



A Resource of the State of Florida

Hurricane Loss Reduction

FOR

HOUSING IN FLORIDA:

**MOBILE HOME REPLACEMENT
PROGRAM IN FLORIDA:**

*WHAT WE KNOW TODAY AND WHERE
WE SHOULD GO IN THE FUTURE*

A Research Project Funded by

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Introduction

Background

During its 1999 session the Legislature of the State of Florida enacted a Hurricane Loss Mitigation Program (s. 215.559) also known as the “Bill Williams Residential Safety and Preparedness act,” (The Act). This program, managed by the Department of Community Affairs (DCA), is funded by an annual legislative appropriation of \$7 million from the Florida Hurricane Catastrophe Fund (s. 215.555).

As part of the act, a percentage of the program’s funds went to the State University System to focus on research. One research track required an examination of the feasibility of developing a recycling program of older, pre-1976 mobile homes.

Specifically the original research track outlined the following research agenda:

Mobile Home Recycling Program. Research will focus on the parameters of recycling programs implemented by other states, including both the technical and regulatory issues involved. The Contractor will coordinate with the Department of Environmental Protection to investigate the feasibility of creating a similar program in the State of Florida. The issues that will be addressed by this research include:

- (a) The incentives needed to make a recycling program work in the State of Florida;
- (b) Does the existing regulatory environment in Florida facilitate the administration of such a program in the state; and

(c) Would such a program be feasible across the board or will there be significant impediments for mobile home residents at the lower end of the social-economic spectrum?

While the language of the track has changed a little over time, the essence of the pursuit remained the same. The goal was not simply to find a way to remove older unsightly mobile homes from communities, but more importantly, the central theme was on recycling as mitigation.

The program then would have to look at issues beyond the technical aspects of removing units from current locations, dismantling them, and recycling the various components. The bigger issues involve how to motivate people to move out of their older, more dangerous units, and ultimately how to fund such a venture. Research findings from the first year of the program emphasized how unique the approach of considering recycling as mitigation was. In fact, no other state has looked at the issue in a similar way. States with recycling programs simply focused on the aesthetic issue – older mobile homes are often unsightly and abandoned.

After year one of the project, it was clear that other models for a program were simply not available. As such, to understand the feasibility of a program to move residents from vulnerable older mobile homes to safer housing a more comprehensive research agenda would be required. In years two through four of the project, a variety of methodologies and analyses were used to better understand the mobile home population and their willingness to participate in programs that would help them move from their vulnerable housing to safer locations.

Focus of Report

While research on this topic has continued over the life of the project, at no point has all the data and findings been synthesized into one comprehensive report with clear recommendation to the State of Florida. As a result, while we know more today than ever about this highly vulnerable population, little has been done to move forward with any possible solutions.

This report brings together a variety of findings developed by and for the International Hurricane Research Center, and consequently for the State of Florida.

Drawing upon previous data and findings, this report:

1. Summarizes the problem by focusing on why pre-1976 mobile homes are vulnerable, examining the scope of the problem in Florida including approximate costs to acquire and replace the units, and the impact of recent hurricanes in Florida on mobile homes;
2. Summarizes characteristics of the pre-1976 mobile home population through an analysis of their demographics, reasons for living in mobile homes and their sense of risk;
3. Summarizes four options for replacement programs that were considered during the project and analyzes the challenges for implementation;
4. Makes a definitive recommendation for the State of Florida in regard to any future replacement/removal programs;
5. Concludes with a discussion of suggestions beyond a replacement/removal program to help decrease the physical and social vulnerability of the pre-1976 population, as well as other generations.

Summary of Problem

As the 2004 hurricane season illustrated, Florida is at great risk of the effects of tropical weather. Four significant hurricanes made landfall. The expectation of higher frequency and intensity of hurricanes and a large population of mobile homes means the risks for widespread wind damage of manufactured homes are significantly higher in Florida than other states. Florida still has over 300,000 pre-1976 mobile homes registered with the Florida Department of Motor Vehicles. An excess of 643,000 manufactured housing unit sections were built between the middle of 1976 and the middle of 1994.

Of these mobile home units, the 338,000 pre-1976 mobile homes are considered at the greatest risk for destruction during a hurricane. This increased vulnerability is due to the lack of uniform standards during the manufacturing period before 1976. Little was done to make these units more structurally sound, and even when uniform standards were implemented midway through 1976, wind resistance was not the focus. Rather, standards were created to help reduce losses due to fire. In sum, while pre-1976 mobile homes are the most vulnerable, those built between the middle of 1976 and 1994 are also vulnerable to high wind events. It is only the third generation of mobile homes built since the middle of 1994 that have any tangible wind resistance.

One of the major issues in analyzing the scope of the problem in Florida is the difficulty of gathering appropriate data. Since the majority of mobile homes are registered in the state in the same way as motor vehicles, the only way to get an accurate picture of the extent of the problem is to analyze the DMV data. During 2000, the first year of this project, the IHRC was given access to this DMV database. At the time, it could only be read from antiquated computer tapes, and in a format that made the

development of an analyzable file extremely challenging. While an updated database would give a more accurate picture, the difficulty of obtaining, reading and analyzing the data also makes the prospect challenging. In addition, as mentioned in numerous previous reports, the DMV database does not indicate where the mobile home is located within the state; it only includes a mailing address for the registrant.

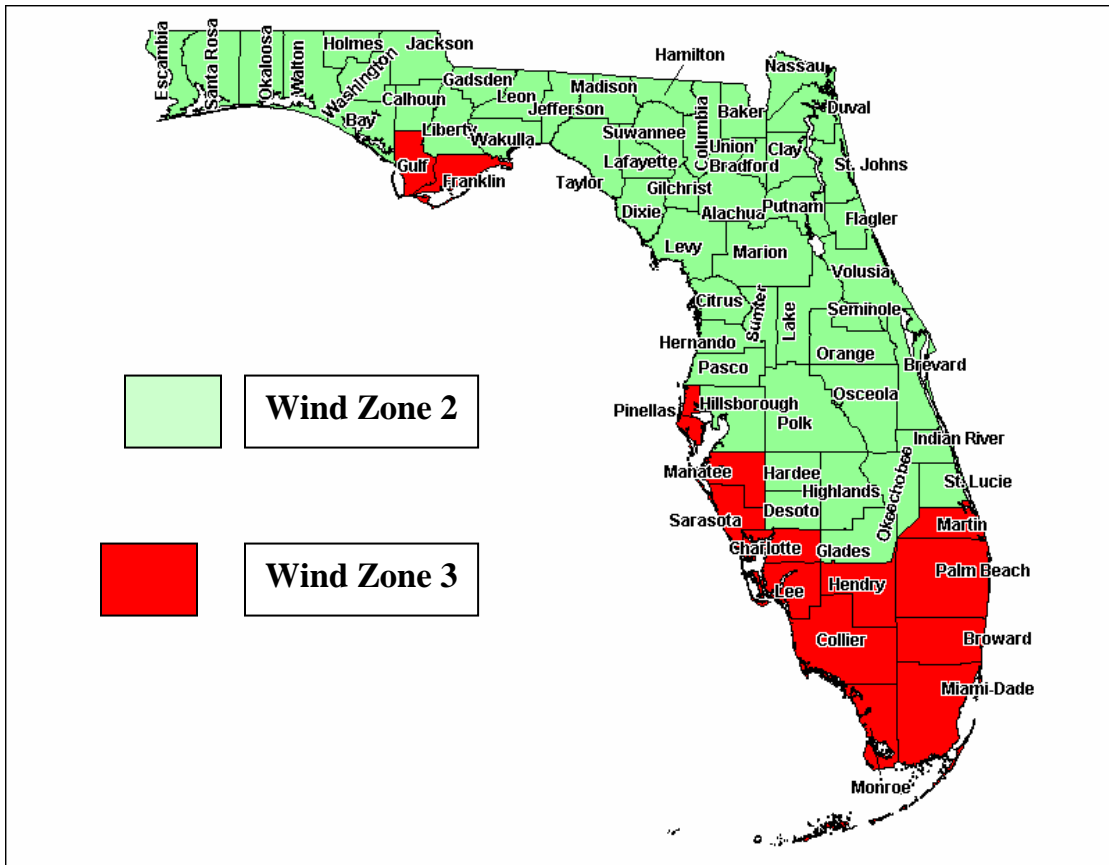
What we do know however is that while our figures do not accurately reflect post-2000 mobile homes, the reality is that older mobile homes rarely leave the housing stock. Older mobile homes move further down to more marginal populations. The most socially vulnerable (poor and elderly) residents of the state are most likely to be living in the most physically-vulnerable housing.

Over 1 million mobile home units are distributed throughout the state. With the largest population centers being coastal counties, it is safe to say that the majority of these units are at greatest risk of hurricane effects. Even more startling is the damage done to mobile homes in non-coastal counties during the 2004 hurricane season. This damage emphasizes that the location of Florida leaves, virtually, all counties vulnerable.

When HUD enacted their last structural change requirements to mobile homes in 1994, coastal counties were designated Zone 1, 2 or 3 based on the likelihood of future hurricane damage, with zone 3 areas requiring mobile homes to be built to the highest wind resistance. Currently 14 counties in Florida are designated Wind Zone 3 counties. For those counties in Wind Zone 3, mobile homes need to be built to withstand stronger wind loads. In Florida, the other 53 counties are designated Wind Zone 2. The map below shows the geographic distribution of wind Zone 3 counties in Florida. Curiously,

the Gulf counties which have often been hard hit are not included in the Zone 3, most vulnerable category.

Figure 1: Map of Florida Counties by Zone



Using Census 2000, analysis of the data allows us a better understanding of the distribution of generation 1 mobile home throughout Florida.

- i. Of the 14 Zone III counties, Pinellas County, with 25,271, has the greatest number of occupied generation 1 mobile homes. Even more significant is that of all the occupied mobile home in Pinellas, 72% were built before 1980.

- ii. Six other Zone III counties have more than 60% of all occupied mobile homes built before 1980. These counties are: Broward, Manatee, Martin, Monroe, Palm Beach, and Sarasota.
- iii. Of all the Zone II counties, Polk County has the most generation I mobile homes with 13,860. Significantly important, however, is that this only represents 30% of all mobile homes in Polk.
- iv. No county in the Zone II area has more than half its mobile homes from generation 1. On the other hand, 7 out of 14 counties in Zone III have half or more of their mobile homes from the earliest, most vulnerable generation.
- v. Overall, 58% of all occupied mobile homes in Zone III are from generation 1, while 35% of all occupied mobile homes in Zone II are the most vulnerable.

The census data analyzed above emphasizes that the highest proportion of the most vulnerable mobile homes (based on being built before any HUD standards) are in those counties with the highest vulnerability to the effects of hurricanes. This combination makes an already risk-filled situation even worse. While overall more pre-1976 mobile home units are in Zone 2 counties, a higher proportion of pre-1976 mobile homes are in Zone 3 counties.

Figure 2: Mobile Home Generation by Wind Zone

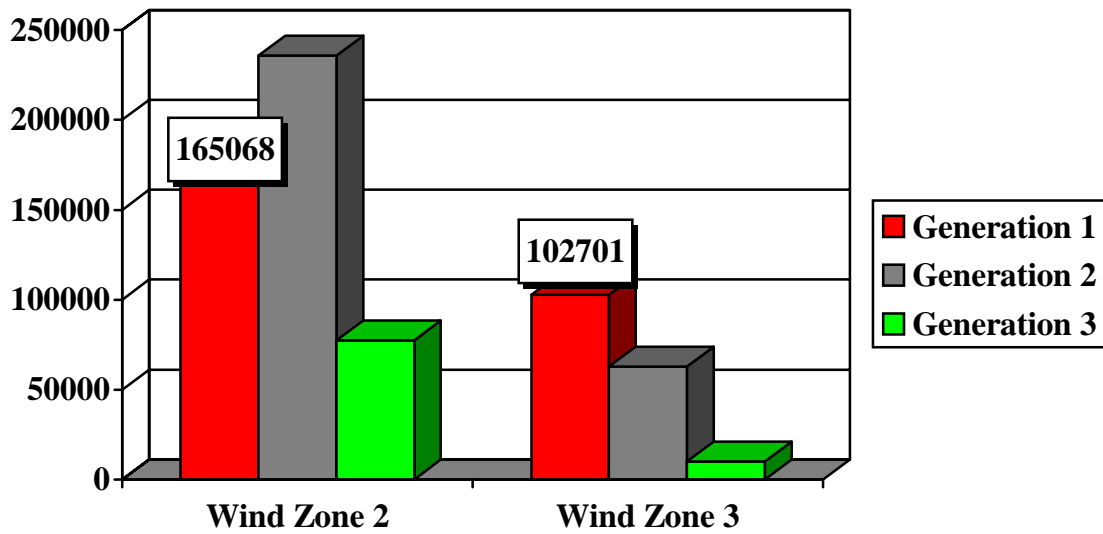
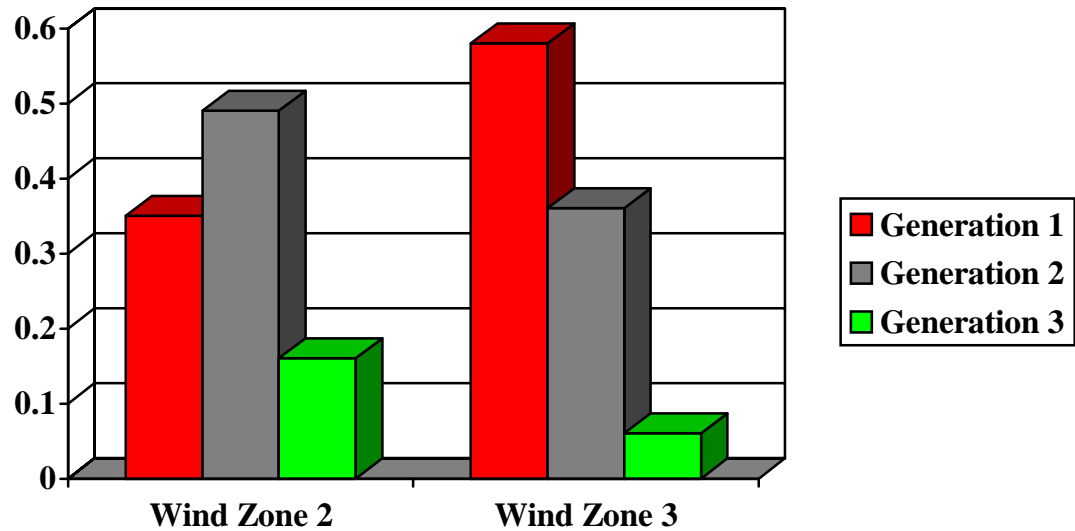


Figure 2 illustrates the raw number distribution of mobile homes based on census 2000 data. In Wind Zone 2, the majority of mobile homes are generation 2 (built between 1977 and 1994) mobile homes, whereas in Wind Zone 3, the majority of mobile homes are generation 1 mobile homes. Again, there are clearly more mobile homes in Wind Zone 2 because Wind Zone 2 includes 53 counties as compared to 14 Wind Zone 3 counties

Figure 3 highlights the proportional differences between the Wind Zone 2 and Wind Zone 3 counties. Almost 60% of all mobile homes in the 14 Wind Zone 3 counties are first generation mobile homes. Less than 10% are third generation, or what we would consider the least vulnerable, mobile homes.

Figure 3: Proportion of All Occupied Mobile Homes by Generation and Wind Zone



The data highlighted in Figures 2 and 3 emphasize that both zone 2 and zone 3 counties have a problem with generation 1 mobile homes; however, proportionately, the problem appears to be even more significant for those counties also considered the most at risk for high wind events. However, emphasis must again be placed on the damage that occurred to mobile homes in inland counties during the 2004 hurricane season. It appears that mobile homes are vulnerable regardless of their location in Florida.

In a study done after 2005's Hurricane Charley in the area hardest hit in Florida, researchers concluded that "the performance of the pre-1976 construction was notably worse" (Appendix A, HUD Report) than mobile homes constructed later. In addition, they note that the pre-1976 units sampled were more likely to be in sites that experienced higher winds. While pre-HUD homes were more likely to experience higher levels of damage, an interesting finding suggested that add-ons such as porches and carports fared poorly regardless of manufacture generation, and contributed to ancillary damage due to

flying debris (IBHS 2005). The assessment of damage from Hurricane Charley can be found at <http://www.huduser.org/Publications/pdf/HurricaneCharley04.pdf>.

As expected, units built after 1994's regulation change performed better. While the findings of this study are interesting and support the notion that pre-1976 mobile homes are the most vulnerable, some caution should be used when considering the analysis. The sampling process used over-sampled post-1994 mobile homes, and consequently under-sampled, pre-1976 homes. As a result, we have less of a picture of the true damage caused to pre-1976 units. However, this project and report give a good start to establishing future damage assessments. Reducing this vulnerable housing stock is clearly challenging.

Analysis of Department of Motor Vehicle data and census data shows that Florida has (conservatively), between 250,000 and 300,000 pre-1976 mobile homes in its housing stock. Using the even more conservative 2000 census figures, there are at least 267,769 occupied pre-1976 mobile homes in Florida. With so many units, the cost to dismantle and move them may be great.

The IHRC in conjunction with the Hemispheric Center for Environmental Technology (HCET) researched anticipated costs of dismantling and moving older mobile home units. In their 2002 HCET report, it is reported that the costs of dismantling and moving older pre-1976 are between \$3,000 and \$4,000 per unit. These costs may be significantly higher if asbestos abatement is required. All pre-1976 units require asbestos inspection. The amount of revenue generated by the recycling component of the dismantled materials is relatively low compared to the cost (about \$450). Overall the

number of pre-1976 mobile homes in Florida coupled with the estimated cost of dismantling and moving suggest a prohibitively expensive endeavor.

As Table 1 illustrates, using a mid-point figure of \$3,500, it is conservatively estimated that it will cost over \$937 million. This figure does not include any actual replacement costs or incentives that might be needed. Table 1 also gives estimates of the amounts that would be needed each year if a replacement program were spread out over a 10, 20 or 30 year period.

Table 1: Estimated Moving and Dismantle Costs for Generation 1 Mobile Homes

Funds:	Objective:
\$937,191,500.00	Total cost to move and dismantle (estimated cost \$3,500 for each unit)
\$93,719,150.00	Total amount needed per year to replace over 10 years
\$46,859,575.00	Total amount needed per year to replace over 20 years
\$31,239,716.67	Total amount needed per year to replace over 30 years

Table 2: Estimated Replacement Costs for Generation 1 Mobile Homes

Funds:	Objective:
\$937,191,500.00	Total Cost to Dismantle and Move
\$6,694,225,000.00	Total Cost to Replace at \$25,000/MH
\$7,631,416,500.00	Total Cost of Replacement
\$763,141,650.00	Total amount needed per year to replace over 10 years
\$381,570,825.00	Total amount needed per year to replace over 20 years
\$254,380,550.00	Total amount needed per year to replace over 30 years

Removing and dismantling the units is only one part of the equation. Offering homeowners replacement units adds considerably to the costs. The smallest mobile homes start at approximately \$30,000. Using a very conservative figure of \$25,000 as the amount each mobile home owner would need to replace their aging unit, Table 2 outlines the overall costs of a program of replacement including replacement and dismantling/moving. As can be seen in Table 2, the costs of such a program are staggering. Research has found that most mobile home manufacturers and retailers do not offer more than a \$1,000 to \$1,500 incentive to new buyers, and often those incentives are for upgrades, and not the basic home cost.

Census data for 2000 estimated that less than 10,000 new Generation 3 mobile homes were bought in Florida in the 10 previous years. There is no way to know the proportion of buyers that were moving into a mobile home for the first time as compared to upgrading their units. However, survey data in past project years indicates that the

majority of those in pre-1976 mobile homes have no mortgage and never have had a mortgage which suggests most are buying these units for cash.

Clearly, considering the scope and cost of a replacement program other alternatives must be considered. To comprehend these different options, a better understanding of the population who lives in these units is required.

Characteristics of Pre-1976 Mobile Home Population

Demographics

Over the last 5 years research has attempted to better understand the population living in pre-1976 mobile homes. Focused surveys of those living in these units and more general surveys looking at mobile home dwellers in general have attempted to get a better understanding of their demographics and attitudes. Understanding the characteristics of this population offers a view of the context in which they are making decisions about their homes and where they live.

The following data was collected in 2001 via telephone interviews on a variety of mobile home related issues. Data was collected for both those living in mobile home parks and those with mobile homes on a private parcel. The data are being analyzed separately because on some issues the two groups are significantly different. While data was collected for those living in all mobile home generations, the analysis included here represents only those living in first generation, pre-1976 mobile homes. In the following tables, the results marked “yes” represent those individuals living in mobile home parks; those marked “no” represent those who indicated they do not live in a park. The tables represent both demographic and attitude data on a variety of issues.

The population living in first generation mobile homes tends to be older and economically marginal. As Table 3 illustrates, the average age of survey respondents living in mobile home parks was a little over 65, with the most common age, 76. Those on private parcels tend to be younger with the average age 55. Age plays a significant role in whether people are interested in participating in less vulnerable housing programs.

Table 3: Age

Respondent's age			
Yes	N	Valid	253
		Missing	12
	Mean		65.38
	Median		69.00
	Mode		76
No	N	Valid	31
		Missing	0
	Mean		55.03
	Median		51.00
	Mode		46 ^a

a. Multiple modes exist. The smallest value is shown

It should come at no surprise that significant portions of those living in first-generation mobile homes are widows and widowers. In mobile home parks, a little over 30% are widowed and another almost 13% on private lots are widowed (See Table 4). Considering the demographics of the United States where women outlive men, it can be assumed that many, if not most, of the widowed population will be women. Older women may be less able or willing to make complicated decisions involving their living arrangements. They may be more likely to ask adult children or friends for advice. Living alone, they may be more likely to worry about the inconvenience of moving, added expenses and losing friends.

Table 4: Marital status

Is your home located in a mobile home park?			Frequency	Percent	Valid Percent	Cumulative Percent
Yes	Valid	Single	35	13.2	13.3	13.3
		Married	106	40.0	40.3	53.6
		Living together	3	1.1	1.1	54.8
		Widowed	82	30.9	31.2	85.9
		Divorced	30	11.3	11.4	97.3
		Separated	3	1.1	1.1	98.5
		Never married	3	1.1	1.1	99.6
		Other, specify	1	.4	.4	100.0
		Total	263	99.2	100.0	
		Missing	dk/nr	2	.8	
	Total		265	100.0		
No	Valid	Single	2	6.5	6.5	6.5
		Married	18	58.1	58.1	64.5
		Living together				
		Widowed	4	12.9	12.9	77.4
		Divorced	6	19.4	19.4	96.8
		Separated				
		Never married	1	3.2	3.2	100.0
		Other, specify				
		Total	31	100.0	100.0	
		Missing	dk/nr			
	Total					

Finally, as can be expected, those living in pre-1976 mobile homes report relatively low income levels with those living in parks the most economically marginal. About 20% of those in parks report an annual income of \$10,000 or less with another 32% reporting their household income between \$10,000 and \$20,000. More than 50% of all respondents indicate incomes of less than \$20,000 a year. (See Table 5 for details)

The social environment of the residents in these older mobile homes reflects their marginal social status. Living with limited income in conjunction with age lends itself to limited options for moving people to less vulnerable locations. In fact, to our earliest inquiries, many indicated no interest in participating in a program to help them relocate.

Table 5: Annual household income

Is your home located in a mobile home park?			Frequency	Percent	Valid Percent	Cumulative Percent
Yes	Valid	UNDER \$5,000	12	4.5	6.5	6.5
		\$5,000 _ \$10,000	26	9.8	14.1	20.5
		\$10,000 _ \$20,000	60	22.6	32.4	53.0
		\$20,000 _ \$30,000	49	18.5	26.5	79.5
		\$30,000 _ \$50,000	25	9.4	13.5	93.0
		\$50,000 _ \$ 75,000	11	4.2	5.9	98.9
		\$75,000 _ \$100,000				
		OVER \$100,000	2	.8	1.1	100.0
		Total	185	69.8	100.0	
		Missing	dk/nr	80	30.2	
	Total		265	100.0		
No	Valid	UNDER \$5,000	1	3.2	4.0	4.0
		\$5,000 _ \$10,000	3	9.7	12.0	16.0
		\$10,000 _ \$20,000	3	9.7	12.0	28.0
		\$20,000 _ \$30,000	6	19.4	24.0	52.0
		\$30,000 _ \$50,000	9	29.0	36.0	88.0
		\$50,000 _ \$ 75,000				
		\$75,000 _ \$100,000	2	6.5	8.0	96.0
		OVER \$100,000	1	3.2	4.0	100.0
		Total	25	80.6	100.0	
		Missing	dk/nr	6	19.4	
	Total		31	100.0		

As suggested earlier, only a small percent of those living in pre-1976 mobile homes currently have a mortgage. Living in their current home, then, is a very affordable option. As Table 6 shows, only about 7% of those living in a mobile home park have a mortgage. A higher percentage of those living on private parcels have a mortgage.

Not having a mortgage can in part explain why people are not interested in any type of program to move to less vulnerable housing. Without a mortgage, housing related expenses are, at a minimum, moderate. Any increased expenses might be impossible for these households to manage. Interestingly, of those that do not currently have a mortgage, the majority have never had a mortgage. Only about 18% who live in mobile home parks

have ever had a mortgage for their mobile home, while 28% on private parcels have had a mortgage (See Table 6).

Table 6: Do you have a mortgage?

Is your home located in a mobile home park?			Frequency	Percent	Valid Percent	Cumulative Percent
Yes	Valid	Yes	18	6.8	6.9	6.9
		No	244	92.1	93.1	100.0
		Total	262	98.9	100.0	
	Missing	dk/nr	3	1.1		
	Total		265	100.0		
No	Valid	Yes	6	19.4	19.4	19.4
		No	25	80.6	80.6	100.0
		Total	31	100.0	100.0	
	Missing	dk/nr				
	Total					

This demographic profile helps explain early findings that indicated people are not interested in participating in a program of replacement. In addition to demographic issues, homeowner attitudes in relationship to their home, hurricanes and risk is also important to consider.

Attitudes

Research has shown that a relationship exists between risk perception and willingness to take protective measures against hazards. Whether these measures are evacuation or structural mitigation, the first step to action is belief that there is a danger. To best understand how attitudes of those in pre-1976 mobile homes, a series of questions were asked during a pre-hurricane season 2004 survey (see the IHRC 2004 final report for sample specifics), to better understand danger assessment and potential responses.

Overall, about 12% of respondents (Table 7) indicated that they are not concerned with hurricanes at all, and another 32% indicate that they are only a little concerned.

Considering all of the respondents live in a pre-1976 mobile home according to DMV data, this finding was startling. It is unknown whether the storms of the 2004 hurricane season altered these attitudes. Of the respondents, only about 26% were very concerned about hurricanes. Overall, this reflects a general perception that their housing is safer than or at least as safe as site-built homes.

Table 7: How concerned are you about the risk of hurricanes?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Not Concerned at All	53	10.4	11.7	11.7
	2 A little concerned	146	28.7	32.2	43.9
	3 Somewhat concerned	137	26.9	30.2	74.2
	4 Very Concerned	117	23.0	25.8	100.0
	Total	453	89.0	100.0	
Missing	9 No Answer	16	3.1		
	System	40	7.9		
	Total	56	11.0		
Total		509	100.0		

Table 8 highlights a more disconcerting finding that almost 23% of respondents think that their mobile home is as safe or safer than a traditionally built single-family house. Motivating people to invest any time or effort in protecting themselves from hurricanes is impossible as long as they believe their type of housing has no additional risk.

Table 8: During a hurricane how safe is your mobile home compared to single-family house?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Much Safer	3	.6	.7	.7
	2 Safer	7	1.4	1.6	2.3
	3 No Difference	88	17.3	20.6	22.9
	4 Less Safe	208	40.9	48.6	71.5
	5 Much Less Safe	122	24.0	28.5	100.0
	Total	428	84.1	100.0	
Missing	9 No Answer	41	8.1		
	System	40	7.9		
	Total	81	15.9		
Total		509	100.0		

These unrealistic perceptions of the dangers of hurricanes are also illustrated by respondents' beliefs regarding the amount of damage a hurricane would do to their mobile home. Perhaps it is because they feel detached from the reality of the hurricane risk, as evidenced in Tables 7 and 8. Perhaps it is difficult for mobile home owners to think about the greater risk to their mobile home as opposed to others. More than likely it is simply that they are not educated to the risk associated with hurricanes, and even less educated in the specific risks to mobile homes.

Overall, though, as Table 9 illustrates, about half of the respondents believe that their mobile homes would still be livable after a hurricane. About 13% believe they would have little or no damage. Only about 22% of the sample recognizes that their mobile home would likely be destroyed in a hurricane.

Table 9: If there was a hurricane, how much damage do you think your mobile home would suffer?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 None	5	1.0	1.5	1.5
	2 Very little	37	7.3	11.3	12.8
	3 Some damage, but livable	129	25.3	39.4	52.3
	4 Major damage, repairable, but not livable	84	16.5	25.7	78.0
	5 Destroyed	72	14.1	22.0	100.0
	Total	327	64.2	100.0	
Missing	9 No Answer	142	27.9		
	System	40	7.9		
	Total	182	35.8		
Total		509	100.0		

Also interesting to note is that 142 respondents simply could not answer the question. They clearly could not imagine what would happen to their mobile home should a hurricane strike. Some commented that it would depend on the strength of the storm, but for the majority it appears that they simply have never thought about the subject.

Trying to overcome these misperceptions is challenging. Part of the equation may be that those living in these older mobile homes enjoy the lifestyle and the amenities of park life, in addition to their perceived affordability. In fact when asked why they live in a mobile home, a significant percentage of 2004 survey respondents reported that the enjoyment of living in a mobile home park is the main reason they own their mobile home. This is followed closely, as seen in Table 10, by respondents indicating that the mobile home was the only home they could afford. For this question, respondents were able to choose as many options that applied to them, and then fill in any other reasons they felt were missing.

The first five options in Table 10 were a list respondents could chose from, while the last two options were common responses noted in the open-ended fill in the blank section. Clearly, many respondents noted that a mobile home is the only way they could afford to live in the location that they wanted, and this usually involved some type of waterfront property.

Table 10: Why do you own your mobile home?

	Count	Pct of Responses	Pct of Cases
I like owning my own home	145	23.7	33.3
Inherited the mobile home	20	3.3	4.6
Earn money by renting out	33	5.4	7.6
Only home I could afford	164	26.8	37.7
Enjoy living in Park	180	29.5	41.4
Affordable location	38	6.2	8.7
Winter home	31	5.1	7.1
Total responses	611		

Understanding the demographics and the attitudes of the residents of these oldest mobile homes is vital to put the issue of a replacement program in context. This context, in conjunction with the cost, helps explain why over the course of this project, none of the three replacement options were considered viable or sustainable. The fourth, as will be illustrated, remains the only option with the potential to reduce the exposure of the State of Florida and its residents who live in pre-1976 mobile homes.

Program Options

Over the history of this project, three replacement options and one safety option have been suggested and explored. These four options focus on finding ways to move residents from highly vulnerable housing to safer options. Panel discussions and survey questions explored whether people would be interested in participating if the program was available. Before the discussion of the four options, some general trends will be analyzed.

Research during Year 4 of this project asked those who own pre-1976 mobile homes how interested they would be in a general program for removal of their current mobile home and credit towards another mobile home. Only about 30% (Table 11) report that they are very interested in a program of removal and replacement.

Table 11: Interest in program for removal of MH and credit towards new MH

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Not interested at all	96	18.9	23.2	23.2
	2 A little interested	66	13.0	16.0	39.2
	3 Somewhat interested	127	25.0	30.8	70.0
	4 Very interested	124	24.4	30.0	100.0
	Total	413	81.1	100.0	
Missing	9 No Answer	56	11.0		
	System	40	7.9		
	Total	96	18.9		
Total		509	100.0		

Fewer, however, are interested in any type of program that relates to a more traditional site-built home. As Table 12 shows, only about 22% are very interested in a program that would assist with credit towards a site-built home. Over 40% are not interested at all.

Table 12: Interest in program for removal of MH and credit towards SITE-BUILT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Not interested at all	169	33.2	41.4	41.4
	2 A little interested	60	11.8	14.7	56.1
	3 Somewhat interested	89	17.5	21.8	77.9
	4 Very interested	90	17.7	22.1	100.0
	Total	408	80.2	100.0	
Missing	9 No Answer	61	12.0		
	System	40	7.9		
	Total	101	19.8		
Total		509	100.0		

While on the surface, these figures seem encouraging, more detailed questions regarding different program options with a panel in the early stages of this research endeavor indicated little interest. As each program option is discussed, results from the panel interviews are highlighted where applicable. While the overall number of respondents on the panel was low, their comments shed light on impediments to developing a program of replacement.

Replacement Option 1

The first option for a recycling program explored was a simple rebate plan. Those in older first generation mobile homes would get a rebate from a manufacturer for turning in their old unit for recycling. The rebate would be applied to the cost of a new mobile home that meets the stricter wind standards. Florida would absorb the costs of dismantling and removal while the manufactured home community would offer the rebate.

The advantages of this type of program of replacement would be that the overall cost to the State of Florida would be minimal while at the same time manufacturers could see an increase in sales. On the other hand, it is likely that the majority of those who own

pre-1976 mobile home will not be able to participate due to financial reasons. In addition, this program requires manufacturers' cooperation.

As the data analysis show, the majority of those who live in pre-1976 mobile homes are economically marginal and/or elderly. Very few currently have a mortgage, and only a handful or so have ever had a mortgage. Even with a rebate (regardless of amount), monthly expenses will rise. For most of this population, this is not an option, particularly for those on fixed incomes.

When the panelists were asked how interested they were in a program that offered up to \$5,000 towards a new mobile home, about 75% said they would not be interested at all, as Table 13 shows. With the addition of those who are only a little interested, about 84% would probably opt out of involvement in a program. None of the panel members indicated that they would be very interested. About 16% who indicate that they are somewhat interested may be a group that might be persuaded through program options to be involved.

Table 13: Interested in rebate program for another MH

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not interested at all	32	68.1	74.4	74.4
	A little Interested	4	8.5	9.3	83.7
	Somewhat Interested	7	14.9	16.3	100.0
	Total	43	91.5	100.0	
Missing	System	4	8.5		
Total		47	100.0		

To better understand why people were not interested in a rebate program, panelists who indicated that they were either not interested or only a little interested were asked why their interest was low.

Major issues appear to be age of resident, economics, and comfort/convenience. A rebate incentive does not appeal to the elderly population living in these older mobile homes in part because of the economics of moving, but also in terms of the inconvenience of moving. The data also suggest that economics and inconvenience of moving are issues for everyone, not just the elderly. Others suggest that their current mobile home is worth more than the \$5,000 offered particularly when additions to the unit are considered.

The inconvenience of moving is the dominant reason why people are not interested in a rebate program. A detailed enumeration of reasons can be found in the IHRC Year 2 Project Final Report.

Replacement Option 2

A second program that was explored would offer those who turn in pre-1976 mobile homes for removal and recycling with assistance with down payments for a site built home or condominium. This program would appeal to those who did not enjoy the mobile home lifestyle. The major advantage to this type of program is that it helps those who are living in mobile homes by circumstance and not desire, get into a safer form of housing that they would prefer.

One of the disadvantages is that it requires the state to find a way to underwrite the program through self-financing or by getting homebuilders to buy into the program. In addition, such a program would have very limited appeal. As discussion has shown, the majority of people living in mobile homes do so because they enjoy the lifestyle. Consequentially, only a very small dent will be put in the overall exposure to losses.

When panel discussants were asked how interested they would be in a program that gave up to \$5,000 towards a down payment on a site built home few indicated interest. This finding reflects that the majority of those in mobile homes wish to stay in mobile homes for either economic or social reasons. Over 95% of panelists indicated that they are not interested in a down payment program for a site built house. (See Table 14) The reasons for this disinterest vary, but are similar to the reasons mentioned for why they are not interested in a rebate program. More emphasis, however, appears to be on the expense of living in a single-family home in comparison to living in a mobile home. Other frequently mentioned reasons were that they prefer to live in a mobile home and not interested in moving,

Table 14: Interested in program for down payment on site built home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not interested at all	41	87.2	95.3	95.3
	Somewhat Interested	1	2.1	2.3	97.7
	Very Interested	1	2.1	2.3	100.0
	Total	43	91.5	100.0	
Missing	System	4	8.5		
Total		47	100.0		

Replacement Option 3

The third replacement option considered was a program that offered those in older units a new mobile home with little or no out of pocket expenses for the safer structure. Originally this type of program seemed more advantageous since more households could participate since they would have no additional costs. One of the biggest problems with options one and two was that they would require significant increased expense on the part of the participant. A second advantage is that it would allow households to stay in mobile homes which many indicated was their preferred housing type.

However, with these advantages come significant disadvantages. The main disadvantage is the cost of such a program. As discussed earlier, dismantling and removing mobile homes in and of itself would be cost prohibitive. Adding the cost of a new post-1994 mobile home to the equation creates an astronomically expensive program. The only funding option for such a program would probably require a significant additional tax on mobile home registrations. Because of the cost, the program would make only a minor dent in the level of exposure. Funding of \$5 million per year would only eliminate about 100 vulnerable homes from the housing stock.

On the surface, offering a newer mobile home in exchange for an older one seemed to be the type of program most would be willing to join. However, this ignored the fact that a newer mobile home may not be able to go into the same lot because of zoning regulations. In addition, even though the unit itself may not increase overall housing costs, these larger units may cause other expenses to increase. Those on fixed incomes may not be willing to participate.

Indeed, when asked level of interest for a program that would offer a newer, mobile home that was built after 1994 in exchange for their current unit, many simply were not interested. Of the three program options, before talking to panelists, the belief was that this option would be the one with significant interest. But, as Table 15 illustrates, almost 80% of panelists indicated that they were not interested in this program at all. About 15% reported that they were somewhat or very interested. These findings were surprising.

Table 15: Interested in program that gives newer Mobile Home

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Not interested at all	34	72.3	79.1	79.1
A little Interested	3	6.4	7.0	86.0
Somewhat Interested	5	10.6	11.6	97.7
Very Interested	1	2.1	2.3	100.0
Total	43	91.5	100.0	
Missing System	4	8.5		
Total	47	100.0		

Looking at the responses from panelists on why they were not interested in a program that would offer them a newer, safer mobile home, the most salient issue appears to be that people simply do not want to move. The cost and inconvenience of packing and moving outweighs the benefit of a newer, safer home. Much of this reflects the general demographics of this population. As discussed earlier, the mean age of those in pre-1976 mobile homes is a little over 65 with the most frequent response 76. Without a doubt, the demographics of the population play a very significant role in their interest in a program.

Realizing that none of the replacement options might appeal to panelists, a final open-ended question was asked to determine what, if anything would motivate panelists to move from their current home. The two most common responses appear to be

“nothing” or “death.” Other reasons included increased expenses. However, the fact that a significant proportion indicated only death would motivate them to leave their mobile home sheds light on the overall problem any program of replacement would encounter.

Non-Replacement Option 4

Should the State of Florida continue to want to pursue a reduction in the number of pre-1976 mobile homes in its housing stock, the previous three options are not feasible based on the economic and social conditions outlined above. A last option has the potential to be the only viable “removal” option in regards to this highly vulnerable population. However, while it is the only viable “removal” option, it is not the only options available to make this population safer. Other “non-removal” options will be discussed in the sixth part of this report.

The final option considered in order to help remove highly vulnerable pre-1976 mobile homes from the housing stock does not involve replacement. Option four suggests that the best course of action for the State of Florida would be to ban or outlaw pre-1976 mobile homes based on safety issues. Current owners would be grandfathered in so that they did not have to replace their home immediately, but the home could not be turned over to another owner in Florida (could be moved out of state). Just as automobiles must meet some minimal safety requirements (brake lights, etc) so should older mobile homes which are a safety hazard to not only those who live in them, but those around them as well.

While this option is the most radical approach, it does have advantages. First, such a program would not require the displacement of households right away. The

program allows people to make plans for when they would have to move into other housing or allows people to live out their lives in their current home. Additionally, Florida can implement such a program without getting mobile home manufacturers or home developers to buy into the program. These benefits, however, may be overshadowed by the disadvantages.

The major disadvantage is that such a policy would probably have significant legal challenges. In addition, because mobile homes are personal property, the State would probably have to offer some type of buy-out to owners. Such a buy-out would be difficult considering the challenges finding a standardized equitable market value. Finally, this type of program would have only a small impact on current exposure to losses as it is a much longer term process. Without any type of current incentive to remove these older mobile homes from the housing stock, it can be expected that they will remain mostly occupied with an increasingly socially vulnerable population.

Of these four options, the only viable option appears to be the most controversial one: banning pre-1976 mobile homes in the State of Florida. And even the viability of this option is questionable considering the overall implications in regards to legal challenges and equitable buy-outs. If the State of Florida wishes to continue pursuing this issue, it is recommended that the idea of a replacement program be scrapped in order to focus efforts on understanding the legal ramifications and challenges of making pre-1976 mobile homes illegal in Florida.

In light of recent U.S. Supreme Court rulings which allow eminent domain for purposes of private economic development, it is possible that the courts would find in favor of a law that makes dangerous pre-1976 mobile homes illegal in Florida. Such a

law would have as its primary intent the reduction of vulnerability of those living in pre-1976 mobile homes. The State should consider legislation that requires mobile homes to be structurally sound, and open for inspection by local jurisdictions. If the mobile home is found to not be structurally sound (either due to degradation or improperly built additions), the State should have the right to deem the mobile home unlivable, and to take appropriate action to remove the danger. The prevalence of attached additions to mobile homes should be a major concern of the State and local jurisdictions.

Major issues will still have to be tackled should the state decide to move forward with such a law. Issues to be addressed include how to fund the program both in terms of administration and in terms of the costs to remove and dismantle these older units.

Additional taxes on mobile home registrations may be fought by the legislature and the mobile home lobby. Asking people to fund a program that ultimately may lead to many losing their property will be difficult to gain support. The only stakeholders that will benefit will be the State of Florida and the federal government through a reduction of exposure to losses due to damage caused by tropical weather.

Ultimately, however, the cost is too high for the State of Florida to do nothing in regards to this issue. As more storms impact Florida and more damages occur, the State of Florida will be called to do more for this socially and physically vulnerable population. Some type of proactive program is in the State's best interest. What is less clear is whether focus on removing these units from Florida is the best course of action.

As this report illustrates, the original vision of some type of program to help people move out of highly vulnerable pre-1976 mobile homes does not seem like a realistic path for the State of Florida to pursue. Should Florida decide to pursue this line

of mitigation activity it should be anticipated that the costs will be high and the length of time to accomplish any noticeable change will be long.

The research undertaken over the last four years does however lend itself to some significant suggestions for future policies and programs to help those in older mobile home reduce their physical exposure to hurricane related damages. The final section of this report highlights some areas that have been discussed over the last four years of this project, but not pursued.

Recommendation for Non-Replacement

In lieu of a program that focuses on moving people out of their older mobile homes, the State of Florida should consider the following options that have been developed as a consequence of the last four years of research. These options have at their core making all residents of mobile homes less vulnerable.

Option 1:

As emphasized in both the current and previous year's report, one of the most alarming findings over the course of this project was the extent to which mobile home owners do not recognize their increased risk to the effects of hurricane force winds. The State of Florida should assess what types of educational programs are in place that specifically target mobile home owners, and consequently, develop educational programs that can fill in the gap. Such educational programs should be targeted to groups that are least likely to accurately assess their risk such as those who live in their mobile homes only part time and the most socially marginal populations such as the elderly and economically disadvantaged.

A first step must be an analysis of what types of educational materials are currently targeted to the mobile home population. Are they on a county by county basis? If so, would a statewide educational program be more effective? Once an understanding of current educational activities is achieved, educational materials specifically focused on mobile home owners should be developed. These materials should educate residents on not only the hurricane risk, but also the increased vulnerability of their units. This should include a frank discussion of the increased vulnerability of pre-1976 mobile homes. Most

residents are probably not aware of the differences between early are more recent mobile home construction.

Option 2:

As discussed earlier in this report, recent assessment of damage to manufactured homes caused by Hurricane Charley (see Appendix A for HUD report) suggests that mobile homes with additions such as porches, carports and garages fared much worse in the storm than those without additions. This finding held true over all three generations of mobile homes. IHRC research over the last five years has explored the issue of additions and the regulatory environment in which these additions can be built. On the whole, counties within Florida require permitting and inspection of mobile home additions. Yet, it appears that very few additions are officially inspected and approved by county personnel.

Mobile homes built in accordance with U.S. Department of Housing and Development guidelines are tested for wind resistance based upon the stand alone unit. Counties regulate additions to the units and may restrict the percentage of the unit that can be “covered” by some type of structural addition or may designate that restrictions can not be tied into the mobile home unit itself. While most counties and even municipalities may have these guidelines, few have the personnel to properly inspect and regulate these additions.

Over the course of the four previous years of this project, examples of mobile home additions in Miami-Dade, Broward, and Polk counties have been examined. In one instance, the entire outer structure of the mobile home was covered with stucco so that you could no longer recognize it as a mobile home. In another case, an entire home was

built around and attached to the original mobile home. Almost all mobile homes have a porch or carport integrated into its overall structure. Table 16 summarizes data from the 2004 survey of pre-1976 mobile home that asked owners about the presence of additions on their mobile homes.

Table 16: Attached Additions to Mobile Home

Dichotomy label	Count	% of Responses	% of Cases
Added:			
Room?	103	17.1	34.83
Attached porch?	177	29.4	59.8
Attached carport?	111	18.4	37.5
New roof/Roof –Over?	174	28.9	58.8
Some type of siding?	24	4.0	8.1
Enclosed porch	14	2.3	4.7
Total responses	603		

Respondents were able to choose any or all of the options given, and to add any others that came to mind. The first four additions listed in Table 16 were listed for the respondents. The last two were common responses given in the open-ended section. Table 16 gives two percentages: 1) percentage of all responses and 2) percentage of cases that responded yes. Alarming, more than 2/3s of respondents indicated that they had some type of addition. The most common additions were added attached porches and new roofs or roof-overs (both around 60%). While only 8.1% of respondents indicate that they have added siding (vinyl or brick), this probably underestimates the true proportions since the option was not given, and these results are gleaned from inserted comments. In addition, these numbers are probably underestimated since the question specifically asked

whether the respondent added to their units. Some who bought the unit with additions may have not reported any changes.

Clearly, the prevalence of additions in conjunction with the findings of the damage assessment after Hurricane Charley emphasize that more needs to be done to regulate and inspect additions to mobile homes. Stricter laws and regulations limiting additions are necessary. A better understanding of how various types of additions impact the structural viability of a mobile home unit should be pursued. Municipal laws that require inspection and/or independence of the structural addition should be enforced.

To understand the scope and nature of the problem, the State of Florida should pursue an inspection program of mobile homes to gauge the seriousness of the situation, and to recommend policies to reduce the vulnerability of these units. A database of inspected mobile homes should be developed that would allow damage assessment of these units after future storms. Regulations should be developed if possible to regulate future additions to mobile homes. Consideration should be given to policies that would require current additions to meet some type of codified standard.

In addition to the above two recommendations, a recommendation from last year's report should be seriously considered if the goal is to reduce the vulnerability of mobile homes, and particularly pre-1976 mobile homes.

Option 3:

Further research needs to be done to better understand insurance issues for mobile home owners. Research from Year 1 highlighted that mobile home owners are limited in their insurance options. A major hurricane in Florida, particularly in a location with large

quantities of mobile homes, could easily cripple what little insurance industry that exists for mobile homes.

Summary

While the idea of a replacement program to reduce the number of older, pre-1976 mobile homes in Florida sounds promising in theory, the reality of implementing such a program in an effective and cost-efficient manner appears impossible. The scope of the problem in Florida is too big to make such a program feasible. As a result, the only feasible solution would be for Florida to enact legislation that would make pre-1976 mobile homes illegal in the state. While this is the most feasible solution, it too is accompanied with significant problems such as the potential for lengthy legal wrangling over the issue. In addition, such a program does not address the increasing vulnerability of second generation mobile homes.

To decrease the vulnerability of Floridians living in mobile homes, the best option appears to be better educational programs in conjunction with enforcement of laws and regulations regarding permitting and inspection of mobile home additions, regardless of the mobile home generation. Simultaneously, structural research (despite the mobile home industry's objections) should be undertaken to both assess the impact of additions on the physical vulnerability of mobile homes and explore affordable mitigation options.

These activities in combination should make some strides in reducing the overall vulnerability of Florida's mobile home housing stock. The only viable way to reduce the number of pre-1976 mobile homes in Florida would be to enact legislation allowing for Florida to force their removal.

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APPENDIX A

AN ASSESSMENT OF DAMAGE TO MANUFACTURED HOMES CAUSED BY HURRICANE CHARLEY



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Assessment of Damage to Manufactured Homes Caused by Hurricane Charley

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Disclaimer

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Summary

On August 13, 2004, the Southwestern Gulf Coast of Florida was struck by Hurricane Charley. HUD quickly assembled a team to assess the performance of manufactured homes and to make any recommendations for continued improvement.

Even though the winds of Hurricane Charley did not generally reach the maximum design wind requirements, this study provided significant information regarding the performance of manufactured homes produced after July 13, 1994, when the revised wind load requirements became effective, as compared to the homes produced under the previous standards. This study helped to assess the effectiveness of Florida's revised installation requirements (effective March 29, 1999), the effectiveness of field installation of siding, and the effect of add-ons on the performance of homes. The evaluation team did not find any home sited on permanent foundations designed in accordance with HUD permanent foundation guidelines for manufactured housing.

Conclusions are as follows:

1. The wind pressures on the manufactured homes in the sample area were approximately 50% to 75% of the design load for homes produced after July 13, 1994 based on the updated HUD code.
2. Post July 13, 1994 homes performed significantly better than Pre-1994 homes at a high level of confidence. Furthermore, pre-HUD homes were much more severely damaged than newer (post 1976) HUD Code units at a high confidence level. This significant trend of improvement was evident in all areas related to the scope of the HUD Code, from roof construction to roof-to-wall connections, to walls and overall structural integrity.
3. Newer foundation installations installed under Florida's revised (1999) Installation Standards typically performed with a relatively low level of damage. However, Post-99 foundation installations were not flawless, and about 40 percent experienced some level of damage (e.g. slipping on piers and damage to vinyl skirting). In addition, modest amounts of scour and undermining of shallow piers due to wind and rain water run-off were noted in some cases.
4. Florida's installation requirements do not establish any performance standards for skirting. In general, there was significant damage to the skirting.
5. Field installation of siding was not as effective as factory installation. In addition, the corners and edges of homes showed a higher general degree of damage than other points of homes.
6. Add-ons such as screened porches, carports and garages generally performed very poorly across all age groups of construction. In most instances, the connections of these add-ons failed, resulting in damage to the home. Aluminum roofing from add-on construction was a common source of wind-borne debris.

7. Tie-down straps were frequently observed to be corroded and rusted. The corrosion may have been accelerated when the straps were embedded in concrete or were in direct contact with ground moisture.
8. Even though not specifically documented, the homes with shutters generally sustained less damage than those without window protection.
9. The evaluation team did not find any homes sited on permanent foundations designed in accordance with HUD permanent foundation guidelines for manufactured housing.

Introduction

On Friday, August 13, 2004, the Southwestern Gulf Coast of Florida was struck by Hurricane Charley, with a maximum over-land wind speed of approximately 110 mph (sustained) and less in highly developed areas of Punta Gorda, Port Charlotte, and surrounding communities. Correspondingly, maximum gust wind speeds are estimated to be 130 mph or less in open overland exposure; an anemometer measurement from the Punta Gorda Airport registered a wind gust of 111 mph, but failed prior to complete passage of the event (NOAA, August 16, 2004). For the region defined by the representative sample of manufactured homes investigated in this study, typical wind speeds are estimated to be in the range of 90 to 110 mph (sustained) at 33 feet from the ground. See the *Event Characterization* section of this report for further details.

While these wind speeds suggest that Hurricane Charley was a strong Category 2 or marginal Category 3 event in terms of its general impact to inland coastal regions and major developed areas, its over-water wind speed at or just prior to initial landfall was reported to be approximately 140 mph (1-minute sustained) – a Category 4 hurricane according to the Saffir-Simpson scale. Data from the National Oceanic and Atmospheric Administration’s Hurricane Research Division regarding the magnitude of Hurricane Charley’s winds as they changed during landfall and during its track inland are discussed later in this report. In general, however, it will be some time before consensus is reached among experts to arrive at a consistent and scientifically agreed upon characterization of Hurricane Charley’s wind field.

Because the hurricane track prediction was abruptly altered only a matter of hours before a mid-evening landfall, residents had limited time to make final preparations and to evacuate. In Punta Gorda, Port Charlotte, and surrounding communities that were hardest hit by Hurricane Charley, damage was severe, resulting in widespread power outage, debilitation of emergency services, loss of life, and large economic losses.

The affected region and communities have a relatively large population of manufactured housing units that serve affordable housing needs ranging from newer upscale owner-occupied communities to older rental-based manufactured housing parks. Because of the importance of manufactured housing, and for other reasons related to its safe regulation in hurricane-prone regions of the United States, the Office of Manufactured Housing Programs of the U.S. Department of Housing and Urban Development (HUD) commissioned this study to assess the damage to manufactured homes. This study follows an objective damage assessment methodology, making statistical analysis of a representative sample of manufactured homes and their performance in Hurricane Charley possible. Such an approach should lead to a better understanding of past decisions, while giving objective guidance for future decision making, as has been demonstrated in prior studies of a similar nature for HUD (McKee and Crandell, 1999; Crandell and McKee, 2000). Statistical findings of this report are also supplemented with important damage observations that are more anecdotal in nature.

While this study permits broad characterizations of the sampled manufactured housing population and its performance, it was intended to provide information related to a few “high priority” issues. Specifically, three key questions were posed for the study:

1. Did newer manufactured housing units (i.e., Post-1994) perform better than older units (i.e., Pre-1994)? HUD Code standards were initiated in June 1976 and updated in July 1994 to improve wind performance based on the experience the Department gleaned from Hurricane Andrew in 1992.
2. Did newer (i.e., post-1999) Florida requirements for foundations and anchorage of manufactured homes perform adequately in comparison to the HUD requirements for permanent foundations that enable Title II financing (e.g., 30-yr mortgage) for manufactured housing?
3. Did the winds of Hurricane Charley produce loads similar to those required in the HUD Code, such that homes built to the newer HUD Code requirements and Florida foundation requirements were fully “tested” by the event?

Sufficient data was collected to provide a statistically conclusive answer to the first question. Observations and data obtained during the survey also provide guidance regarding the above questions, in addition to several other findings. Unfortunately, no manufactured homes on permanent foundations (HUD, 1996) were found in the study region. Therefore the study produced insufficient information to make a direct comparison between performance of HUD permanent foundations and newer Florida foundation installation and anchorage requirements. However, a number of newer Florida foundations were sampled in the study to allow an assessment of their performance.

This report is organized to first provide background information regarding hurricanes, wind, and manufactured housing regulations. The background section is intended to provide a proper context and a level of understanding necessary to best interpret the findings of this study. The background information is followed by a section devoted to characterizing Hurricane Charley and the estimated wind loads experienced by the sampled manufactured homes of this study.

Next, construction characteristics and damage statistics are presented and discussed in a section titled Damage Assessment. In addition, results of statistical inferences regarding the performance of different construction age groups and construction characteristics are provided. Supplemental observations follow in sequence, to address important items not specifically addressed in the statistical damage assessment analyses. The report closes with sections providing conclusions and recommendations.

Background

Classification of Hurricanes

The accepted method of classifying hurricanes is the Saffir-Simpson Scale, which serves as a rough or subjective measure of potential for damage. Hurricanes are categorized into five classes (Table 1) based primarily on the atmospheric pressure depression within the eye of the hurricane. In Table 1, the central eye pressure is also associated with an expected range of maximum wind speed and storm surge. Hurricane Charley's central pressure at or near the time of landfall was 946 mb, with a sustained surface level wind speed estimated to be 123 knots (141 mph) as shown later in Figure 1. Thus, according to central pressure, Hurricane Charley may be classified as a Category 3 hurricane, but by estimated surface winds it may be classified as a Category 4 hurricane at its peak. This contradiction demonstrates the difficulty in uniformly classifying hurricanes and relating them to a subjective description of damage potential.

Table 1
Classification of Hurricanes
By the Saffir-Simpson Damage Potential Scale

Category	Central (Eye) Pressure, mb*	Winds, mph**	Surge, ft.	Potential Damage
1	≥ 980	74 – 95	4 - 5	Minimal
2	965 - 979	96 – 110	6 - 8	Moderate
3	945 - 964	111 – 130	9 – 12	Extensive
4	920 - 944	131 – 155	13 - 18	Extreme
5	< 920	> 155	> 18	Catastrophic

* Standard atmospheric pressure at sea level is about 1013 mb (14.7 psi).

** Maximum sustained (1-minute) wind speed at an elevation of 10 meters (33 feet).

It is useful to compare Hurricane Charley to other storm events for which similar damage assessment studies have been conducted. Hurricane Andrew, recently reclassified by NOAA as a Category 5 hurricane, with sustained wind speeds of more than 155 mph over sea and about 145 mph extending well inland, caused extensive wind damage resulting in at least some amount of lost roof sheathing for 70% of the homes in the area (Crandell, 1993; Crandell, 1998). However, relatively little damage was caused by the storm surge. Conversely, Hurricane Opal had a maximum gust wind speed of about 125 mph at landfall, which corresponds to a sustained wind speed of about 102 mph and a Category 2 on the Saffir-Simpson Scale. Wind damage was moderate in that about 2% of sampled homes had some amount of roof sheathing damage or loss (Crandell, 1996). Unfortunately, Opal's storm surge did extensive damage to many older (unelevated) beach front homes. Other damage characteristics, such as roofing damage or even tree damage, may also be used as a comparative index to determine the relative wind speed and damage potential of events. In general, observed damage from Hurricane Charley appears to fall well below that of Hurricane Andrew, but slightly above that of Hurricane Opal. Therefore, after the time of initial landfall and particularly for some distance

inland in populated areas such as Punta Gorda and Port Charlotte, the wind field of Hurricane Charley may be more reflective of a marginal Category 3 event.

Wind Characteristics

Wind is a highly variable natural phenomenon. Therefore, the magnitude of a wind speed measurement depends on the averaging time over which the measurement is made. As mentioned, hurricanes are generally classified and reported on the basis of a maximum sustained wind speed, meaning an average wind speed observed over a 1-minute interval. While older wind engineering standards and building codes have used the fastest-mile wind speed (based on the average speed of a 1-mile length of wind passing an anemometer), newer wind engineering standards use a gust wind speed basis which is generally considered to have a much shorter averaging time of 3 seconds or less. Truly instantaneous wind speed measurements are difficult if not impossible to make.

It is important to know and understand the averaging time associated with a particular reported wind speed. To assist in this understanding, Table 2 provides typical wind speed conversions between different averaging times for wind speed measurements. For example, Hurricane Charley may be reported at about the time of landfall to have a sustained wind speed of 140 mph, a fastest-mile wind speed of 151 mph, or a gust wind speed of 170 mph. All are theoretically correct; they only differ in the amount of averaging of the “peaks and valleys” that occur in any wind record over a specified time period. In addition to the averaging time conversions, wind speeds are often reported in nautical terms, such as knots. One knot is equal to 1.15 mph. Thus, both unit conversions and averaging time conversions may be necessary to make an “apples-to-apples” comparison of reported wind speeds. Finally, wind speeds are affected by the exposure condition (surface roughness) and elevation above ground level upon which they are based. Therefore, if elevation or exposure differences exist in reported wind measurements, these also need to be normalized to allow for a consistent comparison.

Table 2
Conversion of Wind Speeds
For Various Units and Averaging Times
Used to Report Wind Measurements

Wind Speed Basis	Equivalent Wind Speed Magnitudes								
3-second gust (mph)	90	100	110	120	130	140	150	160	170
Fastest-mile (mph)	76	84	93	103	114	123	132	141	151
Sustained (mph)	74	82	90	99	107	115	123	132	140
Sustained (knots)	64	72	79	86	93	100	107	115	122

Table Notes:

1. Because wind is a highly variable natural phenomenon, the above relationships are considered as typical, but may vary for any given wind record.
2. Conversions are based on the “Durst Curve” (ASCE 7-02, Figure C6-2). For example, the ratio of sustained to 3-second gust wind speed from the Durst Curve is $1.25/1.53 = 0.82$. Therefore, 100 mph 3-second gust wind speed is equivalent to an 82 mph sustained wind speed as shown in the table. Other conversions were made in a similar fashion.

Moving air or wind, when obstructed, must flow around the obstruction. Depending on the shape and size of the obstruction and the speed, density, direction, and turbulence of the wind, regions of low and high pressure are created on the upwind (windward) and downwind (leeward) surfaces of the obstruction. Negative or suction pressures act outward from the surface of the obstruction, and are generally found on leeward building surfaces and immediately downstream from abrupt changes in geometry (e.g., a roof eave or wall corner on the windward face of the building, shown in Appendix E, Figure 7.32). Positive or inward acting pressure acts only on the upwind or windward faces of the building, and is due to stagnation of wind impinging on the obstruction. Needless to say, wind and its load effects involve theoretically complex processes, especially when the dynamic nature of wind is considered.

As a matter of research and public interest, wind tunnel studies of manufactured housing and other low-rise types of construction have been done (Ho, 1992; Gurley et al., 2003; St. Pierre, et al., 2003). These studies indicate the significant effect of obstructions such as adjacent buildings (even if only one or two rows in the upwind direction) that generally reduce wind loads on downwind structures to a degree not fully considered in current wind engineering standards. In short, proper consideration of wind exposure for a given site, as well as the nature of a reported wind speed, are necessary to accurately estimate actual wind loads for a given site and wind event or to prescribe reasonable design loads for the purposes of building regulation.

In addition to external pressures created by wind flowing around a building, internal pressures are present depending on the level of porosity of a given building. In general, buildings are somewhat porous. Therefore, pressures on the external surface will affect pressures on the interior of a building. When a building's envelope is compromised, by loss of a door or breakage of a window on the windward side of the building, for example, internal pressurization occurs. Elevated internal pressures increase the potential for roof blow-off and other types of wind damage. Therefore, the degree to which a building envelope is protected against failure will affect the amount of wind load that the building structure is likely to experience. If a building envelope remains enclosed (e.g., no loss of windows or doors), lower internal pressures are experienced, and structural damage is less likely to occur. Modern wind load standards require that internal pressurization and envelope protection be considered as a part of determining design wind loads in hurricane-prone regions.

Standard 3280.403(f) contains the following language with regard to shutters:

Protection of primary window and sliding glass door openings in high wind areas. For homes designed to be located in Wind Zones II and III, manufacturers shall design exterior walls surrounding the primary window and sliding glass door openings to allow for the installation of shutters or other protective covers, such as plywood, to cover these openings. Although not required, the Department encourages manufacturers to provide the shutters or protective covers and to install receiving devices, sleeves, or anchors for fasteners to be used to secure the shutters or protective covers to the exterior walls. If the manufacturer does not provide shutters or other protective covers to cover these

openings, the manufacturer must provide to the homeowner instructions for at least one method of protecting primary window and sliding glass door openings. This method must be capable of resisting the design wind pressures specified in 3280.305 without taking the home out of conformance with the standards in this part. These instructions must be included in the printed instructions that accompany each manufactured home. The instructions shall also indicate whether receiving devices, sleeves, or anchors, for fasteners to be used to secure the shutters or protective covers to the exterior walls, have been installed or provided by the manufacturer.

[52 FR 4583, Feb. 12, 1987, as amended at 52 FR 35543, Sept. 22, 1987; 58 FR 55009, Oct. 25, 1993; 59 FR 2474, Jan. 14, 1994.]

Discussion of 1994 Changes in the Manufactured Home Wind Standards

As a result of Hurricane Andrew, which struck South Florida on August 24, 1992, there was considerable damage to all kinds of housing, manufactured homes in particular. There were many studies conducted to assess the damage caused by Hurricane Andrew, and to suggest ways to improve the construction of homes in order to minimize future damage. As a result of these studies, HUD published a rule amending the Federal Manufactured Homes Construction and Safety Standards (FMHCSS) on January 14, 1994 (59 FR 2456) in order to improve the resistance of manufactured homes to wind forces in areas prone to hurricanes. An Interpretive Bulletin was issued on April 15, 1994 and published in the Federal Register on April 21, 1994. Another interpretive bulletin was issued on July 1, 1994 (59 FR 126), which established, among other things, the effective date of the revised wind standards as July 13, 1994.

The FMHCSS was modified in many areas to incorporate all the changes required due to revised wind requirements.

According to Sections 3280.305 A and B of *Part 3280, Manufactured Home Construction and Safety Standards and Interpretive Bulletins to the Standards*, issued by the United States Department of Housing and Urban Development:

The design wind loads for Exposure C specified in ANSI/ASCE 7-88, "Minimum Design Loads for Buildings and Other Structures," for a fifty year recurrence interval, and a design wind speed of 100 mph, as specified for Wind Zone II, or 110 mph, as specified for Wind Zone III (Basic Wind Zone Map).

Florida's Anchorage and Installation Requirements

On March 29, 1999, the State of Florida implemented revised anchorage and installation requirements. See the Rules of the Department of Highway Safety and Motor Vehicles Mobile/Manufactured Home Installation Standards, Chapter ISC-1 and ISC-2. These chapters establish a minimum anchor load resistance capacity as well as horizontal and vertical tiedown requirements. The State of Florida also increased the galvanization of the tiedown straps from what had previously been required by the Federal Manufactured Home Construction and Safety Standards (FMHCSS).

According to the Florida Standards, the anchors and the stabilizing devices require hot dipped zinc galvanizing (.60 ounces per square foot) while the straps require hot dipped zinc galvanization at the rate of 1.20 ounces per square foot.

Hurricane Charley

Event Characterization

In preface to this section, any wind speeds reported herein should be considered as preliminary and subject to change as additional data and/or modeling results become available. As shown in Figure 1, the maximum wind speed of Hurricane Charley at approximately the time of landfall was reported to be about 123 knots (141 mph) as a sustained, 1-minute average wind speed at an elevation of 10 m (33 feet) over open water. According to the Saffir-Simpson scale, Hurricane Charley was reported as a Category 4 hurricane at or just prior to landfall.

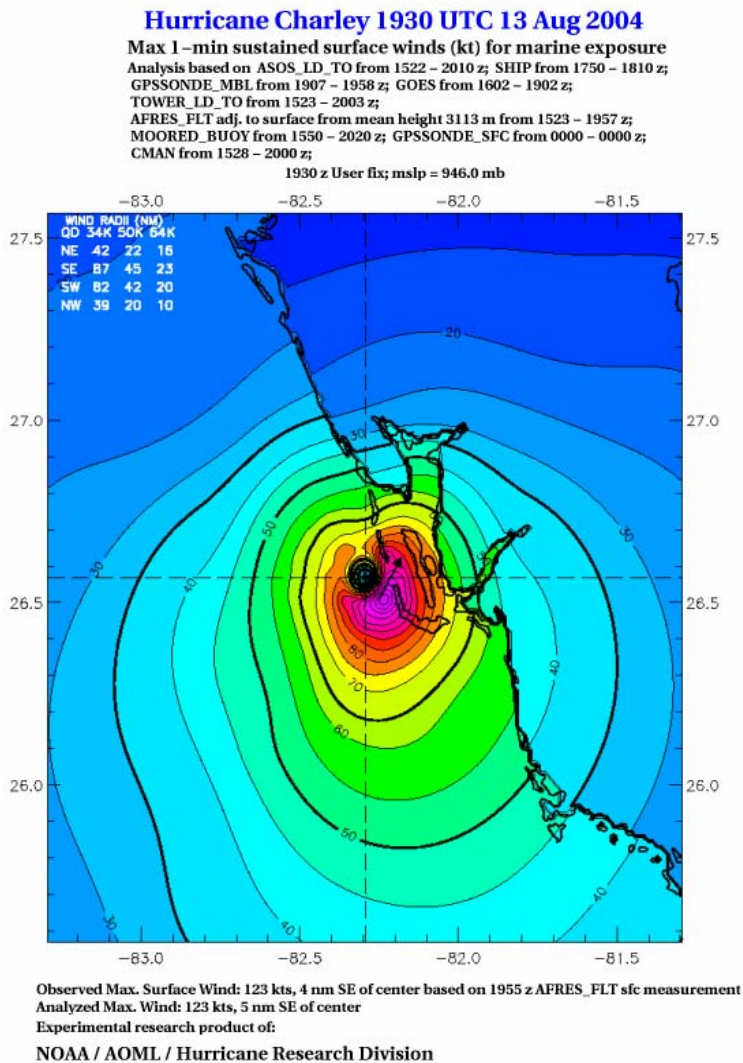


Figure 1. Hurricane Charley Wind Field at Landfall

[Knots, 1-min sustained, over sea exposure, 10 m elevation]

Above image provided by the Hurricane Research Division (HRD) of the National Oceanic and Atmospheric Administration (NOAA) (www.aoml.noaa.gov/hrd/data/registration.html).

The surface roughness of the land and other factors significantly degraded wind speeds near the ground, as Hurricane Charley tracked inland across Punta Gorda, Port Charlotte, and areas farther inland (see Figure 2). Therefore, maximum overland wind speeds in these areas and the extended region from which manufactured housing was sampled for this study appears to have ranged from about 90 to 110 mph (1-minute, sustained) at an elevation of 10 m (33 feet) over an assumed “open” inland exposure (see Figure 2). Considering the gustiness of wind that is not represented in sustained wind speed measurements, the 3-second gust wind speeds experienced over the study region may be roughly characterized as ranging from about 110 to 130 mph (based on the “Durst Curve” from ASCE 7-02 Figure C6-2 and assuming open terrain). In terms of an older representation of wind speed known as fastest-mile wind speed, the estimated fastest-mile wind speeds over the study area ranged from about 93 mph to 114 mph. The wind swath of Figure 2 is based on methods used by the Hurricane Research Division of NOAA (Powell, Houston, and Reinhold, 1996; Powell and Houston, 1996). Based on Figure 2, a typifying wind speed for the study region and sampled homes in general is approximately 100 mph (fastest-mile).

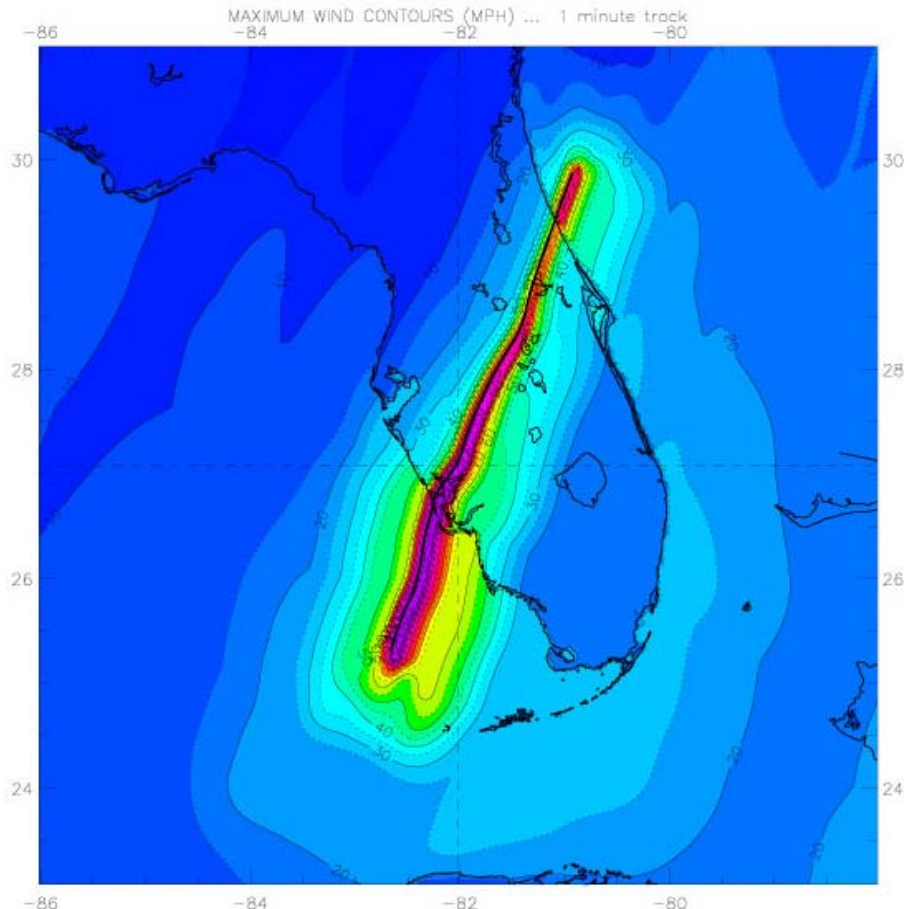


Figure 2. Maximum Wind Speed Contours for Hurricane Charley's Track [MPH, 1-minute sustained, over-sea or over-land exposure, 10 m elevation]

Above image provided by the Hurricane Research Division (HRD) of the National Oceanic and Atmospheric Administration (NOAA) (www.aoml.noaa.gov/hrd/data/registration.html).

Because the inland wind exposure of the sampled manufactured housing stock was primarily built-up due to surrounding development, and often included trees that survived the event, actual near-ground wind speeds may be further reduced. Estimating wind speeds near to the ground surface and within the layer of surface roughness is beyond the scope of this report, even though the issue is quite relevant. The reader is referred to other studies which discuss methods for estimating near-ground wind speeds in suburban and/or wooded terrain conditions (Crandell, et al., 2000). Site exposure considerations are very important to the proper characterization of wind loads on buildings and are addressed in the next section of this report.

Estimated Wind Loads

Wind loads for building designs have evolved over time, and will continue to evolve as better information and scientific knowledge is put to use. At the time the HUD Code was updated in 1994, the ASCE 7-88 standard (ASCE, 1988) was used as the basis for wind loads as shown in Table 3. The wind loads are based on an open site exposure condition. In addition, the wind map in ASCE 7-88, which displayed fastest-mile design wind speeds, was used to create wind zones as shown in Figure 3.

**TABLE 3
HUD Code Wind Pressures**

TABLE OF DESIGN WIND PRESSURES

Element	Wind zone II design wind speed 100 MPH	Wind zone III design wind speed 110 MPH
Anchorage for lateral and vertical stability (See §3280.306(a)):		
Net Horizontal Drag ^{1,2*}	±39 PSF	±47 PSF
Uplift ⁴	-27 PSF	-32 PSF
Main wind force resisting system:		
Shearwalls, Diaphragms and their Fastening and Anchorage Systems ^{1,2}	±39 PSF	±47 PSF
Ridge beams and other Main Roof Support Beams (Beams supporting expanding room sections, etc.)	-30 PSF	-36 PSF
Components and cladding:		
Roof trusses ⁴ in all areas; trusses shall be doubled within 3'-0" from each end of the roof	-39 PSF	-47 PSF
Exterior roof coverings, sheathing and fastenings ^{4,5,7} in all areas except the following	-39 PSF	-47 PSF
Within 3'-0" from each gable end (overhang at end wall) of the roof or endwall if no overhang is provided ^{4,5,7}	-73 PSF	-89 PSF
Within 3'-0" from the ridge and eave (overhang at sidewall) or sidewall if no eave is provided ^{4,5,7}	-51 PSF	-62 PSF
Eaves (Overhangs at Sidewalls) ^{4,5,7}	-51 PSF	-62 PSF
Gables (Overhangs at Endwalls) ^{4,5,7}	-73 PSF	-89 PSF
Wall studs in sidewalls and endwalls, exterior windows and sliding glass doors (glazing and framing), exterior coverings, sheathing and fastenings ⁸ :		
Within 3'-0" from each corner of the sidewall and endwall	±48 PSF	±58 PSF
All other areas	±38 PSF	±46 PSF

NOTES:
¹The net horizontal drag of ±39 PSF to be used in calculating Anchorage for Lateral and Vertical Stability and for the design of Main Wind Force Resisting Systems is based on a distribution of wind pressures of +0.8 or +24 PSF to the windward wall and -0.5 or -15 PSF to the leeward wall.
²Horizontal drag pressures need not be applied to roof projections when the roof slope does not exceed 20 degrees.
³+ sign would mean pressures are acting towards or on the structure; - sign means pressures are acting away from the structure; ± sign means forces can act in either direction, towards or away from the structure.
⁴Design values in this "Table" are only applicable to roof slopes between 10 degrees (nominal 2/12 slope) and 30 degrees.
⁵The design uplift pressures are the same whether they are applied normal to the surface of the roof or to the horizontal projection of the roof.
⁶Shingle roof coverings that are secured with 6 fasteners per shingle through an underlayment which is cemented to a 3/8" structural rated roof sheathing need not be evaluated for these design wind pressures.
⁷Structural rated roof sheathing that is at least 3/8" in thickness, installed with the long dimension perpendicular to roof framing supports, and secured with fasteners at 4" on center within 3'-0" of each gable end or endwall if no overhang is provided and 6" on center in all other areas, need not be evaluated for these design wind pressures.
⁸Exterior coverings that are secured at 6" o.c. to a 3/8" structural rated sheathing that is fastened to wall framing members at 6" on center need not be evaluated for these design wind pressures.

NOTE – All units surveyed were in Charlotte or Lee Counties; therefore Zone III .

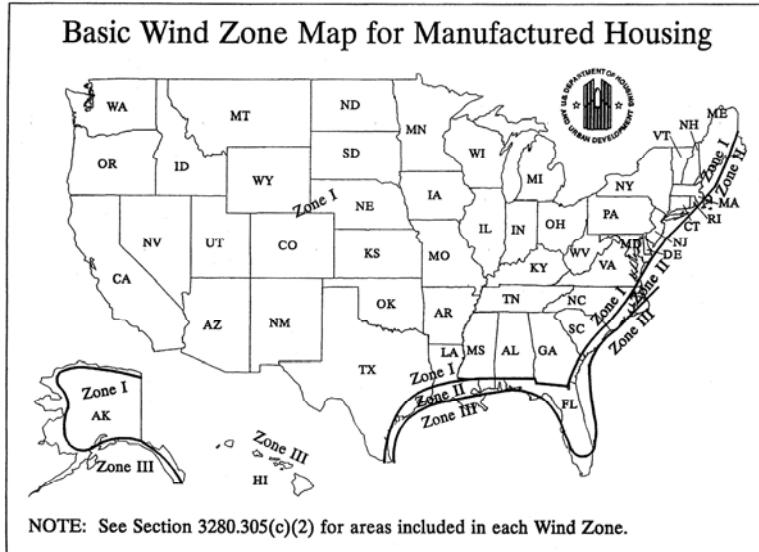


Figure 3. Wind Zones for HUD Code Based on ASCE 7-88 Fastest-Mile Design Wind Speed Map
 (Zone III = 100 mph or greater; Zone II = 90 mph to 100 mph; Zone I = less than 90 mph).

The Punta Gorda/Port Charlotte area falls in Zone III. All homes sampled were in Charlotte and Lee Counties (see Appendix B). The areas where the manufactured homes were sampled were all in Exposure B, with a typical fastest-mile wind speed of 100 mph, estimated (93-114). The wind pressures on the sampled manufactured homes were therefore roughly 50% (mph) of the HUD Code design Main Wind Force Resisting System wind loads and anchorage loads. The components and cladding wind pressures were approximately 75% of the HUD Code design loads.

These estimates are based upon the factors in the ASCE 7-88 Standard that account for the effect of wind speed and terrain roughness on wind load in comparison to the design wind speed and exposure condition used to develop the wind loads in the HUD Code. The 50% value is derived from V , K_z , and G values in ASCE 7-88 for main wind force loads as follows: $(K_B/K_C) \times (G_B/G_C) \times (V_{Actual}/V_{Design})^2 = (0.37/0.8) \times (1.65/1.32) \times (100/110)^2 = 0.5$, or 50% of the HUD Code design Main Wind Force Resisting System wind loads. The 75% value is derived in similar fashion, and pertains to components and cladding loads.

Damage Assessment

Methodology

This damage assessment study of manufactured housing followed a scientific method of sampling and documenting building characteristics and performance. The methodology is similar to that used in previous studies of site-built housing construction following major hurricane, tornado, and earthquake events (Crandell, 1993; Crandell, 1994; Crandell, 1996; Crandell, 1998; Crandell, 2002). A survey form to document housing characteristics and damage was adapted for use with manufactured housing based on similar forms used in the prior studies for site-built housing. The survey form is shown in Appendix A. This approach was taken to allow a comparable data collection and analysis effort.

Two teams of two to three individuals each conducted the survey following a sampling methodology intended to obtain a representative sample of the manufactured housing stock within three age categories of interest (i.e., Pre- and Post-1994 HUD Code units and Pre-1976 non-HUD Code units). Wherever feasible, specific observations were made related to the performance of the foundation system for homes installed after March 29, 1999. The purpose of these observations (case studies) was to assess the impact of the revised Florida installation standards on the overall performance of the manufactured homes.

Damage was co-rated on an initial sample at the beginning of the survey to calibrate the teams to a consistent rating methodology. The damage rating methodology is described in Table 4 and corresponds to only the top portion of page 3 of the damage survey form (Appendix A). It is very important to the proper interpretation of results given later in this study. Other survey form entries related to site or building characteristics do not require explanation.

TABLE 4
Damage Rating Criteria

Damage Category	Damage Levels			
	0	1	2	3
Roof System	No observed damage	Exterior finish damage only	Localized structural damage (e.g., sheathing or gable damage)	Partial or full roof loss
Wall System	No observed damage	Exterior finish damage only	Localized structural damage without collapse	Partial or full collapse of walls
Foundation System	No observed damage	Minor shifting on foundation (i.e., less than ½”) or damage to skirting	Significant shifting on foundation, but still on piers	Foundation shifted off of piers or rolled over
Projectile	No observed damage	Few wall impacts or broken windows	1/3 to 2/3 of glass broken and many wall impacts damaging siding and/or sheathing	Damage from many small projectiles or a large impact causing structural failure
Add-on (e.g., porches and carports)	No observed damage	Exterior finish damage only, but structural intact	Partial destruction	Near to complete destruction

Table Notes:

1. Rating is based on observable damage; therefore, damage classification is subject to some degree of observational error and variance.



Figure 4.1: An Example of Level 3 Roof System and Level 2 Wall System Damage
[Note: In this case, the roof rating was primarily associated with extensive roof sheathing loss; the wall rating was based on some localized structural damage to sheathing in addition to extensive siding damage, even though the walls were essentially structurally intact.]



Figure 4.2: An Example of Level 3 Add-On Damage



Figure 4.3: An Example of Level 1 Wall System Damage
[Note: Damage was limited primarily to wall finishes, i.e. vinyl siding damage]

While the survey form served its purpose, experience during the survey and data entry processes indicates that the form could be improved to facilitate faster and more precise data collection and evaluation. For example, each data entry item should include all possible results to be checked by the assessor (such as indicating whether or not an item is “unknown”). As a rule, items that could not be directly confirmed by observation were either left blank or noted as “unknown” on the survey forms. Thus, for certain characteristics or damage ratings, the sample size may vary to some number less than the total number of units inspected. This outcome is particularly relevant to concealed building characteristics (such as roof or wall sheathing or stud size and spacing), because in many cases damage was not sufficient to allow a non-destructive visual observation to be made.

Samples of manufactured homes were selected from 12 of 17 different manufactured housing developments visited in the region affected by the highest winds of Hurricane Charley (see Figure 4.5 and Table 5). The study region extended from Pine Island at the gulf coast to just north and east of Punta Gorda and Port Charlotte on Route 17. From each study location, one or two representative streets were pre-selected, and the first and every third or fourth home thereafter were sampled on one side of each selected street.

One of the teams did not include homes in its sample where it was evident that the home in question had been manufactured prior to the implementation of the FMHCSS.

The study was conducted over the course of 3½ days, approximately one week after the event (August 18-21, 2004).

Figure 4.5: Approximate Location of Manufactured Housing Study Sites



TABLE 5
Distribution of Manufactured Home Samples
By Study Site Location

Study Site ID	1	2	3	4	5	8	9	12	13	14	16	17	TOTAL
Number of Samples (n)	14	12	6	8	6	4	6	10	13	18	7	1	105

1. Study site ID numbers correspond to Figure 5.5. Study sites not listed in this table had no samples.

In cases where newer (Post-1994) homes were encountered during the survey, these homes were included in the sample whether or not they were selected following the randomized procedure. This sampling variation was done to ensure a suitable sample size of newer homes and to also provide a direct case study of newer homes in close proximity to older homes. Lack of staged sampling within age groups of construction was found to be a drawback of a completely randomized sampling across all ages of construction. Thus, earlier statistical damage studies tended to adequately represent the performance of older construction (i.e., 1950s to 1970s era housing) and the building population as a whole, but did not provide an adequate sample size of the newer construction that comprised a relatively small portion of the overall population of buildings. Since case study homes were “randomly” encountered with no indication of a selection bias (other than age), they were included as part of the sample of homes for this study. One team also used a variation of the sampling methodology whereby only HUD Code homes (e.g., post-1976 or labeled units) were sampled. For each sampled unit, a survey form (Appendix A) was completed.

The sampling methodology resulted in a total of 105 completed survey forms suitable for statistical evaluation. Key data from the forms was coded and reviewed for quality and consistency. In addition, HUD label numbers documented during the survey were used to assign a manufacture date for each unit for which a label was present and readable. The coded data in spreadsheet format is found in Appendix B. Fortunately, the number of samples pre- and post-dating 1994 was split fairly evenly. It should be carefully noted, however, that the sampling technique employed in this survey was designed to obtain a sufficient and representative quantity of newer and older home samples. Therefore the distribution of housing ages in the sample is not reflective of the distribution of the ages of manufactured homes in the sampled population. However, the sample is considered to be representative of the population within the age categories of interest, and is therefore suitable for statistical inferences regarding differences in performance between age groups and related variations in construction characteristics. Thus the data set is valid to answer the questions posed earlier that define the main purpose of this study.

Construction Characteristics

The age distribution of the sampled manufactured homes is shown in Table 6. As mentioned, the sample age distribution does not reflect the population age distribution due to an intended sampling bias to ensure an adequate sample size representative of newer construction.

TABLE 6
Age Distribution of Sampled Manufactured Homes

Age Category	Sample Size (n)	Percent of Sample
Post-1994	52	49.5%
Pre-1994 (HUD Code only)	28	26.7%
Pre-1976 (or non-HUD Code)	17	16.2%
Undetermined Age	8	7.6%

Table Notes:

1. Post-1994 corresponds to homes manufactured after the effective date of July 13, 1994 for implementation of updated wind resistance requirements of the HUD Code.
2. Approximately 42% (22 samples) of the Post-1994 homes either post-dated the effective date of April 1, 1999 for Florida 1999 installation and foundation anchorage requirements, or otherwise met the requirements.
3. Pre-1976 indicates homes that are of unknown age, but which pre-date the initial implementation of federally-mandated standards for manufactured housing construction (i.e., HUD Code).

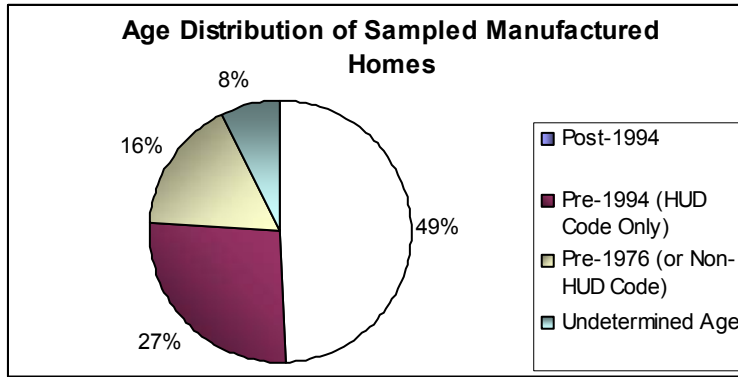


Table 7 summarizes the construction characteristics that were readily observed and documented for the different age categories of homes. Bold entries indicate the typifying characteristics for each age category. Concealed construction materials and methods are not reported due to the limited amount of destruction where such features could be readily observed. Also, the statistics of Table 7 have varying sample sizes due to the ability to collect each type of data. In particular, the sample size for wall sheathing type is relatively small due to the many occasions where siding damage was insufficient to make a non-destructive observation of the underlying sheathing type.

TABLE 7
Sampled Manufactured Housing Characteristics
By Age Category (Percent of Sample)

Characteristic	Post-1994	Pre-1994 (HUD Code only)	Pre-1976 (non-HUD Code)
No. of Units	Single – 3.8% Multi – 96.2%	Single – 25% Multi – 75%	Single – 64.7% Multi – 35.3%
Roofing Type	Shingle – 96.1% Metal – 3.9%	Shingle – 79.2% Metal – 20.8%	Shingle – 0 % Metal – 100%
Siding Type	Vinyl – 98.0% Metal – 2.0%	Vinyl – 67.9% Metal – 32.1%	Vinyl – 25% Metal – 75%
Wall Sheathing	OSB – 51.6% OSB/hdbd – 6.5% Hardboard – 38.7% Fiberboard – 0% Metal – 3.2% None – 0% Other – 0%	OSB – 0% OSB/hdbd – 0% Hardboard – 17.6% Fiberboard – 29.4% Metal – 29.4% None – 11.8% Other – 5.9%	OSB – 0% OSB/hdbd – 0% Hardboard – 6.7% Fiberboard – 0% Metal – 93.3% None – 0% Other – 0%
Foundation Anchor Spacing	~5' – 65.4% 6' to 8' – 26.9% 10' or more – 7.7% None – 0%	~5' – 0% 6' to 8' – 63.6% 10' or more – 27.3% None – 9.1%	~5' – 0% 6' to 8' – 18.8% 10' or more – 62.5% None – 18.8%

Table Notes:

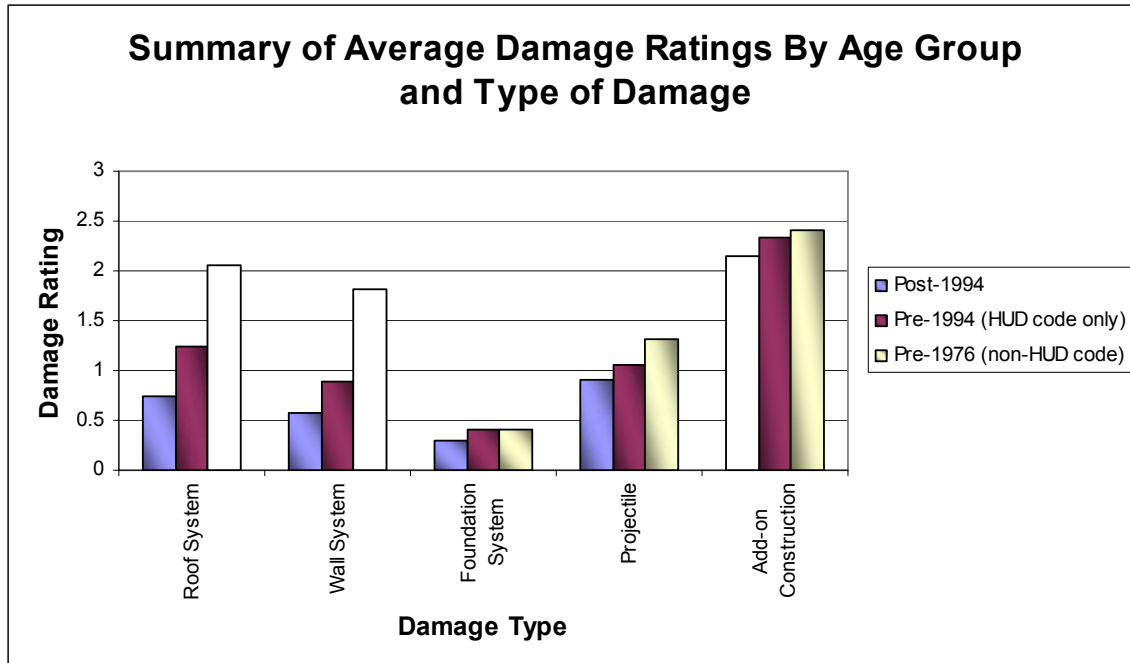
1. Sample size varies within each age category and for each observed characteristic. Unknown entries in the survey forms are not included. Therefore, confidence limits on these statistics when taken as estimates of the population within various age groups may vary considerably.

Damage (Performance) Analysis

The average damage ratings for the types of damage incurred for each age group of the sampled manufactured housing stock are summarized in Table 8. 95% confidence limits are reported for each value on the bases of a two-tailed student *t* score, the sample size for each rating, and applicability of the central limit theorem. To properly interpret this data, the discrete damage rating categories (0, 1, 2, or 3) are treated as a continuous random variable such that the average damage rating must be viewed on a damage level scale of 0 to 3. Damage ratings associated with the four “points” on the damage level scale were previously described. Detailed statistics are found in Appendix C.

TABLE 8
Summary of Average Damage Ratings
By Age Group and Type of Damage
(With 95% Confidence Limits)

Damage Type	Post-1994	Pre-1994 (HUD Code only)	Pre-1976 (non-HUD Code)
Roof System	0.75 ± 0.12	1.25 ± 0.33	2.06 ± 0.64
Wall System	0.58 ± 0.14	0.88 ± 0.29	1.82 ± 0.64
Foundation System	0.29 ± 0.17	0.40 ± 0.32	0.41 ± 0.48
Projectile	0.91 ± 0.19	1.05 ± 0.30	1.31 ± 0.38
Add-on Construction	2.14 ± 0.33	2.33 ± 0.48	2.41 ± 0.55



The trends in *roof and wall system performance* are clear in Table 8. Using a Separate-Variance *t* test, the differences in wall and roof system performance between the different age groups are statistically significant at a confidence level of approximately 99%. Details on the statistical inferences used to compare the average damage ratings are found in Appendix D. Thus, it can be concluded with a high level of confidence that manufactured homes built in accordance with the Post-1994 HUD Code performed significantly better than those pre-dating the revisions that were intended to improve wind performance. As mentioned, Hurricane Charley was not a design level event in most populated areas such that significant structural damage should have been observed. In agreement, the damage data reflect that the average roof and wall damage levels frequently represented by the Post-1994 construction was 0.75 and 0.58, respectively, which corresponds to the modest but frequent occurrence of exterior finish damage. In fact, none of the sampled Post-1994 homes had a damage rating greater than 1 for wall and roof systems.

Conversely, for the Pre-1994 HUD Code construction the frequencies of roof and wall system damage ratings of 2 or greater was 28.6% and 11.5%, respectively (see Appendix C). The performance of the Pre-1976 construction was notably worse, with frequencies of roof and wall system damage ratings of 2 or greater at 64.7% and 53.0%, respectively. A rating of 2 or higher corresponds to structural damage levels ranging from localized to complete destruction of the wall or roof system. Age effects, in addition to the wind load experienced, and to less stringent construction, contributed to the higher damage level of many of the older units.

In addition, the distribution of the Pre-1976 housing sample was such that a greater proportion of units were located in sites that experienced a higher wind speed. Thus, the

higher observed damage level for the Pre-1976 construction was at least modestly biased by this sample distribution effect.

While the Post-1994 foundation construction methods performed well (i.e., average damage rating of 0.29 on a scale of 0 to 3 as shown in Table 8), the performance of foundations meeting the Post-99 Florida installation requirements was not flawless. For example, 9% of these foundations had a damage rating of 2 or higher, while 32 percent had a rating of 1 (refer to Table 5 for rating criteria and Appendix C for damage frequency data). For a sub-design level event, the frequency of this level of damage should have been closer to zero percent of the sampled homes.

Those units with a damage rating of 1 were generally associated with minor foundation slippage on piers and/or significant damage to skirting materials (i.e. vinyl skirting). A damage rating of 2 or higher was associated with more severe damage, such as slipping off foundation piers and toppling of single stacked masonry piers. These higher damage ratings were sometimes attributed to poor installation (i.e. improper anchor installation). Collectively, the level of observed foundation damage relative to the event magnitude indicates that the Post-99 Florida foundation requirements may not perform equivalently to a permanent foundation system as defined by HUD.

While not a statistically significant finding, the newer (Post-1994) units tended to perform better than the Pre-1994 units with regard to *projectile damage* (see Table 8 and Appendix D). Two possible explanations for this apparent trend:

- (1) Newer units may have appeared to more commonly use some form of window or glazing protection (although the presence or absence of shutters was not documented in the study, since many such devices may have been removed immediately after the hurricane).
- (2) Newer units also had windows tested for the higher wind pressures required by the Post-1994 Standards.

The second explanation is more likely to be a factor, because some of the observed broken glazing in older units may have been associated with a lower resistance to wind pressure. The higher wind pressure rating of windows in the newer construction probably improved the impact resistance of standard glazing by a small margin (e.g., better able to resist the impact of small debris such as roof shingle pieces, etc.) (Crandell, 2002). In addition, there are age effects to consider in the resistance of glazing to impacts and wind pressure, just as there are with other parts of a building. Impact damage ratings were also affected by the amount of damage incurred to walls, particularly siding fractures. In a relatively few cases, debris completely penetrating walls was found in the survey.



Figure 5.1: An Example of Debris Penetrating a Wall

Add-on construction was comprised of building portions that were added on to the manufactured unit after installation. These features included garages, screened porches, and carports. Typical construction of porches or carports included aluminum tube framing and thin-gauge aluminum inter-locking roofing panels. As shown in the average damage ratings of Table 8, damage to these types of add-on structures was severe and did not vary appreciably across the different age groups of construction. This type of construction was a major source of wind-borne debris, as shown in Appendix E, Figures 7.1 – 7.6. There were a few cases in the survey where the add-on construction actually performed better than the manufactured home itself (usually an older unit), but these were rare exceptions. In cases where add-ons were substantially constructed (e.g., fully sheathed with wood structural panels and anchored to a foundation or slab), the performance was observed to be good.



Figure 5.2: An Example of Substantial (Level 3) Add-On Damage

Supplemental Observations

As with any damage survey, there are important observations that depend on experience and judgment in addition to the objective sources of documentation, as presented in the previous section. This section of the report addresses such observations which were not necessarily anticipated in the design of the survey form (Appendix A) and which were not within the primary objectives of the study.

Field Installation of Siding

There were numerous instances where the siding was torn or damaged due to wind on the siding of homes, as shown in Appendix E, Figures 7.33 – 7.36. For multi-section homes (which constitute the majority of Post-1994 homes in Table 8), the siding for the end walls is installed on-site. This is done in order to ensure uniform siding on the end walls without a straight line in the center, thereby providing a better appearance.

The manufacturers are required to provide the DAPIA-approved siding installation requirements for use by installers. The field survey team noticed that a disproportionate number of the siding-related damage was on the end walls (field-installed siding). In some instances it was obvious that the fasteners used on-site were not identical to those used at the factory. The quality of the site-installed siding appears to vary. This is explainable by the fact that in factories, some workers install siding with close supervision and inspections by the manufacturer's quality control personnel as well as the In-Plant Primary Inspection Agency (IPIA). The same is not true on-site. While the installers are trained and certified in general installation techniques, they are not equally trained for proper installation of the siding.

As noted in Table 8, there was clear evidence that the roof and walls performed significantly better for the Post-1994 homes, as compared to those homes constructed prior to the effective date of the new FMHCSS with regards to wind protection. The observation team noted that in a relatively large number of cases, the wall damage was at the corners of the home. For roofs, the damage was more prominent at each end, and the overhangs showed light evidence of damage. Please note that these observations were not specifically identified as such on the survey form, but reflected the collective recollection of the team members regarding the location of damage.

There were cases where side wall damage was observed without damage to end walls. These observations may be primarily a function of wind direction. There were also cases observed where screws used for siding installation on all walls of a given unit were installed very precisely (e.g., fastened to every stud). But the fastener head size was apparently too small, allowing the vinyl siding to tear off prematurely. In addition, much of the vinyl siding damage may have been reduced by the use of wind-resistant (reinforced) nail fins. Therefore, problems with siding performance appear to include material specification issues as well as installation quality issues.

As a related topic, most homes with composition shingle roofing (the predominant roof material used on newer units) generally experienced some damage. However, major roofing damage was generally observed whenever there was add-on construction (porches, garages, etc.) attached to the main home. This damage was more severe due to the separation of add-on construction from the main home, causing roof line/siding related damage.

Roof Uplift Load Path at Ridge/Marriage Wall Joint

There were a few instances in newer and older multi-unit buildings where the roof system appeared to separate at the marriage wall joint. These instances were usually accompanied by a large window or sliding door failure that may have resulted in increased internal pressures, although probably not more than should be considered in design. The problem seemed to be related to the manner in which the over-the-roof anchor straps were terminated at the marriage of the two roofs, resulting in a discontinuous uplift load path at the ridge line. Thus, these roofs appeared to be more easily “opened up” along the ridge than if strapping had been terminated in a manner to provide a continuous load path.

Metal Anchor Strap Corrosion

In several instances, one or more metal anchor straps were found to be completely severed due to rust, even on homes not more than 10 years old, as shown in Appendix E, Figures 6.27 – 6.31. In many more cases, progressive red rust was found on anchor straps at or near to the ground level of newer homes. While this did not usually lead to any damage in Hurricane Charley, the situation will worsen as time passes. As a result of this finding, materials or coating specifications that are more resistant to degradation should be considered for strapping and installation practices. Accelerated corrosion due to the contact of galvanized strapping with moist ground or concrete should be more carefully considered in its effects on foundation longevity.

Undermining of Piers

In a number of cases, the shallow pier foundation pads were observed to be at least partially undermined by the scouring action of wind and rainwater runoff. Since these foundations are exposed once the skirting is damaged, scouring effects on shallow piers in sandy soils should be more carefully considered.

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Appendix A – Damage Survey Form

(Manufactured Homes)

Location / Development _____	
Name _____	Date _____
Address _____	<input type="checkbox"/> Single Section
_____	<input type="checkbox"/> Multi Section
Orientation of Home:	
Inspected by: _____	Interior <input type="checkbox"/> Exterior <input type="checkbox"/> Foundation <input type="checkbox"/>
Date of Manufacture: _____	
Date of Installation: _____	
Name of Manufacturer: _____	
Certification (HUD) Label: _____	
Serial # _____	
Roof Type	Metal <input type="checkbox"/> Plywood <input type="checkbox"/> Other _____
Shingles _____	
Fasteners _____	
Wall	
Exterior Wall Siding _____	
Exterior Wall Sheathing _____	
Windows _____	
Exterior Wall Framing _____	
Large Windows _____	
Sliding Doors _____	
Roof to Wall Connections _____	
Interior Wall Material	
Floor Framing _____	
Floor Sheathing _____	
Wall to Floor Connections _____	
Size & Spacing of Steel Frame _____	
Outrigger Spacing _____	

HURRICANE JEANNE DAMAGE ASSESSMENT (CONTINUED)

Foundation Typical Block & Piers Ground Anchors & Straps: Yes <input type="checkbox"/> No <input type="checkbox"/>
Anchor Spacing According to Florida Requirements Yes <input type="checkbox"/> No <input type="checkbox"/>
Permanent Foundation Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure <input type="checkbox"/>
Block Skirting Wall Yes <input type="checkbox"/> No <input type="checkbox"/>
Alternate Anchoring System (describe) _____
Conditions of Homes in Close Proximity <input type="checkbox"/> Standing Minimal Damage <input type="checkbox"/> Standing Significant Damage <input type="checkbox"/> Not Standing
Describe _____ _____ _____ _____

*Identify the photograph numbers for this inspection

HURRICANE JEANNE DAMAGE ASSESSMENT

COMPONENT/LOCATION	DAMAGE LEVEL				COMMENTS
	None	0-1/3	1/3-2/3	Over 2/3	
BUILDING CONDITION					
Integrity of Roof					
Integrity of Walls					
Integrity of Foundation					
Projectile Damage					
Porch/Balconies					
ROOF					
Roofing/Connection					
Sheathing/Connection					
Rafters/Trusses					
Soffit/Fascia					
Roof-to-Wall Connection					
Gable End Condition					
EXTERIOR WALLS					
Veneer/Siding					
Sheathing					
Wall to Floor Connections					
Windows					
Doors					
INTERIOR WALLS					
CEILINGS					
FLOORS					
Floor Framing					
Sheathing					
Water Damage					
Foundation to Floor Connections					
FOUNDATION					
Piers					
Straps					
Strap connections to frame					
Strap connection to anchor					
Anchor					
Type of soil					
Other					
EXPOSURE					
MODE OF FAILURE					
GENERAL COMMENTS/PHOTOGRAPH #					

Appendix B – Coded Survey Data

HURRICANE CHARLEY (August 13, 2004) HUD MANUFACTURED HOUSING DAMAGE ASSESSMENT

Survey Date: August 18 to August 21, 2004 (5 to 8 days after event)

Survey Extent: 17 manufactured housing developments, from Pine Island inland to Northeast of Port Charlotte
Total Number of (includes samples from selected developments and case
Units Surveyed: 110 studies of post-94 units when encountered)

TEAMS:

- Rick, Ashok,
- 1 Roger*
- Lane, Shawn,
- 2 Jay*
- 3 Lane, Roger*
- 4 Shawn, Jay*
- * = recorder

Damage Rating Key (typical rating criteria):

ROOF	0=no damage, 1=exterior finish damage only, 2=sheathing/gable damage, 3=partial or full roof blow-off
WALL	0=no damage, 1=exterior finish damage only, 2=sheathing/local damage but standing, 3=partial or full wall collapse
FOUNDATION	0=no damage, 1=minor shifting apparent, 2=significant shifting but on piers and standing and/or few piers collapsed, 3=roll-over or shifted off piers
PROJECTILE	0=no damage, 1=few wall impacts and/or limited glass breakage, 2=large impact and/or 1/3 or more windows broken, 3=many impacts and/or most glass broken
ADD-ONS	0=no damage, 1=roofing damage, but standing, 2=partial collapse, 3= total collapse -- uses worst rating for roof, wall, or foundation (does not include projectile or add-on ratings)
OVERALL	

Notes on Survey Sheets 1-62 only:

NOTE: #55-62 case studies in Port Charlotte Village were surrounded by older (pre-94) units with 13 of 64 (about 20 percent) having severe roof or roof and wall damage (up to total destruction)
No post-94 units were found with severe damage in survey samples or case studies.

General Conclusions:

1. No permanent foundation installations found in sample or case studies.
2. Post-94 units performed better than Pre-94 units on average for roof, wall, and foundation performance.
3. Negligible difference in performance relative to projectile and add-on performance for all age groups.
4. Add-on (e.g., aluminum carport or porch posts and roofing) performance was notably bad, except in few cases where add-on garages were built to meet wind code (e.g., plywood or OSB sheathing, strapping, anchors into concrete footings, etc.)
5. Wind data is forthcoming. Wind event was likely less than 145 sustained (standard meteorological conditions) for study area. Estimated wind speed was probably in the range of 90 to 110 mph (sustained) for the study region based on 10m elevation and open exposure. This estimate is based on experience with tree, infrastructure, and building damage for other recent events (e.g., Andrew and Opal) which bracket the level of damage observed.
6. Suburban and shielded (treed) exposures played a significant role in reducing wind loads experienced relative to HUD Code basis for design. Even so, there were notable differences in post- and pre-94 unit performance. The wind loads were not sufficient to determine performance at loading levels exceeding or approaching intended safety margins for design (e.g., overturning safety margin of 1.5 was not "tested").
7. Rusted through uplift and shear strapping was found on several buildings, including many no more than 7 to 10 years old.
8. Age effects (as well as difference in construction requirements) may explain some of the difference between Pre- and Post-94 unit performance.
9. Better performance of overall Post-94 group vs. subset of Post-99 units needs further study to explain and additional samples.

10. Not all samples are included in this preliminary analysis.

Summary Damage Rating Statistics (Sheets 1-62 only):

Average (all)	1.2	1.0	0.3	1.2	2.3	1.4
Average (pre-94)	1.6	1.4	0.3	1.2	2.3	1.8
Average (post-94)	1.0	0.5	0.1	1.1	2.3	1.0
Average (post-99)	0.8	0.9	0.6	1.3	2.4	1.1
	ROOF	WALL	FND	PROJ.	ADD-ON	OVERALL

Sample size varies; Post-99 sample is relatively small.

Age of units is not confirmed in many cases.

SURVEY LOGISTICS				UNIT CHARACTERISTICS				
Sheet No.	Site No.	Devel Name	Street Address	No. of Sections	Age Category	HUD Code?	Date of Manuf.	HUD Label No.
1	1	Lakeland Village	#100, 5601 D	2	pre-94	Yes	1/28/1992	FLA 492270
2	1	Lakeland Village	#97	2	pre-94	Yes	8/27/1992	FLA 503818,
3	1	Lakeland Village	#94	2	pre-94	Yes	1/6/1994	FLA 538398
4	1	Lakeland Village	#105	2	post-94	Yes	4/3/1997	FLA 614436
5	1	Lakeland Village	#108	2	post-94	Yes	7/13/1995	FLA 572515
6	1	Lakeland Village	#111	2	post-94	Yes	9/10/1996	FLA 601661
7	2	Pine Acres	? Bernaden R	1	pre-94	Unk	Unk	Unk
8	2	Pine Acres	6539 Bernade	1	pre-94	No	Unk	none
9	2	Pine Acres	? Bernaden R	1	pre-94	No	Unk	none
10	2	Pine Acres	6585 Bernade	1	pre-94	No	Unk	none
11	2	Pine Acres	6736 Bernade	2	pre-94	Yes	Unk	Yes (unread
12	2	Pine Acres	1801 Polly Ct	1	pre-94	No	Unk	none
13	2	Pine Acres	1812 Holly Ct	2	post-94	Yes	3/13/1995	FLA 563068
14	3	Ventura Lakes	69 Foxfire Ct.	2	post-94	Yes	6/6/2003	FLA 740525,
15	3	Ventura Lakes	71 Foxfire Ct.	2	post-94	Yes	10/31/2001	FLA 715731
16	3	Ventura Lakes	73 Foxfire Ct.	2	post-94	Yes	Unk	Unk
17	3	Ventura Lakes	75 Foxfire	2	post-94	Yes	Unk	Unk
18	4	Riverside Oaks	84 Heatherwo	2	post-94	Yes	2/10/1998	FLA 636582
19	4	Riverside Oaks	87 Heatherwo	2	post-94	Yes	6/17/1997	FLA 620890
20	4	Riverside Oaks	90 Heatherwo	2	post-94	Yes	1/23/1997	FLA 610027
21	4	Riverside Oaks	93 Heatherwo	2	post-94	Yes	Unk	Unk
22	5	September Estates	Ferrell Rd.	1	post-94	Yes	11/24/1997	FLA 032467
23	5	September Estates	Ferrell Rd.	1	pre-94	No	Unk	none
24	5	September Estates	Ferrell Rd.	1	pre-94	Yes	7/30/1979	FLA 088901
25	12	Windmill	2 Den Helder	2	pre-94	No	Unk	none
26	12	Windmill	6 Den Helder	2	post-94	Yes	4/7/1995	FLA 566202
27	12	Windmill	8 Den Helder	1	pre-94	No	Unk	none
28	12	Windmill	7 Rotterdam	2	post-99	Yes	6/19/2001	FLA 709650
29	12	Windmill	6 Rotterdam	2	pre-94	Unk	Unk	sn: CH12714
30	12	Windmill	14 Den Helde	2	pre-94	No	Unk	none
31	12	Windmill	21 Den Helde	2	pre-94	No	Unk	none
32	13	Buttonwood Village	187 Buttonwo	1	post-99	Yes	11/25/2003	FLA 747514
33	13	Buttonwood Village	184 Buttonwo	2	post-94	Yes	12/14/1995	FLA 583230,
34	13	Buttonwood Village	181 Buttonwo	1	pre-94	No	Unk	none
35	13	Buttonwood Village	178 Buttonwo	1	pre-94	No	Unk	none
36	13	Buttonwood Village	126? Buttonwo	2	post-99	Yes	6/10/2004	FLA 756628
37	13	Buttonwood Village	127 Buttonwo	2	post-99	Yes	6/10/2004	FLA 756626
38	13	Buttonwood Village	175 Buttonwo	1	pre-94	Yes	1/19/1978	FLA 039492
39	13	Buttonwood Village	172 Buttonwo	1	pre-94	Yes	doesn't exist	FLA 894865
40	13	Buttonwood Village	171 Buttonwo	2	post-99	Yes	8/1/2004	FLA 759807,
41	9	Burnt Store Colony	22 Colony Pk	2	pre-94	Yes	8/13/1990	FLA 462950
42	9	Burnt Store Colony	32 Colony Pk	2	pre-94	Yes	2/7/1986	FLA 317262
43	9	Burnt Store Colony	41 Colony Pk	2	pre-94	Yes	1/12/1990	FLA 447995
44	14	S. Punta Gorda	795 Almar Dr	2	pre-94	Unk	Unk	unk
45	14	S. Punta Gorda	4100 Almar	1	pre-94	No	Unk	none
46	14	S. Punta Gorda	4130 Almar D	2	post-99	Yes	12/16/2002	FLA 733879
47	14	S. Punta Gorda	4132 Almar	2	pre-94	No	Unk	none
48	14	S. Punta Gorda	4300 Almar	1	pre-94	No	Unk	none
49	14	S. Punta Gorda	4330 Almar	1	pre-94	No	Unk	none

SURVEY LOGISTICS				UNIT CHARACTERISTICS				
Sheet No.	Site No.	Devel Name	Street Address	No. of Sections	Age Category	HUD Code?	Date of Manuf.	HUD Label No.
50	14	S. Punta Gorda	4420 Almar	2	pre-94	No	Unk	none
51	14	S. Punta Gorda	4520 Almar	2	pre-94	No	Unk	none
52	14	S. Punta Gorda	4610 Almar	2	pre-94	Unk	Unk	Unk
53	14	S. Punta Gorda	5022 Almar	2	post-99	Yes	4/2/2004	FLA 753611
54	14	S. Punta Gorda	5100 Almar	2	post-99	Yes	2/19/2002	FLA 720907
55	16	Port Charlotte Villa	241 Weatherl	2	post-99	Yes	10/12/1999	FLA 680638,
56	16	Port Charlotte Villa	66 Weatherby	2	post-99	Yes	2/26/2001	FLA 704723
57	16	Port Charlotte Villa	220 Club Ln	2	post-99	Yes	2/7/2002	FLA 720878
58	16	Port Charlotte Villa	191 Club Ln	2	post-99	Yes	7/28/2000	FLA 693715
59	16	Port Charlotte Villa	#335	2	post-94	Yes	6/25/1997	FLA 619713,
60	16	Port Charlotte Villa	#49	2	post-94	Yes	11/15/1997	FLA 631771
61	16	Port Charlotte Villa	#32	2	post-94	Yes	8/22/1997	FLA 622779
62	17	Harbor View Park	#12E	2	post-99	Yes	11/5/1999	FLA 681234,
63	1	Lakeland Village	#113 ?	2	Unk	Unk	Unk	Unk
64	1	Lakeland Village	#107 ?	2	post-94	Yes	9/16/1994	FLA 553562
65	1	Lakeland Village	#203	2	post-94	Yes	6/24/1998	FLA 647827
66	1	Lakeland Village	#220	2	post-94	Yes	8/16/1996	FLA 597891
67	1	Lakeland Village	#121	2	post-94	Yes	1/31/1996	FLA 585473,
68	1	Lakeland Village	#207	2	Unk	Unk	Unk	Unk
69	1	Lakeland Village	#104	2	post-94	Yes	10/22/1997	FLA 629843,
70	1	Lakeland Village	#117	2	post-94	Yes	10/28/1997	FLA 628401
71	2	Pine Acres	#3A, 6526	2	pre-94	Yes	12/4/1980	FLA 139970,
72	2	Pine Acres	6672	1	pre-94	Yes	5/17/1989	FLA 427152
73	2	Pine Acres	6559	1	pre-94	Yes	4/26/1983	FLA 213576
74	2	Pine Acres	6626	1	pre-94	Yes	1/20/1989	FLA 414633
75	2	Pine Acres	6525	1	pre-94	Yes	4/8/1983	FLA 213401
76	3	Ventura Lakes	#94	2	post-99	Yes	6/12/2003	FLA 740352
77	4	Riverside Oaks	#98, Sandlew	2	post-94	Yes	2/3/1995	FLA 564260
78	4	Riverside Oaks	#101	2	pre-94	Yes	2/14/1992	FLA 493939
79	4	Riverside Oaks	#102	2	post-94	Yes	10/13/1995	FLA 579554
80	4	Riverside Oaks	#17	2	pre-94	Yes	1/12/1993	FLA 512743
81	5	September Estates	15246 Buzzar	2	post-99	Yes	1/23/2001	FLA 702674
83	5	September Estates	15300 Buzzar	2	pre-94	Yes	10/12/1984	GEO 311160
84	5	September Estates	Farrell St.	2	post-99	Yes	6/14/2004	FLA 757891
85	8	Cherry Estate	3057 Sloop L	2	post-99	Yes	2/11/2002	FLA 720134
86	8	Cherry Estate	3025 Sloop L	2	post-99	Yes	7/21/2003	FLA 742089
87	8	Cherry Estate	2991 Sloop L	2	post-99	Yes	7/20/2001	FLA 710889
88	8	Cherry Estates	2970 Sloop L	2	post-99	Yes	1/11/2002	FLA 718007
89	12	Windmill	3 Amsterdam	2	pre-94	Unk	Unk	Unk
90	12	Windmill	14 Alligator	2	post-94	Yes	7/16/1996	FLA 647885
91	13	Buttonwood Village	64 Clarendow	2	pre-94	Yes	6/17/1988	FLA 394848
92	13	Buttonwood Village	69 Clarendon	2	pre-94	Yes	2/13/1992	FLA 493558
93	13	Buttonwood Village	73 Buttonwod	2	post-99	Yes	7/22/2003	FLA 742362
94	13	Buttonwood Village	72 Buttonwod	2	pre-94	Yes	2/25/1994	FLA 541485
97	9	Burnt Store Colony	#172, 15550	2	pre-94	Yes	1/29/1988	FLA 384809
98	9	Burnt Store Colony	#37	2	post-99	Yes	5/3/2004	FLA 755241
99	9	Burnt Store Colony	#38	2	pre-94	Yes	3/15/1988	FLA 387675
101	12	Windmill	#19 Amsterda	2	pre-94	Unk	Unk	Unk
103	3	Ventura Lakes	#91	2	post-99	Yes	9/28/2001	FLA 713969
104	14	By the Sea	5341 River Ba	2	post-94	Yes	1/18/1999	FLA 661379,
105	14	By the Sea	5535 River Ba	2	pre-94	Yes	1/1/1989	Unk
106	14	By the Sea	5511 River Ba	2	pre-94	Yes	8/13/1993	FLA 528884,
107	14	By the Sea	5471 River Ba	2	pre-94	Yes	1/1/1990	Unk
108	14	By the Sea	5465 River Ba	2	post-99	Yes	6/21/2004	FLA 757345,
109	14	By the Sea	5447 River Ba	2	pre-94	Yes	1/1/1990	Unk
110	14	By the Sea	5415 River Ba	2	pre-94	Yes	1/1/1986	Unk

Total Number of Samples = 105

Unk = "unknown" and means either form was left blank or data was not obtainable for various reasons.

CONSTRUCTION & SITE CHARACTERISTICS

Sheet No.	Roofing Type	Siding Type	Bracing Type	Fnd Anc present?	Anchor Spacing (ft)	Meet 99 req's?	Wind Exposure
1	Shingle	Vinyl	Fiberboard	Yes	Unk	No	B
2	Shingle	Vinyl	Fiberboard	Unk	Unk	Unk	B
3	Shingle	Vinyl	Fiberboard	Yes	Unk	Unk	B
4	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
5	Shingle	Vinyl	OSB	Unk	Unk	Unk	B
6	Shingle	Vinyl	OSB	Yes	Unk	Unk	B
7	Metal	Metal	Unk	Yes	8	No	B-tree
8	Metal	Metal	Metal	No	None	No	B-tree
9	Metal	Metal	Metal	Yes	10	No	B-tree
10	Metal	Alum	Unk	No	None	No	B-tree
11	Shingle	Alum	Unk	Yes	10	No	B
12	Metal	Metal	Metal	No	Unk	No	B
13	Shingle	Vinyl	OSB/hdbrd	Yes	5	Yes	B
14	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
15	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
16	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
17	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
18	Shingle	Vinyl	Unk	Yes	8	No	B-tree
19	Shingle	Vinyl	Unk	Yes	8	No	B-tree
20	Shingle	Vinyl	Unk	Yes	8	No	B-tree
21	Shingle	Vinyl	Unk	Yes	10	No	B-tree
22	Metal	Metal	Metal	Yes	20	No	B-tree
23	Metal	Metal	Metal	Yes	12	No	B-tree
24	Metal	Vinyl	Metal	Yes	10	No	B-tree
25	Metal	Metal	Metal	Yes	6	No	B
26	Shingle	Vinyl	OSB	Yes	5	Yes	B
27	Metal	Metal	Metal	Yes	10	No	B-shielded
28	Metal	Vinyl	OSB	Yes	5	Yes	B
29	Metal	Vinyl	Hardboard	Yes	10	No	B
30	Metal	Metal	Hardboard	Yes	20	No	B
31	Metal	Metal	Metal	Yes	14	No	B
32	Shingle	Vinyl	Unk	Yes	5	Yes	B
33	Shingle	Vinyl	OSB/hdbrd	Yes	5	Yes	B
34	Unk	Unk	Unk	Yes	8	No	B
35	Metal	Metal	Metal	Yes	8	No	B
36	Shingle	Vinyl	Unk	Yes	5	Yes	B
37	Shingle	Vinyl	Unk	Yes	5	Yes	B
38	Metal	Metal	Metal	Yes	10	No	B
39	Metal	Metal	Metal	Yes	8	No	B
40	Shingle	Vinyl	Hardboard	Yes	5	Yes	B
41	Shingle	Vinyl	Unk	Yes	6	No	B
42	Shingle	Alum	Unk	Yes	8	No	B
43	Metal	Vinyl	Unk	Yes	8	No	B
44	Metal	Vinyl	Unk	Yes	10	No	B
45	Metal	Vinyl	Metal	Yes	10	No	B
46	Shingle	Vinyl	Hardboard	Yes	5	Yes	B
47	Metal	Metal	Metal	Yes	12	No	B
48	Metal	Vinyl	Metal	Unk	Unk	No	B
49	Metal	Metal	Metal	Yes	12	No	B

CONSTRUCTION & SITE CHARACTERISTICS							
Sheet No.	Roofing Type	Siding Type	Bracing Type	Fnd Anc present?	Anchor Spacing (ft)	Meet 99 req's?	Wind Exposure
50	Metal	Vinyl	Metal	Yes	12	No	B
51	Metal	Vinyl	Metal	Yes	16	No	B
52	Metal	Vinyl	Metal	Unk	Unk	No	B
53	Shingle	Vinyl	OSB	Yes	5	Yes	B
54	Shingle	Vinyl	OSB	Yes	5	Yes	B
55	Shingle	Vinyl	OSB	Yes	5	Yes	B
56	Shingle	Vinyl	OSB	Yes	5	Yes	B
57	Shingle	Vinyl	OSB	Yes	5	Yes	B
58	Shingle	Vinyl	OSB	Yes	5	Yes	B
59	Shingle	Vinyl	OSB	Yes	6	No	B
60	Shingle	Vinyl	OSB	Yes	8	No	B
61	Shingle	Vinyl	OSB	Yes	7	No	B
62	Shingle	Vinyl	Hardboard	Yes	5	Yes	B
63	Shingle	Vinyl	none	Yes	Unk	Unk	B
64	Shingle	Vinyl	Unk	Yes	Unk	Unk	B
65	Shingle	Vinyl	Unk	Yes	Unk	No	B
66	Shingle	Unk	Unk	Yes	Unk	No	B
67	Shingle	Vinyl	Hardboard	Yes	Unk	No	B
68	Shingle	Unk	Unk	Yes	Unk	Unk	B
69	Shingle	Vinyl	Hardboard	Unk	Unk	Unk	B
70	Shingle	Vinyl	OSB	Yes	Unk	Unk	B
71	Unk	Metal	None	Yes	Unk	No	B
72	Shingle	Metal	Unk	Yes	Unk	Unk	B
73	Shingle	Metal	Metal	Yes	Unk	Unk	B
74	Shingle	Metal	Metal	Yes	8	No	B
75	Metal	Metal	Unk	Yes	Unk	Unk	B
76	Shingle	Vinyl	Unk	Unk	Unk	Unk	B
77	Shingle	Vinyl	Unk	Yes	Unk	Unk	B-tree
78	Shingle	Vinyl	Unk	Yes	Unk	Unk	B-tree
79	Shingle	Vinyl	Hardboard	Yes	Unk	Unk	B-tree
80	Shingle	Vinyl	Fiberboard	Yes	Unk	Unk	B-tree
81	Shingle	Vinyl	Unk	Yes	Unk	Yes	B-tree
83	Shingle	Vinyl	Hardboard	No	None	No	B-tree
84	Shingle	Vinyl	Unk	Yes	Unk	Yes	B-tree
85	Shingle	Vinyl	OSB	Unk	Unk	Unk	B-tree
86	Shingle	Vinyl	Unk	Unk	Unk	Unk	B-tree
87	Shingle	Vinyl	Unk	Yes	Unk	Unk	B-tree
88	Shingle	Vinyl	Unk	Unk	Unk	Unk	B-tree
89	Metal	Metal	Unk	Yes	Unk	No	B
90	Shingle	Vinyl	Unk	Yes	Unk	Unk	B
91	Shingle	Vinyl	none	Yes	Unk	No	B
92	Shingle	Vinyl	Foamboard	Yes	Unk	No	B
93	Shingle	Unk	Unk	Unk	Unk	Unk	B
94	Unk	Vinyl	Unk	Unk	Unk	Unk	B
97	Shingle	Vinyl	Unk	Unk	Unk	No	B
98	Shingle	Vinyl	Unk	Unk	Unk	Yes	B
99	Shingle	Vinyl	Unk	Yes	Unk	No	B
101	Metal	Vinyl	Metal	Yes	Unk	Unk	B
103	Shingle	Vinyl	Hardboard	Yes	Unk	Unk	B
104	Unk	Vinyl	OSB	Yes	6	No	B
105	Unk	Vinyl	Masonite	Unk	Unk	No	B
106	Shingle	Vinyl	Fiberboard	Unk	Unk	No	B
107	Shingle	Vinyl	Unk	Yes	8	No	B
108	Shingle	Vinyl	Unk	Yes	5	Yes	B
109	Shingle	Vinyl	Hardboard	Yes	Unk	No	B
110	Unk	Vinyl	Hardboard	Yes	8	No	B

DAMAGE RATINGS						
Sheet No.	Roof	Walls	Foundation	Projectile	Add-ons	Overall
1	2	1	0	2	3	2
2	2	1	0	2	3	2
3	1	0	0	2	3	1
4	1	0	0	1	1	1
5	1	0	0	1	1	1
6	1	0	0	1	3	1
7	0	1	0	0	0	1
8	0	0	0	1	0	0
9	3	3	2	1	3	3
10	0	0	0	0	0	0
11	1	0	0	1	2	1
12	3	3	2	Unk	3	3
13	1	1	2	2	n/a	2
14	1	1	0	1	3	1
15	1	1	0	1	1	1
16	1	0	0	1	3	1
17	1	0	0	0	3	1
18	0	0	0	0	2	0
19	0	0	0	0	1	0
20	1	0	0	0	2	1
21	1	0	0	1	0	1
22	1	1	0	2	3	1
23	1	0	3	1	3	3
24	1	1	0	Unk	3	1
25	3	3	0	2	3	3
26	1	1	0	2	3	1
27	1	1	0	2	2	1
28	1	1	0	2	2	1
29	1	2	1	3	3	2
30	1	1	0	1	3	1
31	3	2	0	1	2	3
32	0	0	0	1	3	0
33	1	1	0	1	3	1
34	3	3	0	Unk	3	3
35	3	1	0	1	3	3
36	1	1	1	1	n/a	1
37	1	1	3	1	n/a	3
38	0	1	0	1	3	1
39	1	2	1	1	3	2
40	1	1	1	1	n/a	1
41	0	0	0	1	1	0
42	1	1	0	0	1	1
43	0	0	0	0	0	0
44	3	1	0	2	3	3
45	3	3	0	2	3	3
46	1	1	1	1	3	1
47	3	3	0	Unk	3	3
48	2	1	0	2	3	2
49	3	3	0	Unk	3	3

DAMAGE RATINGS						
Sheet No.	Roof	Walls	Foundation	Projectile	Add-ons	Overall
50	0	1	0	1	3	1
51	3	3	0	2	1	3
52	1	1	0	1	3	1
53	0	1	0	1	0	1
54	1	1	1	2	n/a	1
55	1	1	0	2	2	1
56	1	1	1	1	3	1
57	1	1	0	2	3	1
58	1	1	0	1	3	1
59	1	1	0	1	3	1
60	1	1	0	1	3	1
61	0	1	0	1	2	1
62	1	1	0	1	3	1
63	1	1	0	1	n/a	1
64	1	1	1	Unk	3	1
65	1	1	1	1	2	1
66	1	1	1	1	3	1
67	1	1	0	Unk	3	1
68	1	1	0	Unk	3	1
69	1	0	0	Unk	2	1
70	1	0	0	1	3	1
71	3	3	1	2	n/a	3
72	1	0	0	0	3	1
73	1	1	Unk	Unk	3	1
74	2	2	2	Unk	Unk	2
75	2	1	1	1	2	2
76	0	0	0	0	0	0
77	1	0	0	1	2	1
78	1	1	Unk	Unk	Unk	1
79	1	1	0	1	3	1
80	3	1	Unk	Unk	3	3
81	1	0	0	0	3	1
83	1	1	Unk	Unk	Unk	1
84	0	0	0	1	Unk	0
85	1	1	Unk	Unk	Unk	1
86	0	0	0	0	0	0
87	0	0	0	0	2	0
88	0	0	0	0	0	0
89	3	2	Unk	2	Unk	3
90	1	0	1	0	2	1
91	2	1	Unk	Unk	Unk	2
92	1	1	2	1	Unk	2
93	1	1	0	0	2	1
94	1	1	Unk	1	3	1
97	1	Unk	Unk	1	Unk	1
98	0	0	1	Unk	0	1
99	1	1	0	1	3	1
101	1	1	1	1	Unk	1
103	1	1	0	Unk	3	1
104	0	1	0	1	Unk	1
105	3	1	0	1	3	3
106	0	0	0	1	1	0
107	1	0	0	0	0	1
108	0	0	0	1	n/a	0
109	1	Unk	Unk	2	3	1
110	1	1	1	1	3	1

Appendix C - Detailed Construction Characteristic and Damage Data

SUMMARY OF DAMAGE RATINGS FOR ENTIRE SAMPLE

ENTIRE SAMPLE (HUD and non-HUD homes of all ages) (n= 105)						
Rating Statistics	Roof	Walls	Foundation	Projectile	Add-ons	Overall
AVG RATING=	1.14	0.91	0.34	1.05	2.26	1.26
Std Error =	0.09	0.08	0.07	0.07	0.12	0.09
95% Conf. Limits =	0.17	0.16	0.14	0.15	0.23	0.18
Std DEV =	0.90	0.84	0.68	0.68	1.08	0.90
COV =	0.79	0.92	2.01	0.65	0.48	0.71
n =	105	103	95	87	86	95
Damage Frequencies	Roof	Walls	Foundation	Projectile	Add-ons	Overall
% with 0 rating	20.0%	31.1%	75.8%	19.5%	12.8%	14.7%
% with 1 rating	60.0%	55.3%	16.8%	57.5%	9.3%	60.0%
% with 2 rating	5.7%	4.9%	5.3%	21.8%	17.4%	9.5%
% with 3 rating	14.3%	8.7%	2.1%	1.1%	60.5%	15.8%
TOTALS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Unknown entries not included)

(NOTE: averaging of the entire data set is somewhat meaningless since the sampling method did not follow actual age distribution of population of manufactured housing units. However, it does characterize the overall sample. It is not representative of overall manufactured housing population performance. Within age groups below, the damage statistics are representative.)

SAMPLE DISTRIBUTION BY MAP STUDY SITE NUMBERS

Map Site No. =	1	2	3	4	5	8	9	12	13	14	16	17	TOTAL
Samples (n) =	14	12	6	8	6	4	6	10	13	18	7	1	105

SUMMARY OF DAMAGE RATINGS BY AGE CATEGORIES

1994 - PRESENT HUD-CODE HOMES (n= 52)						
Rating Statistics	Roof	Walls	Foundation	Projectile	Add-ons	Overall
AVG RATING=	0.75	0.58	0.29	0.91	2.14	0.88
Std Error =	0.06	0.07	0.09	0.09	0.16	0.07
95% Conf. Limits =	0.12	0.14	0.17	0.19	0.33	0.15
Std DEV =	0.44	0.50	0.61	0.63	1.08	0.52
COV =	0.58	0.86	2.07	0.69	0.51	0.58
n =	52	52	51	46	43	51
Damage Frequencies	Roof	Walls	Foundation	Projectile	Add-ons	Overall
% with 0 rating	25.0%	42.3%	76.5%	23.9%	14.0%	17.6%
% with 1 rating	75.0%	57.7%	19.6%	60.9%	9.3%	78.4%
% with 2 rating	0.0%	0.0%	2.0%	15.2%	25.6%	2.0%
% with 3 rating	0.0%	0.0%	2.0%	0.0%	51.2%	2.0%
TOTALS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Unknown entries not included)

SUB-SAMPLE DISTRIBUTION BY MAP STUDY SITE NUMBERS

Map Site No. =	1	2	3	4	5	8	9	12	13	14	16	17	TOTAL
Samples (n) =	9	1	6	6	3	4	1	3	6	5	7	1	52

CONSTRUCTION CHARACTERISTICS (% of sampled homes, unknowns not included)

No. of Units	1 unit	2 or more	Siding Type	Vinyl	Metal	Alum						
	3.8%	96.2%	Type	98.0%	2.0%	0.0%						
Roofing Type	Shingle	Metal	Wall Shtg Type	OSB	SB/hardboa	Hardboard	Fiberboard	Metal	Foamboard	None		
	96.1%	3.9%	Type	51.6%	6.5%	38.7%	0.0%	3.2%	0.0%	0.0%		
Foundation	5' or less		6' to 8'	10' or more	None							
Anchor Spacing	65.4%		26.9%	7.7%	0.0%							

PRE-1994 HUD CODE UNITS ONLY (n= 28)						
Rating Statistics	Roof	Walls	Foundation	Projectile	Add-ons	Overall
AVG RATING=	1.25	0.88	0.40	1.05	2.33	1.35
Std Error =	0.16	0.14	0.15	0.15	0.23	0.20
95% Conf. Limits =	0.33	0.29	0.32	0.30	0.48	0.41
Std DEV =	0.84	0.71	0.68	0.67	1.06	0.88
COV =	0.68	0.80	1.70	0.64	0.46	0.65
n =	28	26	20	21	21	20
Damage Frequencies	Roof	Walls	Foundation	Projectile	Add-ons	Overall
% with 0 rating	14.3%	26.9%	70.0%	19.0%	9.5%	15.0%
% with 1 rating	57.1%	61.5%	20.0%	57.1%	14.3%	45.0%
% with 2 rating	17.9%	7.7%	10.0%	23.8%	9.5%	30.0%
% with 3 rating	10.7%	3.8%	0.0%	0.0%	66.7%	10.0%
TOTALS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Unknown entries not included)

SUB-SAMPLE DISTRIBUTION BY MAP STUDY SITE NUMBERS

Map Site No. =	1	2	3	4	5	8	9	12	13	14	16	17	TOTAL
Samples (n) =	3	6	0	2	2	0	5	0	5	5	0	0	28

CONSTRUCTION CHARACTERISTICS (% of sampled homes, unknowns not included)

No. of Units	1 unit	2 or more	Siding Type	Vinyl	Metal	Alum						
	25.0%	75.0%	Type	67.9%	25.0%	7.1%						
Roofing Type	Shingle	Metal	Wall Shtg Type	OSB	SB/hardboa	Hardboard	Fiberboard	Metal	Foamboard	None	Other	
	79.2%	20.8%	Type	0.0%	0.0%	17.6%	29.4%	29.4%	5.9%	11.8%	5.9%	
Foundation	5' or less		6' to 8'	10' or more	None							
Anchor Spacing	0.0%		63.6%	27.3%	9.1%							

Note:

All confidence limits are based on Student t with 0.05 level of significance. Std Error = Std DEV / sqrt (n) and is the standard error estimate for the mean or average damage rating.

Reference:

Ott, Lyman, *An Introduction to Statistical Methods and Data Analysis*, Third Edition, PWS-Kent Publishing Company, Boston, MA. 1988.

Appendix C (continued)

PRE-1976 (NON-HUD CODE UNITS ONLY) (n= 17)						
Rating Statistics	Roof	Walls	Foundation	Projectile	Add-ons	Overall
AVG RATING=	2.06	1.82	0.41	1.31	2.41	2.24
Std Error =	0.30	0.30	0.23	0.17	0.26	0.28
95% Conf. Limits =	0.64	0.64	0.48	0.38	0.55	0.59
Std DEV =	1.25	1.24	0.94	0.63	1.06	1.15
COV =	0.61	0.68	2.28	0.48	0.44	0.51
n =	17	17	17	13	17	17
Damage Frequencies	Roof	Walls	Foundation	Projectile	Add-ons	Overall
% with 0 rating	17.6%	17.6%	82.4%	7.7%	11.8%	11.8%
% with 1 rating	17.6%	29.4%	0.0%	53.8%	5.9%	17.6%
% with 2 rating	5.9%	5.9%	11.8%	38.5%	11.8%	5.9%
% with 3 rating	58.8%	47.1%	5.9%	0.0%	70.6%	64.7%
TOTALS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Unknown and n/a entries not included)

SUB-SAMPLE DISTRIBUTION BY MAP STUDY SITE NUMBERS

Map Site No. =	1	2	3	4	5	8	9	12	13	14	16	17	TOTAL
Samples (n) =	0	4	0	0	1	0	0	4	2	6	0	0	17

CONSTRUCTION CHARACTERISTICS (% of sampled homes, unknowns not included)

No. of Units	1 unit	2 or more	Siding	Vinyl	Metal	Alum							
	64.7%	35.3%	Type	25.0%	68.8%	6.3%							
Roofing	Shingle	Metal	Wall Shtg	OSB	SB/hardboa	Hardboard	Fiberboard	Metal	Foamboard	None	Other		
Type	0.0%	100.0%	Type	0.0%	0.0%	6.7%	0.0%	93.3%	0.0%	0.0%	0.0%		
Foundation	5' or less	6' to 8'	10' or more	None									
Anchor Spacing	0.0%	18.8%	62.5%	18.8%									

SUMMARY OF DAMAGE RATINGS BY FOUNDATION ANCHORAGE METHOD

POST-1994 HUD CODE UNITS MEETING FLORIDA 1999 FOUNDATION ANCHORAGE REQUIREMENTS (n= 22)						
Rating Statistics	Roof	Walls	Foundation	Projectile	Add-ons	Overall
AVG RATING=	0.77	0.77	0.55	1.29	2.40	1.00
Std Error =	0.09	0.09	0.17	0.12	0.27	0.13
95% Conf. Limits =	0.19	0.19	0.35	0.26	0.58	0.27
Std DEV =	0.43	0.43	0.80	0.56	1.06	0.62
COV =	0.56	0.56	1.47	0.44	0.44	0.62
n =	22	22	22	21	15	22
Damage Frequencies	Roof	Walls	Foundation	Projectile	Add-ons	Overall
% with 0 rating	22.7%	22.7%	59.1%	4.8%	13.3%	13.6%
% with 1 rating	77.3%	77.3%	31.8%	61.9%	0.0%	77.3%
% with 2 rating	0.0%	0.0%	4.5%	33.3%	20.0%	4.5%
% with 3 rating	0.0%	0.0%	4.5%	0.0%	66.7%	4.5%
TOTALS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Unknown and n/a entries not included)

Appendix D - Statistical Inferences

STATISTICAL TESTS OF DIFFERENCES IN MEAN DAMAGE RATINGS

(Separate-Variance t Test)

Level of significance is the minimum level at which the null hypothesis (e.g., average performance is not different) can be rejected in favor of the research hypothesis that group 1 performance is better (e.g., lower average damage rating) than group 2. Confidence level is inverse of level of significance and is the maximum value at which the null hypothesis (i.e., no difference) may be rejected.

A. (1) Post 1994 vs. (2) Pre-1994 HUD code units only

	Roof	Walls	Foundation	Projectile	Add-ons	Overall
avg1-avg2=	-0.5000	-0.3077	-0.1059	-0.1346	-0.1938	-0.4676
s1 =	0.4372	0.4989	0.6097	0.6263	1.0819	0.5156
n1 =	52	52	51	46	43	51
s2 =	0.8444	0.7114	0.6806	0.6690	1.0646	0.8751
n2 =	28	26	20	21	21	20
t' =	-2.929068	-1.975743	-0.606804	-0.779016	-0.68014	-2.242122
c =	0.126168	0.197331	0.239413	0.285751	0.335286	0.11984
DOF =	34	37	31	36	40	24
Significance	0.003016	0.027839	0.2742	0.220531	0.250167	0.017231
Confidence	99.6984%	97.2161%	72.5800%	77.9469%	74.9833%	98.2769%

B. (1) Post-1994 vs. (2) Pre-1976 non-HUD code units

	Roof	Walls	Foundation	Projectile	Add-ons	Overall
avg1-avg2=	-1.3088	-1.2466	-0.1176	-0.3946	-0.2722	-1.3529
s1 =	0.4372	0.4989	0.6097	0.6263	1.0819	0.5156
n1 =	52	52	51	46	43	51
s2 =	1.2485	1.2367	0.9393	0.6304	1.0641	1.1472
n2 =	17	17	17	13	17	17
t' =	-4.238095	-4.049829	-0.483557	-1.995835	-0.888715	-4.706472
c =	0.038549	0.050511	0.123149	0.2181	0.290117	0.063089
DOF =	17	17	20	19	29	18
Significance	0.000277	0.000416	0.316976	0.030245	0.190734	8.8E-05
Confidence	99.9723%	99.9584%	68.3024%	96.9755%	80.9266%	99.9912%

C. (1) Pre-1994 HUD Code vs. (2) Pre-1976 non-HUD code units

	Roof	Walls	Foundation	Projectile	Add-ons	Overall
avg1-avg2=	-0.8088	-0.9389	-0.0118	-0.2601	-0.0784	-0.8853
s1 =	0.8444	0.7114	0.6806	0.6690	1.0646	0.8751
n1 =	28	26	20	21	21	20
s2 =	1.2485	1.2367	0.9393	0.6304	1.0641	1.1472
n2 =	17	17	17	13	17	17
t' =	-2.363018	-2.838259	-0.042941	-1.141736	-0.225869	-2.60255
c =	0.217338	0.177894	0.308521	0.410799	0.447582	0.330904
DOF =	24	22	28	26	34	29
Significance	0.013285	0.004783	0.483027	0.131985	0.411328	0.007214
Confidence	98.6715%	99.5217%	51.6973%	86.8015%	58.8672%	99.2786%

Appendix E - Photographs



Figure 6.1: Destroyed Add-On Construction



Figure 6.2: Destroyed Add-On Construction



Figure 6.3: Destroyed Add-On Construction



Figure 6.4: Destroyed Add-On Construction



Figure 6.5: Destroyed Add-On Construction



Figure 6.6: Destroyed Add-On Construction



Figure 6.7: Damaged Sidewall and Endwall Siding



Figure 6.8: Destroyed Manufactured Home Built Prior to 1976



Figure 6.9: Destroyed Manufactured Home



Figure 6.10: Destroyed Manufactured Home



Figure 6.11: Failure of Wall and Roof System



Figure 6.12: Destroyed Manufactured Home



Figure 6.13: Destroyed Manufactured Home Built Prior to 1976



Figure 6.14: Destroyed Manufactured Home Built Prior to 1976



Figure 6.15: Destroyed Manufactured Home Built Prior to 1976



Figure 6.16: Destroyed Manufactured Home



Figure 6.17: Failure of Roof System



Figure 6.18: Manufactured Home Survived the Hurricane Wind Forces



Figure 6.19: Manufactured Home Survived the Hurricane Wind Forces



Figure 6.20: Manufactured Home Survived the Hurricane Wind Forces



Figure 6.21: Manufactured Home with Shutters Survived Hurricane Wind Forces



Figure 6.22: Manufactured Home Slightly Shifted from its Foundation



Figure 6.23: Manufactured Home Slightly Shifted from its Foundation



Figure 6.24: Manufactured Home Installed in Accordance with Florida Installation Law with Anchors at about 5 ft. on Center.



Figure 6.25: Manufactured Home Installed with Short Ground Anchors



Figure 6.26: Manufactured Home Installed with Alternative Anchoring System



Figure 6.27: Corroded Ground Anchor Strap



Figure 6.28: Corroded Ground Anchor Strap



Figure 6.29: Corroded Ground Anchor Strap



Figure 6.30: Corroded Ground Anchor Strap



Figure 6.31: Corroded Ground Anchor Strap



Figure 6.32: Damaged Corner Part of the Home



Figure 6.33: Damaged Endwall Siding



Figure 6.34: Damaged Endwall Siding



Figure 6.35: Damaged Endwall Siding



Figure 6.36: Damaged Endwall Siding



Figure 6.37: Scouring Action of Wind and Rain Water Runoff



Figure 6.38: Scouring Action of Wind and Rain Water Runoff