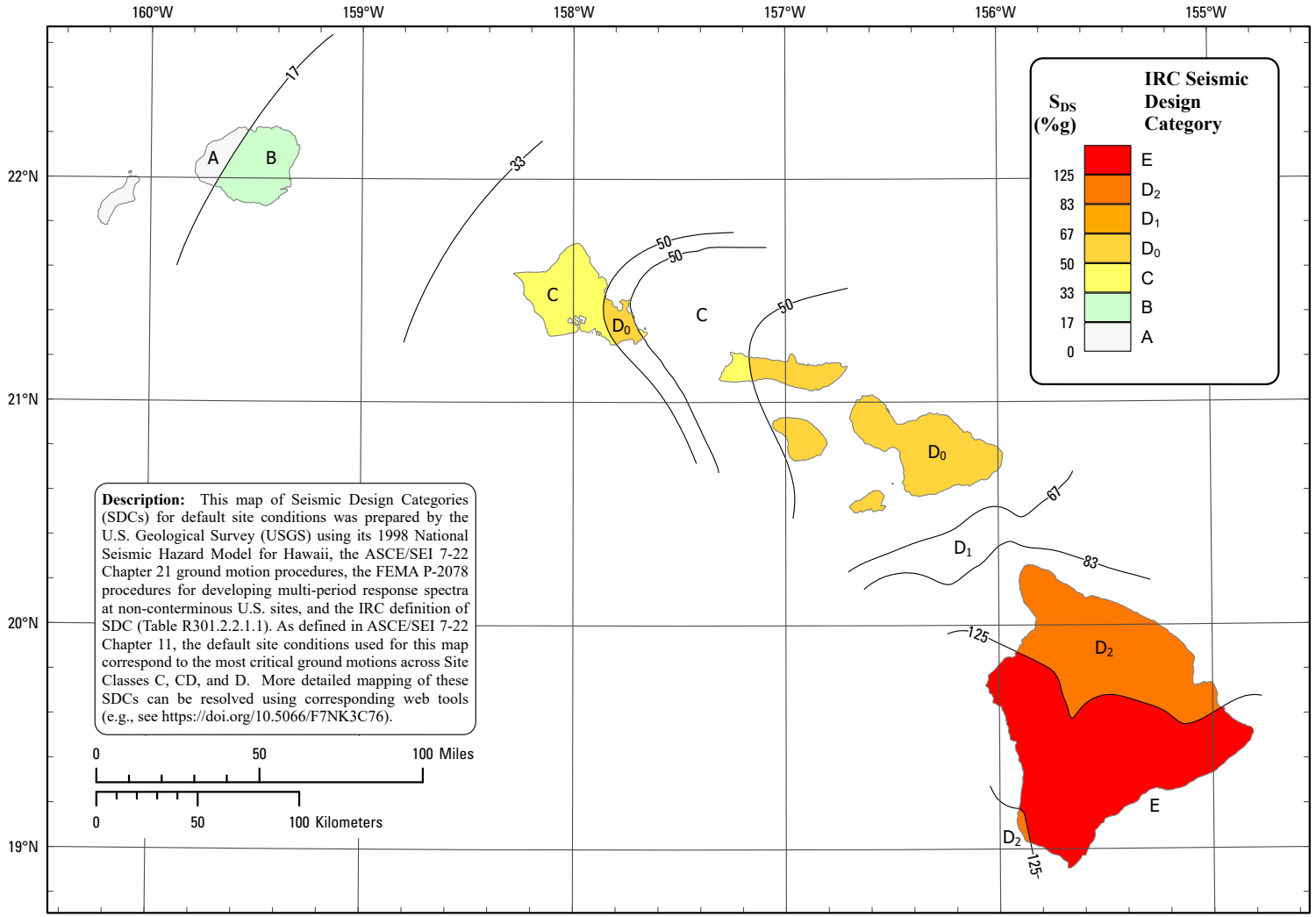
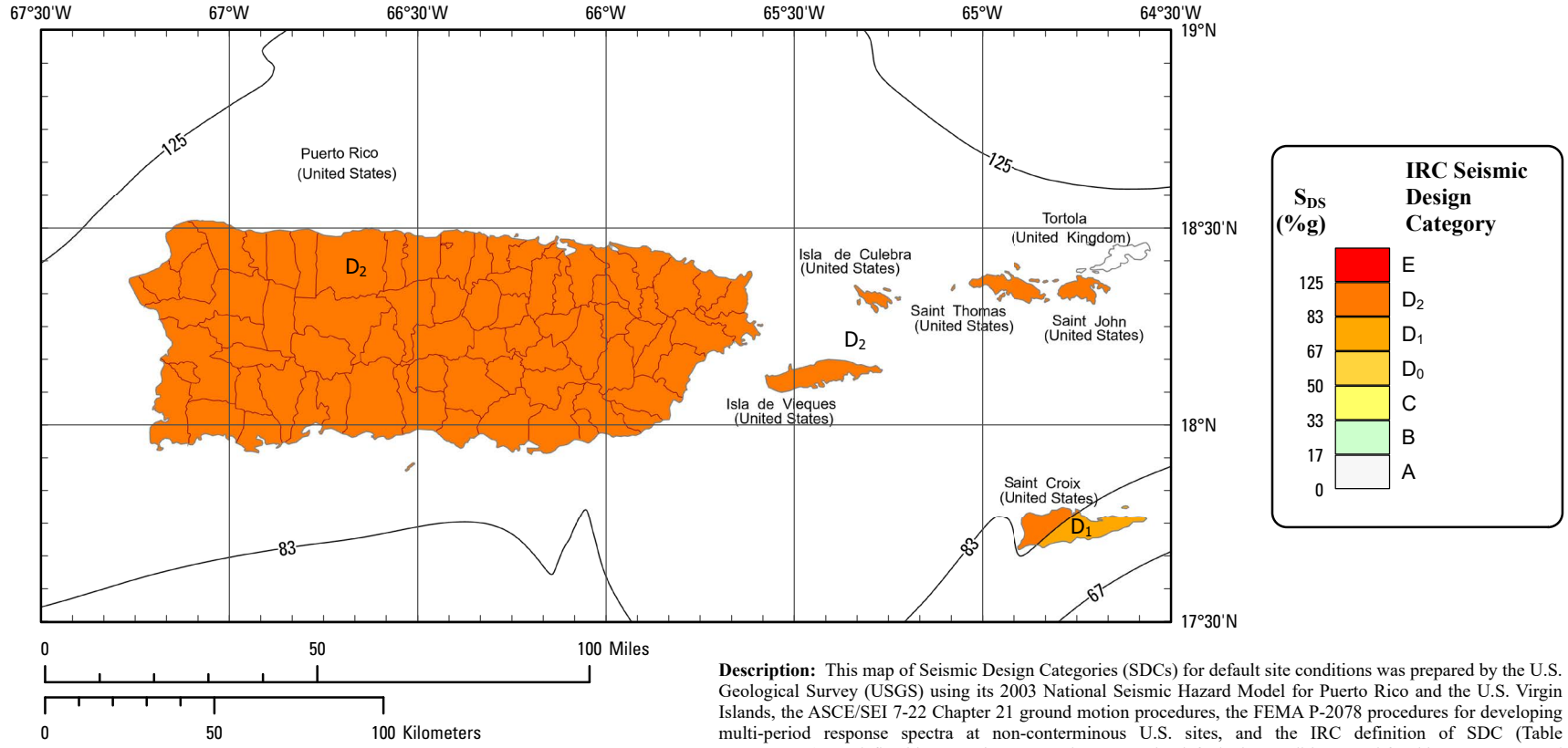
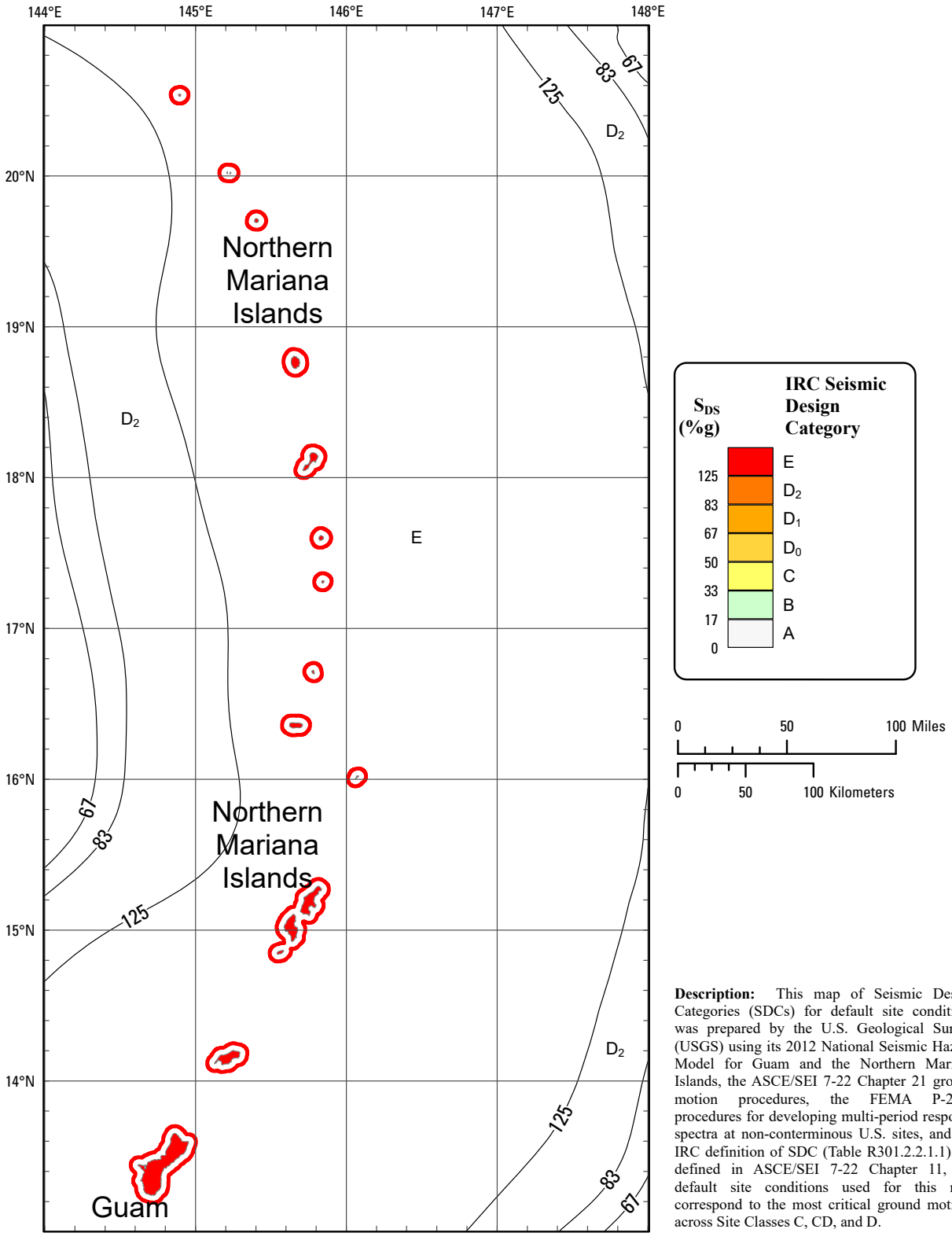


Figure 4. Seismic Design Category Map for 2024 IRC - Hawaii (Color)



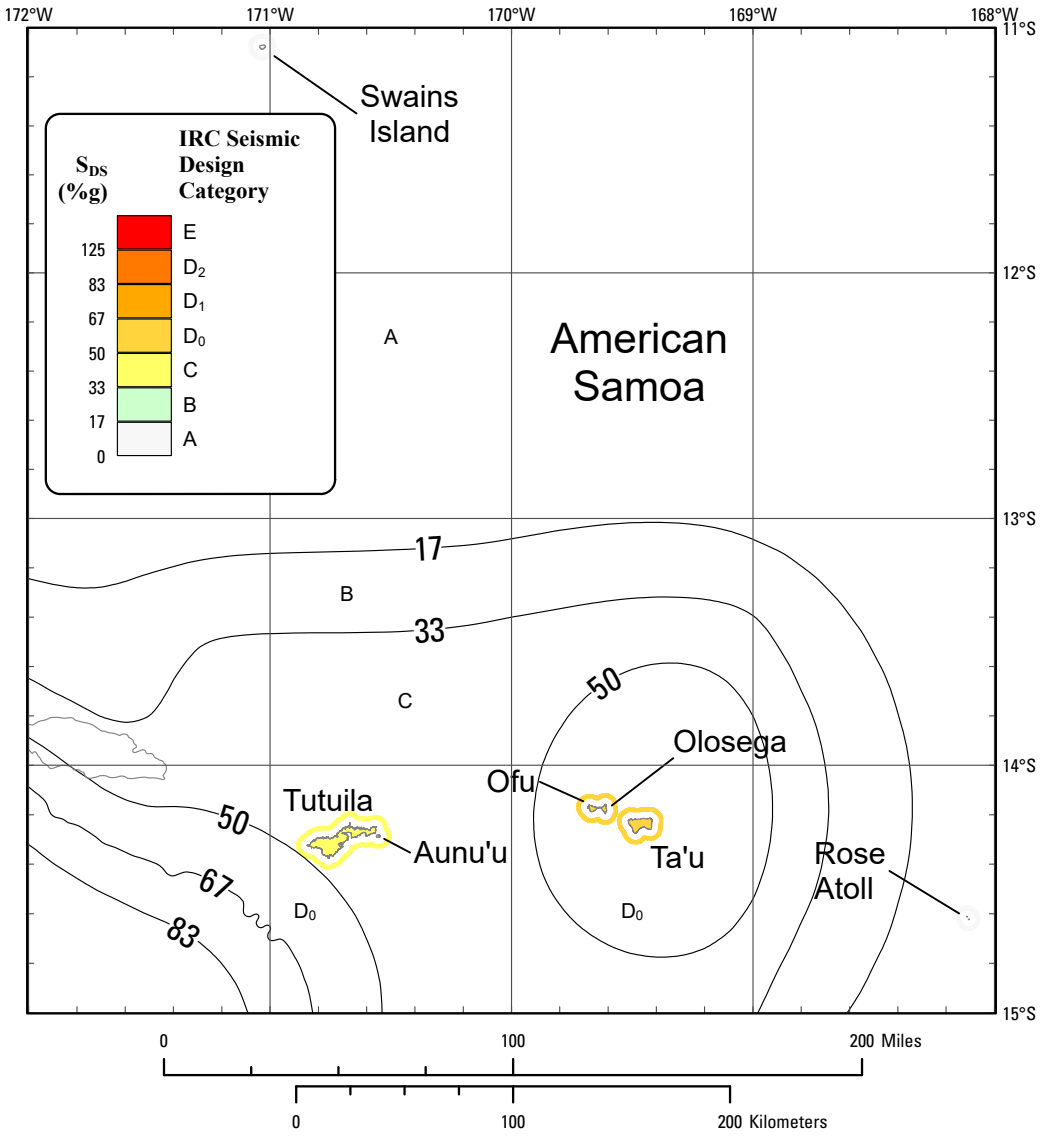
Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2003 National Seismic Hazard Model for Puerto Rico and the U.S. Virgin Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 5. Seismic Design Category Map for 2024 IRC - Puerto Rico and U.S. Virgin Islands (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for Guam and the Northern Mariana Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 6. Seismic Design Category Map for 2024 IRC - Guam and Northern Mariana Islands (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for American Samoa, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 7. Seismic Design Category Map for 2024 IRC - American Samoa (Color)

Seismic Design Category Maps for 2024 IRC (Black and White)

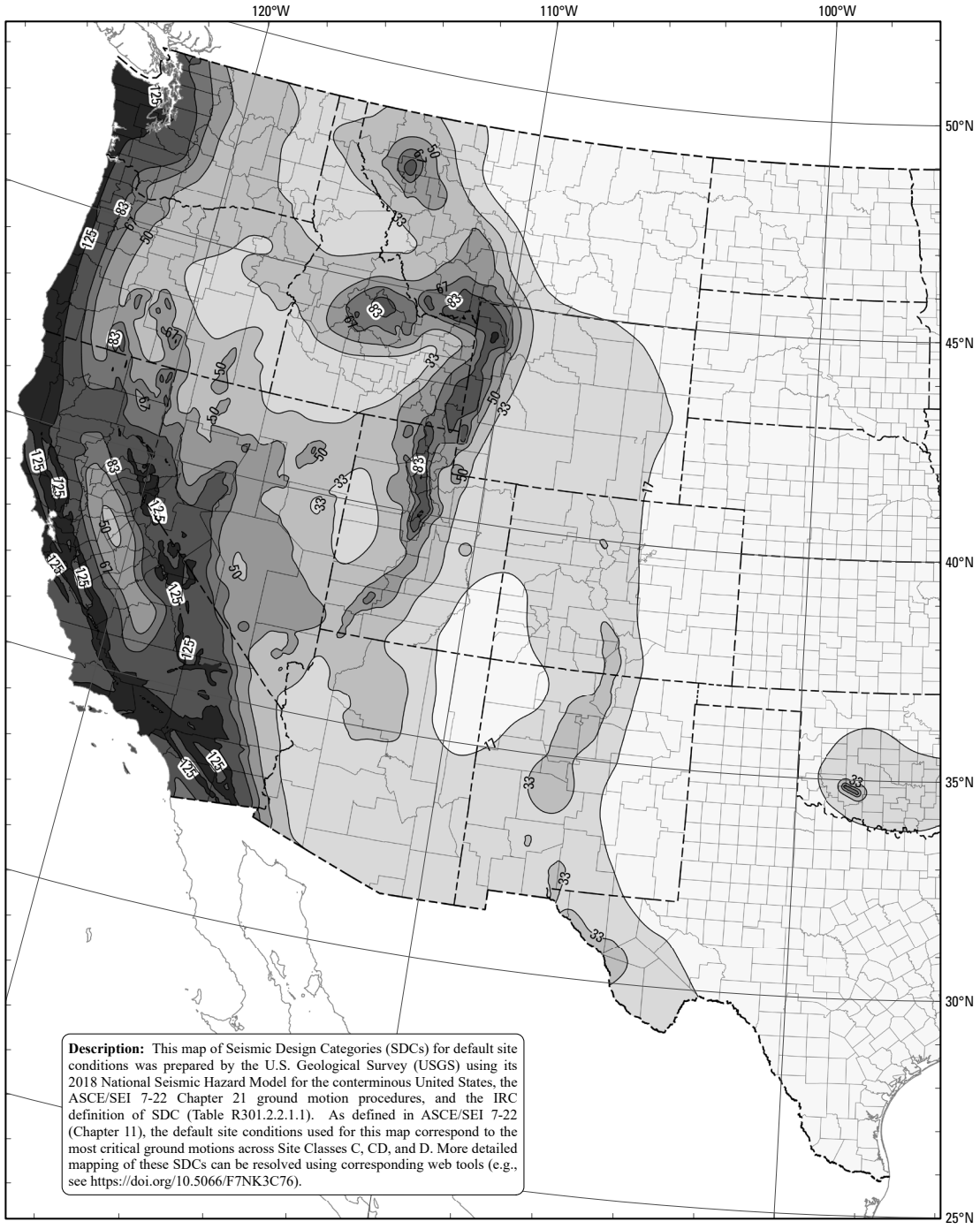


Figure 8. Seismic Design Category Map for 2024 IRC - Western U.S. (Black and White)

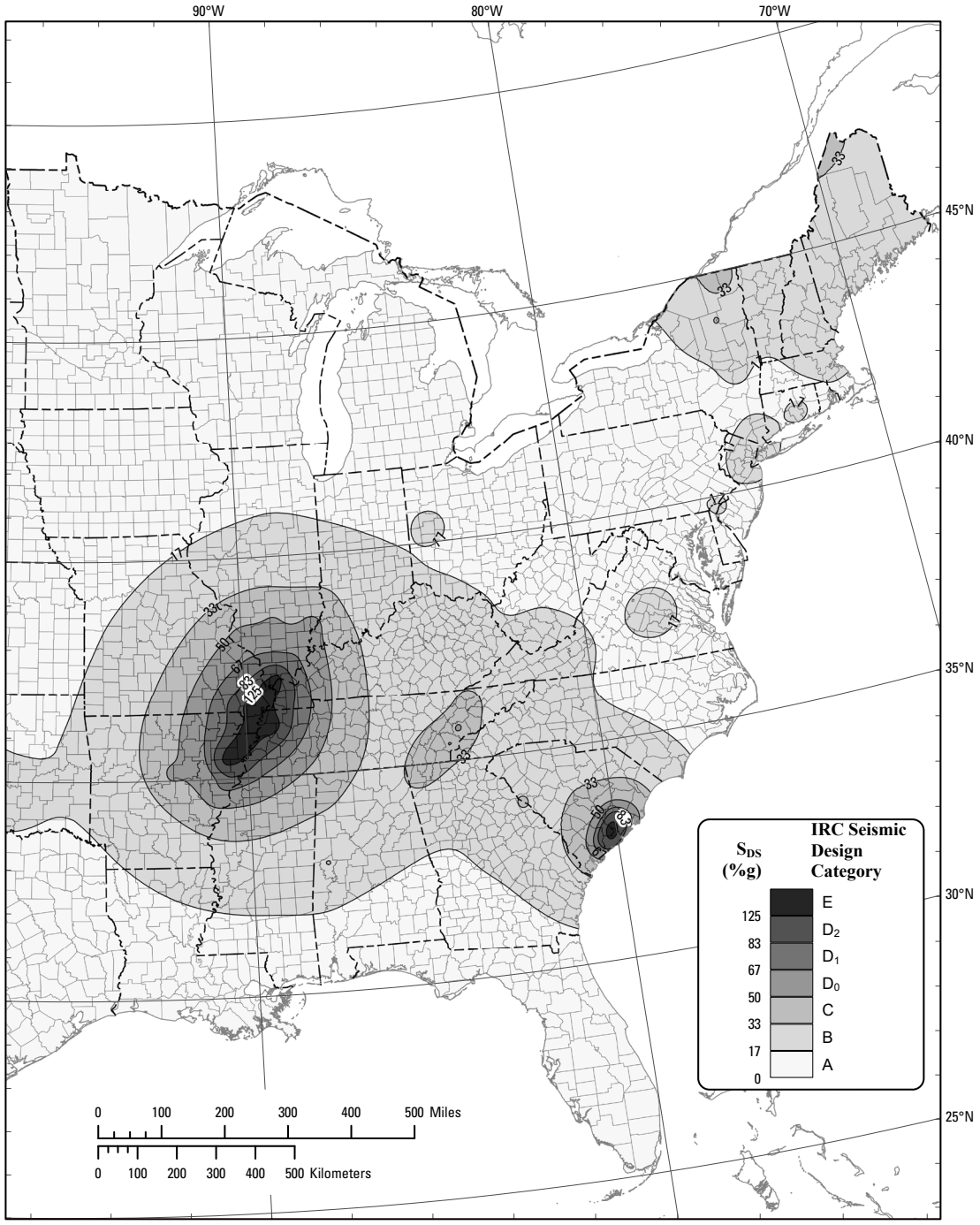
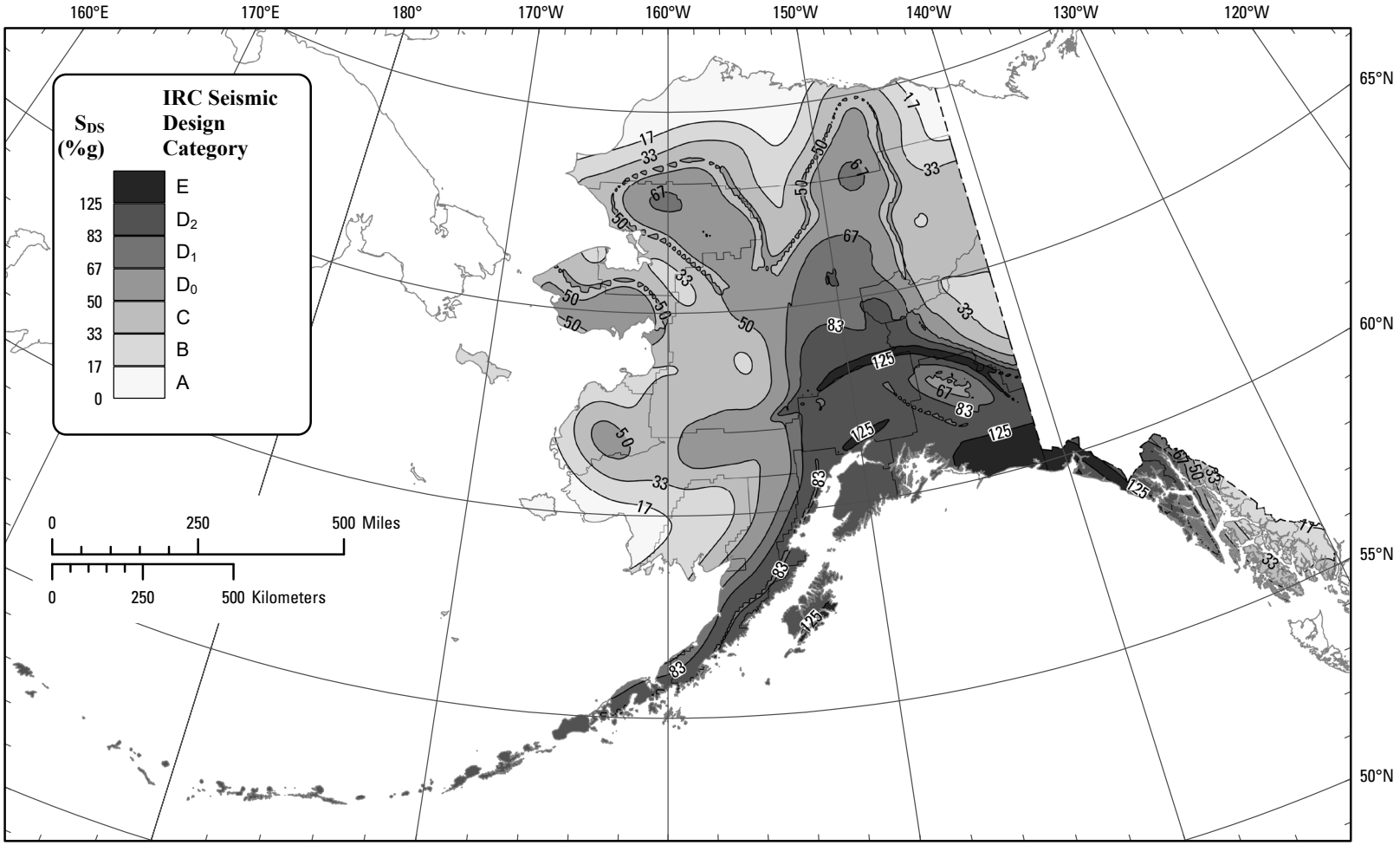


Figure 9. Seismic Design Category Map for 2024 IRC - Eastern U.S. (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2007 National Seismic Hazard Model for Alaska, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 10. Seismic Design Category Map for 2024 IRC - Alaska (Black and White)

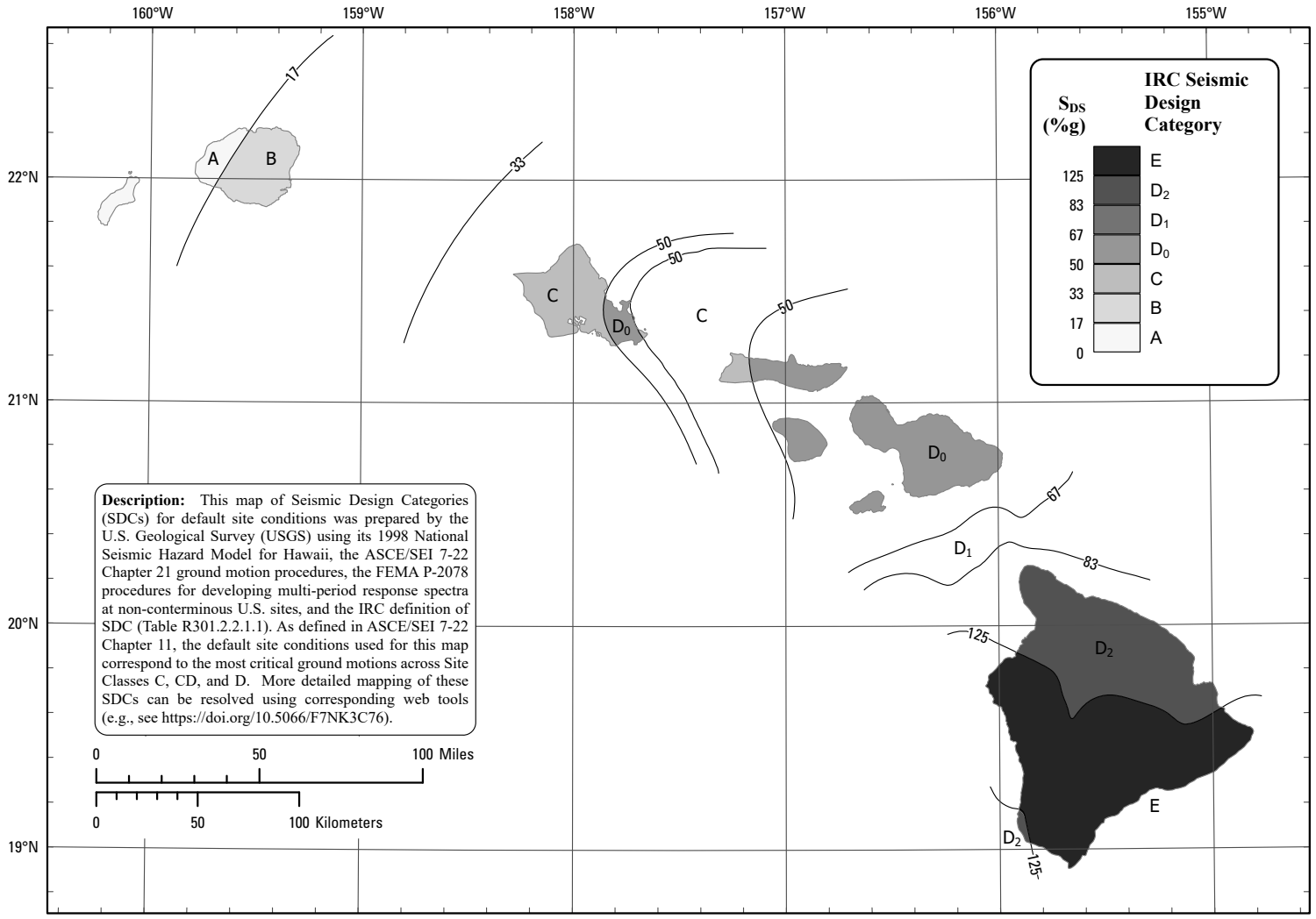
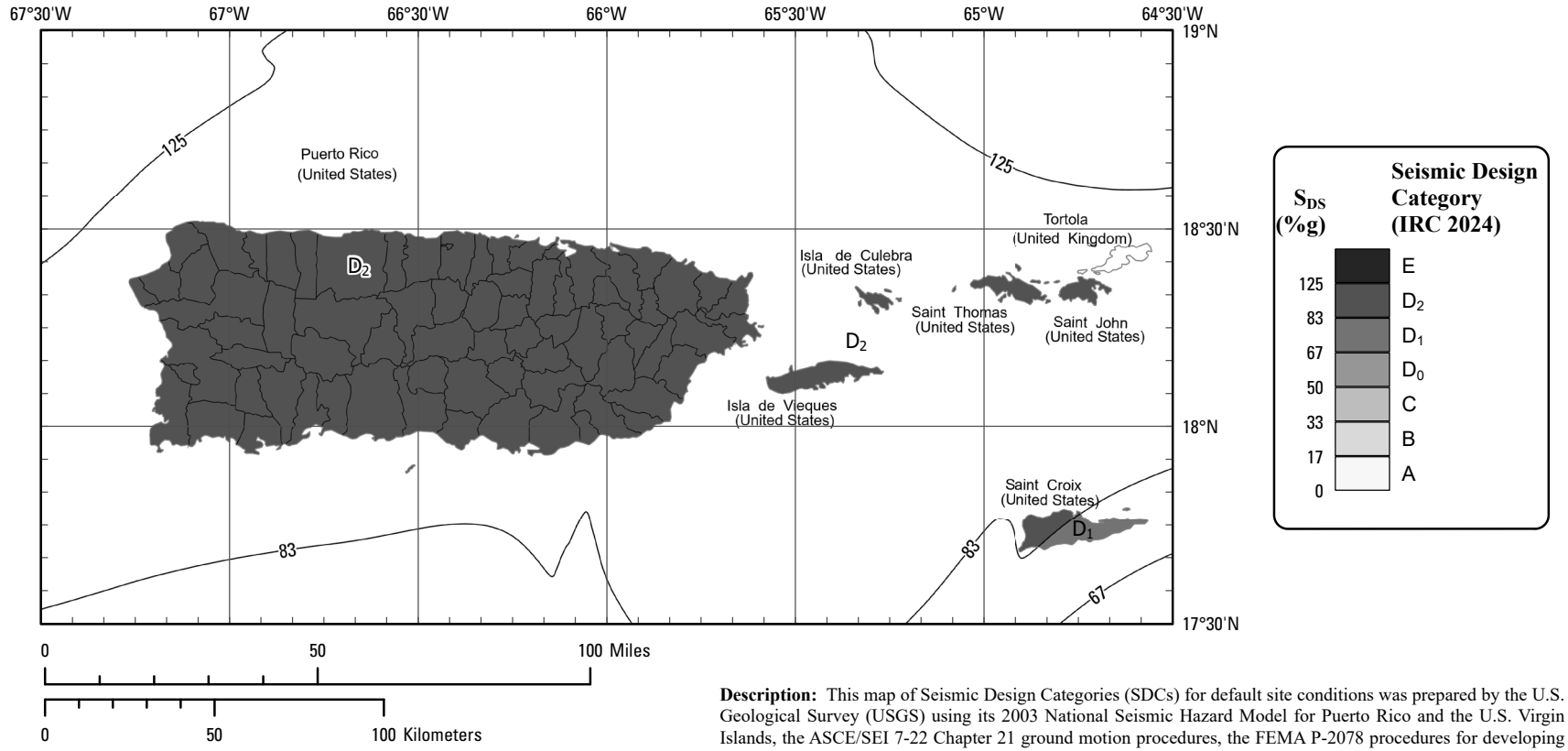
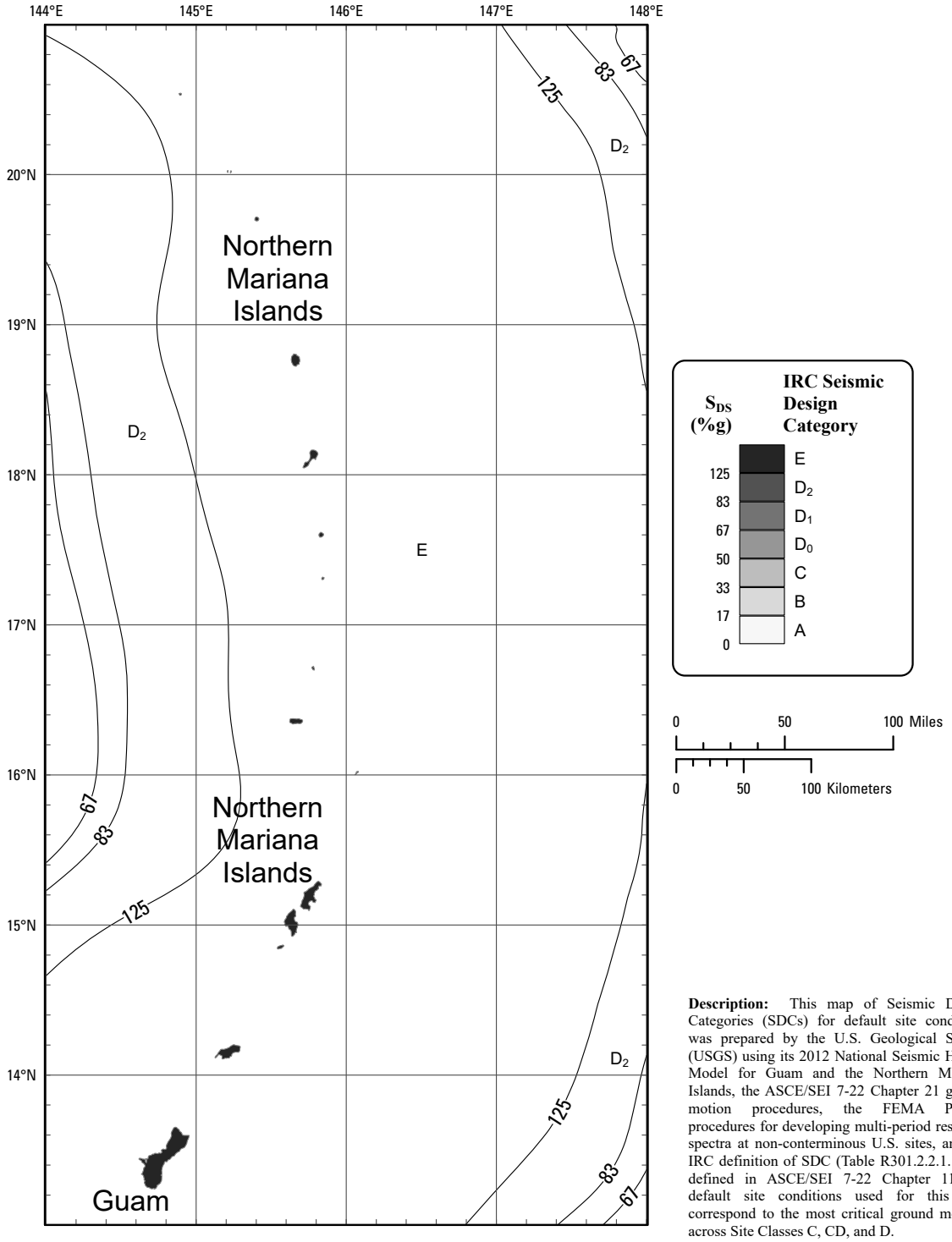


Figure 11. Seismic Design Category Map for 2024 IRC - Hawaii (Black and White)



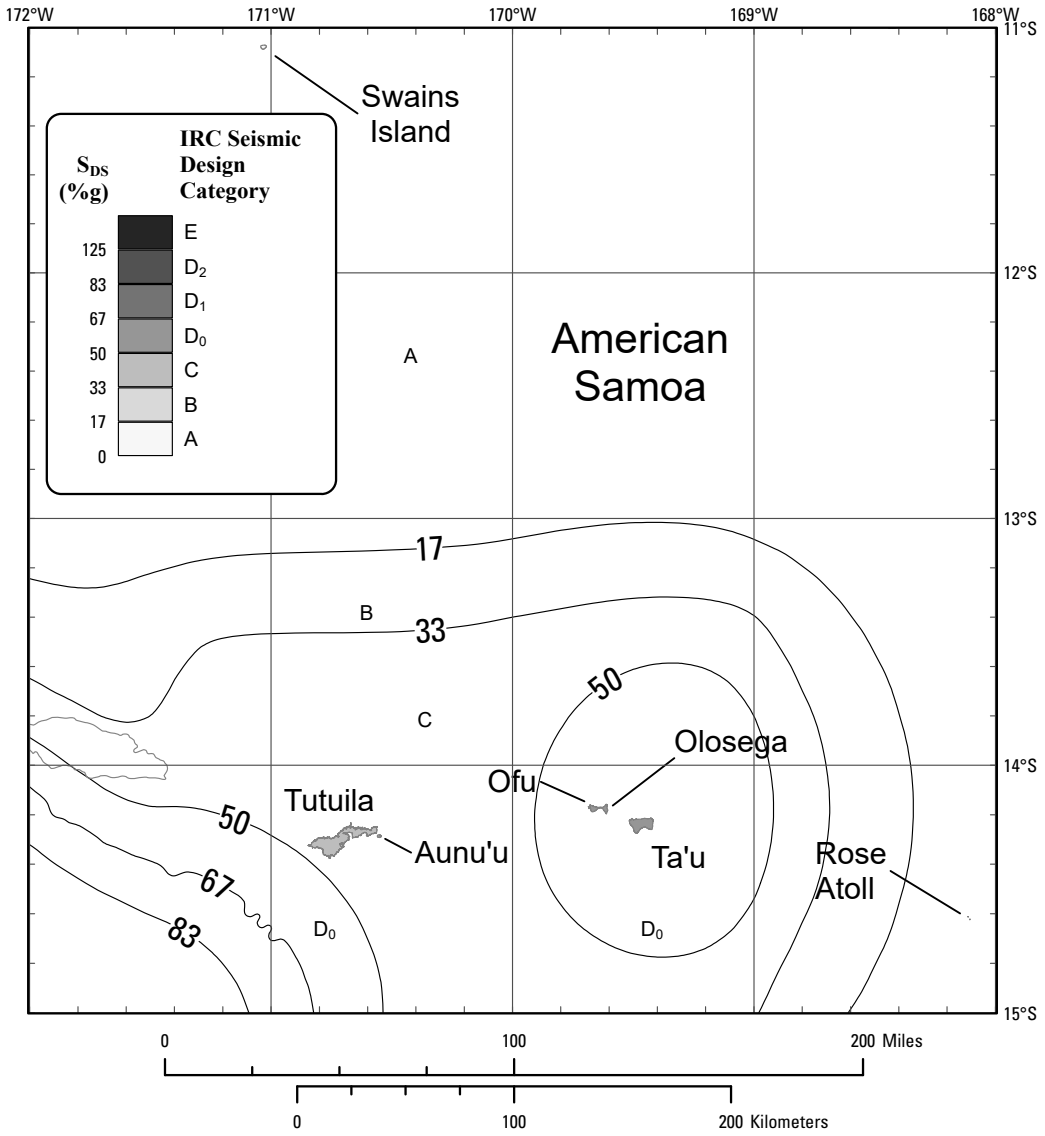
Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2003 National Seismic Hazard Model for Puerto Rico and the U.S. Virgin Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 12. Seismic Design Category Map for 2024 IRC - Puerto Rico and U.S. Virgin Islands (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for Guam and the Northern Mariana Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 13. Seismic Design Category Map for 2024 IRC - Guam and Northern Mariana Islands (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for American Samoa, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the IRC definition of SDC (Table R301.2.2.1.1). As defined in ASCE/SEI 7-22 Chapter 11, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 14. Seismic Design Category Map for 2024 IRC - American Samoa (Black and White)

Seismic Design Category Maps for 2024 IBC (Color)

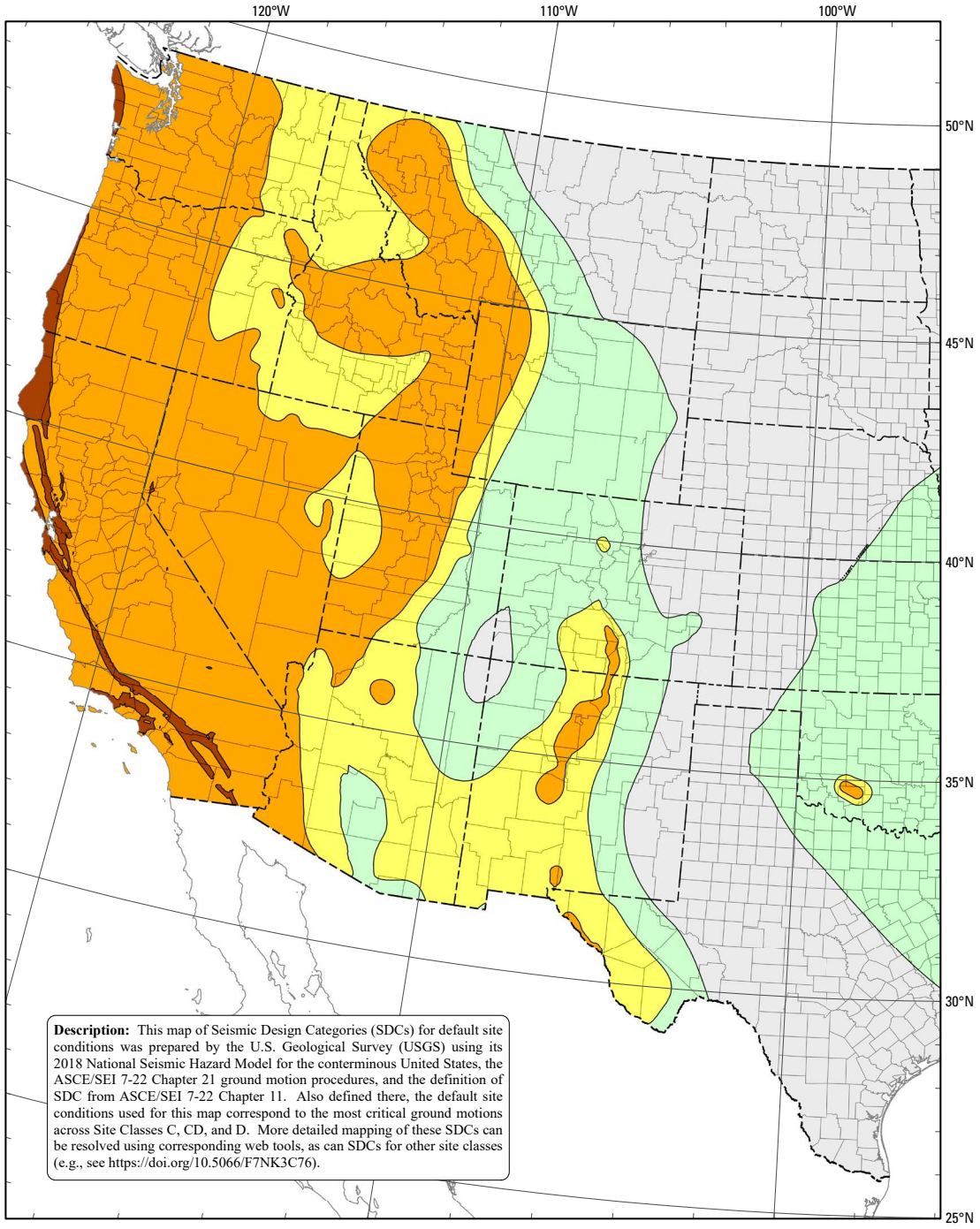


Figure 15. Seismic Design Category Map for 2024 IBC - Western U.S. (Color)

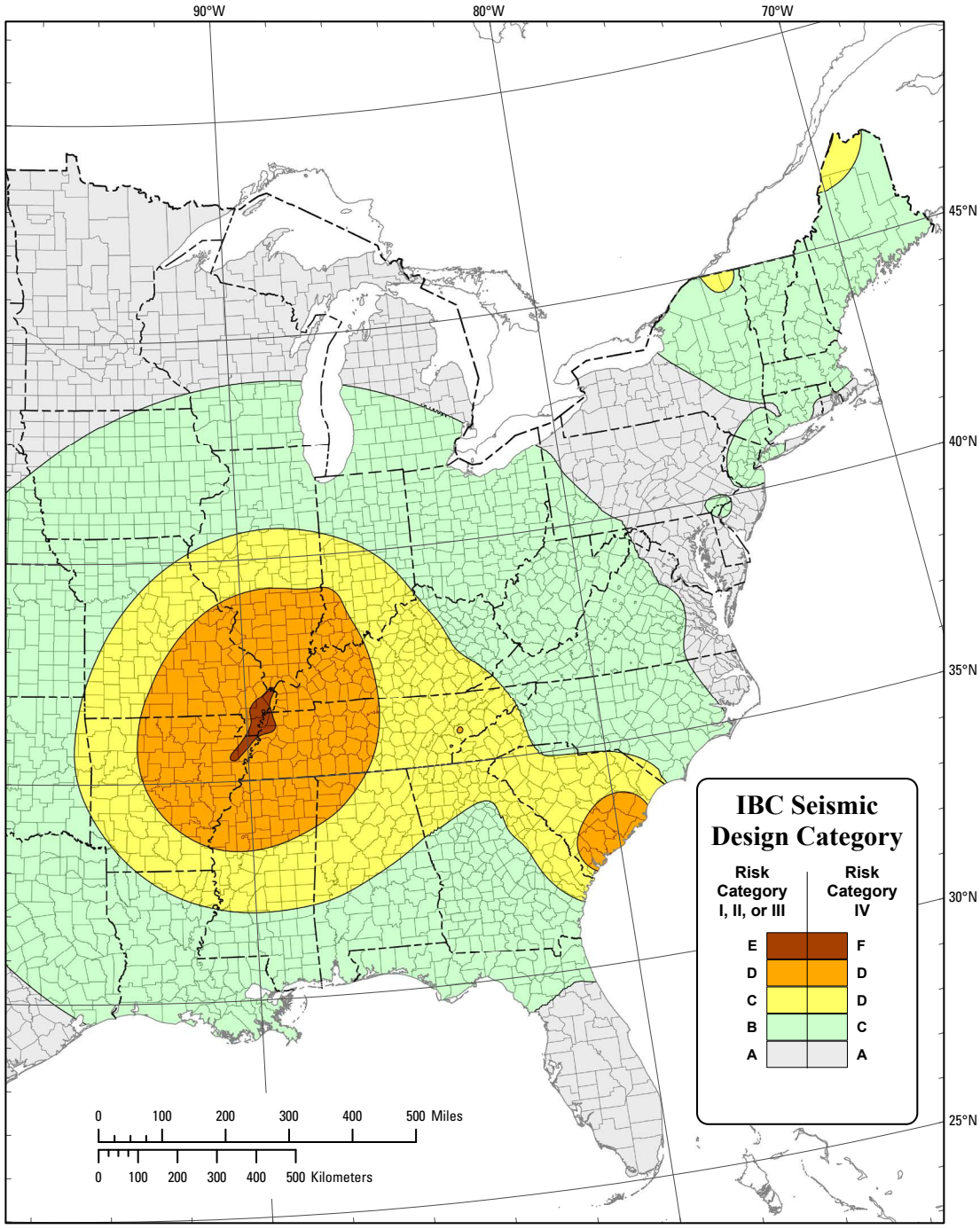
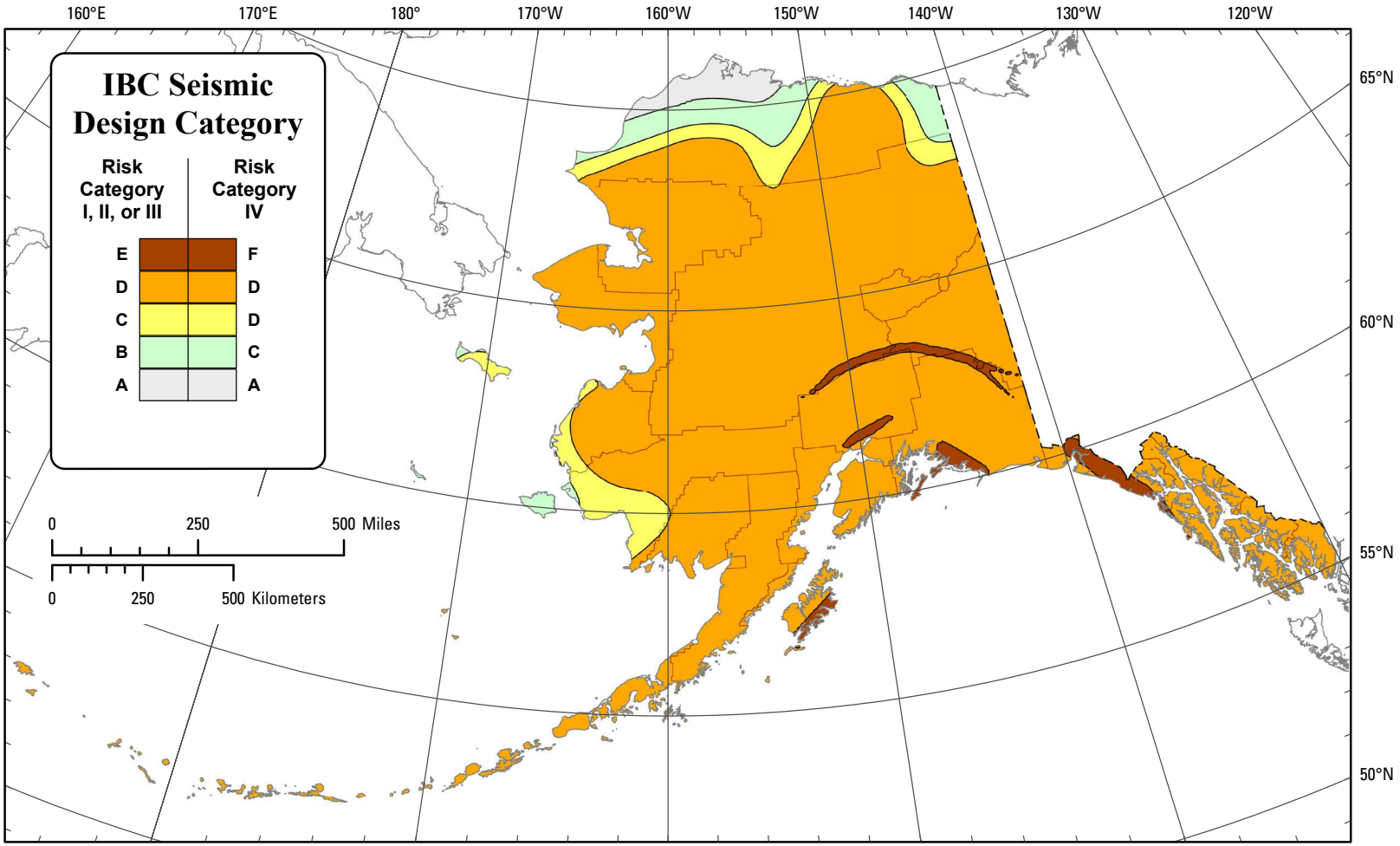


Figure 16. Seismic Design Category Map for 2024 IBC - Eastern U.S. (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2007 National Seismic Hazard Model for Alaska, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools, as can SDCs for other site classes (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 17. Seismic Design Category Map for 2024 IBC - Alaska (Color)

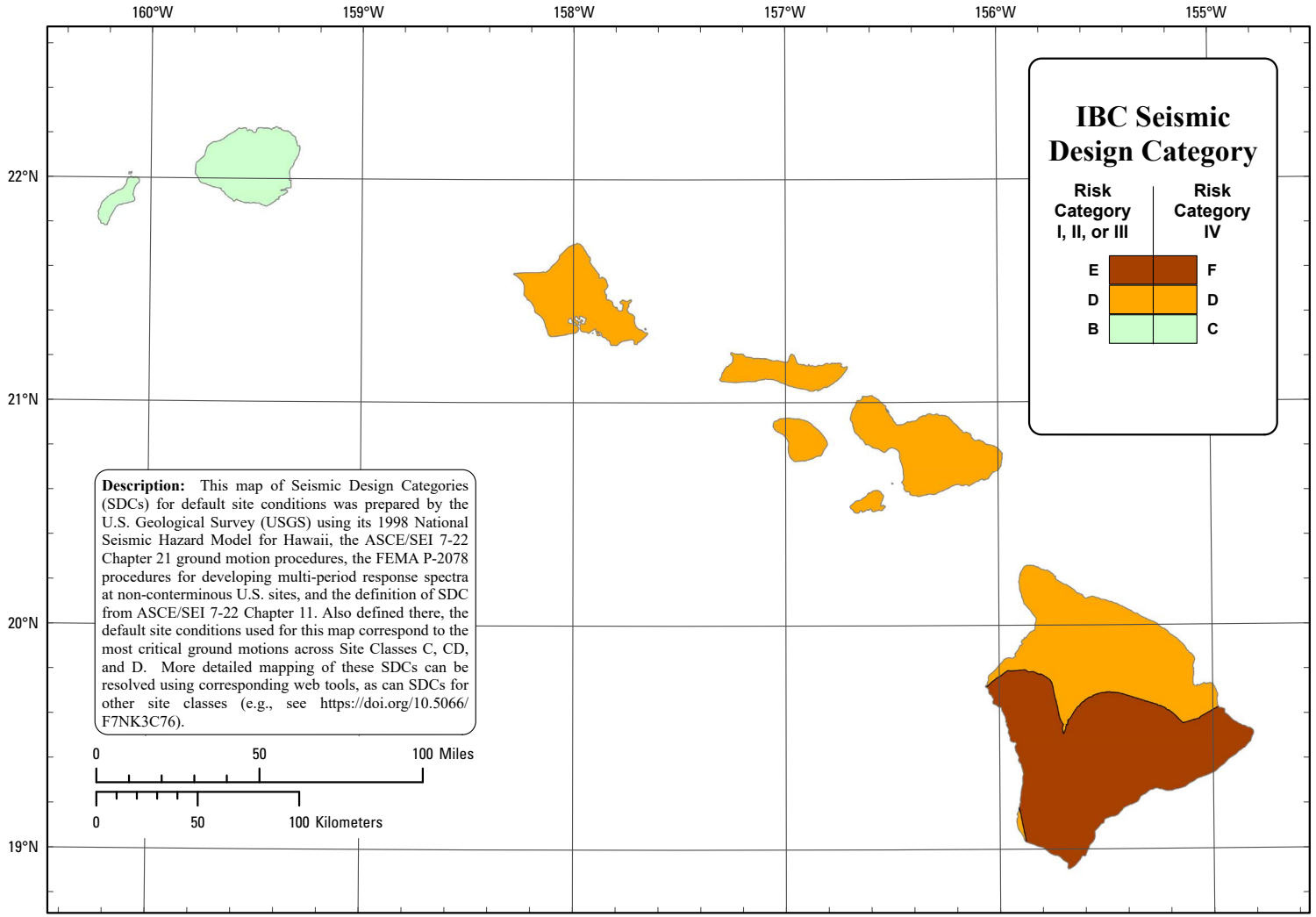
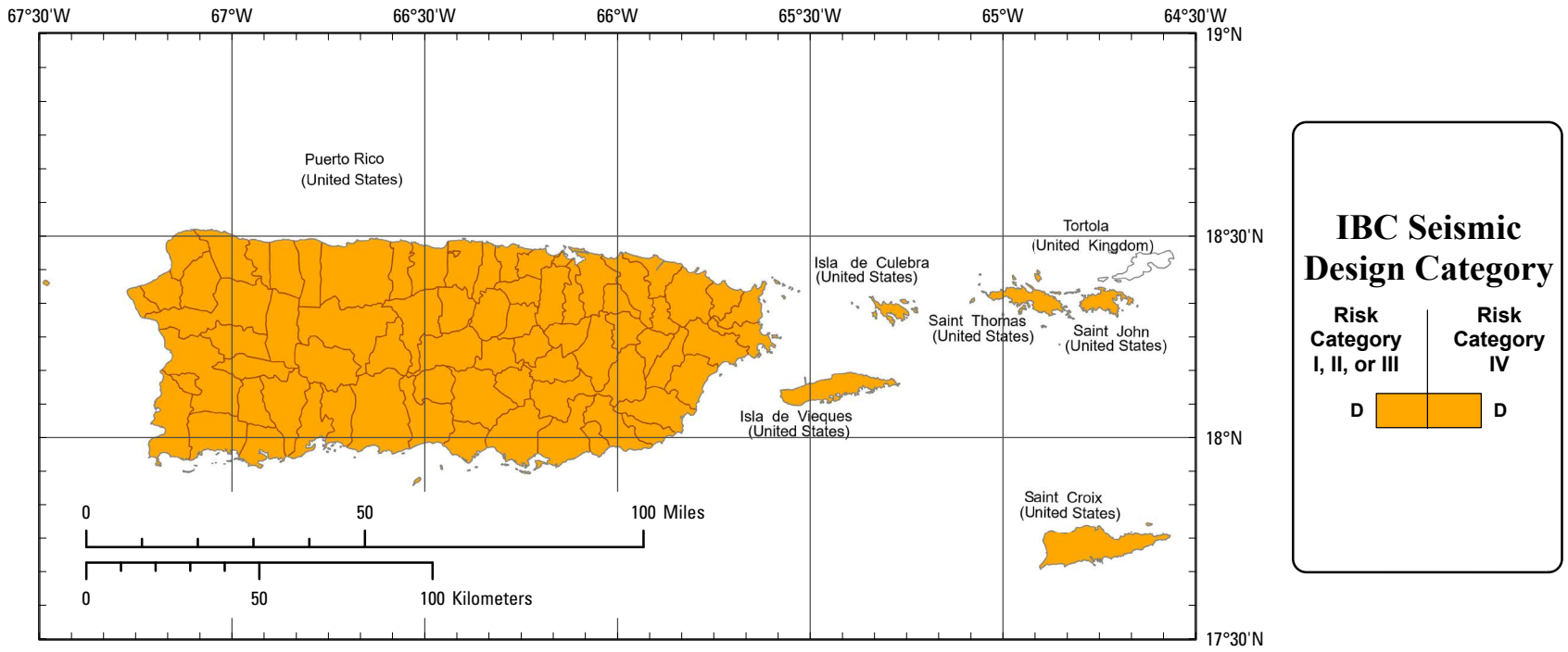


Figure 18. Seismic Design Category Map for 2024 IBC - Hawaii (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2003 National Seismic Hazard Model for Puerto Rico and the U.S. Virgin Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 19. Seismic Design Category Map for 2024 IBC - Puerto Rico and U.S. Virgin Islands (Color)

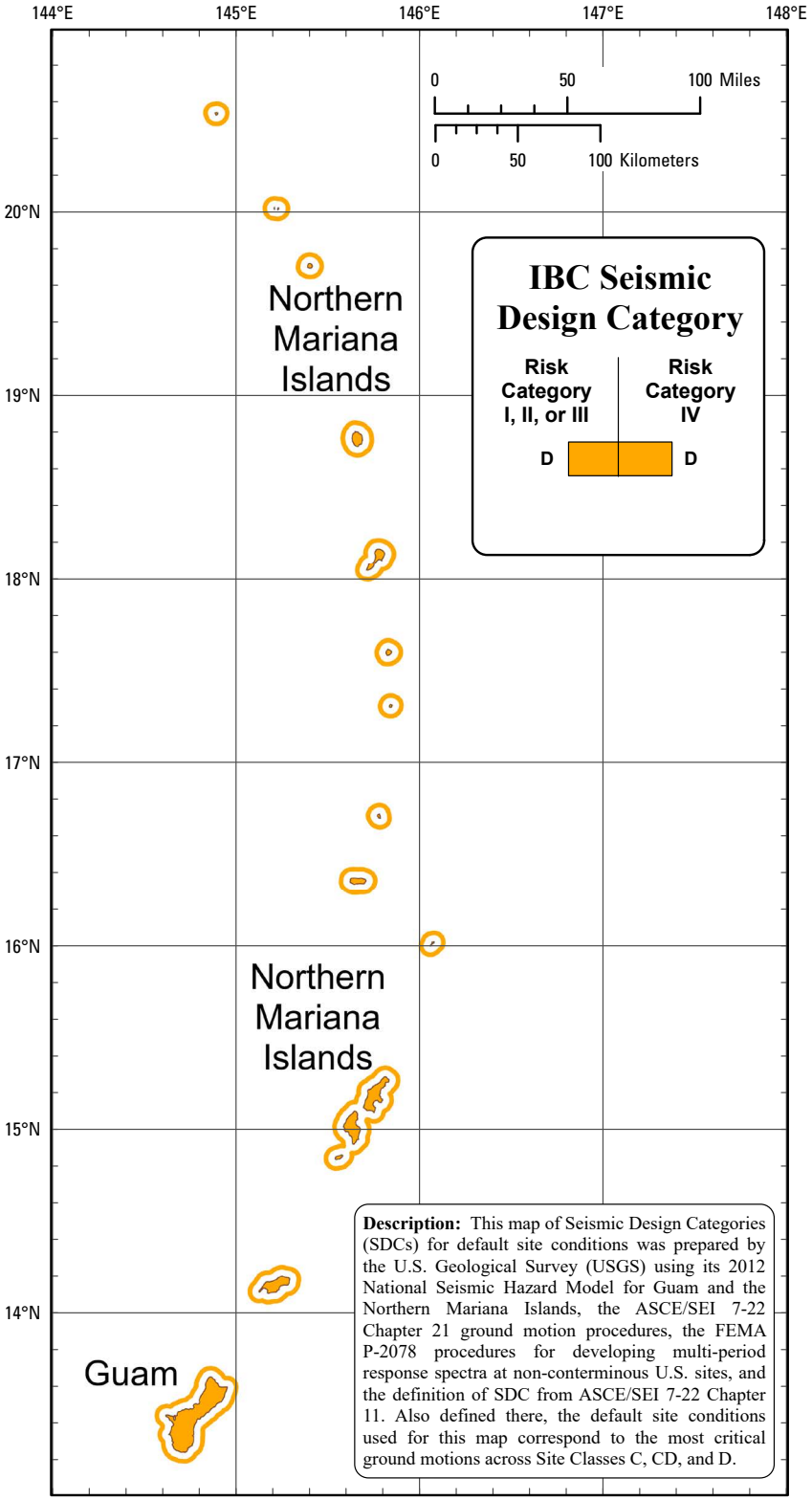
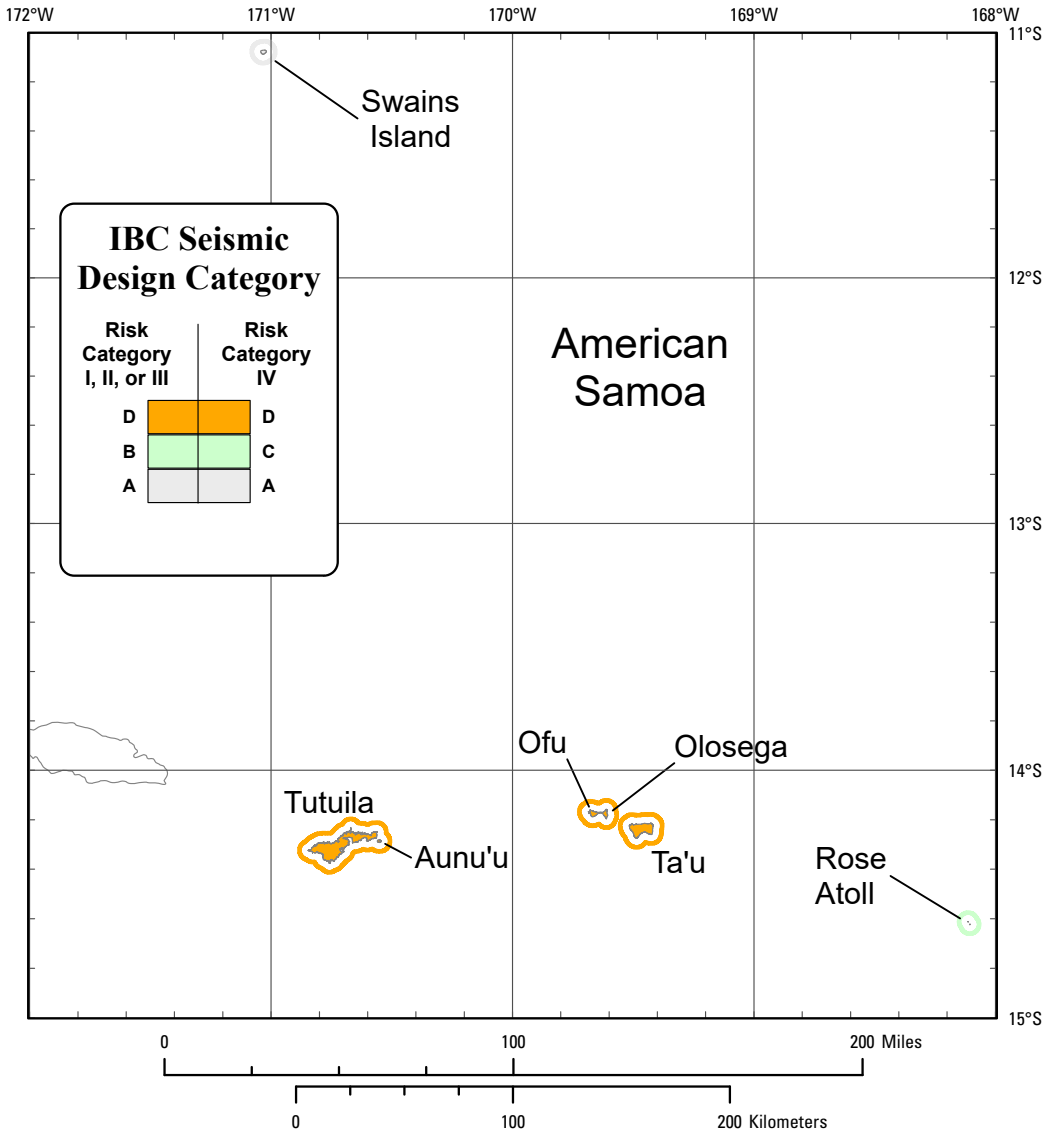


Figure 20. Seismic Design Category Map for 2024 IBC - Guam and Northern Mariana Islands (Color)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for American Samoa, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 21. Seismic Design Category Map for 2024 IBC - American Samoa (Color)

Seismic Design Category Maps for 2024 IBC (Black and White)

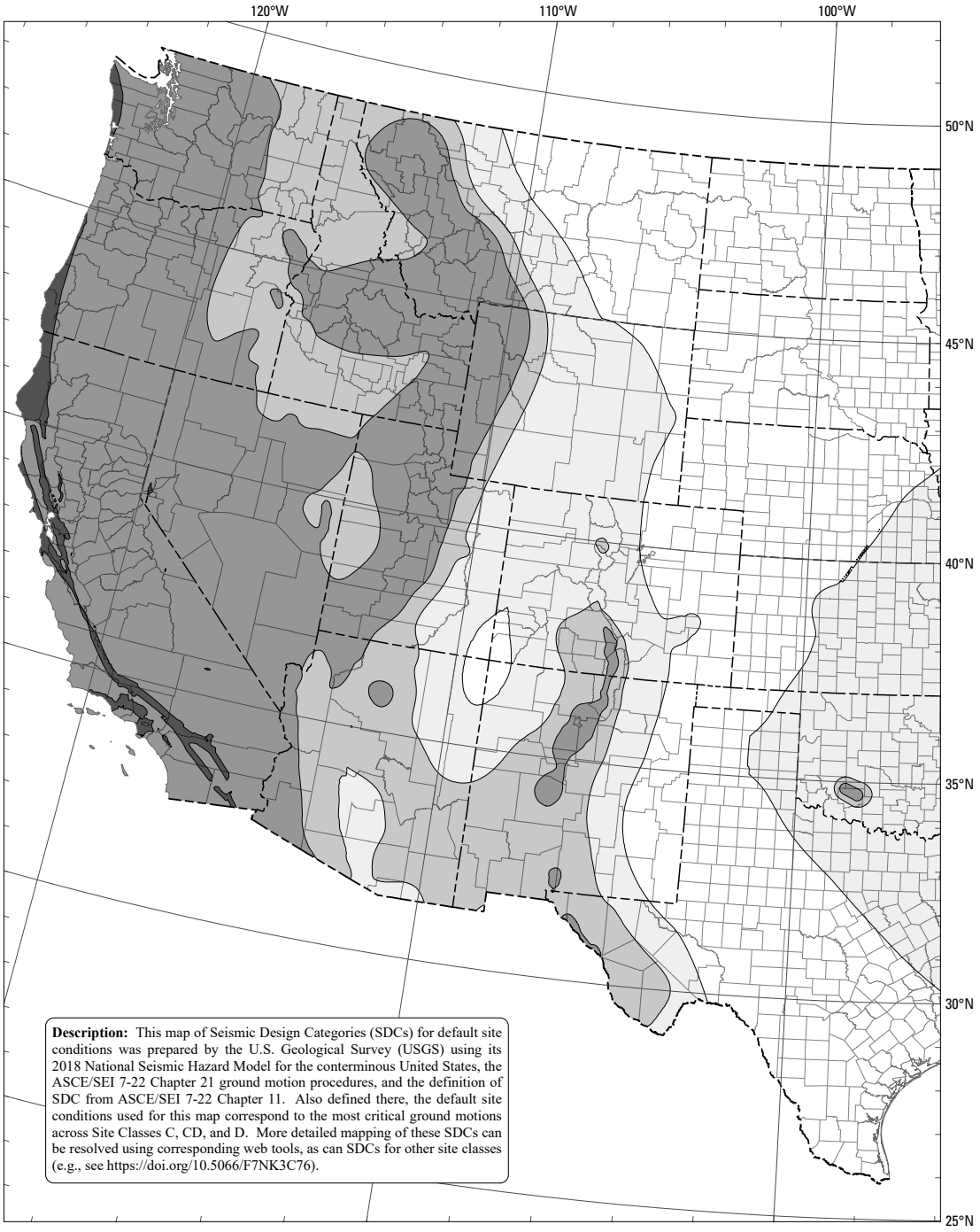


Figure 22. Seismic Design Category Map for 2024 IBC - Western U.S. (Black and White)

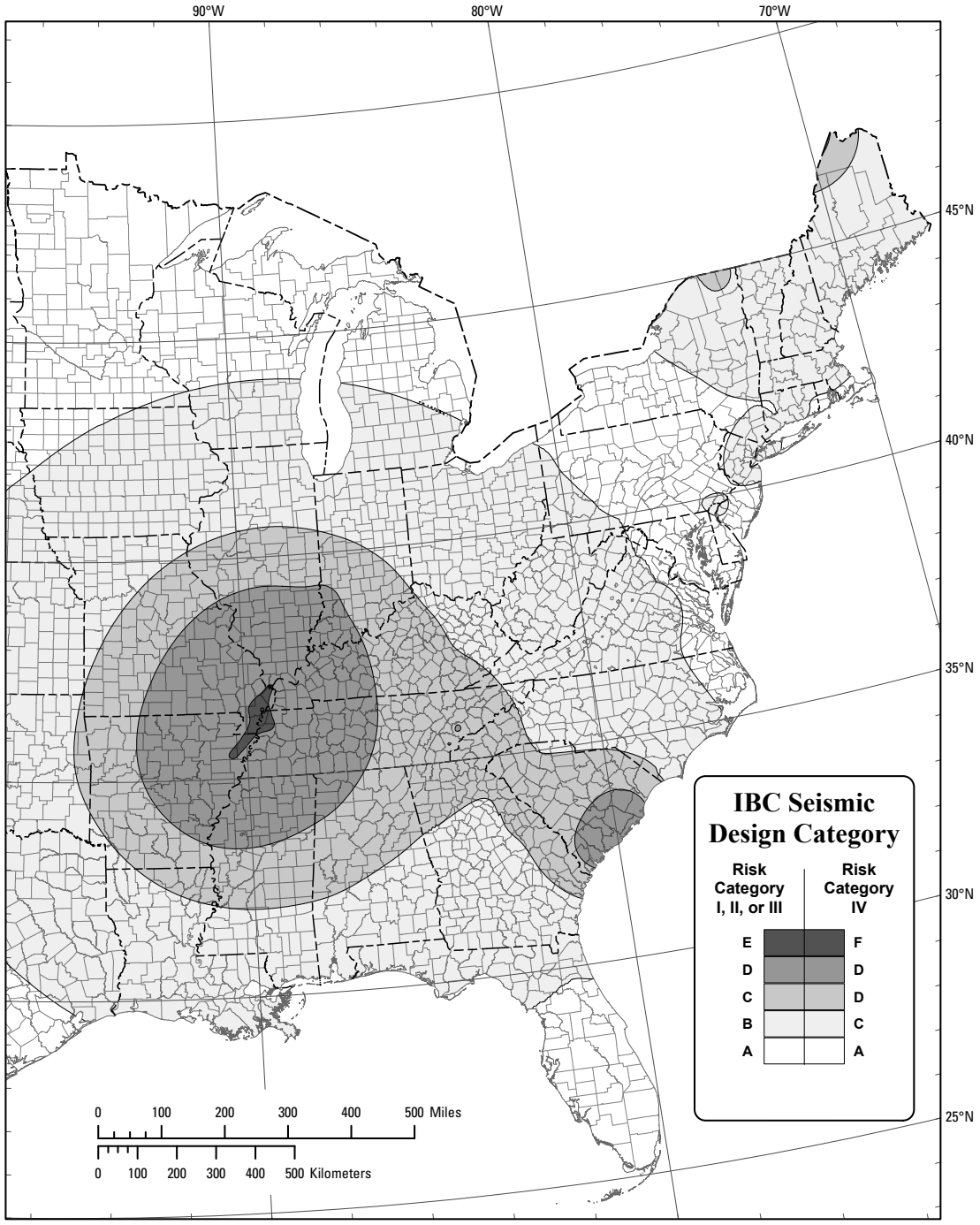
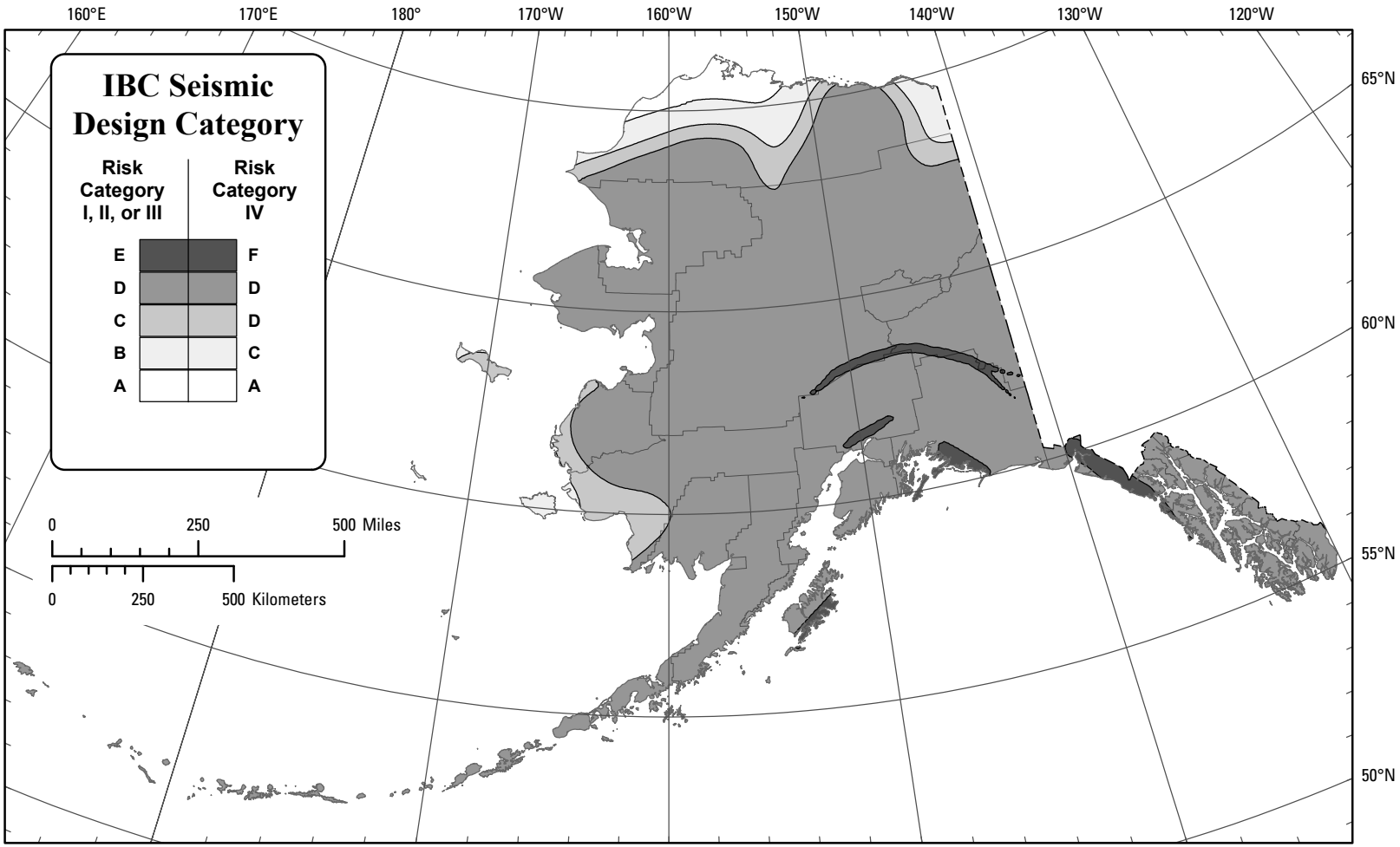


Figure 23. Seismic Design Category Map for 2024 IBC - Eastern U.S. (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2007 National Seismic Hazard Model for Alaska, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D. More detailed mapping of these SDCs can be resolved using corresponding web tools, as can SDCs for other site classes (e.g., see https://doi.org/10.5066/F7NK3C76).

Figure 24. Seismic Design Category Map for 2024 IBC - Alaska (Black and White)

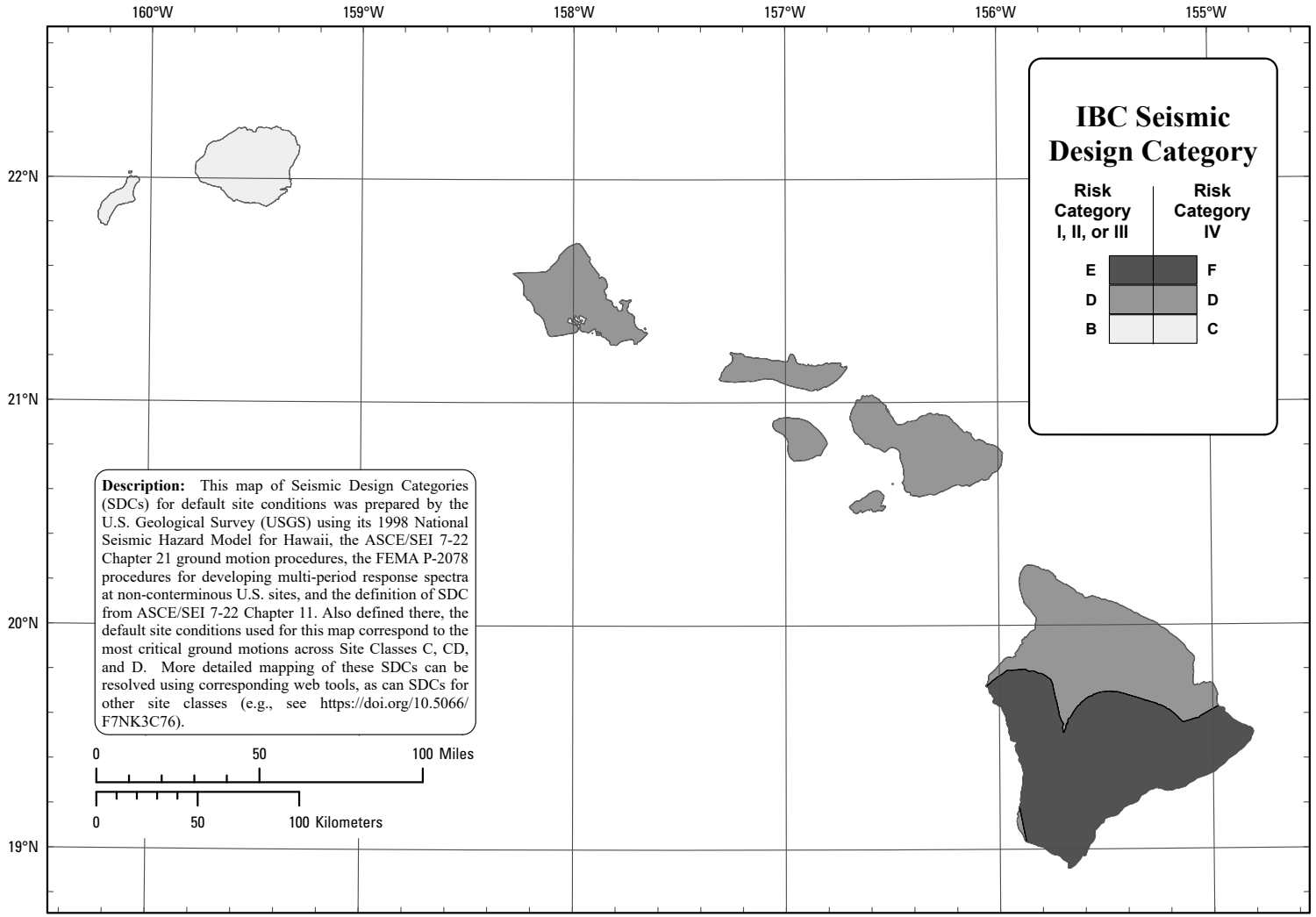
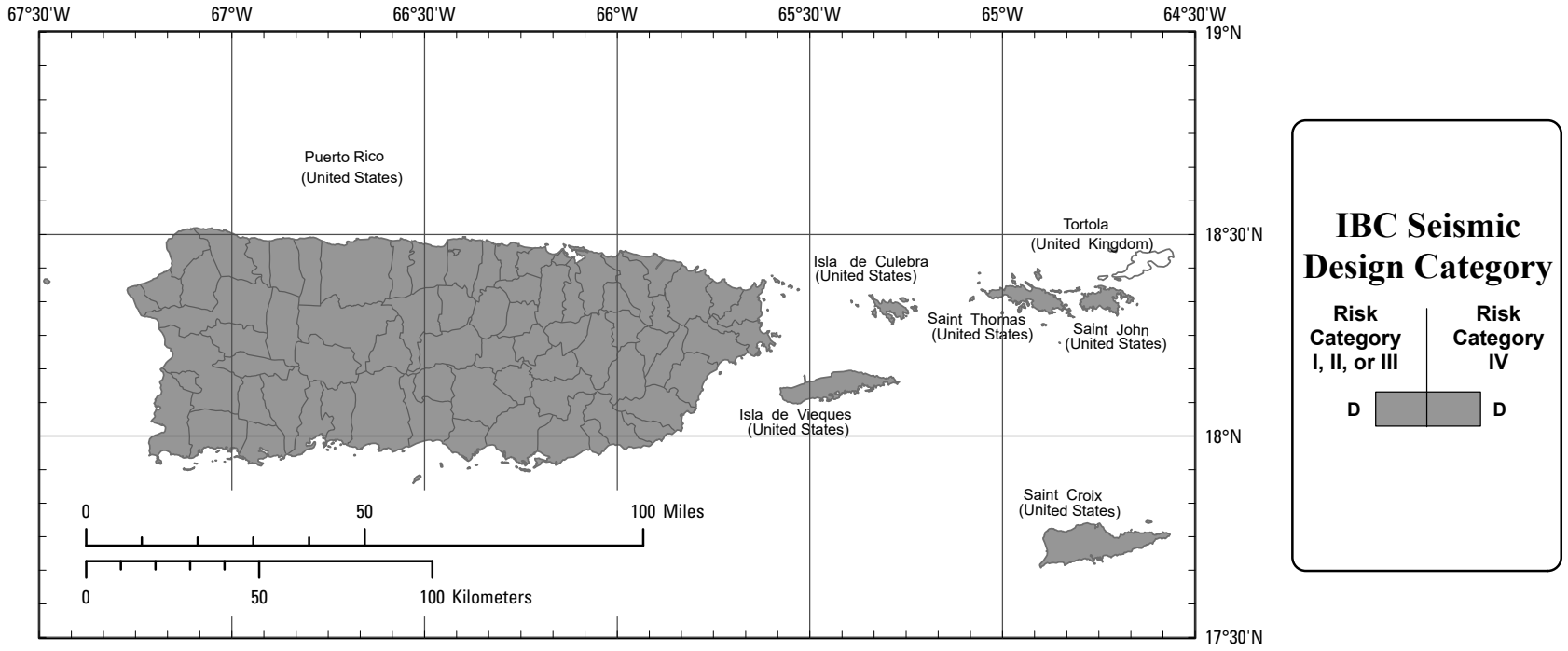


Figure 25. Seismic Design Category Map for 2024 IBC - Hawaii (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2003 National Seismic Hazard Model for Puerto Rico and the U.S. Virgin Islands, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 26. Seismic Design Category Map for 2024 IBC - Puerto Rico and U.S. Virgin Islands (Black and White)

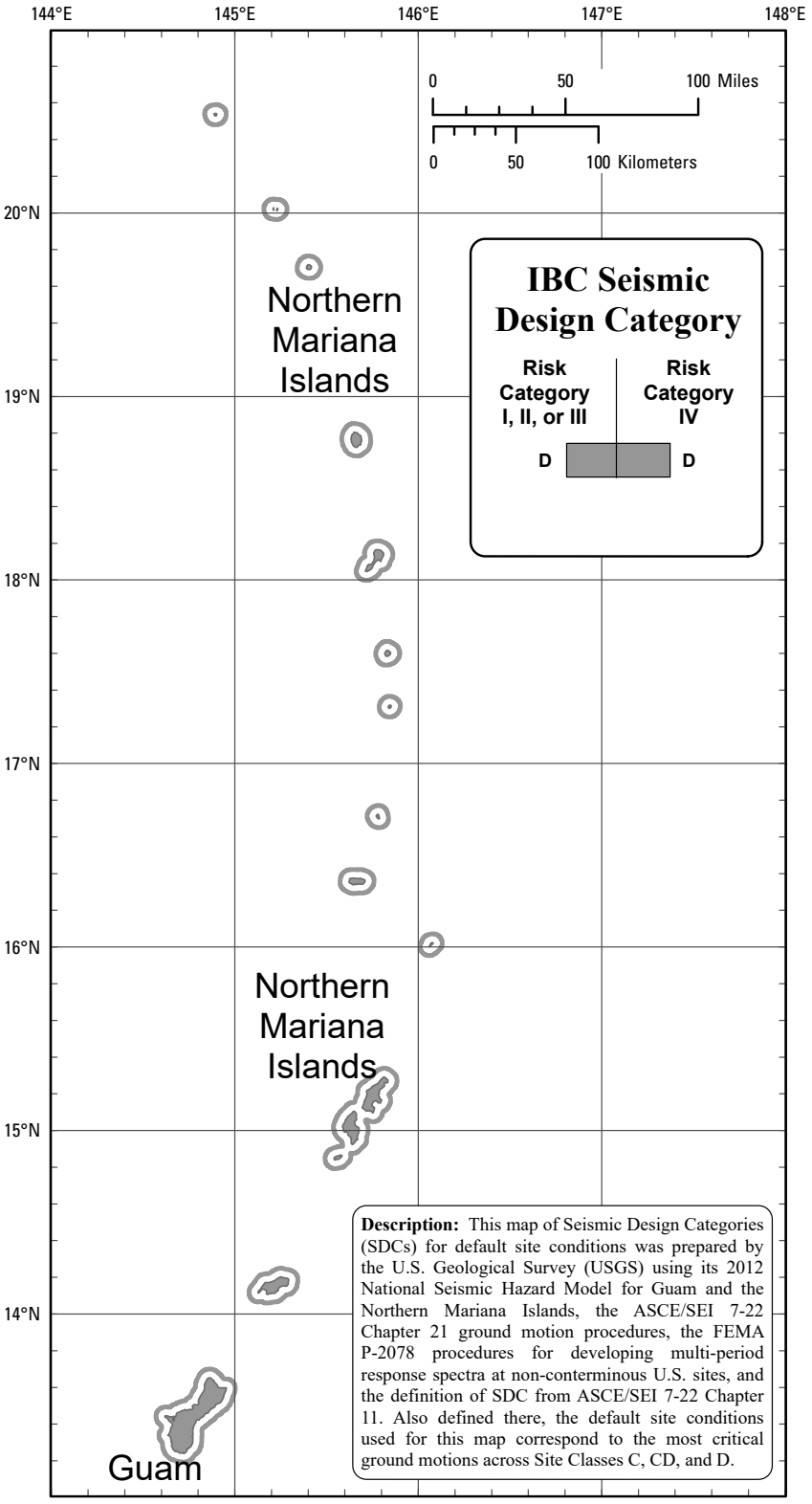
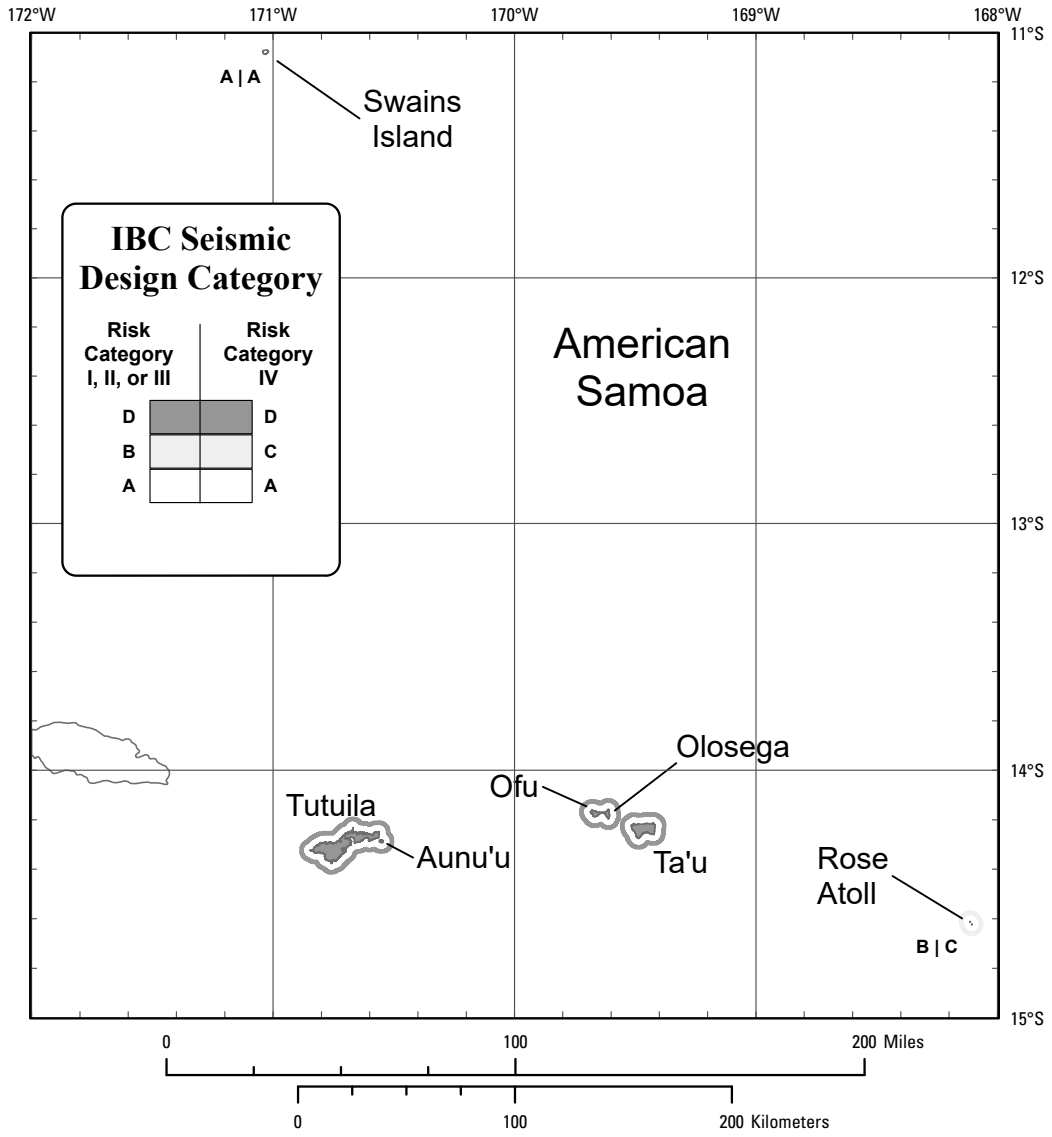


Figure 27. Seismic Design Category Map for 2024 IBC - Guam and Northern Mariana Islands (Black and White)



Description: This map of Seismic Design Categories (SDCs) for default site conditions was prepared by the U.S. Geological Survey (USGS) using its 2012 National Seismic Hazard Model for American Samoa, the ASCE/SEI 7-22 Chapter 21 ground motion procedures, the FEMA P-2078 procedures for developing multi-period response spectra at non-conterminous U.S. sites, and the definition of SDC from ASCE/SEI 7-22 Chapter 11. Also defined there, the default site conditions used for this map correspond to the most critical ground motions across Site Classes C, CD, and D.

Figure 28. Seismic Design Category Map for 2024 IBC - American Samoa (Black and White)

Acknowledgments

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