

Appendix G:  
Consultative Guidance for Implementation of  
Public Shelter Design Criteria

## **Appendix G – Consultative Guidance for Implementation of Public Shelter Design Criteria**

### **G.0 PUBLIC SHELTER DESIGN CRITERIA**

The public shelter design criteria, which are also known as the EHPA criteria, were developed to ensure that appropriate new educational facilities can serve as public hurricane evacuation shelters. The EHPA criteria provide supplemental code provisions to existing applicable codes and standards. The EHPA criteria are performance-based, with limited prescriptive options provided to serve as a guide toward achieving the required level of performance.

The SREF public shelter design criteria are promulgated in section 423.25, *Florida Building Code—Building* (FBC). This section of the code applies to public schools (K-12) and community colleges. The Division also recommends use of the EHPA criteria for new state university, and other state, local and privately-owned facilities that are suitable to serve as public hurricane evacuation shelters.

The EHPA criteria were also prepared to ensure that new educational facilities could meet or exceed applicable national design and construction standards, guidelines and “best practices.” In particular, the American Red Cross’ ARC 4496 must be consulted during the planning and design process for an EHPA; see Appendix C. ARC 4496 is the minimum hurricane shelter criteria used by the Division, American Red Cross and local emergency management officials for surveying, evaluating and designating public hurricane shelters.

ARC 4496 can also be viewed at the following web address:

<http://www.floridadisaster.org/Response/engineers/documents/newarc4496.pdf>

Limited guidance is also provided to assist with design of EHPA’s when pre-designated as Special Needs Shelters (SpNS). There currently aren’t any consensus codes and standards published specifically for SpNS’s. However, the guidance included in this Plan is consistent with policies and recommendations distributed by the Department of Health.

### **G.1 EHPA Occupancy Period**

For planning purposes, the EHPA is assumed to be occupied at its maximum occupant capacity for, at a minimum, a continuous eight (8) hour period during impact by a major hurricane (i.e., Category 3 or higher). Off-site and unprotected on-site structures and utilities must be assumed to be inoperable, damaged or destroyed.

Though the EHPA criteria assume an 8-hour design occupancy period, hurricane evacuation shelters may be occupied for six to 12 hours in advance of arrival of hurricane force winds, and six to 12 hours (or longer) after hurricane force winds subside. Boards, design professionals and emergency managers should consider this fact during the design

of an EHPA. A design planning guide of 24 hours at maximum occupant capacity of the EHPA may be more appropriate. A minimum design occupancy of 24 hours is also consistent with the International Code Council's *Standard on the Design and Construction of Storm Shelters* (ICC 500).

## **G.2 Structural Requirements**

The wind load performance objective of modern building codes and standards is to prevent or reduce deaths and injuries within the built environment. This is achieved through design and construction of buildings such that, under design loads, primary load carrying systems remain stable and do not collapse. Survival without collapse implies that occupants should be able to find an area of relative safety inside the structure during a severe wind event. Localized damage, breach of the structural envelope and flow of wind through the structure and water damage are acceptable. However, this design philosophy is not necessarily acceptable for public hurricane shelters (and certain other essential facilities).

Hurricane Andrew and other subsequent major hurricanes demonstrated that the potential exists for hundreds of shelter occupants to find themselves scrambling for safety as the structural envelope of a designated public shelter progressively disintegrates. This scenario is unacceptable to emergency management and other public officials. The EHPA criteria were developed to significantly enhance the safety of public hurricane shelters, and enhance their ability to survive and continue to serve the public after exposure to a major hurricane. Therefore, the performance expectation for EHPA's is that not only the structural frame resist collapse in a Category 3 or greater hurricane, but that the exterior envelope components, cladding materials and assemblies must also remain sufficiently intact to protect building occupants and preserve the mass care function.

**G.2.1 Wind Loads.** EHPA's are required to be designed and constructed in accordance with the wind load provisions of the American Society of Civil Engineers Standard 7, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7). The minimum design wind speed is per ASCE 7's basic wind speed map, and using the importance factor (*I*) for an Occupant Classification Category III or IV (essential facility). Also, to ensure that the EHPA remains an enclosed structure (and avoid a partially enclosed condition, which would invalidate the design), building openings are also required to withstand impact by windborne debris in accordance with *Test Standard for Determining Resistance From Windborne Debris SSTD 12* (SSTD 12).

The selection of an appropriate design wind speed is critical to the performance of public hurricane shelters. ASCE 7's wind speed map is based upon approximately a 100-year recurrence level. The Category III/IV importance factor (1.15) is used to adjust the wind speed design up to about a 200-year recurrence level to account for a greater degree of hazard due to the nature of a facility's occupancy. This is the minimum wind design and construction requirement for EHPA's, and reflects the **minimum** national design standard for designated hurricane shelters.

However, the EHPA code provisions highly recommend that the ASCE 7 map wind speed be increased by 40 miles per hour, with an importance factor of 1.00. The Division also highly recommends the 40 mile per hour increase in base wind speed. The 40 mile per hour increase in base wind speed translates into wind designs of as high as 190 miles per hour in south Florida, to as low as 140 miles per hour in inland north-central Florida. The 40 mile per hour increase in base wind speed is used to adjust the wind speed design up to about a 1,000-year recurrence interval, and is consistent with the Department of Energy’s DOE-STD-1020 hurricane wind Performance Category (PC) 3 criteria. Figure G-1 illustrates a 1,000-year recurrence interval wind speed map for Florida. The Department of Energy’s enhanced performance expectations are that its facilities not only resist collapse, but that occupants, critical equipment and contents be protected from wind, windborne and falling debris, rainwater intrusion, and continue to maintain operation as an essential facility. The Department of Energy’s enhanced performance expectations are more consistent with public hurricane shelter design and construction performance expectations than ASCE 7’s minimum design standard.

DOE-STD-1020-2002 can be viewed at the following web address:

<http://www.floridadisaster.org/Response/engineers/documents/STD-10202002.pdf>

Another consideration when selecting a design wind speed is differences between ASCE 7 and hurricane intensity wind speed measurements. ASCE 7’s basic wind speed map uses a 3-second gust wind measurement method. However, the National Hurricane Center (NHC) and National Weather Service (NWS) categorize hurricanes using the Saffir-Simpson Hurricane Intensity Scale, which uses a one-minute sustained wind measurement method. Table G-1 provides a comparison of common wind measurement methods. For comparison purposes, visualize an anemometer (measures wind force and velocity) with Table G-1 representing concurrent scales on its wind speed display dial, similar to a vehicle speedometer that registers vehicle speed in both miles per hour and kilometers per hour. The anemometer will read about 135 miles per hour on the 3-second gust scale when the 1-minute sustained scale reads 111 miles per hour.

<b>TABLE G-1. Equivalent Basic Wind Speeds</b>						
Wind Speed Conversion						
3-second gust, fastest-mile and 1-minute sustained velocities (mph)						
<b>Wind Measurement Method</b>	<b>Saffir-Simpson Hurricane Intensity Scale</b>					
	<b>Category 1</b>	<b>Category 2</b>	<b>Category 3</b>	<b>Category 4</b>	<b>Category 5</b>	<b>Extreme Category 5</b>
<b>3-second Gust</b> (ASCE 7 and 2004 Florida Building Code)	90	117	135	160	190	230
<b>Fastest-Mile</b> (Standard Building Code)	75	100	117	141	170	209
<b>1-minute Sustained</b> (National Hurricane Center)	74	96	111	131	156	188

The NHC defines a major hurricane as one that achieves Category 3 or higher intensity on the Saffir-Simpson Scale; see Appendix F for hurricane category definitions. National guidance also indicates that all of Florida is subject to exposure to major hurricane conditions, with some locations in South Florida and the panhandle regions especially susceptible to severe hurricanes. Therefore, to ensure that public hurricane shelters are designed and constructed to resist major hurricanes, the 40 mile per hour increase in base wind speed is critical to achieve the EHPA performance expectation. Table G-2 provides a comparison summary of hurricane shelter performance objectives to be considered when selecting an appropriate design wind speed.

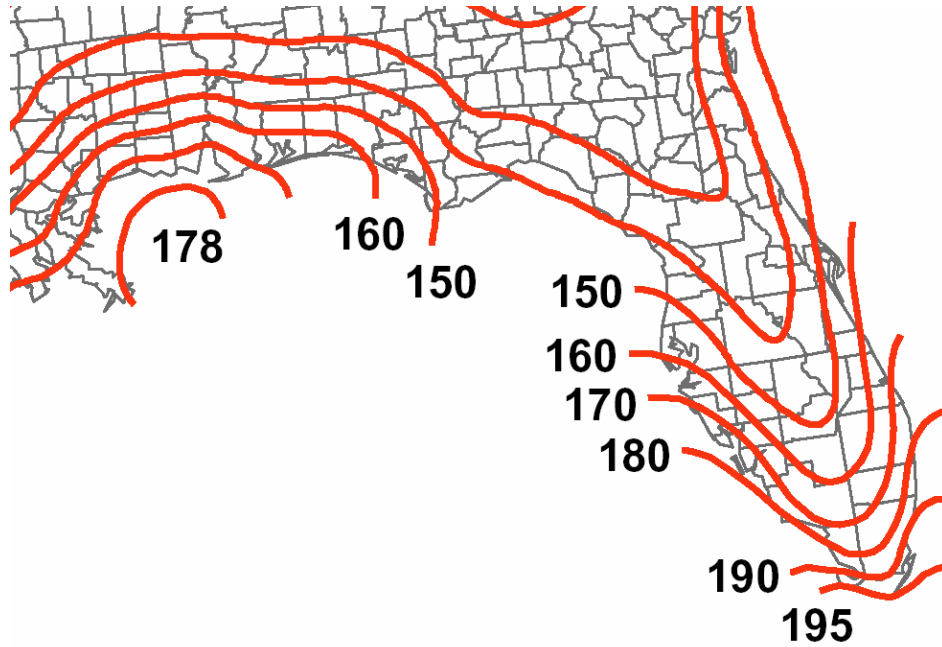
The 40 mile per hour increase in design wind speed is especially important for certain types of buildings. Buildings with tall exterior walls, long span lightweight roof systems, wide roof overhangs, located in open areas with minimal sheltering, etc., are particularly vulnerable to damage in “design-level-events.” The Division strongly recommends use of the 40 mile per hour increase in design wind speed for buildings that possess these characteristics.

The Division also recommends use of exposure C when calculating wind design load, regardless of the design wind speed selected or the environmental conditions surrounding the proposed facility. Both ASCE 7 and the FBC permit use of exposure B in areas more than a mile from the coast, which can significantly reduce the required design capacity of a facility. Use of exposure B is an unconservative approach, which is inconsistent with hurricane shelter performance expectations. Severe hurricanes, like Hurricane Andrew, tend to scour the environment by blowing over trees and flattening lightweight or poorly constructed structures. This scouring reduces the sheltering effect of a facility’s normal environment. Severe hurricanes can also produce “micro-burst” and weak to moderate tornado-type damage, which can devastate a small area and negate the influence of any local environmental sheltering. Therefore, for consistency with ICC 500 and the Federal Emergency Management Agency’s (FEMA) publication *Design and Construction Guidance for Community Shelters* (FEMA 361), the Division recommends use of exposure C when calculating design wind load.

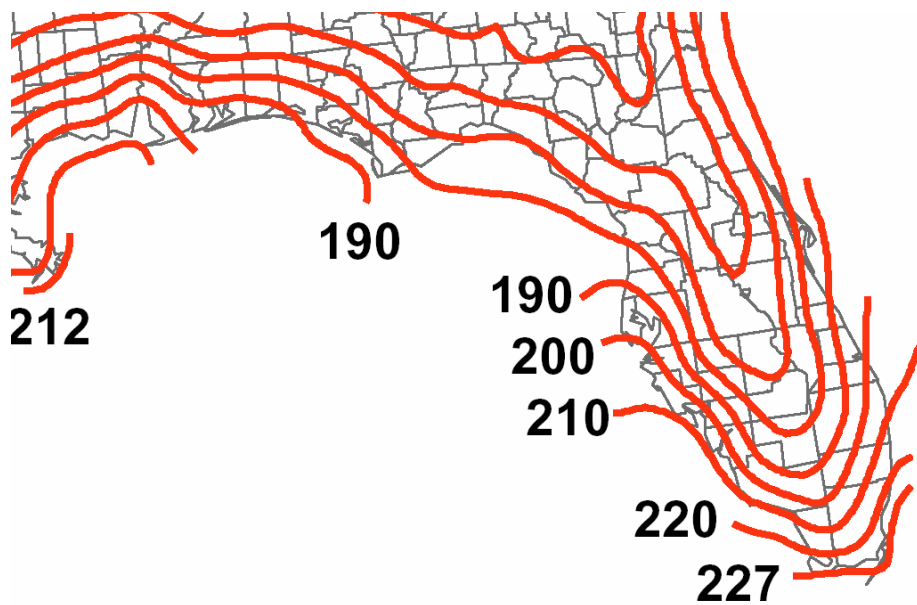
The EHPA code recommended 40 mile per hour increase in design wind speed is not intended to achieve a near-ultimate (or “near-absolute”) level of protection for building occupants. However, it does provide an “enhanced” (or intermediate) level of protection between minimum ASCE 7 design requirements and near-ultimate levels of protection. Both the ICC 500 and DOE-STD-1020 category PC-4 base their near-ultimate hurricane wind designs on 10,000-year recurrence interval events; i.e., a one (1) percent or less chance of occurrence during the life of a structure. Figure G-2 illustrates a 10,000-year recurrence interval wind speed map for Florida. FEMA 361 uses a tornado based design to achieve near absolute protection; i.e., 200 mph EF 4 tornado is the design basis for Florida.

The EHPA criteria also require that roof assemblies remain waterproof (i.e., rain tight) to preserve the emergency management function. Therefore, roof weather membranes (or secondary rain barriers) must meet the wind load requirements.

**Figure G-1. 1,000-year Wind Recurrence Map for Florida**  
Source: International Code Council



**Figure G-2. 10,000-year Wind Recurrence Map for Florida**  
Source: International Code Council



**G.2.2 Windborne Debris Impact.** All exterior surface components and cladding materials of EHPA's, and their supporting assemblies, are required to resist windborne debris impact. This includes walls, roofs, windows, skylights, glass block, doors, louvers, etc. This requirement is applicable to all EHPA's, regardless of proposed siting in a location outside of the normal windborne debris regions prescribed in ASCE 7 or the FBC. The minimum debris impact standard is SSTD 12. That is, the pertinent cladding materials and assemblies must, at a minimum, resist penetration by a nominal 2"x4" lumber plank weighing nine (9) pounds propelled at 34 miles per hour and striking "end-on" and perpendicular to the assembly. Though not specifically cited in section 423.25.4.1, FBC, windborne debris impact resistant assemblies meeting the requirements of section 1609.1.4, FBC (i.e., ASTM E 1886 and ASTM E 1996, or Miami-Dade TAS 201, 202 and 203) are recognized by the Division as suitable alternatives. Table G-2 provides a comparison summary of hurricane shelter performance objectives to be considered when selecting an appropriate windborne debris impact standard. Construction assemblies that are "deemed to comply" with section 1626, FBC, are also considered suitable. For guidance on additional types of assemblies that have been tested and passed large missile performance criteria, please see Appendix K.

However, please note that the Department of Education has stated that roof assemblies must be tested and certified to meet SSTD 12 as an assembly. This applies to district school board and community college facilities. With the exception of code prescribed concrete deck assemblies, "deemed to comply" assemblies will not be approved by the Department of Education. Therefore, "deemed to comply" assemblies are only applicable to other state and local agency facilities.

The Florida Department of Education's list of approved roof decks can be found at the following web address:

<http://www.fldoe.org/edfacil/formsplanreview.asp>

The Division recommends that facilities that may be subjected to an unusual barrage of heavy debris and building wreckage incorporate a more rigorous debris impact standard. This includes facilities that are located within 300 feet of significant exposure to unanchored large object debris sources or poorly constructed/partially engineered buildings. An example is an EHPA facility proposed to be located adjacent to a partially engineered unreinforced masonry building; portions of roof and wall materials, roof top equipment and building contents may be entrained into the wind field as the weak building disintegrates under severe wind loads. This heavy debris can have devastating impacts upon inadequate roof and wall components, cladding materials and assemblies, and potentially create significant breaches in the shelter building's structural envelope. Also, intrusion of heavy debris through the shelter building's envelope can present a hazard to building occupants.

For unusual windborne debris hazard exposure, the Division, at a minimum, recommends the hurricane wind hazard debris impact resistance criteria published in DOE-STD-1020, or equivalent performance standard. DOE-STD-1020 requires that the

facility’s exterior envelope components, cladding materials and assemblies resist penetration by a nominal 2”x4” sawn lumber plank weighing 15 pounds propelled at 50 miles per hour and striking “end-on” and perpendicular to the assembly; or as an alternative, a nine (9) pound 2”x4” propelled at about 80 miles per hour. This is about a 135 percent increase in impact momentum over SSTD 12’s basic large missile impact standard. There are products on the market that have been (or could be) certified to this level of performance, and DOE-STD-1020 provides “deemed to comply” type guidance for roof and wall assemblies. FEMA 361 also provides debris impact design guidance for facilities located in areas potentially exposed to extreme intensity wind events and extraordinary debris impact loadings.

<b>Table G-2. Summary of Wind Storm Design Criteria</b>						
Crosswalk of ASCE 7, EHPA, DOE-STD-1020, and ICC 500 Performance Criteria						
<b>Performance Category</b>	<b>X</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>Wind Hazard Return Period (years)</b>	< 100	≤ 100	100	200	1,000	10,000
<b>Wind Design Criteria</b>	Does not meet ARC 4496	Code plus meets ARC 4496	ASCE 7 or Code, plus ARC 4496	ASCE 7, essential facility plus ARC 4496	ASCE 7 plus ~40 mph	ASCE 7 plus ~70 mph
<b>Design Wind Speed, V (mph), 3-second gust</b>	< 90	100±	100 -150	100-150 (tornado @ 150)	140-190 (tornado @ 160+)	170-220 (tornado @ 200+)
<b>Importance Factor, I</b>	≤ 1.00	≤ 1.00	1.00	1.15	1.00	1.00
<b>Exposure Category</b>	N/A	N/A	Code	ASCE 7 (Exposure C recommended)	ASCE 7 (Exposure C recommended)	C
<b>Directionality Factor, Kd</b>	N/A	N/A	Code	ASCE 7 (0.85)	1.00	1.00
<b>Internal Pressure Coefficient, GCpi</b>	N/A	N/A	Code	ASCE 7 (hurricane @ ±0.18, or tornado @ ±0.55)	ASCE 7 (hurricane @ ±0.18, or tornado @ ±0.55)	ASCE 7 (hurricane @ ±0.18, or tornado @ ±0.55)
<b>Load Combinations</b>	N/A	N/A	Code	ASCE 7	ASCE 7	ASCE 7**
<b>Hurricane Windborne Debris Impact Criteria</b>	N/A	Equivalent to 7/16” plywood; max. height 30* ft.	2x4 timber plank, 9 lb @ 34 mph; max. height 30* ft.	2x4 timber plank, 9 lb @ 55 mph; max. height 60* ft.	2x4 timber plank, 15 lb @ 50 mph or 9 lb @ 75 mph; max. height 60* ft	2x4 timber plank, 15 lb @ 50 mph or 9 lb @ 90 mph; max. height 60* ft
<b>Tornado Windborne Debris Impact Criteria</b>	N/A	N/A	N/A	2x4 timber plank, 15 lb @ 80 mph; max. height 150* ft.	2x4 timber plank, 15 lb @ 84 mph; max. height 150* ft.	2x4 timber plank, 15 lb @ 90 mph; max. height 200* ft.
* - Glazed openings in exterior envelope of hurricane shelters and critical support areas located above large missile protection height indicated in this table should at a minimum resist penetration to small missile standards. ** - For PC 4, applicable ASCE 7 basic load combinations of sections 2.3.2 and 2.4.1 may be modified per section 302, ICC 500 (when published); section 5.4, FEMA 361; or sections 3.2.3 and 3.2.4, DOE-STD-1020.						



In addition to ASCE 7, the EHPA criteria, DOE-STD-1020-2002 and FEMA 361, it should be noted that the PC 3 and PC 4 design wind speeds and hurricane windborne debris impact criteria illustrated in Table G-2 are partially based on data considered by the ICC storm shelter committee during development of ICC 500. As an example, for hurricane shelters the ICC committee selected a nine pound 2"x4" sawn lumber plank as the representative debris missile for hurricanes, regardless of basic design wind speed velocity. Only the tornado design criteria will use the 15 pound missile. However, the 9 lb 2x4's test velocity is based on a percentage (40 percent) of the shelter's design wind speed, so the missile's required minimum test velocity changes with geographic location of the shelter; i.e., missile speed of 64 mph in the 160 mph wind zone of north Florida to 90 mph in the 225 mph wind zone of the Florida Keys.

The design professionals-of-record should consider the fact that occupants of EHPA's may open doors and windows during hurricane conditions. This human behavior was often reported during the 2004 hurricane season; see section G.2.5 for additional information. The basic design criteria for essential facilities, including EHPA's, assumes a substantially enclosed structure with controlled air movement and pressure changes (positive and negative). Though it is not known if occupants would purposely open fenestrations during a near design-level-event, designers should consider the effect that opening of the largest operable door or window would have on an EHPA's enclosure classification. If the enclosure classification changes due to the opening, the designer should consider possible mitigation measures (e.g., partially enclosed design classification, construction of air-trap/air-lock vestibules, access-limiting measures, etc.)

**G.2.3 Foundations and Floor Slabs.** The finished floor elevation of EHPA's and their essential life safety and emergency support systems are required to be elevated above the maximum storm surge inundation elevation associated with a Category 4 hurricane event. In multistory or elevated buildings, this applies to the lowest EHPA floor. The storm surge elevations are identified by reviewing the most current Sea, Lake and Overland Surges from Hurricanes (SLOSH) studies and atlases.

Some computer-based SLOSH models are also available, such as SLOSH Display Program version 1.40. These models list several elevations based upon "hurricane scenario," which includes storm intensity, forward speed and track. It is not uncommon for a site located in a Category 4 or 5 storm surge zone to be listed as "dry" for all but a few scenarios, and could possibly be dry for all scenarios due to elevation of local grade. The EHPA design requirement is the highest elevation listed for a Category 4 hurricane event.

The Division's minimum recommendation for rainfall flood design elevation for EHPA's is ASCE *Flood Resistant Design and Construction* (ASCE 24) Classification Category IV, Essential Facility. That is, the minimum elevation must be at least one (1) foot above base flood elevation (BFE) or a community's Design Flood Elevation, whichever is greater. However, where determined, the lowest habitable EHPA floor elevation should be at or above the 500-year flood elevation.

**G.2.4 Certifications.** Board and emergency management agencies have often found that it is difficult, if not impossible, to document that a facility was designed and constructed to the EHPA criteria after the passage of time. Construction drawing notes often do not provide the required information, and building officials, design professionals-of-record, constructors, product manufacturers and providers, and other relevant agents move on to other projects. Maintaining a viable record to certify that a facility has been designed and constructed to meet the EHPA criteria is critical.

The following information is needed by emergency managers to document that a facility is an EHPA:

1. Statement that the wind design conforms to the provisions of the Public Shelter Design Criteria, Section 423.25, Florida Building Code with year of revision specified
2. Statement that the building or EHPA, as applicable, is capable of withstanding or exceeding wind loads according to ASCE 7 structural design criteria (this statement is essential for ARC planners)
3. Basic Wind Speed, mph
4. Wind Importance Factor ( $I$ )
5. Wind Exposure
6. Wind Directionality Factor ( $K_d$ )
7. Internal Pressure Coefficient ( $GC_{pi}$ )
8. Provide documentation that windows, doors and other exterior components comply with SSTD 12 or other applicable performance standards (e.g., ASTM E 1886 and E 1996, FBC High Velocity Hurricane Zone testing protocols TAS 201, 202 and 203, etc.); documentation may include large missile impact product approval notice(s), certified lab test results, etc.
9. Floor plan drawing or image indicating location of EHPA portions of the facility; includes drawing or image indicating the entire facility when applicable

The documentation can be provided in the form of a certification statement letter or memorandum, or as a note page within the construction drawings of record. It is requested that the design professionals-of-record sign and seal the certification document(s), and forward the certification to the board, local emergency management agency and Division.

**G.2.5 Observations from the 2004 and 2005 Hurricane Seasons.** Following the 2004 and 2005 hurricane seasons, federal, state and local building code and mitigation assessment teams observed the types of damages found in the most heavily impacted areas of Florida. In general, the impacted EHPA's performed in a manner similar to other recently constructed light commercial facilities. That is, there were no observed structural failures but improvements were recommended for cladding integrity and weather protection. In particular, roof coverings, light metal wall coverings, soffits and door hardware damage led to rainwater intrusion.

The following is a summary of selected recommendations for critical/essential facilities (which includes shelters):

1. To better ensure adequate performance of shelters, the 40 mile per hour increase in base wind speed should be required and not just “highly recommended.”
2. Ensure that appropriate ASCE 7 Exposure Categories are selected during the design process; ensure full wind loads are calculated in open areas (Exposure C) where reductions are not appropriate.
3. The minimum windborne debris impact criteria should be increased from the current SSTD 12/ASTM E 1996 Level D (9 lb 2”x4” @ 34 mph) basic protection to the essential facility Level E (9 lb 2”x4” @ 50 mph) enhanced protection.
4. Assure code compliance through increased enforcement of construction inspection requirements, such as the Threshold Inspection Law.
5. It was recommended that designers calculate loads on building envelope cladding and components (including soffits), roof coverings and roof top equipment and specify/detail adequate attachments to resist the loads. A minimum safety factor of 2 is typically recommended.
6. For roof coverings, a secondary weather-resistant underlayment is recommended to improve rainwater intrusion protection.
7. Designers should clearly indicate on the construction drawings the area of the facility that was designed to function as the high wind shelter or hardened core area.
8. Perform follow-up inspections every five years or after a hurricane to identify interior moisture damage that may affect the structure or building envelope.
9. It was recommended that designers consider and use guidance found in *Design Guide for Improving School Safety in Earthquakes, Floods and High Winds* (FEMA 424).

To view the full Hurricane Charley and Hurricane Ivan Mitigation Assessment Team Reports, please see FEMA 488 and 489 at the following web addresses:

<http://www.fema.gov/fima/mat/fema488.shtm>

<http://www.fema.gov/fima/mat/fema489.shtm>

Also, FEMA 424 can be viewed at the following web address:

<http://www.fema.gov/fima/rmsp424.shtm>

There was one finding during the 2004 hurricane season that is related to human behavior that could increase the vulnerability of shelters. About forty (40) percent of the sites reported that persons (evacuees, shelter staff and managers, and public safety officials) purposely opened windows and doors during hurricane conditions. The reasons for the openings varied from admittance of late arrivals, to smoking, distribution of food

and other supplies, fresh air ventilation, and equipment repairs or maintenance. Buildings are designed to be enclosed structures, and openings of possibly as small as one (1) percent of a building's exterior envelope can cause internal pressures that exceed original design loads. This essentially negates the benefits of any added window protection.

In less intense storms, such as the conditions experienced by most of the shelters in 2004, the effects caused by the openings were minimal, with occupants experiencing only minor atmospheric pressure changes and a temporary, but exaggerated, creaking of lightweight roof decks (e.g., metal). However, when doors were opened on building sides perpendicular to or opposite the windward facing walls, the doors occasionally were pulled open violently by suction forces. This may have damaged some doors making them impossible to re-close, and in one case may have broken a door window pane. For additional findings specific to occupied hurricane shelters during the 2004 season, please see Chapter 5, Performance of Public Shelters during the 2004 Hurricane Season, of the *2005 Shelter Retrofit Report*. The *2005 Shelter Retrofit Report* can be viewed at the following web address:

<http://floridadisaster.org/documents/SRR05.pdf>

**G.2.6 Roof Rainfall Drainage.** The EHPA criteria requires that roof drain systems be sized for normal use (i.e., 100-year, 1-hour rainfall design per FBC—Plumbing, Figure 1106.1), and when applicable also required to have additional emergency overflow scuppers that can accommodate a two (2) inch per hour rainfall rate. However, this emergency overflow capacity can be less than that required by Chapter 11, FBC—Plumbing. The Division recommends that where Section 1107, FBC—Plumbing applies to an EHPA roof (i.e., drainage confining roof perimeter construction or parapets), that at a minimum the secondary (emergency) roof drains or scuppers be designed/sized per Chapter 11, FBC—Plumbing (ranges from 4.3 to 5 inches). The designer may also want to consider a higher 1-hour rainfall rate than required by FBC. For public hurricane shelters, the Division recommends a minimum of an eight (8) inch, 1-hour rainfall rate. This is approximately a 2,000-year, 1-hour recurrence rainfall rate for Florida, so a very low probability event.

### **G.3 Location and Site Requirements**

**G.3.1 Emergency Access.** EHPA's are required to have at least one major means of access for emergency vehicles that is above the 100-year floodplain. However, this requirement may be impractical in some areas due to generally low-lying topography. Therefore, this requirement can be waived by the board with concurrence of the local emergency management agency or the Division. A potential EHPA with access routes below the 100-year floodplain may be subject to isolation due to hurricane rainfall flooding, and should be reviewed as a potential exemption request per section 2.2.1 of this Plan.

**G.3.2 Landscaping and Parking.** Landscaping around the EHPA must be designed to preserve safety and emergency access. Trees must not conflict with overhead or underground utilities, including electricity, telecommunications, potable and wastewater, natural gas, etc. Trees, utility poles or other tall structures are required to be located to avoid lay-down or impact hazard for the EHPA and its occupants. The Division recommends that trees located within 50 feet of an EHPA be limited to trunk diameters that do not exceed about six (6) inches at maturity. This recommended standoff distance will prevent medium-size trees from inflicting battering damage to EHPA roofs, walls, windows and doors and reduce the potential for entry and egress door blockage.

Trees that exceed 12 inch trunk diameters cause most of the lay-down impact damage to buildings. Therefore, the Division recommends that trees that typically exceed 12 inches in diameter at maturity should be located with a standoff distance of more than 100 feet from their base to the closest potential impact point of an EHPA's outside perimeter wall; preferably a standoff distance of more than 115 feet. However, due to their relatively greater height potential, pine trees (e.g., Slash, Spruce, Shortleaf, Longleaf, Loblolly, etc.) should be located with a standoff distance of more than 125 feet from the EHPA; preferably a standoff distance of more than 140 feet.

Tall tree species in Florida typically have trunk diameters at breast height (about four feet from the ground) of 12 to 36 inches and trunk heights of about 60 to 140 feet. Some species with continued growth may significantly exceed a trunk diameter of 36 inches, but seldom exceed heights of 140 feet. For planning purposes, with the exception of pine trees, the ratio of maximum expected (mature) tree diameter in inches to the total tree height in feet is about 1:3.5 (+/- 15%). As an example, for planning purposes, trees that can grow to a trunk diameter of 24 inches will reach a height of about 84 feet (+/- 13 feet). Pine trees have a greater height to diameter ratio than other tree species, which is closer to 1:4 (+/- 15%). These planning guides are useful for most tall trees (e.g., pine, oak, hickory, magnolia, maple, pecan, sycamore, etc.) that may pose a lay-down hazard to an EHPA during its expected life.

Structures, equipment and other objects within 300 feet of the EHPA's perimeter should be anchored to avoid generating large windborne, falling or roll-over debris. Vehicles must be parked more than 50 feet from the perimeter of the EHPA during hurricane conditions.

**G.3.3 Rainfall Drainage.** The civil designer may also want to consider the potential for exceptionally high rainfall rates that will exceed normal site drainage design standards. The following are select maximum single-day (24 hour) rainfall records for locations in Florida:

- Pensacola – 11.68 inches
- Crestview – 11.44 inches
- Apalachicola – 10.67 inches
- Tallahassee – 8.86 inches
- Jacksonville – 6.33 inches
- Yankeetown – 38.7 inches (Florida Record)

St. Petersburg – 15.45 inches  
Tampa – 11.45 inches  
Orlando – 8.19 inches  
Fort Myers – 9.92 inches  
West Palm Beach – 15.22 inches  
Miami – 12.56 inches  
Key West – 22.75 inches

Other extreme rainfall events of note for the United States:

Alvin, TX (1979) – 43 inches  
Dauphin Island, AL (1997) – 32.5 inches  
Hackberry, LA (1962) – 22.0 inches  
Americus, GA (1994) – 21.1 inches

During slow-moving large “wet” hurricanes, a 10 to 20 inch or greater rainfall event is quite possible. The designer should consider the impact that flooded parking lots, overwhelmed storm drains and retention ponds, closed basin ponding, riverine and sheetflow flooding, and dam or reservoir containment failure may have on an occupied EHPA.

An essential performance requirement of hurricane shelters is that they not be inundated by rainfall flooding. For design purposes, the Division recommends that the EHPA’s civil designer consider the effects of an extraordinary event on the site drainage design. The designer should assume pre-hurricane saturated soil conditions and at-capacity drainage retention structures, then apply a hurricane-caused single-day rainfall event of about 30 inches. This is approximately a point maximum 2,000-year, 24-hour recurrence rainfall rate (1 sq.mi. basin) for most of Florida, so a very low probability event.

#### **G.4 Hurricane Shelter Capacity**

A minimum of fifty percent of the net square feet of certain types of rooms and spaces (referred to as “included spaces”) of new educational facilities are required to be constructed to meet the EHPA criteria. The calculated EHPA capacity is used by board staff, emergency managers and design professionals to determine the shelter occupant capacity and infrastructure-related requirements (potable water, toilets, sinks, parking, etc.) EHPA’s may be located in a single large room or a combination of rooms, located on one or more stories, and possibly in more than one building. To begin the EHPA capacity calculation process, identify those rooms or spaces that are to be excluded. Section 423.25.3.1, FBC and s. 252.385(4)(b), F.S. serve as guides for identifying excluded space.

The following is a summary of the excluded spaces:

**Excluded Spaces.** Spaces such as mechanical, plumbing, electrical, telecommunication and information technology utility equipment rooms, storage rooms and closets, exterior/outside circulation and corridors, restrooms and shower areas, kitchen and food preparation rooms, science labs, computer and information technology labs, vocational and industrial technology labs and shops, library and media rooms and labs, administrative office and support areas, record vaults, attics and crawl spaces.

**Included Spaces.** All other rooms and areas not listed as an excluded space.

To determine the net square feet of EHPA floor area, subtract the floor area square feet of excluded spaces from the gross square feet of the facility. The board, with the concurrence of the local emergency management agency or the Division may adjust the list of excluded/included spaces or the formula for calculation of design capacity.

To be consistent with the Division's statewide hurricane shelter survey and retrofit program, the capacity of an EHPA may be based upon "net usable floor area" in lieu of net floor area. Net usable floor area is defined as follows:

**Net Usable Floor Area.** Floor area of included spaces reduced to account for partitions and walls, columns, fixed or movable objects, furniture, equipment or other features that under probable conditions cannot be removed or stored during use as a hurricane shelter.

The following empirical reduction factors can be used to determine net usable floor area:

1. Reduce the gross floor area of assembly areas with concentrated furnishings or fixed seating by 50 percent. Examples are auditoriums, amphitheater classrooms, etc. To calculate a room's net usable floor area, multiply gross floor area by a **reduction factor (RF)** of 0.50.
2. Reduce the gross floor area of assembly areas with unconcentrated furnishings and without fixed seating by 35 percent. Examples are conference rooms, educational classrooms and skills labs, dining areas, band and music rooms, etc. To calculate a room's net usable floor area, multiply gross floor area by a RF of 0.65.
3. Reduce the gross floor area of assembly areas with open floors and without fixed seating by 15 percent. Examples are gymnasiums, dance floors, exhibition galleries, open multipurpose rooms, interior/inside circulation corridors and areas, etc. Retractable seating is not considered fixed seating. To calculate a room's net usable floor area, multiply gross floor area by a RF of 0.85.

A more comprehensive list of Department of Education room design codes, descriptions and RFs is available in Appendix H. Reduction values listed are empirical in that they are based upon large-scale typical conditions. Boards, local emergency

management agencies and design professionals may adjust the empirical reduction factors to address site-specific conditions.

The capacity of an EHPA is calculated using 20 square feet per occupant. The FBC formula is as follows:

$$\text{(Gross Floor Area, sq.ft. - } \Sigma \text{ Excluded Floor Areas, sq.ft.)} / 20 = \text{Occupant Capacity}$$

To calculate occupant capacity based upon net usable floor area, the formula is:

$$\Sigma \text{(Included Gross Floor Areas, sq.ft. x RF)} / 20 = \text{Usable Occupant Capacity}$$

The designer should be aware that SpNS “client” occupant capacity is based upon 60 square feet per client. The 60 square feet includes an allowance for care-givers, medical staff, medical equipment and supplies, and a cot or bed. Therefore, no additional space allowance is required for these personnel or material.

It should be noted that in an emergency, on a short-term basis during hurricane conditions, the American Red Cross and emergency management officials may temporarily reduce the occupant floor area requirement to 15 square feet per occupant. This emergency contingency measure does not affect the EHPA criteria’s requirement to use 20 square feet per occupant to calculate design capacity.

## **G.5 Plumbing and Sanitation**

It is essential that the EHPA remain a safe and sanitary environment. The plumbing and sanitary provisions of the EHPA criteria are primarily based upon the American Red Cross’s publication *Mass Care—Preparedness and Operations* (ARC 3041). ARC 3041 requires that emergency shelters, regardless of cause(s) necessitating their need, provide a minimum level of service.

In general, support systems for toilets, sinks and other essential water distribution and disposal systems are required to be capable of supplying water and containing waste for the design capacity of the EHPA. Plumbing and valve systems of toilets and sinks within the EHPA may be designed for conversion to emergency operation to meet the required demand. The method selected to achieve the required level of performance is at the discretion of the board, design professionals and emergency management agencies.

It should be noted that EHPA plumbing and sanitation design requirements should not be reduced for pre-designated SpNS facilities. SpNS client capacity is calculated based on 60 sq.ft. per client instead of the 20 sq.ft. used for the general population. This may give the appearance of a reduced design load for critical support systems. However, the 60 sq.ft. includes an allowance for care-givers and the additional medical staff necessary for operating the shelter. Therefore the plumbing and sanitary systems must be designed to accommodate a loading condition similar to that found in general population shelters.



**G.5.1 Potable Water.** The EHPA criteria do not specify a minimum potable water requirement. ARC 3041 requires a minimum of five (5) gallons of potable water per person per day for all uses (i.e., drinking water, hygiene, food preparation, etc.) Given that the EHPA planning assumption is 8-hours, or one-third (1/3) of a day, the Division recommends that the minimum potable water requirement be one-third of the ARC’s daily requirement, or 1.67 gallons (6.3 liters or 0.223 cubic feet) per person for all uses. A minimum of two quarts (1/2 gallon or 2 liters) per person should be for drinking water purposes. As an example, an EHPA with a design occupant capacity of 250 persons (includes both evacuees and management staff) will require a minimum of 418 gallons (1,580 liters or 55.8 cubic feet) of potable water. This is a relatively small quantity of water if it must be extended for more than 24 hours, so conservation measures are recommended (i.e., identify and provide access to sources for clean non-potable water for toilet flushing and certain other hygiene activities, etc.)

It should be noted that both the shelter environment (temperature and humidity) and physical condition/health of evacuees (e.g., age, diet, medications, pregnancy/nursing, etc.) can significantly affect drinking water needs. Table G-3 can be used as a guide to estimating minimum drinking water needs as shelter temperatures rise.

<b>Table G-3. Estimate of Minimum Daily Drinking Water Needs in Unconditioned Shelters</b>			
<b>Shelter’s Daily Mean Temperature, °F</b>	<b>Daily Drinking Water Needs<sup>1</sup>, quarts (liters)</b>		
	<b>Normal Demand (normal activity or at rest)</b>	<b>Moderate Demand (moderate work load)</b>	<b>High Demand (hard work load)</b>
<b>70 °F</b>	2 (1.9)	3 (2.8)	5 (4.7)
<b>80 °F<sup>2</sup></b>	3.5 (3.3)	5 (4.7)	7.5 (7.1)
<b>90 °F<sup>3</sup></b>	6 (5.7)	8.5 (8.0)	11.5 (10.9)
<b>100 °F<sup>4</sup></b>	8.5 (8.0)	12 (11.4)	15 (14.2)
<sup>1</sup> - Source: <i>Medical Aspects of Harsh Environments, Volume 1</i> , 2001, Chapter 1 Introduction to Heat-related Problems in Military Operations, Figure 1-3 <sup>2</sup> - Caution: 80 - 90°F Fatigue possible with prolonged exposure <sup>3</sup> - Extreme Caution: 90 - 105°F Heat exhaustion possible with prolonged exposure <sup>4</sup> - Danger: 105°F or higher; Heat stroke possible with prolonged exposure			

The potable water can be provided by on-site wells or water treatment package plants, stored in a permanent flow-through tank, or less preferably, stored in temporary containers or bladders. Since temporary systems will be infrequently used (possibly less than once a year), they will require regular maintenance to ensure operational viability. Large volume tanks must also be monitored to assure sufficient chlorine residual. Systems that rely on pumps or other electro-mechanical equipment will require a back-up power supply.

In some circumstances, an alternative to large volume tank storage, and its associated plumbing and valve systems, is on-demand delivery of potable water. If this approach is used, the EHPA will need a delivery and protected storage area for the bulk water. This approach has significant benefits and drawbacks. The benefits are minimal

(or no) construction costs associated with this approach, and there are no recurring maintenance or contamination concerns. The drawbacks are logistical and financial: who is going to be responsible for ordering, receiving, distributing, paying for, and if necessary, disposing of the water in time of need? These issues are not show-stoppers, but require a written agreement to assure operational viability.

**G.5.2 Toilets and Sinks.** Both ARC 3041 and the EHPA criteria require one (1) toilet and one (1) sink per 40 occupants of design capacity. The toilets and sinks can be fixed units incorporated into the EHPA during design and construction, or less preferably portable/temporary toilets and hand washing facilities. The EHPA required toilets and sinks are not in addition to those required for normal school occupancy, and are to be included in the overall facility fixture count. Generally there are sufficient quantities of toilets and sinks required for normal school occupancy capacity to meet the EHPA requirement. The designer will need to consider placement of the fixtures such that the needs of both the normal school occupancy and the EHPA requirements are served.

EHPA required toilets and sinks must be accessible from within the protected area, or must be accessible via a protected passageway that meets the EHPA criteria. Portable chemical toilets may also require separation from occupied spaces and circulation of fresh air. Also, consider how a portable toilet will be delivered, serviced and removed from the facility. This may require a larger door opening than normal and the use of removable door frame mullions.

For pre-designated SpNS facilities, low-profile toilets, sinks and grab bars installed in elementary classroom water closets and toilet rooms are inadequate for adult special needs clients. The Division recommends that the designer incorporate permanent or adaptive structural and fixture size elements that can safely and expediently accommodate adult special needs clients.

**G.5.3 Showers.** Given that the EHPA criteria assume only an 8-hour occupancy, ARC 3041's normal shower requirement can be relaxed. Therefore, showers are not an EHPA code requirement. However, boards and design professionals should consider that post-hurricane recovery shelters normally require one (1) shower per 40 occupants.

**G.5.4 Wastewater.** The EHPA criteria require that the plumbing system be capable of containing (or otherwise disposing of) the wastewater generated by the design capacity occupant load. During the 2004 and 2005 hurricane seasons, about 30 percent of occupied hurricane shelters experienced wastewater/sewage back-up into the facility. It is critical that wastewater be prevented from backing up into the EHPA. This can be accomplished through installation of storage tanks, a wastewater treatment package plant, or other suitable measure.

For those facilities with an on-site wastewater lift station, the lift station reservoir can be sized to meet the storage requirement. The lift station reservoir must be set at a lower elevation than the EHPA to prevent back-up of wastewater into the shelter area. The lift station should also be equipped with an emergency back-up power system to

support drainage into the local utility system. As a contingency, the stored wastewater can be drained and properly disposed of by a mobile pump unit.

Instead of a tank, an alternative is to utilize the waste drain pipe as the storage container. In this method, the pipe is over-sized to accommodate the required volume of waste on the facility side of the back-flow preventer. Wastewater and sewage back-up is normally caused by continued disposal (or flushing) of wastewater into the drain pipe system after the utility side back-flow preventer has closed; the drain pipe has insufficient capacity for continued use. With an over-sized drain pipe, the waste is stored in the pipe until the utility system is restored. A drainage connection or fixture should be incorporated into the drain pipe to accommodate expedient drainage and proper disposal by a mobile pump unit.

The Division recommends that the wastewater system design be based upon a ratio of 1.5 gallons wastewater for every gallon of potable water. In addition to the basic potable water design volume, the 1.5:1 ratio provides extra capacity for solid materials and introduction of non-potable water into the system (e.g., toilet flushing). Thus, based upon a minimum recommended potable water load of 1.67 gallons per occupant, the minimum recommended wastewater capacity is 2.5 gallons (0.334 cubic feet) per occupant. The Division recommends that the reservoir capacity be based upon a 24-hour design occupant capacity instead of the 8-hour design capacity (i.e., 5 gallons per occupant instead of 1.67 gallons). As an example, an EHPA with a design occupant capacity of 250 persons (includes both evacuees and management staff) will require a minimum wastewater storage capacity of 1,875 gallons (250.7 cubic feet).

**G.5.5 Garbage Disposal.** The Division recommends that janitorial service areas be located within the EHPA, and provisions be considered for temporary storage or disposal of solid wastes and garbage.

## **G.6 Electrical and Emergency Power Systems**

Back-up and emergency power provisions are an important feature for hurricane evacuation shelters. Utility electrical power can be disrupted for a few hours to several days (or possibly weeks) following arrival of hurricane conditions. During a utility electrical power outage, EHPA's must remain a safe and sanitary environment. Life-safety systems must continue to function, minimal lighting must be provided to support safe movement, security and emergency egress needs, and adequate ventilation provided to maintain a habitable environment.

At a minimum, the EHPA criteria require installation of an emergency electrical power system with an outlet for coupling to a back-up portable generator. The EHPA criteria do not require installation of a permanent electrical power generator, but rely on emergency battery power and "pre-wiring" the facility's electrical system to accept expeditious and safe installation of a compatible portable generator. Therefore, the minimum EHPA requirement relies upon on-demand delivery of a compatible electrical

power generator. If the on-demand approach is used, the EHPA will need a protected storage area for the generator.

The on-demand approach has significant benefits and drawbacks. The benefits are reduced initial construction costs, minimal recurring maintenance expenses and no fuel-degradation concerns. The drawbacks are logistical and financial: who is going to be responsible for ordering, receiving, installing, maintaining, refueling, redeploying and paying for the generator in time of need? Very few, if any, boards or local government agencies possess an adequate quantity of compatible portable generators to meet EHPA requirements. Also, state and federal agencies do not normally deploy portable emergency power generators until at least 24 hours after impact by hurricane conditions, and in many cases it may be more than 72 hours. These issues are not show-stoppers, but require emergency power provisions be included in board and local facilities and emergency operations plans (and possibly a written agreement) to assure operational viability.

Boards and design professionals must note that state and local emergency management agencies are under no statutory or code obligation to provide portable emergency generator(s) for EHPA's. Boards and design professionals are responsible for developing an appropriate EHPA emergency power capability to maintain a safe and sanitary environment for a minimum of the required 8-hour design occupant capacity.

For facilities that are pre-designated to serve as SpNS facilities, the Division strongly recommends that the emergency power system be designed to accommodate additional branch circuits to support medical equipment, refrigeration of medical supplies and air-conditioning of client occupied areas. These special requirements may exceed basic EHPA design criteria, but post-construction retrofitting to accommodate these requirements is often difficult and costly. The Division strongly encourages the designer to coordinate with local emergency management and county health department staff when designing SpNS facilities.

## **G.7 Emergency Management Considerations**

**G.7.1 Shelter Manager's Office.** The EHPA criteria require that an administrative office be identified for shelter management use and included within the EHPA. The office is required to have provisions for standby power, lighting, communications, main fire alarm control panel and storage for the manager's equipment. Communications may include both internal (within the EHPA) and external (to outside shelter support agencies) communications.

The EHPA criteria do not specify a minimum floor area requirement for shelter management needs. ARC 4496 recommends that shelter management functions be based upon a minimum of 40 square feet per staff person. Therefore, the Division recommends that the shelter manager's office be a minimum of 40 square feet of net floor area, and an additional 40 square feet per assistant manager(s), communications person(s) and equipment storage. As an example, assuming the shelter manager and assistant manager

occupy a single office area with equipment storage, the shelter manager's office should have about 120 net square feet of floor area (i.e., 40 sq.ft. x 3 management functions = 120 sq.ft.) The communications person(s) may be located in adjacent spaces.

**G.7.2 Signage.** A sign with a floor plan drawing or image indicating the EHPA's location and perimeter boundaries or limits is required to be mounted in the shelter manager's office.

**G.7.3 Food Service.** The EHPA criteria states that "where feasible, include counter tops for food distribution functions in the EHPA's." ARC 3041 requires that emergency shelters have a feeding area and a means of storing, preparing and distributing food (and concurrently drinking water). Ideally, for sanitation purposes, emergency managers and shelter support agencies prefer to have feeding-related areas separate from general population areas. However, to maximize utilization of the EHPA's floor area during hurricane conditions, this preference can be relaxed and feeding areas occupied by a shelter population.

ARC 3041 normally requires 2,500 calories per person per day (approximately 3½ pounds of unprepared food). However, on a temporary basis, a hurricane shelter's feeding services can be relaxed. For design purposes, the EHPA planning assumption is 8-hours, or one-third (1/3) of a day. Therefore, the Division recommends that boards and design professionals plan for distribution of about one-third of the ARC's daily requirement, or about 833 calories (about one and one-sixth (1 1/6) pounds per person). This minimum feeding requirement can be met via "bag lunches" or heavy snacks. As an example, an EHPA with a design occupant capacity of 250 persons (includes both evacuees and management staff) will require a minimum of 293 pounds of food. Given that bag lunches and one-quart containers of bottled water can be distributed from a movable table (or straight out of bulk delivery boxes or containers), a fixed counter top may not be required; thus the "where feasible" preface in the code.

**G.7.4 Supplemental Space Allocations.** Ideally, in addition to shelter management space needs, adequate space should be set aside within the EHPA for registration, emergency medical care, safety and fire considerations, janitorial services and sanitation. For post-hurricane recovery shelter operations, ARC 3041 also recommends addition of space for storage of bulk food and supplies, food preparation and feeding, separate rooms for general population, elderly and families with small children, sleeping areas, recreation, and possible storage of occupants' belongings. It should be noted that ARC 3041's minimum space requirement for post-hurricane recovery shelters is 40 to 60 square feet per occupant, instead of the EHPA criteria's 20 square feet per occupant.

**G.7.5 Parking.** EHPA vehicle parking areas may be paved or unpaved, but must be located more than 50 feet from the EHPA.

**G.8 Americans with Disabilities Act Shelter Requirements.** The Americans with Disabilities Act (ADA) requires shelters to provide equal access and service to all persons. For guidance on meeting ADA emergency shelter requirements please see Appendix L.

**G.9 Comparison of Florida's EHPA to the International Code Council's ICC 500.**

The ICC 500 is scheduled to be published in 2008 and so will become a consideration for design of hurricane shelters in the future. Florida's EHPA code provisions were considered during preparation of ICC 500 so there are many design consistencies between them. However, the objective of the ICC storm shelter committee was to ensure a high-degree of safety for shelter occupants. Therefore, wind design provisions are based on a near-ultimate hurricane event. Table G-4 provides a comparison of Florida's EHPA criteria and ICC 500.

<b>Table G-4. Comparison of Florida Building Code's Public Shelter Design Criteria (EHPA) and the International Code Council's ICC 500 Hurricane Shelter Standard</b>		
<b>Design Criteria</b>	<b>2004 FBC EHPA with 2006 Revisions</b>	<b>(2007 Draft) ICC 500</b>
<b>Design Occupancy Period</b>	8 hours	24 hours
<b>Net Usable Floor Space per Occupant</b>	20 sq.ft. all adults and children	20 sq.ft. for standing, seated or wheelchair; 40 sq.ft. for bedridden
<b>Sanitary Facilities</b>	Toilets 1:40 Handwashing 1:40	Toilets 1:50 Handwashing 1:100
<b>Potable Water Capacity, minimum</b>	No Capacity Given	1 Gallon per Occupant
<b>Wastewater Capacity, minimum</b>	No Capacity Given	1.5 Gallons per Occupant
<b>Flood Design Criteria</b>	ASCE 7	ASCE 7 and ASCE 24
<b>Storm Surge Flood Elevation (if applicable)</b>	EHPA must be located outside Cat. 1, 2 or 3 evacuation zones. EHPA floor slab must be elevated above maximum inundation of a Category 4 hurricane.	No limitation on location of hurricane shelter in storm surge evacuation zones. Lowest floor slab must be elevated above maximum inundation of a Category 5 hurricane.
<b>Inland Rainfall Flooding</b>	Floor slab of lowest finished floor must be elevated above base flood elevation plus one (1) foot.	Lowest floor slab of occupied shelter must be elevated to the higher of the following elevations at the site: 1) flood having 0.2% annual chance; 2) flood elevation having 1% annual chance plus two (2) feet; and 3) if not in mapped special flood hazard area, flood elevation of the highest recorded flood elevation plus two (2) feet
<b>Rain Loads</b>	FBC—Plumbing, Section 1106 (100-year recurrence interval normal drains, plus 2 inch per hour overflow; total of 2 inch emergency overflow capacity)	ICC 500, Section 303.1 (100-year recurrence interval normal drains, and 100-year plus 3 inch per hour overflow; ranges from total of 7.3 to 8 inch emergency overflow capacity)

<b>Hurricane Wind Load Design</b>	ASCE 7	ASCE 7 with modifications
<b>Design Wind Speed</b>	ASCE 7 Basic Wind Speed Map (100-year recurrence interval)	ICC 500 Hurricane Wind Speed Map (10,000-year recurrence interval)
<b>Importance Factor, <i>I</i></b>	1.15	1.00
<b>Directionality Factor, <i>K<sub>d</sub></i></b>	0.85	1.00
<b>Optional Increase in Design Wind Speed</b>	Basic Design Wind Speed plus 40 mph ( <i>I</i> =1.0) recommended; adjusts design wind speed upwards to approx. 1,000 to 2,000-year recurrence interval	Not Applicable
<b>Exposure</b>	ASCE 7	ASCE 7 Exposure C (Exposure B may be applied to MWFRS in certain situations)
<b>Enclosure Classification</b>	ASCE 7	ASCE 7 with largest door or window on each side individually considered an opening (breach)
<b>Load Combinations</b>	ASCE 7	ASCE 7 with reductions per ICC 500 Chap. 3
<b>Building Enclosure Missile Impact Criteria (all surfaces)</b>	SBC/SSTD 12 (large missile: 9 lb 2x4 @ 34 mph)	ASTM E 1886 and E 1996 with modifications (large missile: 9 lb 2x4 Vertical Surface=0.4*Design Wind Speed Horizontal Surface=0.1*Design Wind Speed)
<b>Impact Testing Procedures</b>	SBC/SSTD 12	ASTM E 1886 or E 1996 as modified by ICC 500 Chap. 8
<b>Weather Protection (rainwater intrusion)</b>	Exterior envelope and air intakes/vent assemblies must meet design wind loads; Roof covering to be specified and designed to meet wind uplift forces and meet ASTM and Factory Mutual Standards	All exterior components and cladding assemblies and roof coverings must be designed and installed to meet design wind loads
<b>Fire Separation</b>	Applicable Code	Applicable Code plus 2 hour fire resistance rating of walls/assemblies that separate shelter areas from the host building
<b>Natural Ventilation</b>	FBC (5% of internal floor area per occupant)	12 net sq.in. of vent area openings per occupant
<b>Mechanical Ventilation</b>	2 cfm per sq.ft. of EHPA floor area (i.e., 40 cfm per occupant)	Ventilation rate determined by applicable building code for normal use of space (typically 15 cfm per occupant)
<b>Emergency Lighting</b>	FBC	1 foot-candle
<b>Standby Lighting</b>	10 foot-candles	10 foot-candles

<b>Standby Power System</b>	Required; minimum loads: emergency lighting, illuminated exit signs, fire protection and alarm systems, four (4) electrical receptacles in shelter manager's office, and minimum ventilation	Required; minimum loads: standby lighting and life safety/fire protection and alarm systems
<b>Permanent Standby Electric Generator</b>	Not Required	Not Required
<b>Special Inspections</b>	EHPA's are designated "threshold buildings" and subject to special structural inspections	Community shelters are subject to special inspections and structural observations
<b>Peer Review</b>	Not Required	Construction documents for community shelters with design occupancies greater than 300 are subject to peer review