Structural Engineers Association of Colorado (SEAC)
Wind Loads Committee

March 6, 2025

Recommendations Relating to the ASCE 7-22 Wind and Tornado Load Provisions as Referenced in the 2024 IBC and IRC

The 2024 International Building Code (IBC) and the 2024 International Residential Code (IRC) reference ASCE 7-22 for the determination of design wind loads. The wind load provisions of ASCE 7-22 contain significant changes relative to the prior edition (ASCE 7-16) that impact design in and around the Colorado Special Wind Region (SWR). SEAC has provided resources and guidance for wind design within the Colorado SWR using the prior editions of the ASCE 7 standard. To resolve unanswered questions relating to the evolution and application of ASCE 7-22 in Colorado, the SEAC Wind Loads Committee has identified a need for a revised Colorado wind study. This study is currently being commissioned and is being funded by SEAC members, industry partners, local municipalities, and awards including a FEMA BRIC grant and a grant from the NCSEA Foundation. This document provides background and interim recommendations until more detailed and comprehensive guidance becomes available. An abbreviated summary of these recommendations begins on page 5.

Colorado Front Range Gust Map

The Colorado Front Range Gust Map was first introduced in 2006 for use with ASCE 7-02 and 7-05 and contained 50-year recurrence wind speed contours for Front Range communities from Sedalia north to the Wyoming border. This map was based on historical surface measurements and was targeted at mean recurrence intervals up to 100 years. The Gust Map was updated in 2013 to be used with ASCE 7-10, which utilized wind maps with recurrence intervals of 700 years (Risk Category II), 1700 years (Risk Categories III & IV) and 300 years (Risk Category I) in Chapter 26. Changes in ASCE 7-16 and 7-22 that impact use of the 2013 Gust Map include:

- Alterations to the boundaries of the Colorado SWR
- Wind speed map contour changes that reduce design wind speeds throughout the Rocky Mountain Region
- Adding a new wind speed map for Risk Category IV structures with a 3000 year recurrence interval
- Incorporation of the ASCE Wind Design Geodatabase (Accessed via the online ASCE 7 Hazard Tool) for determination of location-specific wind speeds, including within portions of the Colorado SWR

Colorado Special Wind Region

The boundaries of the Colorado Special Wind Region were changed in ASCE 7-16 to resolve a graphical inconsistency unintentionally introduced between ASCE 7-93 and ASCE 7-95. This had the effect of relocating Colorado's Special Wind Region to the west, excluding significant areas to the east of the foothills that were previously included and including some areas to the west that were previously excluded. ASCE 7-22 and the 2024 IBC and IRC have since amended the eastern boundary of the SWR north of Sedalia to follow the eastern border of the Colorado Front Range Gust Map. While this change corrects the boundaries for the northern Front Range communities that are included in the 2013 Gust Map, it excludes numerous southern Front Range communities with well-documented histories of high wind speeds resulting from the downslope winds that the SWR is intended to address. Use of the ASCE 7-22 Colorado SWR boundaries south of Sedalia to the New Mexico border may therefore result in unconservative designs along the eastern margin of the SWR.

The limits of the SWR south of Sedalia have never been substantiated by any rigorous or comprehensive regional wind study. The SEAC Wind Loads Committee is currently working to commission a revised Colorado wind study that will establish meaningful and accurate boundaries for the SWR and provide updated reliability-based design wind speeds, utilizing the most current data and methodologies, spanning the entire Colorado SWR. However, many Colorado communities will be adopting the 2024 IBC and IRC prior to completion of this study. In the interim, the SEAC Wind Loads Committee has developed recommendations for supplemental boundaries to the SWR to incorporate known and suspected areas of potentially extraordinary winds from Sedalia south to the New Mexico border. The recommended interim eastern boundary generally follows Interstate I-25 and/or the eastern SWR boundary published in ASCE 7-10. Appendix A provides an annotated map showing the historical evolution of the SWR boundaries in Colorado and the interim supplemental boundaries recommended by the SEAC Wind Loads Committee.

ASCE Wind Design Geodatabase / Online ASCE 7 Hazard Tool

The 2024 IBC, IRC, and ASCE 7-22 now explicitly reference the ASCE Wind Design Geodatabase for determination of site-specific design wind speeds, including within the Colorado SWR. The online ASCE 7 Hazard Tool (https://asce7hazardtool.online) is also referenced as the primary means to access the database, "or approved equivalent." The SEAC Wind Loads Committee has found the output of the ASCE 7 Hazard Tool to vary in its content and presentation over time, such that it should be regarded as a work in progress. It is further evident that modifications to the tool have, at times, not been subject to the same process of committee review or deliberation as is the body of the standard. Therefore, while the tool may provide a helpful and convenient interpretation of the wind hazard for a given site, it should not be regarded as the definitive guidance for sites in or around the Colorado SWR. In all cases, the Authority Having Jurisdiction (AHJ) has final authority to determine the wind design criteria, and the online hazard tool does not reference or report the criteria legally adopted by each jurisdiction. The AHJ's local amendments must therefore be consulted to determine the applicable design requirement.

Currently, the Online ASCE 7 Hazard Tool incorporates the Colorado Gust Map geodata for sites within the ASCE 7-22 SWR north of Sedalia and generally provides appropriate design wind speeds from there north to the Wyoming border and west to the continental divide. However, the hazard tool currently has several significant limitations that should be understood by anyone using it in or around the Colorado SWR:

- The boundaries of the SWR act as hard lines between the Colorado Gust Map data and the ASCE 7-22 wind speed map. No interpolation at the SWR boundary is performed and interpretation of values along these boundaries is left to the discretion of the user.
- The Colorado Gust Map extended westward only to the continental divide where mapped wind speeds reach a maximum. With the ASCE 7-22 SWR extending west of the Continental Divide, the hazard tool currently applies the maximum wind speed from the Continental Divide to the western SWR boundary for latitudes north of Sedalia.
- Within the entire boundaries of the SWR the hazard tool provides design wind speeds along with a notification that the site is within the SWR. North of Sedalia, the Colorado Gust Map wind speeds are reported, while south of Sedalia the ASCE 7-22 mapped wind speeds are reported. No warning or distinction is provided to differentiate wind speeds within the SWR that are based upon the Colorado Gust Map geodata versus those that are taken from the ASCE 7-22 mapped values that do not account for the effects of the local wind climate.
- The hazard tool implements the eastern boundary of the SWR as published in ASCE 7-22 south of Sedalia, which as outlined above, is erroneously located too far west to encompass known areas of downslope winds along the southern portions of the Front Range.

Altitude Air Density Adjustment

ASCE 7-16 and 7-22 include a ground elevation factor to adjust for air density, K_e, that has been incorporated by reference in the 2018 through 2024 IBCs. Prior to incorporation of the ground elevation factor in ASCE 7-16, wind pressures were commonly reduced in Colorado by engineers using reference tables in the commentary of ASCE 7-10 and earlier, as allowed with either formal or tacit approval from AHJs.

The 2024 IRC, consistent with prior editions, does not incorporate an adjustment for air density at elevation. The SEAC Wind Load Committee has inquired with multiple members of the IRC code development committee, and it is our understanding that the decision to forgo an air density adjustment factor was motivated by a desire for simplicity and not due to technical engineering concerns should such a factor be incorporated into the IRC design provisions. It is possible to account for air density using the K_e factor in combination with the IRC wind bracing and pressure tables by using an equivalent design wind speed at sea level (V_e) calculated from the applicable basic design wind speed at elevation (V) using the following equation:

$$V_e = V\sqrt{K_e}$$

The designer may then use V_e throughout the IRC for determination of wind pressure and wall bracing requirements that are reduced for air density at elevation. It is the opinion of the SEAC Wind Load Committee that this methodology provides a rational and appropriate approach to wind design using the IRC in Colorado.

Winter Windiness

As incorporated and referenced in the 2024 IBC, ASCE 7-22 Chapter 7 has new snow drift load provisions that incorporate a winter wind parameter (W_2) that is based on analyses of the percent of the time that wind speed is above 10 mph during the months of October through April. Figure 7.6-1 that has been included in ASCE7-22 provides mapped values of the winter wind parameter that range across Colorado from a value of 0.55 along the Kansas border to 0.25 on the southwestern slope. This variation in winter windiness across Colorado results in approximately a factor of 2 difference in the magnitude of drift loads calculated on one side of the state versus the other, all other things being equal. However, the ASCE 7-22 Commentary elaborates that the winter wind parameter was developed based upon data from airport weather stations, none of which were located in the Colorado SWR or above tree line. At locations above tree line or within SWRs, the commentary suggests basing the winter wind parameter on any available weather records.

There is currently insufficient research available to provide general guidance on the relationship between winter windiness and snow drifting in the area of the Colorado SWR. While detailed study may indicate higher frequency of elevated winter winds along the foothills, the specific wind effects responsible for the designation of the SWR are downslope (westerly) winds, which tend to be dry and are rarely associated with significant snowfall. By contrast, significant snow events along the Colorado Front Range are usually associated with upslope (northerly and/or easterly) winds that deposit their moisture upon encountering the elevated foothills terrain from the opposite direction. Therefore, an association between perennial downslope winter windiness and snow drifting is not well established within this region. Local experience has typically been that drifting effects become more significant (and associated structural failures historically more prevalent) as one travels east toward the Kansas border, which is consistent with the trend in the mapped values of the winter windiness parameter provided by ASCE. As you ascend into the mountains, ground snow loads steeply increase, and the effects of drift loading become less critical.

Due to the lack of available research on the topic at this time, the SEAC Wind Load Committee is unable to provide definitive technical guidance on the effects of winter windiness as it relates to snow drifting in and around the Colorado SWR. Based upon our review of a limited number of representative sites, we note that drift design load demands will tend to increase with use of ASCE 7-22 on the eastern plains while decreasing along and west of the Front Range using the winter windiness parameters as currently mapped by ASCE. Given the historic prevalence of drift-related failures on the eastern plains, the associated increase in drift loads in that region is likely appropriate. It is currently unsubstantiated whether associated decreases in drift loads are appropriate along and west of the Front Range. We recommend that practitioners and AHJs consider the following when evaluating what winter windiness parameters to consider while using ASCE 7-22 on sites in and around the Colorado SWR:

- Historic local weather patterns, observations, and/or data.
- The historic prevalence of structural performance issues related to snow drifting.
- Comparison of ASCE 7-22 drift loads with those that have previously been used for design in the area.
- Reference to case-specific studies, comparisons, and/or regional subject matter expertise.

Tornado Design

Newly introduced in ASCE 7-22 is a chapter specifying Tornado Loads (Chapter 32) for tornado-prone regions, which are defined generally as all areas of the United States east of the Continental Divide. Historically, design for tornadoes has not been required in the United States except for special structures such as nuclear facilities and storm shelters, despite the annual damage to human life and property from tornadoes regularly exceeding that from tropical storms and hurricanes combined. Tornado design has long been considered unnecessary from the perception that tornadoes are spatially limited and that the chance of impacting a building is therefore negligibly low. However, tornadic activity has been shown to occur more commonly than previously thought, and a rigorous reliability assessment indicates that tornado pressures may actually control design for some larger buildings. Accordingly, the new provisions seek to provide increased tornado resilience for certain larger and higher importance structures that pose higher risk and consequences from tornado damage. Tornado design is required exclusively for Risk Category III and IV structures above a threshold footprint area. The tornado design provisions do not set out to make such buildings as robust as storm shelters, which are expected to hold up to rare and extreme tornadoes, but rather to improve the resiliency of these buildings to more common small and moderate storms. It should be emphasized that ICC 500 is still the reference document for design requirements for tornado shelters, whether or not these shelters are located in buildings for which ASCE Chapter 32 tornado design is required.

Due to the limited applicability to higher risk category structures having larger footprints, most structures will still not be required to be designed for tornadoes. For more information, refer to the National Council of Structural Engineers Associations (NCSEA) Structural Engineering for Tornados FAQ at www.ncsea.com/app/uploads/2024/02/NCSEA-Tornado-FAQ.pdf and ASCE 7-22 Chapter 32.

Interim Recommendations

The Wind Loads Committee offers the following summary of our interim recommendations regarding the changes in ASCE 7-22 that impact wind design in the 2024 IBC and IRC.

- **Design wind speeds for jurisdictions within the limits of the area covered by the 2013 Colorado Front Range Gust Map should continue to be determined using the wind speed contours presented in that report.** This report continues to provide the most accurate and applicable wind design criteria along the Colorado Front Range north of Sedalia. The continued use of the 2013 Gust Map contours is justified in accordance with ASCE 7 Section 26.5.3, which allows the use of appropriate regional climatic data to determine design wind speeds. If desired, continuity along the eastern edge of the Front Range can be achieved by interpolating between the 115 mph contour for Risk Category II structures in the 2013 Gust Map and the 110 mph contour in ASCE 7-22. We recommend that communities within the limits of this study amend their codes to reference, “Colorado Front Range Gust Map – ASCE 7-10 Compatible, dated November 18, 2013,” for their design wind speeds. This report is publicly available on the SEAC website, currently at the following web address: https://seacolorado.org/docs/FINAL-COLORADO-FRONT-RANGE-GUST-MAP-2013.pdf.

- **Design wind speeds for Risk Category IV structures should be based on the following table:**

50 Yr Gust Speed* (Risk Category II)	700 Yr Gust Speed (Risk Category II)	3000 Yr Gust Speed (Risk Category IV)
90	115	125
100	125	140
110	140	155
120	150	170
130	165	185
140	175	195
180	225	255

*V_{ASD} (for reference and comparison with ASCE 7-05 and earlier

- **The boundaries of the Front Range Special Wind Region need to be updated and extended from those shown in IBC 2024/ASCE 7-22.** Addition of the proposed supplemental boundaries in Appendix A resolves unintended inconsistencies and gaps that have developed the ASCE 7 standard. Communities within the supplemental boundaries of the Special Wind Region should take special care in their amendments to strike or amend all IBC and IRC 2024 references that permit use of the wind speed maps in ASCE 7-22; otherwise, use of unconservative wind speeds may be permitted.

- **Use of the ASCE 7 Hazard Tool / Wind Design Geodatabase.** The output of online hazard tools should be treated with caution and always cross-referenced with the AHJ's amendments, the ASCE 7 standard, and the 2013 Colorado Front Range Gust Map. These online tools have been found to report misleading and/or erroneous wind hazards, particularly near the margins of the SWR and along the limits of the Colorado Gust Map geodata. For communities that are contained entirely within the geographical limits of the 2013 Colorado Front Range Gust Map and for those that are located entirely outside of the SWR (including the supplemental boundaries provided in Appendix A) the ASCE 7 Hazard Tool output for ASCE 7-22 has generally been reliable and appropriate. Such communities may find that they can now adopt the building code provisions for wind speed without further amendment except to affirm usage of the ASCE 7 Hazard Tool. For communities that cross and/or are located along the margins of the SWR and/or the Colorado Gust Map, reference to the online hazard tool is more likely to be problematic, and amendments that preclude its use may be prudent. Such communities should evaluate the output of the ASCE 7 Hazard Tool relative to their existing wind design criteria, the 2013 Colorado Front Range Gust Map, and other local resources or expertise.

- **Altitude Air Density Adjustment.** The ground elevation factor, K_e, is now codified within the 2024 IBC and may be used to reduce wind pressures for reduction in air density at elevation, consistent with prior engineering practice in many parts of Colorado. The 2024 IRC has not elected to incorporate the ground elevation factor, evidently for simplicity. However, a rational and appropriate method for incorporating the wind pressure reduction for air density within the wind bracing and pressure tables of the IRC is to use an equivalent sea level wind speed, V_e, as given by the following equation:

$$V_e = V\sqrt{K_e}$$

- **Winter Windiness.** The ASCE 7-22 Standard now accounts for the frequency of winter winds in the determination of drift loads, but none of the airport weather stations utilized to develop the winter wind parameter (W_2) were within the Colorado SWR or above tree line. The ASCE 7 commentary currently suggests basing the winter wind parameter at such locations upon any available weather records, though the provisions do not preclude use of the mapped values. Use of the mapped winter wind parameters would typically result in higher drift loads toward the eastern border of Colorado and lower drift loads along and west of the Front Range, compared to those calculated using ASCE 7-16. It is currently unconfirmed whether winter windiness associated with the frequent and generally dry downslope winds responsible for the Colorado SWR should be coupled for drift design purposes with snowfall from predominantly upslope storms. We recommend that practitioners and AHJs consider the following when evaluating what winter windiness parameters to consider while using ASCE 7-22 on sites in and around the Colorado SWR:
    - Historic local weather patterns, observations, and/or data.
    - The historic prevalence of structural performance issues related to snow drifting.
    - Comparison of ASCE 7-22 drift loads with those that have previously been used for design in the area.
    - Reference to case-specific studies, comparisons, and/or regional subject matter expertise.

- **Tornado Design.** ASCE 7-22 Chapter 32, covering Tornado Loads, is new to the Standard and requires consideration of wind pressures from tornadoes for certain larger and higher importance Risk Category III and IV structures designed according to the 2024 IBC. Therefore, most structures will still not be required to be designed for tornadoes. For more information, refer to the National Council of Structural Engineers Associations (NCSEA) Structural Engineering for Tornados FAQ currently at www.ncsea.com/app/uploads/2024/02/NCSEA-Tornado-FAQ.pdf and ASCE 7-22 Chapter 32.

The above recommendations are strictly advisory in nature and are not a substitute for the designer's engineering knowledge and professional judgment. We do not make any warranty, expressed or implied, or assume any legal liability or responsibility for the use, application of, and/or reference to opinions, findings, conclusions, or recommendations included in this document. The opinions, conclusions, and recommendations expressed herein are solely those of the document's authors. The recommendations have not been endorsed by the Structural Engineers Association of Colorado Board of Directors or the General Membership. The recommendations do not supersede local building code regulations, and their usage is subject to the approval of the AHJ.

Respectfully submitted,
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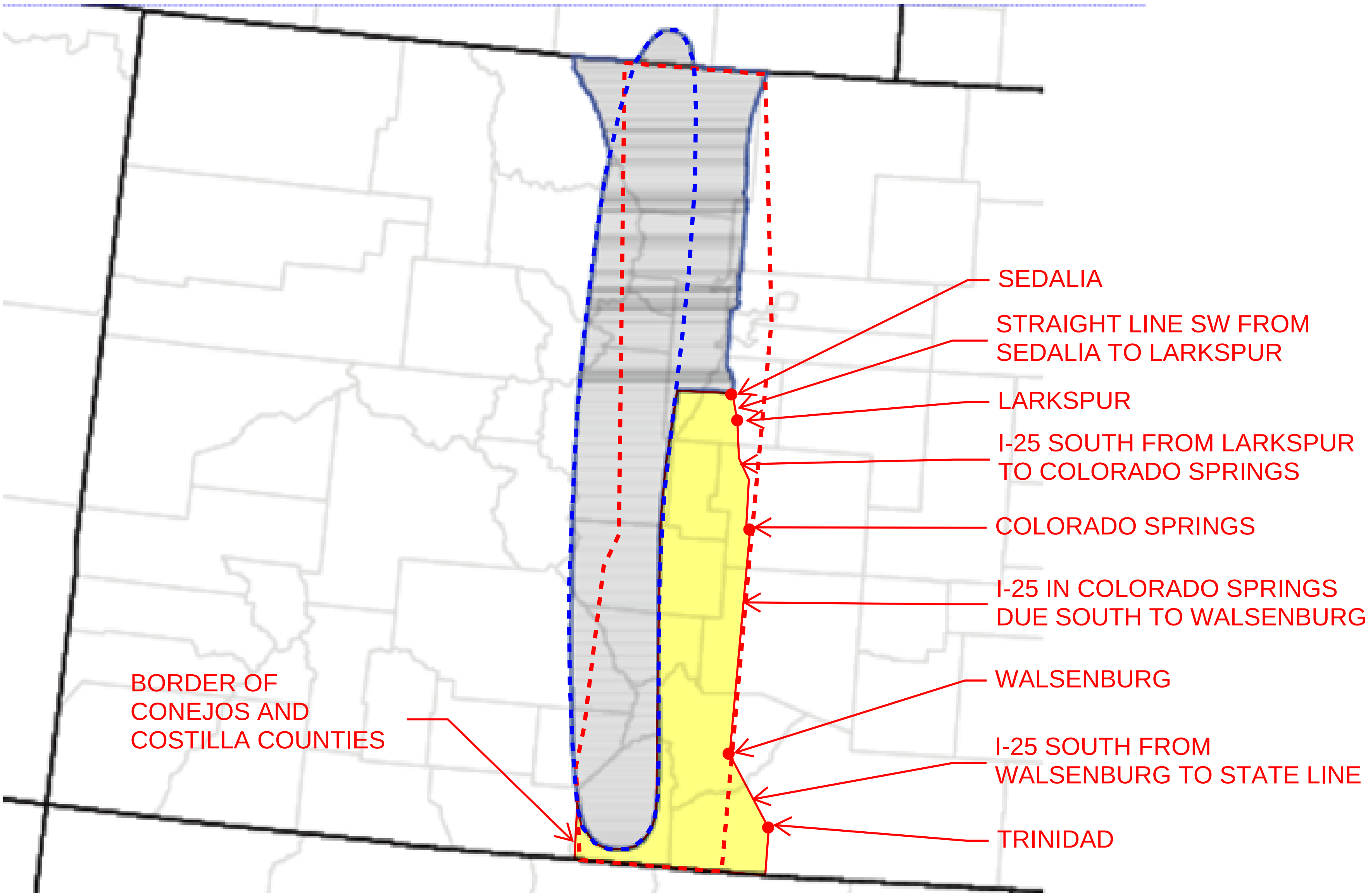
APPENDIX A: COLORADO SWR BOUNDARY MAP



- ASCE 7-10 SWR BOUNDARIES
- ASCE 7-16 SWR BOUNDARIES
- ASCE 7-22 SWR BOUNDARIES
- INTERIM SUPPLEMENTAL BOUNDARIES*

* SUPPLEMENTAL BOUNDARIES ARE PROVIDED AS INTERIM GUIDANCE PENDING COMPLETION OF A COMPREHENSIVE COLORADO WIND HAZARD STUDY. IN THE JUDGEMENT OF THE SEAC WIND COMMITTEE, THESE ADDITIONS ARE NECESSARY AND APPROPRIATE TO ADDRESS INADVERTENT OMISSIONS IN ASCE 7-16 AND 7-22. THE PROPOSED ADDITIONS ARE PRELIMINARY, APPROXIMATE, AND INFORMATIVE IN NATURE AND SHOULD NOT BE TAKEN AS THE DEFINITIVE MARGINS OF THE SWR FOR PURPOSES OF DESIGN AT ANY PARTICULAR SITE. DEFINITION OR SELECTION OF WIND HAZARDS FOR DESIGN SHALL BE THE RESPONSIBILITY OF THE AUTHORITY HAVING JURISDICTION (AHJ) AND/OR THE QUALIFIED DESIGNER, AS APPLICABLE.