OFFICE OF INSURANCE REGULATION

HOME STRUCTURE RATING SYSTEM

MARCH 30, 2007

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Part I

Executive Summary

Discussion

The Home Structure Rating System (HSRS) was presented to the Advisory Board by Lawrence A. Twisdale, Jr., PhD, PE, of Applied Research Associates, Inc., during an Advisory Board Meeting that was held in Gainesville, Florida on March 21, 2007. **The Advisory Board concurred with the HSRS Methodology by unanimous voice vote at the conclusion of the presentation.**

The HSRS is a system that is similar to the Home Resistance Rating (HRR) that is currently used to calculate home rating scores within the My Safe Florida Home (MSFH) program. The HSRS has been developed to provide a measure of the relative ability of a structure to withstand the forces that are associated with a sustained severe tropical windstorm or hurricane.

The HSRS produces scores between 1 and 100 and has been designed to include room at the top of its scale to accommodate future building code improvements and implementation of code-plus mitigation techniques.

HSRS score calculations include consideration of all of the primary and secondary features that are considered in HRR score calculations, but the HSRS also includes consideration of wind zone location and terrain that are associated with each home that is inspected.

HSRS score calculations include consideration of eight primary features that include:

1. Roof shape – Hip or Other;
2. Secondary Water Resistance –Yes or No;
3. Roof Cover – After Florida Building Code or Not;
4. Roof Deck Attachment – Three levels of attachment strength;
5. Roof-to-Wall Connection – Four levels of connection strength;
6. Opening Protection – Three levels of protection for wind-borne debris;
7. Number of Stories – Two levels – one story and two or more stories; and
8. Roof Covering Type – Tile and Non-Tile.

Eleven secondary factors are also considered and are incorporated in HSRS score calculations in the form of adjustment factors. These secondary factors include:

1. Dimensional Lumber Deck;
2. Masonry Walls;
3. Reinforced Masonry Walls;
4. Opening Coverage;

5. Un-braced Gable End;
6. Foundation Restraints;
7. Reinforced Concrete Roof Deck Integral with Reinforced Concrete Walls or Reinforced Masonry Walls;
8. Enhanced Roof Deck;
9. Soffits;
10. Vinyl Siding; and
11. Window, Door and Skylight Water Leaking Potential.

HSRS calculations also employ the following ***objective measures*** to determine the score:

- The home's basic construction and wind damage mitigation features;
- The home's location, as determined by its Florida Building Code wind zone location;
- The home's wind resistance structural features in relation to a Florida Building Code home that is built in the home's specific wind zone location; and
- The home's terrain exposure —that is, Terrain C for coastal locations and Terrain B for inland suburban locations.

The HSRS, which is based on loss cost relativities, was designed to be consistently interpreted throughout Florida and within each of the eight wind zones in the State.

The HSRS was designed and developed so that its implementation within the MSFH Program would not impose additional training requirements on personnel who have previously received training in the version of the MSFH Program that employed the HRR rating scale. In this regard, while significant software changes were required because of HSRS development, external features of the MSFH program were essentially unchanged. In this regard, the Home Survey Checklist was unchanged and MSFH homeowner reporting required only minor changes.

HSRS Testing

The HSRS has been subjected to extensive tests, including:

- Basic Testing, which involved development of rating scores for a group of selected test homes, specifically, 68 homes for 8 wind zones and 2 terrains – Terrain C and Terrain B – resulting in 1088 test cases;
- Unit Testing, which involved development of rating scores for the 1088 test cases that were employed for Basic Testing, but in this instance testing was accomplished using a version of the Database and Data Dispatch System (DBDDS) application system that had been modified to incorporate HSRS; and

- System Testing, which involved executing the modified application system that incorporates the HSRS against the home inspection data for 13,462 homes that were inspected during the MSFH pilot program.

HSRS Advisory Board Meetings and Teleconferences

HSRS Advisory Board meetings and HSRS Project Status Teleconferences were employed throughout the period that HSRS was under development. Meeting and teleconference dates are listed below.

March 21, 2007 – Advisory Board Meeting
February 28, 2007 – HSRS Project Status Teleconference
February 14, 2007 - HSRS Project Status Teleconference
January 31, 2007 – HSRS Project Status Teleconference
January 24, 2007 – HSRS Project Status Teleconference
January 17, 2007 - HSRS Project Status Teleconference
January 3, 2007 - HSRS Project Status Teleconference
December 8, 2006 – Advisory Board Meeting
November 29, 2006 - HSRS Project Status Teleconference
November 8, 2006 - HSRS Project Status Teleconference
November 1, 2006 - HSRS Project Status Teleconference
October 27, 2006 – Advisory Board Meeting
October 11, 2006 - HSRS Project Status Teleconference
September 27, 2006 – HSRS Project Status Teleconference
September 20, 2006 – HSRS Project Status Teleconference
September 6, 2006 - HSRS Project Status Teleconference
August 24, 2006 - HSRS Project Status Teleconference
August 23, 2006 - HSRS Project Status Teleconference
August 16, 2006 - HSRS Project Status Teleconference

HSRS Website

An HSRS website was created to support the HSRS development project and includes meeting and teleconference agendas, meeting minutes and teleconference summaries. The website can be accessed at www.floir.com/HomeStructureRatingSystem.htm.

Recommendations

The recommendations that follow are offered for consideration.

- It is recommended that the HSRS that is reflected in **Appendix A** – "Home Structure Rating System Methodology and Development" -- be accepted and approved.

- It is recommended that technical assistance be provided by Applied Research Associates, Inc. to ensure successful integration of the new HSRS within the statewide implementation of the MSFH Program.

- It is recommended that the system testing of the HSRS that was accomplished using home inspection data that were acquired as a result of inspecting 13,462 homes during the MSFH pilot program be accepted and approved as having fulfilled the requirement that was established by Chapter 2006-12, Section 39, Laws of Florida, for implementing a pilot program for use of the rating system in the MSFH Program.

- It is recommended that modification to the Database and Data Dispatch System (DBDDS) by incorporating the HSRS System and subsequent statewide deployment of the modified system within the MSFH Program be accepted as having fulfilled the requirement that was established by Chapter 2006-12, Section 39, Laws of Florida, for an Operational Plan to be developed for statewide implementation of the new rating scale.

- It is recommended that the requirement for development of a Uniform Home Grading Scale that was established by Section 40, HB 1A be considered to have been satisfied by adoption of the Home Structure Rating System.

- It is recommended that suggested future updates to Loss Relativities within a study that was completed by Applied Research Associates, Inc. in 2002, as well as future updates to the HSRS that are suggested in **Appendix B**, be evaluated for possible adoption by a technically qualified group comprised of representatives from the following:

    - The Office of Insurance Regulation;
    - The Department of Financial Services;
    - The Department of Community Affairs;
    - Applied Research Associates, Inc.;
    - The Federal Alliance for Safe Homes;
    - The Florida Home Builders Association;
    - The Florida Building Commission;
    - The Florida Insurance Council;
    - The Institute of Business and Homes Safety;
    - The Florida Manufactured Housing Association;
    - The Program for Resource Efficient Communities, Institute of Food and Agricultural Sciences; and
    - Shimberg Center for Affordable Housing, Rinker School of Building Construction, College of Design, Construction and Planning.

- It is recommended that the HSRS be included in appropriate outreach education and training programs that are designed to inform Florida citizens statewide with regard to the nature, purpose and application of the HSRS for assessing and

improving the ability of their homes to withstand the forces that are involved in sustained severe tropical windstorms and hurricanes.

Project Reporting Requirements

As required by Chapter 2006-12, Section 39, Laws of Florida, this report is being submitted to the Governor of Florida, to the President of the Florida Senate, and to the Speaker of the Florida House of Representatives. Copies of this report will also be forwarded to the Florida Chief Financial Officer, Florida Attorney General and Florida Commissioner of Agriculture and Consumer Services.

Part II

Background

Section 39, Senate Bill 1980, which was created by the Florida 2006 Legislature and which is now known as Chapter 2006-12, Section 39, Laws of Florida, requires the Office of Insurance Regulation (Office) in consultation with representatives from other state agencies and other organizations to study and develop a program that will provide an objective rating system that will allow homeowners to enhance the relative ability of Florida properties to withstand the wind load from a severe tropical storm or hurricane.

The legislation identified above requires that the rating system shall be designed in a manner that is easy to understand for the property owner, based on proven verifiable mitigation techniques and devices, and be able to be implemented based on a visual inspection program.

The legislation identified above also requires the Department of Financial Services (DFS) to implement a pilot program for use of the rating system in the Florida Comprehensive Hurricane Damage Mitigation Program, which is now known as the My Safe Florida Home (MSFH) program. It should be noted in this regard, however, that the MSFH pilot program began before development of the rating system, which is known as the Home Structure Rating System (HSRS), begun. Accordingly, home inspection data acquired during the MSFH pilot program was employed to test the HSRS and this testing should serve to satisfy the requirement for implementing a pilot program to determine the nature, construction and effectiveness of the HSRS.

This Office negotiated a contract with the Shimberg Center for Affordable Housing, of the University of Florida, for the development of the rating scale, or HSRS. The University of Florida, in turn, subcontracted with Applied Research Associates, Inc. (ARA) for the actual design, development and testing of the HSRS.

Advisory Board Composition

Pursuant to the legislation identified above the Office established an HSRS Advisory Board that was comprised of representatives from the following organizations:

- Department of Community Affairs – Mr. Mo Madani, Manager, Building Codes and Standards Office;
- Department of Financial Services – Ms. Tami Torres, Special Program Administrator, Representing CFO Alex Sink, My Safe Florida Home;
- Federal Alliance for Safe Homes – Ms. Leslie Chapman-Henderson, President/CEO;
- Florida Insurance Council – Mr. George Grawe, Counsel, Allstate Insurance Company;
- Florida Home Builders Association – Mr. Jack Glen, Technical Affairs Director;
- Florida Manufactured Housing Association – Mr. James Ayotte, Executive Director;
- Florida State University, Risk Management and Insurance, College of Business – Mr. James Carson, PhD, Midyette Eminent Scholar in Risk Management;
- Institute for Business and Homes Safety – Mr. Tim Reinhold, PhD, Director of Engineering and Vice President; and
- Mercedes Homes – Mr. Stuart McDonald, Corporate Vice President of Operations.

NOTE: Because of its expertise in building homes that are capable of withstanding severe tropical windstorms and hurricanes, the Office requested Mercedes Homes to provide a representative to serve on the HSRS Advisory Board.

University of Florida Project Team Composition

The University of Florida team that supported the development of the HSRS included:

- Robert C. Stroh, Sr., PhD, Principle Investigator, Research Professor, Director of the Shimberg Center for Affordable Housing, Rinker School of Building Construction, College of Design, Construction and Planning;
- Pierce H. Jones, PhD, Co-Principle Investigator, Professor and Director of the Program for Resource Efficient Communities, Institute of Food and Agricultural Science;
- Kathleen C. Ruppert, PhD, Associate Extension Scientist, Institute of Food and Agricultural Sciences;
- Ronald A. Cook, PhD, Professor, Department of Civil Engineering, College of Engineering;
- Kurtis R. Gurley, PhD, Associate Professor, Department of Civil Engineering, College of Engineering;
- Ajay Shanker, PhD, Associate Professor, Rinker School of Building Construction, College of Design, Construction and Planning; and

- Craig R. Miller, PhD, Research Assistant, Programs for Resource Communications, Institute of Food and Agricultural Sciences.

Applied Research Associates, Inc. Representation

Applied Research Associates, Inc. was represented by:

Lawrence A. Twisdale, Jr., PhD, PE.

Office of Insurance Regulation Project Team Composition

The Office of Insurance Regulation team that supported development of HSRS included:

- A. E. “Dan” Callahan, Inspector General;
- Bonnie Deering, Audit Director;
- Dave Foy, Chief of Staff; and
- Chris Bailey, Government Relations.

Supporting Documents

Supporting documents that are relevant to this report include:

- **Attachment A** – “Home Structure Rating System Methodology Development” that was developed by Applied Research Associates, Inc.;

- **Attachment B** – “Updating Loss Relativities for Florida’s Insurance Credit System For Hurricane Wind Loss Mitigation Construction Features and Integration into a Statewide Home Structure Rating System” that was developed by Lawrence A. Twisdale, Jr., PhD, PE, of Applied Research Associates, Inc.;

- **Attachment C** – Florida legislation and laws that are relevant to development of a home rating scale.

Concluding Comments

Developing the HSRS has been both very demanding and challenging. We would be remiss if we were not to recognize the contributions of all members of the Advisory Board and the teams that were involved with regard to the HSRS Development Project. Special mention, of course, must be made with regard to the contributions of **Lawrence A. Twisdale, Jr.**, PhD, PE, of Applied Research Associates, Inc. Dr. Twisdale’s tenacity, patience, professionalism, imaginative thinking and capacity for sustained hard work have been singularly outstanding during this project and have contributed immeasurably toward successful development of the HSRS.

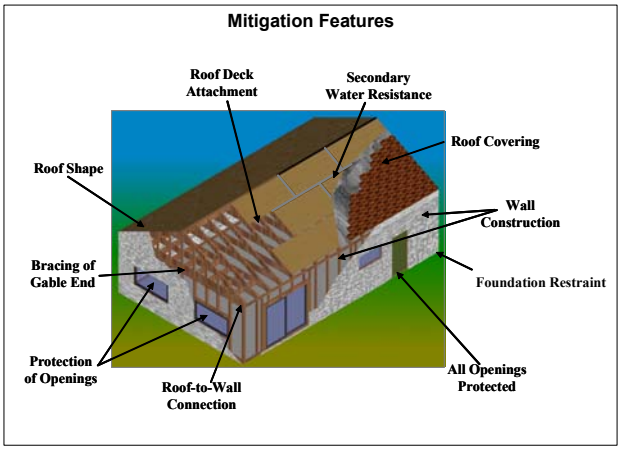
Appendix A

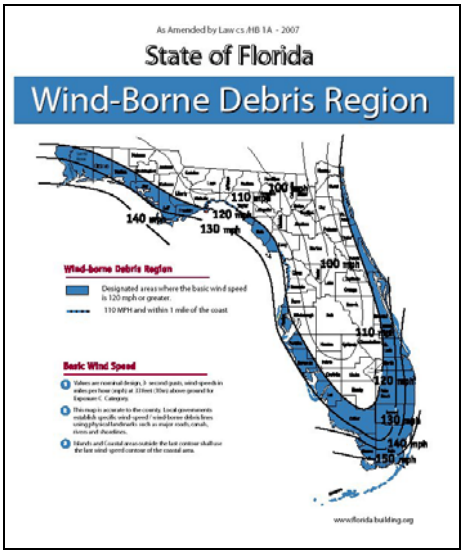
Home Structure Rating System Methodology Development

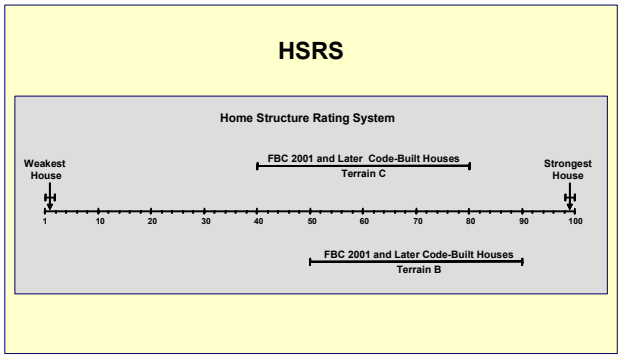
March 27, 2007

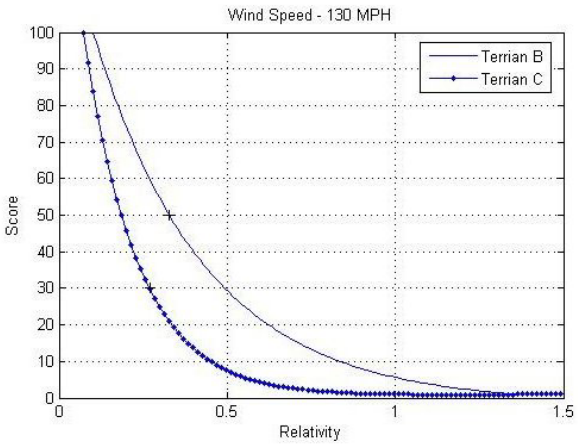
Final Report

Home Structure Rating System - Methodology Development for Hurricane Wind Effects









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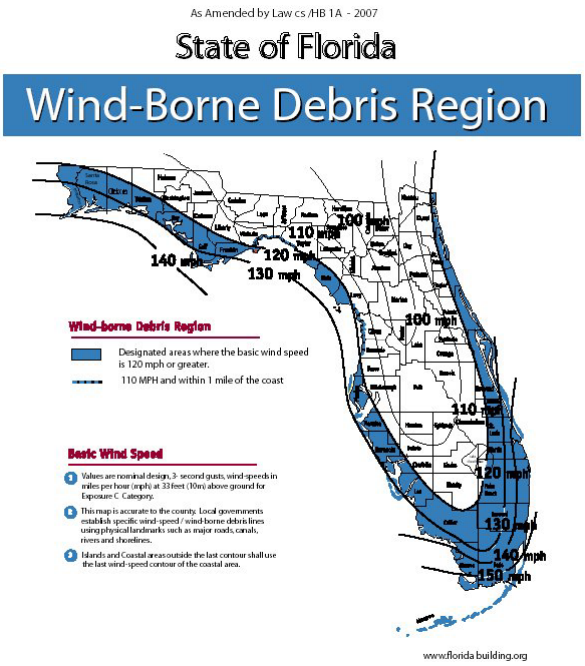
EXECUTIVE SUMMARY

A Home Structure Rating System (HSRS) has been developed to provide an objective measure of the relative ability of a Florida home to withstand wind effects from sustained severe tropical windstorms and hurricanes. This rating system is based on an inspection procedure that uses readily verifiable (visual) methods to determine the building's construction and wind mitigation features.

The rating system produces a score between 1 and 100, with 1 being the score for a very weak structure and 100 the score for a very strong, code-plus structure. The system was designed to allow room in the top portion of the scale for building code improvements over time and for implementation of code-plus mitigation techniques. The scale produces the greatest relative change in score for code and code-plus construction.

Objective Measures. The system includes the following measures to determine the score:

1. The home's basic construction and wind damage mitigation features;
2. The home's location in Florida, as determined by its Florida Building Code wind zone location;
3. A set of wind resistive features relative to a Florida Building Code (2001 version, adopted 3-1-2002) home, built in that specific wind zone location; and
4. A simplified terrain exposure of the home, which considers coastal locations (Terrain C) and inland suburban locations (Terrain B).



The score within each of Florida's "wind zones" is based on eight primary and eleven secondary inputs from these four groups of measures. The score does not reflect structures that may be attached to the home, such as screen enclosures or carports.

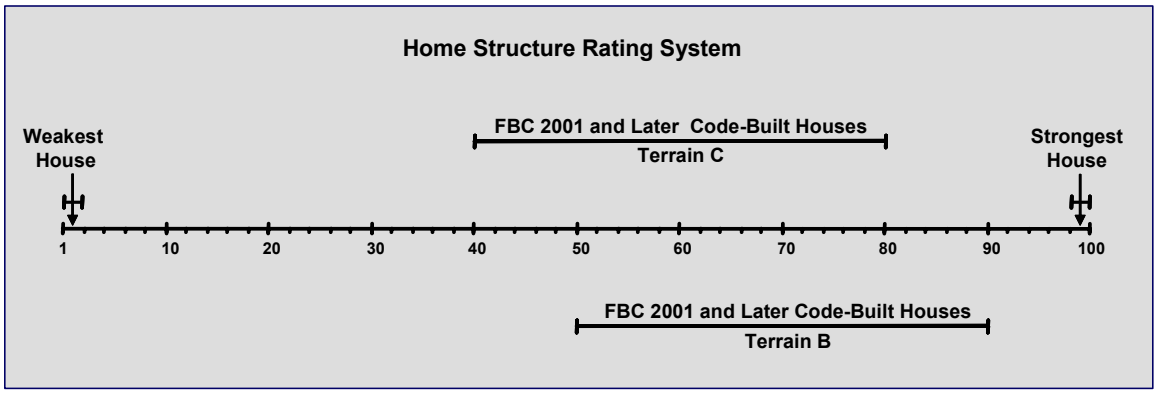
Score Interpretation. The HSRS score is founded in loss cost relativities. It measures the home's relative ability to withstand hurricane wind effects as an integrated structural system, including: roof covering, roof shape, roof deck, roof-to-wall, wall, wall-to-foundation, openings, and other components. A weakness in one or more of these building envelope components has a measurable affect on the score.

The HSRS was designed to be interpreted in a reasonably consistent manner throughout the State:

1. Within each of the wind zones in the State, the score for a FBC 2001 (and later) code-built home lies within a scoring range of 40 to 90.
2. FBC 2001 and later code construction with one or more code-plus improvements will always produce a score within or greater than the design range.
3. Effective loss mitigation improvements to a house, from among the 19 primary and secondary features, always produce higher scores.

4. A house in a Terrain B wind zone location scores higher than the same house in a Terrain C location within the same wind zone.

The range of score for FBC 2001 and later code-built homes is illustrated in the following figure.



Hence, a house with a score of 50 can be interpreted consistently, regardless of the wind zone location. In more severe wind zones (such as 120 mph and above), a house will need to have stronger construction features to achieve a good score than the same house in a milder wind zone (such as 100 mph).

The HSRS rating is not intended to be used or interpreted as a simplified stand-alone insurance rating measure. The HSRS scale was developed using loss relativities with a nonlinear risk-averse scoring function to promote wind mitigation of homes. While insurance rate differentials are determined from the same home inspection information as the HSRS rating, the determination of insurance rate differentials for wind mitigation features is more complicated than can be represented by a two-digit score. As the HSRS and insurance rate differentials further evolve, and as long as the HSRS is founded in loss cost relativities, the rating score and insurance rate differentials should be reasonably correlated.

Testing. The developed HSRS has been tested and statistically compared to the Hurricane Resistance Rating (HRR) used in the My Safe Florida Home pilot program. The HSRS scores are generally lower than the HRR scores, but result in a higher range of scores for code and code-plus construction. The testing confirms that the HSRS scores are performing in a reasonable manner and provide a consistent range of scores across wind zones, based on the home's construction and wind damage mitigation features. The HSRS scores increase monotonically with increasing mitigation of a house.

Limitations. While this initial HSRS has many desirable features, it also has many limitations. It is based largely on research done in the 2001-2002 period for single-family, site-built houses. The current HSRS rating system should not be applied to manufactured housing or multifamily structures. While the methodology is based on significant prior research, the relative scores are limited by our basic knowledge, estimation methods, and numerous uncertainties. Care must be taken to ensure that the score is interpreted as a relative, best-estimate measure that is subject to further refinement and improvement. Much additional data exists now to improve the estimation of building performance and to validate the relative differences in construction and damage mitigation features, including new-code construction. The HSRS scale will need to evolve with improved methodologies and recognize further improvements in the building code. The ratings of homes will therefore need periodic updating to best reflect the structure's ability to withstand hurricane wind effects. A rough guess on the accuracy of a house's relative position on the HSRS scale is about ±10 points.

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1. INTRODUCTION

1.1 Background

During the My Safe Florida Home Pilot Program, Applied Research Associates, Inc. developed a Hurricane Resistance Rating (HRR) to objectively rate each inspected home. The HRR is implemented in the Florida Department of Financial Services "Database and Data Dispatch System" (DBDDS).

The HRR is a scale from 0 to 100 that measures the resistance of the home to hurricane damage and loss. It uses data collected during a MSFH inspection and processes the data to produce a hurricane resistance score. An HRR score of 0 represents the weakest house and a score of 100 represents the strongest house. HRR scores are produced for the existing home and for each mitigation improvement plan. For example, the existing home may rate a 52, while the mitigated home might rate a 58, 63, and 69, depending on which one of the three mitigation plans is used to improve the structure.

The HRR score is based on loss cost relativities and were derived from research done over 5 years ago. The initial loss relativity study was performed by ARA in 2002 [1]. An extension of that work was done in 2003 [2] to include two-story homes and homes with tile roof covers. The HRR also includes an extra level for classifying opening protection, based on an ARA study in 2003 that evaluated "Ordinary" types of shutters that existed prior to the development of shutter impact standards [3].

The HRR provides a measure of the expected building performance independent of the building location. That is, the building rating is independent of the building location within the State. If a building with identical construction features is inspected in different parts of the State, the home will have the same HRR score. Hence the HRR score does not reflect the fact that the hurricane risk and building code requirements vary dramatically across the State. This approach was used in the pilot program due to its simplicity, ease of adoption from previous research, and limited schedule and budget considerations in the pilot program.

During HSRS Advisory Board discussions regarding the development of a rating system, the desirability of including building location, terrain, and building code became important objectives. If the rating system could properly reflect the differences in code-built houses in different regions of the State, then the interpretation of the results would have a consistent basis that objectively reflected both hurricane hazard risk and the structure's wind migration features.

1.2 Requirements

Pursuant to Section 39, Senate Bill 1980, now known as Chapter 2006-12, Section 39 of the Laws of Florida, the Office of Insurance Regulation (Office), in consultation with a designated Advisory Board, was tasked with studying and developing a program that will provide an objective rating system that will allow homeowners to evaluate the relative ability of Florida properties to withstand the wind load from a sustained severe tropical storm or hurricane.

The Office is required by this legislation to ensure that the rating system is designed in a manner that is easy to understand for the property owner, based on proven readily verifiable mitigation techniques and devices, and able to be implemented based on a visual inspection program.

Section 39, Senate Bill 1980, or Section 39, Chapter 2006-12, also indicates that the Department of Financial Services (DFS) will implement a pilot program for use of the rating system in the Florida Comprehensive Hurricane Damage Mitigation Program, or My Safe Florida Home (MSFH); however, the MSFH pilot program began before development of the Home Structure Rating System (HSRS) begun. Accordingly, inspection data acquired during the MSFH pilot program has been employed to test the HSRS and this testing should serve to satisfy the requirement for implementing a pilot program to determine the nature and construction of the rating scale and to determine the effectiveness of the HSRS rating scale.

1.3 Objective and Scope

Section 39 in the Laws of Florida 2006-12 reads, in part:

> *"…shall study and develop a program that will provide an objective rating system that will allow homeowners to evaluate the relative ability of Florida properties to withstand the wind load from a sustained severe tropical storm or hurricane. The rating system will be designed in a manner that is easy to understand for the property owner, based on proven readily verifiable mitigation techniques and devices, and able to be implemented based on a visual inspection program."*

The objective of this project was to develop this rating system for single-family houses. The rating system is referred to as the "Home Structure Rating System" (HSRS). The detailed scope of work to develop the HSRS included the following tasks:

1. Adapt previous research on loss relativities [1] to the HSRS.
2. Consider recent wind tunnel testing on one- and two-story homes.
3. Develop the HSRS methodology.
4. Update the DBDDS database to incorporate the HSRS methodology.
5. Perform unit and system testing of the HSRS for the MSFH pilot program database of inspected houses.

The scope of work was limited to hurricane wind effects and did not consider hurricane-induced flooding. The work was necessarily limited to a short-term update of previous research on loss mitigation. In addition, the scope of this project did not include updating or revising the inspection form developed in the MSFH pilot program.

1.4 Organization of Report

This report documents the short term research to develop the HSRS. Section 2 reviews the work to update the loss relativities for purposes of developing the HSRS. Section 3 documents the HSRS methodology and the functions that transform loss relativities to HSRS

scores. Section 4 presents example HSRS score results and provides the testing results of the HSRS with comparisons to the HRR. The summary of the work is given in Section 5 and references are included in Section 6.

For convenience, Appendix A includes documentation of the HRR and Appendix B includes the MSFH inspection form. Complete documentation of the development of the HRR and DBDDS for the MSFH pilot program is given in References 4, 5, and 6. The updated documentation of the HSRS DBDDS is given in References 7, 8, and 9.

Appendix C contains MSFH example "Home Inspection Reports" for the HRR and HSRS.

1.5 Acknowledgment

Applied Research Associates, Inc. (ARA) performed this work under subcontract to the University of Florida. We acknowledge this support and appreciate the comments and suggestions of Dr. Robert Stroh, the project manager.

We appreciate comments and suggestions from the HSRS Advisory Board, the Office of Insurance Regulation, and the Florida Department of Financial Services.

ARA takes full responsibility for the accuracy of this report and the in-house testing we performed on the HSRS. We would appreciate any comments or suggestions on ways to improve the HSRS.

2. LOSS COST RELATIVITIES

2.1 Background

The term "loss cost" is an insurance term that measures the long term statistical average of loss for a particular building and a particular hazard over a one year period. The hurricane loss costs for a single building is the long-term statistical average of annual losses (divided by the building value). Loss costs are the mathematical expected value of losses (normalized by building value) over many years at a particular location. For a particular building type, the loss costs will vary from location to location as a result of variations in both the hurricane hazard risk and terrain (aerodynamic roughness)[1]. Loss costs are a fundamental measure used by insurance companies to establish insurance rates.

Hurricane and wind hazard loss costs are dependent on the building's location, basic construction features, and wind mitigation construction features. Weak buildings have high losses relative to building value (high loss costs) and strong building have low losses relative to building value (low loss costs).

Loss relativities are produced by normalizing loss costs for each building type by dividing by the loss costs of the weakest house (or some other arbitrarily selected house). Figure 2-1 illustrates how loss relativities can be produced for three different homes. The average annual losses for hurricane wind hazards are first estimated for each home, considering the location, terrain, basic construction features and wind mitigation features. The average annual losses are normalized to produce loss costs (per thousand dollars of building value). Normalizing the loss costs by the weakest building produces a relativity of one for the weakest building and relativities less than one for the stronger buildings. In this example, House 2 has a loss relativity that is 58% of House 1 and is therefore more resistant to wind damage than House 1. In summary, loss relativities provide a single non-dimensional measure of a building's ability to withstand damage/economic loss from hurricane wind effects.

2.2 Basic Loss Relativities

The starting point for loss relativities consists of work done in 2001-2002 [1]. The basic approach used to estimate loss relativities is shown in Figure 2-2. Buildings were modeled with different construction features, sizes, roof shapes, and building values. A total of 288 combinations of wind resistive features were modeled for each of three house models and two terrains. These buildings were located at 31 different locations throughout the State (17 Terrain B locations and 14 Terrain C locations). Loss costs were estimated for each building and

[1] The effect of terrain (i.e., the reduction in windspeed near the ground produced by the frictional effects of buildings and vegetation) has a significant impact on windspeeds and, hence, wind-induced damage and loss. The magnitude of the reduction of windspeed at any height is a function of the size and density of the obstructions (buildings, trees, etc.) on the ground, as well as the fetch (distance) the wind has blown over a given terrain. The importance of terrain is recognized in most national and international wind loading codes through the use of simplified terrain categories defined, for example, as open terrain (C), suburban terrain (B), etc. See References 1 and 7 for more discussion. The use of terrain in the HSRS is limited to simplified "building code terrain" designations.

3 Houses with Different Wind Mitigation Features	Value	Avg Annual Loss (AAL, $)	(AAL / Value)	Loss Costs (per $1000)	Loss Relativity
1.	$300,000	$1,800	0.006	$6.00	1.00
2.	$200,000	$700	0.0035	$3.50	0.58
3.	$100,000	$400	0.004	$4.00	0.67

Figure 2-1. Example of Loss Cost Relativities for Three Different Houses.

normalized to produce loss relativities for each location. The loss relativities were then averaged to produce a state-wide set of relativities for insurance rate differentials.

The primary wind resistive building features (see Figure 2-3) considered in Reference 1 included:

1. Roof Shape (2 - hip or other)
2. Secondary Water Resistance (2 – Yes or No)
3. Roof Cover (2 – FBC or non-FBC)
4. Roof Deck Attachment (3 - A, B, or C)
5. Roof-Wall Connection (4 - toe-nail, clips, single wrap, or double wrap)
6. Opening Protection (3 - no protection, basic protection, or hurricane protection)

The number of levels of each feature is given in parentheses. For example, two roof shapes were considered: hip and other. Multiplying the possible combinations of these 6 features produces $2 \times 2 \times 2 \times 3 \times 4 \times 3 = 288$ entries in the basic relativity table for each Terrain. Two terrains, ASCE terrain exposures B and C [10], were analyzed.

In addition to the primary mitigation features listed above, the loss relativity study included secondary rating factors. These included:

1. Dimensional lumber deck
2. Masonry walls
3. Reinforced masonry walls

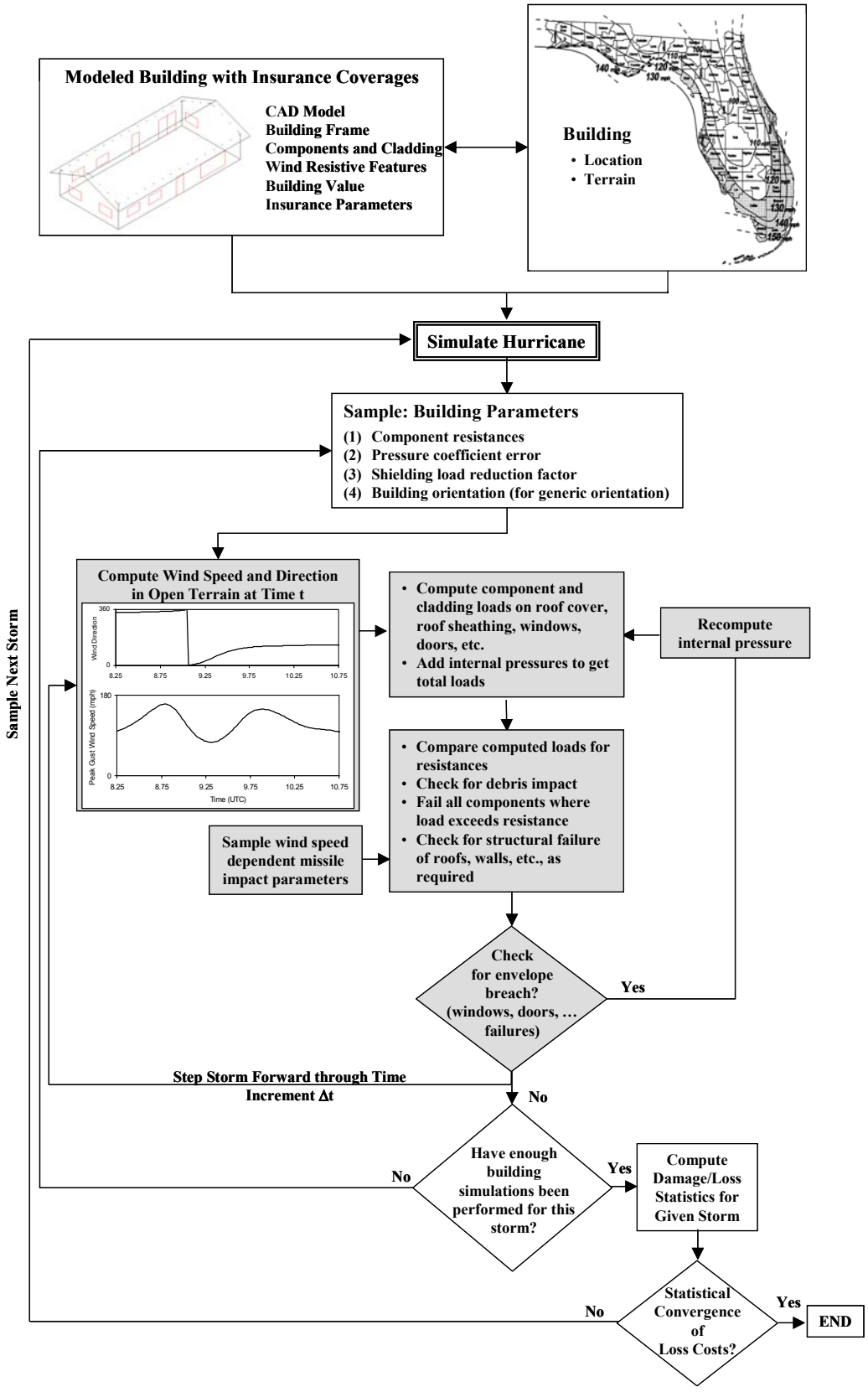


Figure 2-2. HURLOSS Building Damage Simulation Methodology [1].

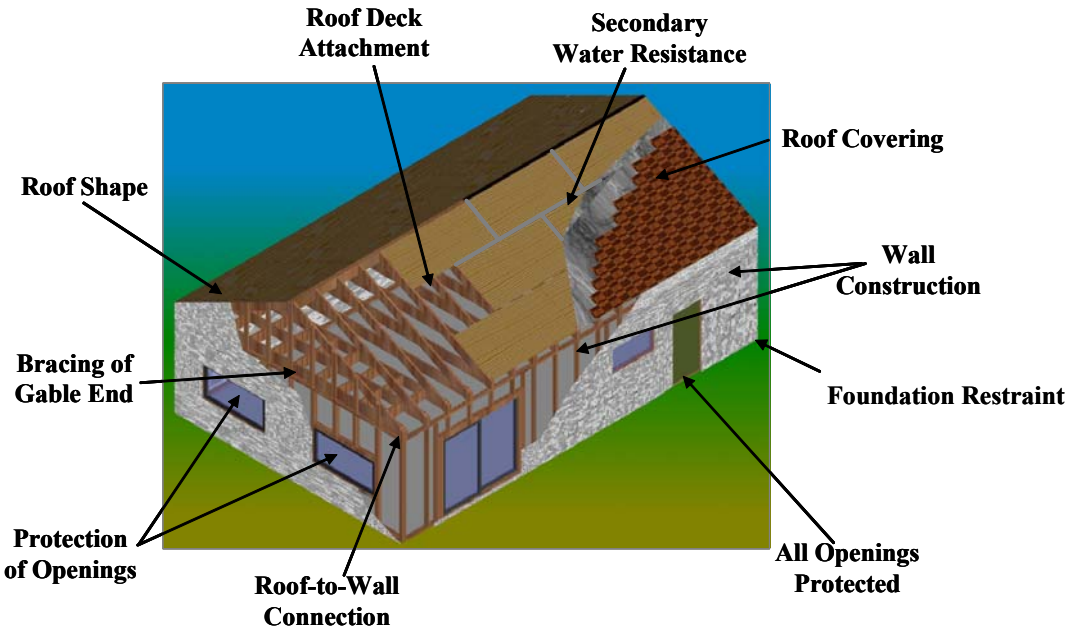


Figure 2-3. Primary Wind Resistive Features.

4. Reinforced concrete roof deck integral with reinforced masonry or concrete walls
5. Opening Protection: all openings protected *vs.* just glazed openings protected
6. Unbraced gable end
7. Foundation restraint

The secondary factor adjustments were applied in a multiplicative fashion to the primary relativity.

New Florida Building Code (2001 FBC, adopted 3-1-02)[2] houses were designed and analyzed in Reference 1 and a separate table of relativities was developed for these buildings. The reader is urged to review Reference 1 for more information, including definitions and descriptions of these features.

Following the publication of the 2002 loss relativity report, ARA performed two additional studies [2,3] to extend the results to include:

1. Number of Stories (2 – one or two (or more))
2. Roof Cover Type (2 – tile or non-tile)
3. Ordinary Opening Protection

By integrating the results of the three studies [1,2,3], the number of relativities in the basic table increases to 1,536 entries for each terrain for a total of 3,072 relativities for both terrains. These "basic" relativities are still adjusted by the secondary factors.

[2] Houses permitted after March 1, 2002 should meet the 2001 and later versions of the FBC. Later versions of the FBC have further enhancements which need to be considered in future research.

In the absence of new research, the use of these three studies produces the best starting point for developing an initial HSRS.

2.3 Short-Term Adjustments to Basic Relativities

The research to develop the loss relativities was performed 6 years ago. Reference 1 documents the scope limitations in that original study. Field surveys following the 2004-5 Florida hurricanes provide much new data for updating the original study. Suggestions for updating the loss relativities are discussed in Reference 11.

In the development of this initial HSRS, there was insufficient time and resources to perform the research to completely update the loss relativity study. However, two areas were identified for consideration in the initial development of the HSRS. These areas were roof pressure coefficients and secondary water resistance.

2.3.1 Roof Pressure Coefficients

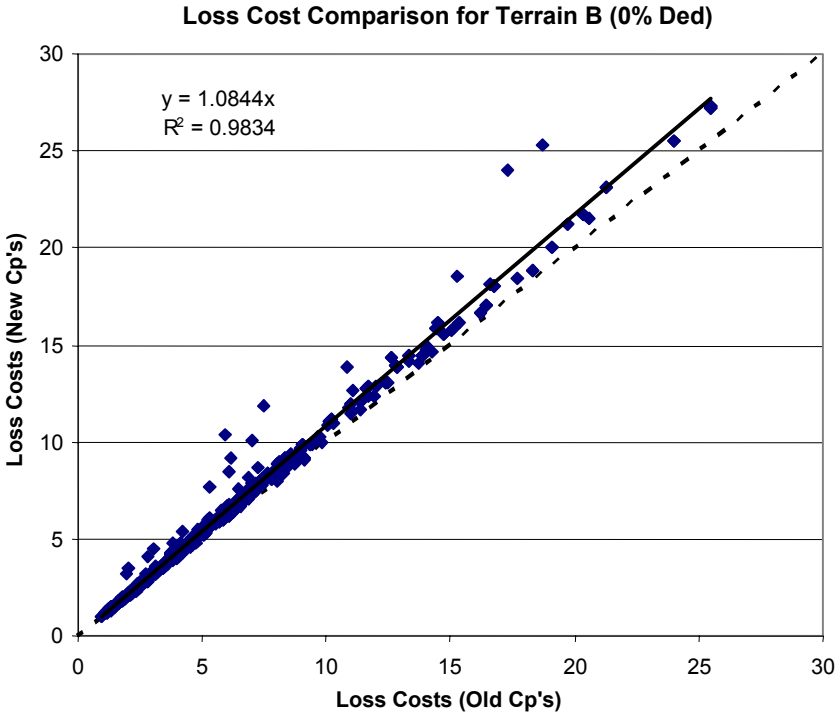
The Florida Department of Community Affairs funded a research project [12] entitled "Mitigation of Two Story Single Family Residences". In this project, ARA conducted wind tunnel tests on one-, two-, and three-story buildings for the purposes of improving the wind pressure coefficients in the design of new buildings. Some of the key conclusions in Reference 12 for component and cladding loads included:

1. ***Gable Roof***. The small area pressure requirements for components and cladding loads are underestimated in ASCE 7, except for the eave region of the roof. Hence the design loads in the Florida Building Code for new gable roof residences are underestimated.
2. ***Hip Roof.*** The pressure coefficients are underestimated in most roof zones for two- and three-story hips.

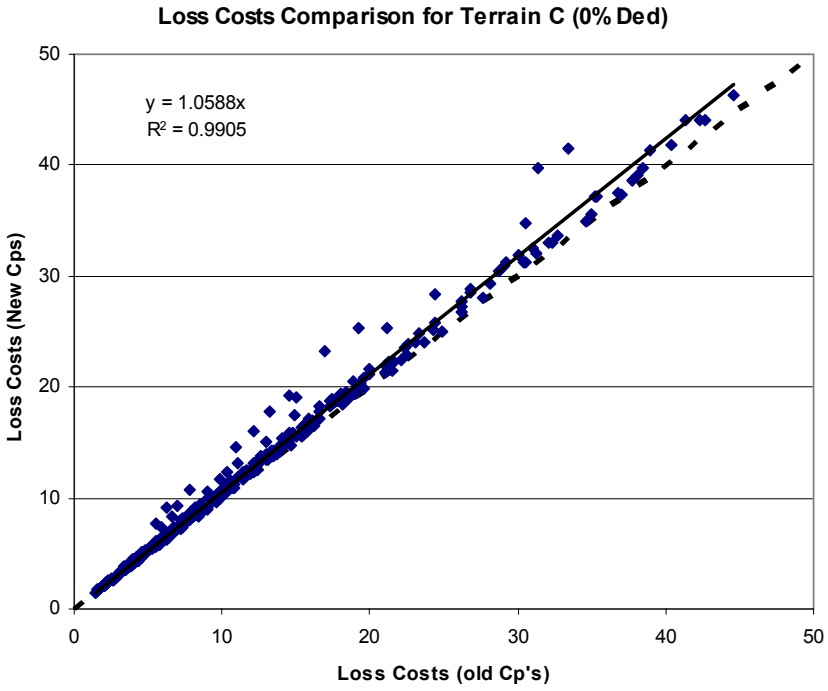
Additional wind tunnel testing with a range of roof slopes is being funded by the Florida Department of Community Affairs to supplement these results. The new wind tunnel testing will be completed in 2007. We anticipate that the final new pressure coefficients will make their way into ASCE 7 and the Florida Building Code.

The improved roof pressure coefficient modeling was incorporated into HURLOSS, and we produced estimated losses for the new pressure coefficient (C_p) loading models for a subset of houses and locations within the State (a total of 720 simulations). We repeated these runs using the loading models used in the 2002 loss relativity studies. Figure 2-4 compares the loss costs with old and new C_p's. The results show that there is about an 8% increase in losses for Terrain B and a 6% increase in losses for Terrain C. These increases indicate that losses estimated in 2002 are underestimated, on average, and that it is likely that (all other parameters being equal) roof covering and roof deck failures will occur at a slightly higher rate than indicated in the 2002 loss relativity study.

These HURLOSS simulations with the new C_p's were used in the analysis of location and terrain to determine the minimum and maximum loss costs on a county-by-county basis. In the



(a) Terrain B



(b) Terrain C

Figure 2-4. Ratio of Loss Costs for New and Old Roof Pressure Coefficients.

final HSRS approach discussed in Section 3, we abandoned the county-by-county approach in favor of a wind zone approach. We were not able to include the new C_p work in the final HSRS methodology because there was insufficient time and resources to rerun code design houses (reference houses in the wind zone approach) with the new C_p's. The changes to the tables were too complex to incorporate with just a partial set of runs. The next update to the loss relativities should include the new C_p's in the expanded and full set of building simulations.

2.3.2 Secondary Water Resistance

Secondary Water Resistance (SWR) or Secondary Water Barrier is a redundant layer of protection that protects the building from water penetration if the roof covering fails. Roof coverings often fail in hurricanes and are generally the first component of the building envelope to be damaged. Often, the underlayment is also torn and becomes separated from the roof deck, exposing the house interior to water penetration through the cracks in the roof deck. SWR covers the seams in the roof deck and provides for redundant water proofing of the house. SWR is not a code requirement and hence falls into the "code-plus" category. SWR is discussed in more detail in References 1 and 13.

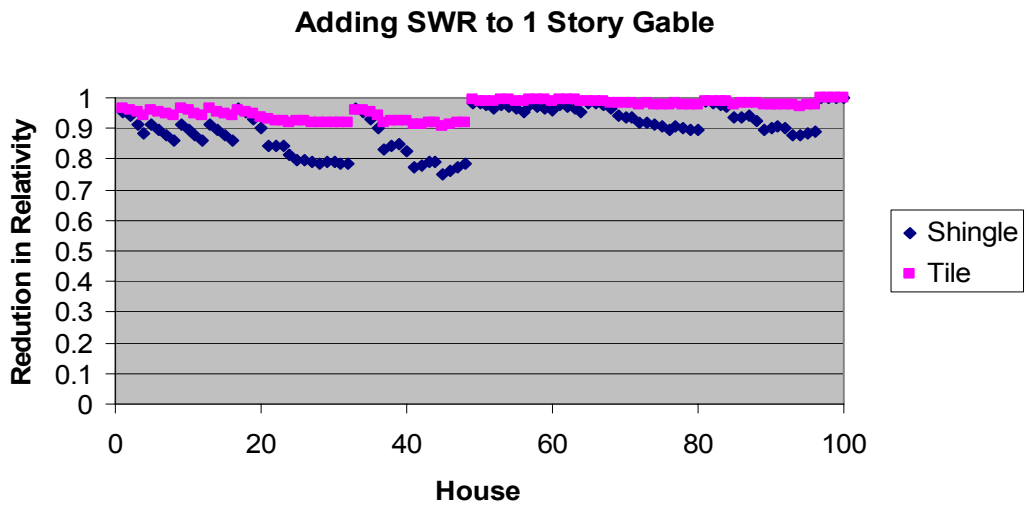
SWR was modeled in the original loss relativity studies [1,2,3]. It provides notable reductions in loss for some houses. Figure 2-5 illustrates these reductions for one- and two-story gable houses in Terrain B for the case of ground up losses. The plots are ratios of the loss costs with SWR divided by the loss costs without SWR. The effect of SWR is greater for two-story houses than one-story houses because two-story houses experience higher windspeeds due to the higher roof heights. We have plotted gable roof shapes since gables experience higher roof covering loss than hips due to the roof shape aerodynamics.

The 2002 loss relativity studies did not consider water penetration into the building through leaky openings, such as undamaged windows, doors, soffits and vents. These non-modeled effects were treated in a general compression of the relativities. That is, the relative difference predicted by the model was compressed to account for non-modeled building features and damage modes, such as water leakage.

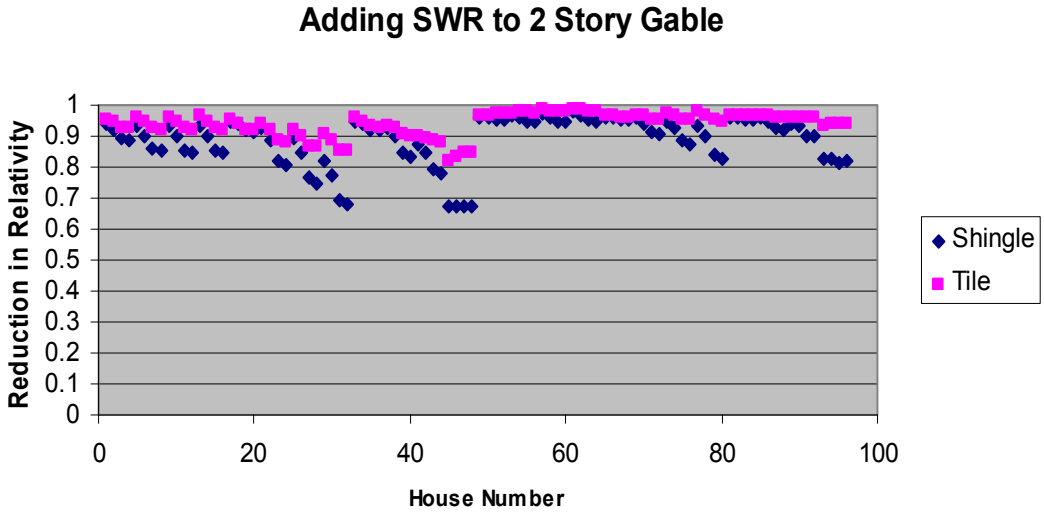
Due to many field observations of leakiness of windows, doors, vents, and soffits in hurricanes, we judged that the effectiveness of SWR should be capped. This capping is also consistent with the introduction of a Secondary Factor on water penetration through windows and doors (see Section 2.4). We elected to cap the loss relativity reduction at 0.8 for one-story houses and 0.75 for two-story houses. This capping only affects the strongest houses and is consistent with the fact that these houses will be subject to water penetration of components other than the roof deck.

2.3.3 Use of Ground-Up Losses

The basic loss relativity tables in the 2002 report [1] are based on 2% deductible. The 2002 loss relativity report [1] was developed for insurance rate differentials (mitigation credits) for wind mitigation features. The basic tables were developed for 2% deductible and several simplified methods were discussed to treat other deductibles, including 0% deductible. The HRR scale also used the 2% deductible case.



(a) One-Story Gable – Terrain B



(b) Two-Story Gable – Terrain C

Figure 2-5. Reduction in Loss Relativity with SWR.

The 0% deductible case represents the most applicable case for developing a house rating scale for wind vulnerability. Losses estimated for no deductible are often referred to as "ground-up" losses. Ground-up losses represent the most fundamental measure of a building's performance in that the losses are not allocated between insurer and building owner. In terms of rating a building for hurricane resistance, ground-up losses give us a measure than does not depend on any deductible assumption. A loss is a loss regardless of who pays for it. In general the payment of losses always comes back to the homeowner-citizen through either out of pocket expenses to cover the deductible costs, insurance costs, and or tax costs. Hence, the use of ground-up loss costs is selected as the best measure for developing the HSRS.

The difference between ground-up losses and losses after deductible adjustments was discussed in Reference 1. The effect of deductible on loss costs is greatest for strong buildings. Weak buildings fail more often with higher losses and hence the effect of a relatively small deductible (on the loss costs) is less. To illustrate this effect, Figure 2-6 shows the results of the 720 HURLOSS runs with the new C_p's for the case of no secondary water resistance on the buildings. The loss costs for ground up losses averaged over all the houses is 1.19 times the loss costs for 2% deductible. For weak houses the difference in loss costs is small (3% increase), whereas for very strong houses, the increase easily exceeds 20%. Hence, the use of ground-up losses for the HSRS will not include any compression of the differences between weak and strong houses (resulting from deductibles). The rating measure will more accurately reflect the true performance of the buildings.

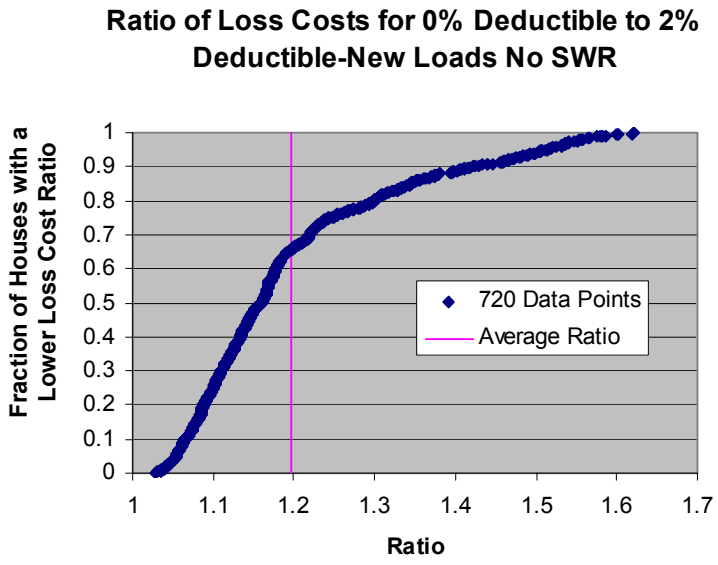


Figure 2-6. Ratio of Ground-Up Loss Costs to 2% Deductible Loss Costs.

2.4 Updated Loss Relativities

Tables 2-1 and 2-2 show the basic relativities for Terrain B and Tables 2-3 and 2-4 show the relativities for Terrain C. These updated relativities are used in the development of the HSRS.

The loss relativities in these tables are normalized to the weakest house in each terrain, which is a two-story gable with tile roof cover, no SWR, toe-nail roof-to-wall connection, deck attachment A (6 penny nails at 6-12" spacing), no opening protection, and non-FBC roof cover. This cell is shaded and is located in Table 2-1 for Terrain B and Table 2-3 for Terrain C.

These relativities are the combination of work done in References 1, 2, and 3. The first 4 columns in each table are similar to the data in Reference 1. However, since these tables are for 0% deductible, they are not exactly the same, when renormalized, as those in Reference 1. Also, recall that the relativities in Reference 1 were slightly compressed (see Appendix C of Reference 1), whereas these are not.

Table 2-1. Ground-Up Loss Relativities: Terrain B with Non-FBC Roof Cover

				TERRAIN B															
				One Story Shingle				Two Story Shingle				One Story Tile				Two Story Tile			
Roof	Roof Deck	Roof-Wall	Opening	Gable		Hip		Gable		Hip		Gable		Hip		Gable		Hip	
Cover	Attachmen	Connection	Protection	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr
Non-FBC	A	Toe Nails	None	0.677	0.648	0.464	0.439	0.997	0.937	0.773	0.716	0.720	0.697	0.553	0.532	1.000	0.956	0.819	0.778
			Ordinary	0.579	0.544	0.400	0.373	0.850	0.785	0.652	0.588	0.673	0.647	0.520	0.497	0.903	0.856	0.741	0.695
			Basic	0.481	0.440	0.337	0.306	0.703	0.633	0.532	0.460	0.626	0.596	0.487	0.463	0.805	0.756	0.662	0.611
			Hurricane	0.425	0.376	0.290	0.252	0.640	0.566	0.473	0.393	0.598	0.564	0.467	0.439	0.758	0.706	0.624	0.569
		Clips	None	0.510	0.465	0.355	0.312	0.774	0.708	0.618	0.553	0.686	0.661	0.532	0.509	0.899	0.859	0.765	0.726
			Ordinary	0.464	0.417	0.319	0.276	0.693	0.620	0.545	0.471	0.647	0.619	0.502	0.478	0.831	0.787	0.701	0.656
			Basic	0.418	0.368	0.284	0.241	0.613	0.532	0.472	0.389	0.608	0.577	0.472	0.446	0.764	0.716	0.637	0.586
			Hurricane	0.394	0.340	0.263	0.218	0.577	0.490	0.438	0.349	0.591	0.556	0.459	0.430	0.736	0.684	0.609	0.553
		Single Wraps	None	0.509	0.464	0.354	0.312	0.745	0.680	0.618	0.554	0.688	0.663	0.532	0.509	0.893	0.854	0.766	0.727
			Ordinary	0.463	0.415	0.319	0.276	0.673	0.600	0.546	0.471	0.648	0.620	0.502	0.477	0.826	0.782	0.702	0.656
			Basic	0.417	0.367	0.284	0.241	0.602	0.520	0.473	0.389	0.607	0.577	0.472	0.446	0.760	0.710	0.638	0.586
			Hurricane	0.394	0.339	0.263	0.217	0.571	0.483	0.438	0.349	0.589	0.555	0.459	0.430	0.734	0.683	0.609	0.554
		Double Wraps	None	0.504	0.459	0.351	0.309	0.737	0.673	0.612	0.548	0.681	0.656	0.526	0.504	0.884	0.846	0.758	0.719
			Ordinary	0.459	0.411	0.316	0.274	0.667	0.594	0.540	0.467	0.641	0.614	0.497	0.472	0.818	0.774	0.695	0.650
			Basic	0.413	0.363	0.281	0.239	0.596	0.515	0.468	0.385	0.601	0.571	0.467	0.441	0.752	0.703	0.631	0.580
			Hurricane	0.390	0.336	0.260	0.215	0.566	0.478	0.434	0.346	0.583	0.549	0.454	0.426	0.727	0.676	0.603	0.548
	B	Toe Nails	None	0.630	0.608	0.448	0.428	0.925	0.875	0.733	0.684	0.640	0.615	0.525	0.504	0.898	0.856	0.760	0.719
			Ordinary	0.520	0.494	0.384	0.362	0.758	0.709	0.603	0.553	0.594	0.567	0.495	0.475	0.783	0.740	0.680	0.639
			Basic	0.409	0.381	0.320	0.297	0.590	0.544	0.472	0.423	0.548	0.520	0.465	0.445	0.669	0.625	0.600	0.558
			Hurricane	0.337	0.303	0.269	0.242	0.515	0.468	0.405	0.353	0.512	0.479	0.445	0.422	0.608	0.562	0.555	0.512
		Clips	None	0.355	0.299	0.280	0.224	0.601	0.536	0.452	0.359	0.561	0.521	0.482	0.449	0.714	0.662	0.631	0.569
			Ordinary	0.323	0.271	0.254	0.205	0.509	0.442	0.394	0.309	0.529	0.491	0.458	0.427	0.647	0.595	0.580	0.521
			Basic	0.290	0.244	0.227	0.186	0.417	0.349	0.337	0.260	0.498	0.461	0.433	0.405	0.581	0.528	0.529	0.473
			Hurricane	0.268	0.218	0.217	0.177	0.369	0.295	0.312	0.237	0.486	0.447	0.427	0.399	0.550	0.494	0.509	0.454
		Single Wraps	None	0.341	0.273	0.278	0.222	0.502	0.415	0.436	0.330	0.557	0.514	0.482	0.449	0.679	0.619	0.627	0.562
			Ordinary	0.307	0.246	0.252	0.201	0.435	0.351	0.381	0.286	0.525	0.484	0.458	0.427	0.619	0.558	0.576	0.514
			Basic	0.273	0.219	0.226	0.181	0.368	0.287	0.326	0.245	0.494	0.454	0.433	0.405	0.558	0.498	0.525	0.466
			Hurricane	0.260	0.208	0.216	0.175	0.338	0.256	0.305	0.229	0.484	0.444	0.426	0.399	0.536	0.474	0.507	0.451
		Double Wraps	None	0.338	0.270	0.275	0.220	0.475	0.374	0.432	0.327	0.551	0.509	0.477	0.445	0.671	0.608	0.621	0.557
			Ordinary	0.304	0.243	0.249	0.199	0.412	0.314	0.377	0.283	0.520	0.479	0.453	0.423	0.612	0.549	0.570	0.509
			Basic	0.270	0.216	0.224	0.179	0.348	0.261	0.323	0.242	0.489	0.449	0.429	0.401	0.552	0.490	0.520	0.462
			Hurricane	0.257	0.206	0.214	0.173	0.325	0.243	0.302	0.226	0.479	0.439	0.422	0.395	0.531	0.468	0.502	0.446
	C	Toe Nails	None	0.630	0.609	0.446	0.426	0.923	0.874	0.734	0.685	0.638	0.612	0.525	0.504	0.894	0.852	0.758	0.716
			Ordinary	0.519	0.495	0.384	0.362	0.756	0.708	0.604	0.555	0.590	0.565	0.495	0.474	0.778	0.737	0.678	0.637
			Basic	0.408	0.381	0.321	0.298	0.588	0.543	0.474	0.425	0.543	0.517	0.465	0.444	0.662	0.622	0.598	0.557
			Hurricane	0.334	0.302	0.267	0.241	0.515	0.470	0.405	0.352	0.506	0.477	0.443	0.421	0.598	0.558	0.551	0.527
		Clips	None	0.348	0.290	0.277	0.222	0.593	0.527	0.446	0.348	0.549	0.505	0.481	0.448	0.699	0.641	0.624	0.555
			Ordinary	0.315	0.264	0.251	0.203	0.498	0.435	0.388	0.302	0.519	0.479	0.457	0.426	0.632	0.579	0.573	0.510
			Basic	0.282	0.239	0.225	0.184	0.403	0.343	0.330	0.255	0.488	0.452	0.432	0.404	0.565	0.517	0.521	0.465
			Hurricane	0.259	0.214	0.215	0.177	0.353	0.290	0.306	0.233	0.477	0.440	0.426	0.399	0.532	0.484	0.503	0.466
		Single Wraps	None	0.328	0.262	0.275	0.220	0.482	0.389	0.426	0.320	0.546	0.497	0.480	0.446	0.654	0.580	0.618	0.541
			Ordinary	0.294	0.235	0.249	0.199	0.415	0.331	0.371	0.278	0.514	0.470	0.456	0.424	0.595	0.530	0.568	0.498
			Basic	0.261	0.209	0.223	0.179	0.347	0.274	0.316	0.237	0.483	0.443	0.431	0.402	0.537	0.479	0.518	0.455
			Hurricane	0.248	0.199	0.214	0.173	0.315	0.244	0.296	0.222	0.474	0.436	0.426	0.398	0.512	0.459	0.499	0.458
		Double Wraps	None	0.324	0.259	0.273	0.218	0.442	0.332	0.422	0.316	0.540	0.492	0.476	0.441	0.641	0.556	0.612	0.536
			Ordinary	0.291	0.233	0.247	0.197	0.379	0.284	0.367	0.276	0.509	0.465	0.451	0.420	0.583	0.507	0.562	0.493
			Basic	0.258	0.206	0.221	0.177	0.316	0.237	0.313	0.235	0.478	0.438	0.427	0.398	0.526	0.458	0.512	0.451
			Hurricane	0.246	0.197	0.212	0.172	0.292	0.219	0.293	0.219	0.469	0.432	0.422	0.394	0.504	0.442	0.494	0.454

Table 2-2. Ground-Up Loss Relativities: Terrain B with FBC Roof Cover

				TERRAIN B															
				One Story Shingle				Two Story Shingle				One Story Tile				Two Story Tile			
Roof	Roof Deck	Roof-Wall	Opening	Gable		Hip		Gable		Hip		Gable		Hip		Gable		Hip	
Cover	Attachmen	Connection	Protection	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr
FBC	A	Toe Nails	None	0.607	0.598	0.402	0.395	0.937	0.902	0.700	0.672	0.504	0.500	0.358	0.355	0.798	0.777	0.621	0.606
			Ordinary	0.503	0.493	0.335	0.327	0.777	0.747	0.569	0.543	0.452	0.448	0.324	0.321	0.689	0.672	0.535	0.522
			Basic	0.399	0.389	0.267	0.259	0.618	0.592	0.439	0.414	0.400	0.396	0.290	0.287	0.580	0.567	0.449	0.437
			Hurricane	0.334	0.322	0.215	0.206	0.551	0.527	0.372	0.347	0.366	0.363	0.265	0.262	0.527	0.515	0.404	0.394
		Clips	None	0.421	0.411	0.271	0.262	0.688	0.665	0.522	0.505	0.458	0.456	0.328	0.326	0.677	0.667	0.550	0.543
			Ordinary	0.373	0.362	0.237	0.227	0.600	0.577	0.443	0.424	0.417	0.414	0.299	0.296	0.602	0.593	0.481	0.474
			Basic	0.325	0.314	0.203	0.192	0.512	0.489	0.364	0.342	0.376	0.372	0.269	0.267	0.527	0.518	0.413	0.405
			Hurricane	0.299	0.286	0.181	0.169	0.472	0.448	0.326	0.301	0.354	0.351	0.255	0.251	0.496	0.488	0.381	0.373
		Single Wraps	None	0.418	0.408	0.273	0.263	0.654	0.636	0.520	0.504	0.458	0.455	0.328	0.326	0.666	0.659	0.549	0.543
			Ordinary	0.371	0.360	0.238	0.228	0.575	0.556	0.441	0.422	0.416	0.413	0.298	0.296	0.594	0.587	0.480	0.474
			Basic	0.323	0.312	0.203	0.192	0.496	0.475	0.363	0.340	0.375	0.371	0.269	0.266	0.521	0.514	0.412	0.406
			Hurricane	0.298	0.285	0.181	0.169	0.461	0.439	0.325	0.301	0.354	0.351	0.255	0.251	0.493	0.486	0.381	0.374
		Double Wraps	None	0.414	0.404	0.270	0.260	0.648	0.630	0.515	0.499	0.453	0.451	0.324	0.322	0.660	0.653	0.543	0.538
			Ordinary	0.367	0.357	0.235	0.225	0.569	0.550	0.437	0.418	0.412	0.409	0.295	0.293	0.588	0.581	0.476	0.470
			Basic	0.320	0.309	0.201	0.190	0.491	0.470	0.359	0.337	0.371	0.368	0.266	0.264	0.516	0.509	0.408	0.401
			Hurricane	0.295	0.282	0.180	0.168	0.457	0.435	0.322	0.298	0.351	0.347	0.252	0.249	0.488	0.481	0.377	0.370
	B	Toe Nails	None	0.570	0.562	0.390	0.383	0.873	0.839	0.670	0.644	0.438	0.434	0.336	0.333	0.720	0.698	0.576	0.561
			Ordinary	0.455	0.447	0.323	0.317	0.701	0.673	0.535	0.513	0.390	0.385	0.307	0.304	0.600	0.582	0.493	0.480
			Basic	0.340	0.332	0.257	0.251	0.529	0.507	0.400	0.381	0.341	0.336	0.277	0.274	0.480	0.466	0.409	0.399
			Hurricane	0.262	0.253	0.201	0.195	0.451	0.432	0.327	0.309	0.300	0.295	0.252	0.249	0.414	0.402	0.362	0.352
		Clips	None	0.265	0.249	0.193	0.178	0.524	0.499	0.343	0.315	0.340	0.335	0.281	0.277	0.511	0.499	0.417	0.407
			Ordinary	0.236	0.222	0.172	0.159	0.429	0.406	0.292	0.265	0.311	0.305	0.259	0.255	0.445	0.434	0.369	0.360
			Basic	0.207	0.194	0.151	0.139	0.335	0.312	0.240	0.216	0.281	0.276	0.237	0.233	0.379	0.368	0.322	0.313
			Hurricane	0.183	0.168	0.142	0.131	0.284	0.260	0.217	0.194	0.269	0.263	0.231	0.227	0.346	0.335	0.305	0.296
		Single Wraps	None	0.243	0.222	0.190	0.173	0.405	0.378	0.320	0.288	0.335	0.329	0.280	0.276	0.466	0.455	0.409	0.399
			Ordinary	0.214	0.194	0.169	0.154	0.341	0.314	0.272	0.242	0.306	0.300	0.259	0.255	0.407	0.396	0.362	0.353
			Basic	0.184	0.167	0.148	0.134	0.276	0.250	0.224	0.196	0.276	0.270	0.237	0.233	0.348	0.337	0.316	0.307
			Hurricane	0.173	0.155	0.141	0.129	0.246	0.218	0.206	0.179	0.267	0.261	0.231	0.227	0.325	0.314	0.300	0.291
		Double Wraps	None	0.240	0.219	0.188	0.172	0.366	0.336	0.317	0.285	0.332	0.326	0.278	0.273	0.454	0.445	0.404	0.395
			Ordinary	0.211	0.191	0.167	0.152	0.307	0.276	0.269	0.239	0.302	0.297	0.256	0.252	0.396	0.387	0.359	0.350
			Basic	0.182	0.163	0.146	0.133	0.247	0.216	0.222	0.194	0.273	0.267	0.234	0.231	0.339	0.328	0.313	0.304
			Hurricane	0.171	0.153	0.139	0.127	0.226	0.194	0.204	0.177	0.264	0.258	0.228	0.224	0.318	0.306	0.297	0.288
	C	Toe Nails	None	0.567	0.559	0.389	0.383	0.871	0.838	0.670	0.643	0.435	0.430	0.335	0.332	0.715	0.693	0.575	0.560
			Ordinary	0.453	0.445	0.323	0.317	0.699	0.672	0.534	0.512	0.387	0.383	0.306	0.303	0.595	0.578	0.492	0.479
			Basic	0.338	0.331	0.257	0.251	0.527	0.506	0.399	0.381	0.339	0.335	0.277	0.274	0.475	0.462	0.408	0.398
			Hurricane	0.260	0.253	0.201	0.195	0.450	0.431	0.325	0.309	0.297	0.293	0.253	0.249	0.411	0.400	0.361	0.359
		Clips	None	0.256	0.240	0.191	0.175	0.517	0.491	0.336	0.305	0.329	0.322	0.278	0.275	0.497	0.483	0.408	0.396
			Ordinary	0.229	0.215	0.170	0.156	0.422	0.399	0.286	0.258	0.302	0.296	0.257	0.253	0.432	0.420	0.362	0.351
			Basic	0.201	0.189	0.149	0.138	0.327	0.307	0.235	0.212	0.275	0.270	0.236	0.232	0.368	0.358	0.316	0.306
			Hurricane	0.177	0.164	0.141	0.130	0.272	0.252	0.212	0.191	0.263	0.258	0.230	0.226	0.334	0.325	0.298	0.297
		Single Wraps	None	0.227	0.203	0.187	0.169	0.383	0.352	0.304	0.262	0.321	0.313	0.278	0.273	0.436	0.422	0.395	0.381
			Ordinary	0.200	0.180	0.166	0.150	0.322	0.294	0.259	0.223	0.294	0.287	0.256	0.252	0.383	0.371	0.351	0.338
			Basic	0.174	0.157	0.145	0.132	0.260	0.237	0.213	0.183	0.267	0.261	0.235	0.230	0.331	0.320	0.307	0.296
			Hurricane	0.163	0.147	0.139	0.127	0.229	0.207	0.197	0.170	0.259	0.253	0.229	0.226	0.309	0.300	0.292	0.289
		Double Wraps	None	0.223	0.195	0.185	0.167	0.321	0.273	0.301	0.256	0.318	0.310	0.275	0.270	0.413	0.396	0.391	0.378
			Ordinary	0.196	0.172	0.164	0.149	0.269	0.228	0.256	0.217	0.291	0.284	0.254	0.249	0.363	0.348	0.348	0.335
			Basic	0.169	0.149	0.143	0.130	0.217	0.183	0.211	0.177	0.265	0.258	0.232	0.228	0.314	0.300	0.304	0.293
			Hurricane	0.161	0.144	0.137	0.126	0.199	0.168	0.195	0.165	0.257	0.251	0.227	0.223	0.296	0.284	0.289	0.287
Concrete			None	0.133	0.133	0.133	0.133	0.187	0.187	0.187	0.187	0.219	0.219	0.219	0.219	0.262	0.262	0.262	0.262
			Ordinary	0.124	0.124	0.124	0.124	0.175	0.175	0.175	0.175	0.204	0.204	0.204	0.204	0.245	0.245	0.245	0.245
			Basic	0.115	0.115	0.115	0.115	0.162	0.162	0.162	0.162	0.189	0.189	0.189	0.189	0.227	0.227	0.227	0.227
			Hurricane	0.109	0.109	0.109	0.109	0.153	0.153	0.153	0.153	0.179	0.179	0.179	0.179	0.215	0.215	0.215	0.215

Table 2-3. Ground-Up Loss Relativities: Terrain C with Non-FBC Roof Cover

				TERRAIN C															
				One Story Shingle				Two Story Shingle				One Story Tile				Two Story Tile			
Roof	Roof Deck	Roof-Wall	Opening	Gable		Hip		Gable		Hip		Gable		Hip		Gable		Hip	
Cover	Attachmen	Connection	Protection	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr
Non-FBC	A	Toe Nails	None	0.681	0.646	0.543	0.515	0.946	0.890	0.826	0.772	0.772	0.745	0.632	0.609	1.000	0.956	0.882	0.841
			Ordinary	0.588	0.543	0.443	0.406	0.809	0.746	0.667	0.601	0.699	0.665	0.555	0.523	0.864	0.816	0.739	0.689
			Basic	0.495	0.441	0.343	0.297	0.672	0.603	0.509	0.430	0.625	0.585	0.478	0.438	0.729	0.676	0.595	0.538
			Hurricane	0.428	0.366	0.272	0.218	0.654	0.581	0.487	0.405	0.575	0.530	0.433	0.387	0.711	0.657	0.578	0.519
		Clips	None	0.590	0.548	0.442	0.404	0.844	0.788	0.722	0.671	0.728	0.701	0.589	0.564	0.923	0.885	0.820	0.787
			Ordinary	0.520	0.469	0.366	0.318	0.717	0.647	0.586	0.515	0.665	0.631	0.523	0.490	0.804	0.759	0.693	0.647
			Basic	0.450	0.390	0.290	0.233	0.589	0.506	0.449	0.359	0.602	0.561	0.456	0.415	0.686	0.633	0.565	0.508
			Hurricane	0.409	0.342	0.254	0.203	0.574	0.488	0.434	0.341	0.573	0.526	0.429	0.383	0.672	0.618	0.553	0.492
		Single Wraps	None	0.580	0.538	0.441	0.403	0.815	0.761	0.722	0.671	0.726	0.698	0.588	0.564	0.909	0.875	0.820	0.787
			Ordinary	0.513	0.461	0.366	0.318	0.693	0.624	0.585	0.515	0.663	0.628	0.522	0.489	0.795	0.752	0.693	0.648
			Basic	0.445	0.383	0.290	0.233	0.572	0.488	0.448	0.359	0.600	0.558	0.456	0.415	0.680	0.628	0.567	0.509
			Hurricane	0.410	0.342	0.254	0.203	0.560	0.474	0.433	0.341	0.573	0.527	0.429	0.382	0.667	0.615	0.553	0.493
		Double Wraps	None	0.575	0.533	0.437	0.399	0.806	0.753	0.714	0.665	0.719	0.691	0.583	0.558	0.900	0.867	0.812	0.779
			Ordinary	0.507	0.456	0.362	0.315	0.686	0.618	0.579	0.510	0.656	0.622	0.517	0.484	0.787	0.744	0.686	0.641
			Basic	0.440	0.379	0.287	0.230	0.566	0.483	0.444	0.355	0.594	0.553	0.452	0.410	0.673	0.622	0.561	0.504
			Hurricane	0.406	0.339	0.252	0.201	0.555	0.469	0.429	0.337	0.567	0.522	0.424	0.378	0.661	0.608	0.548	0.488
	B	Toe Nails	None	0.625	0.599	0.530	0.508	0.887	0.842	0.801	0.756	0.709	0.686	0.611	0.590	0.926	0.886	0.841	0.802
			Ordinary	0.508	0.476	0.421	0.394	0.725	0.680	0.621	0.573	0.611	0.580	0.526	0.501	0.758	0.714	0.681	0.640
			Basic	0.391	0.353	0.312	0.280	0.563	0.518	0.441	0.390	0.512	0.473	0.441	0.412	0.589	0.543	0.521	0.478
			Hurricane	0.307	0.265	0.235	0.198	0.541	0.495	0.416	0.364	0.443	0.397	0.392	0.358	0.566	0.519	0.502	0.458
		Clips	None	0.474	0.433	0.350	0.291	0.723	0.671	0.553	0.472	0.605	0.566	0.508	0.465	0.776	0.730	0.656	0.593
			Ordinary	0.383	0.335	0.285	0.232	0.558	0.496	0.429	0.352	0.532	0.489	0.452	0.411	0.638	0.588	0.552	0.493
			Basic	0.293	0.237	0.220	0.176	0.392	0.322	0.305	0.232	0.459	0.412	0.396	0.358	0.501	0.445	0.449	0.393
			Hurricane	0.236	0.188	0.191	0.153	0.370	0.298	0.290	0.218	0.429	0.376	0.380	0.342	0.485	0.428	0.436	0.380
		Single Wraps	None	0.410	0.342	0.326	0.260	0.615	0.547	0.499	0.388	0.579	0.528	0.499	0.448	0.707	0.651	0.635	0.563
			Ordinary	0.336	0.271	0.266	0.213	0.476	0.403	0.394	0.297	0.513	0.461	0.445	0.399	0.589	0.531	0.538	0.473
			Basic	0.263	0.210	0.206	0.165	0.338	0.259	0.289	0.217	0.447	0.395	0.391	0.350	0.472	0.411	0.442	0.383
			Hurricane	0.231	0.185	0.189	0.152	0.321	0.241	0.277	0.208	0.427	0.374	0.379	0.340	0.457	0.396	0.432	0.372
		Double Wraps	None	0.390	0.312	0.322	0.258	0.535	0.438	0.494	0.381	0.573	0.519	0.494	0.443	0.674	0.611	0.628	0.558
			Ordinary	0.320	0.256	0.263	0.211	0.422	0.326	0.390	0.293	0.507	0.453	0.440	0.395	0.568	0.503	0.533	0.468
			Basic	0.250	0.200	0.204	0.163	0.309	0.232	0.287	0.215	0.442	0.388	0.387	0.347	0.462	0.395	0.438	0.379
			Hurricane	0.229	0.183	0.188	0.150	0.295	0.221	0.274	0.206	0.423	0.370	0.375	0.336	0.449	0.382	0.427	0.368
	C	Toe Nails	None	0.621	0.597	0.531	0.509	0.883	0.838	0.797	0.752	0.707	0.684	0.611	0.591	0.924	0.884	0.839	0.799
			Ordinary	0.504	0.474	0.422	0.394	0.722	0.678	0.619	0.571	0.604	0.577	0.525	0.502	0.751	0.712	0.679	0.639
			Basic	0.386	0.351	0.312	0.280	0.561	0.517	0.440	0.389	0.501	0.469	0.440	0.412	0.578	0.539	0.520	0.479
			Hurricane	0.303	0.265	0.234	0.198	0.537	0.494	0.415	0.364	0.431	0.393	0.390	0.358	0.553	0.514	0.499	0.457
		Clips	None	0.468	0.428	0.348	0.289	0.715	0.663	0.548	0.462	0.594	0.552	0.505	0.458	0.765	0.716	0.646	0.573
			Ordinary	0.374	0.330	0.282	0.230	0.543	0.489	0.423	0.346	0.519	0.478	0.449	0.407	0.622	0.575	0.543	0.480
			Basic	0.279	0.232	0.216	0.173	0.372	0.314	0.297	0.229	0.443	0.404	0.392	0.356	0.480	0.434	0.440	0.387
			Hurricane	0.218	0.174	0.188	0.151	0.349	0.291	0.282	0.215	0.409	0.366	0.376	0.340	0.461	0.416	0.427	0.375
		Single Wraps	None	0.395	0.321	0.319	0.255	0.599	0.525	0.481	0.361	0.559	0.495	0.492	0.433	0.680	0.610	0.615	0.516
			Ordinary	0.320	0.256	0.260	0.208	0.455	0.385	0.379	0.285	0.493	0.438	0.439	0.389	0.562	0.502	0.522	0.442
			Basic	0.245	0.196	0.202	0.161	0.311	0.246	0.278	0.208	0.427	0.382	0.386	0.346	0.444	0.394	0.430	0.368
			Hurricane	0.211	0.169	0.187	0.149	0.293	0.229	0.265	0.199	0.407	0.363	0.374	0.337	0.430	0.380	0.419	0.359
		Double Wraps	None	0.361	0.289	0.314	0.251	0.483	0.362	0.470	0.353	0.544	0.463	0.487	0.428	0.620	0.510	0.609	0.504
			Ordinary	0.293	0.234	0.256	0.205	0.376	0.282	0.370	0.278	0.482	0.414	0.435	0.384	0.523	0.435	0.517	0.429
			Basic	0.225	0.180	0.197	0.158	0.269	0.202	0.271	0.203	0.419	0.366	0.382	0.341	0.425	0.360	0.426	0.353
			Hurricane	0.208	0.167	0.183	0.147	0.254	0.191	0.259	0.194	0.403	0.357	0.370	0.332	0.413	0.350	0.415	0.345

Table 2-4. Ground-Up Loss Relativities: Terrain C with FBC Roof Cover

				TERRAIN C															
				One Story Shingle				Two Story Shingle				One Story Tile				Two Story Tile			
Roof	Roof Deck	Roof-Wall	Opening	Gable		Hip		Gable		Hip		Gable		Hip		Gable		Hip	
Cover	Attachmen	Connection	Protection	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr	no swr	swr
FBC	A	Toe Nails	None	0.618	0.605	0.487	0.477	0.897	0.861	0.773	0.740	0.593	0.586	0.469	0.462	0.855	0.827	0.739	0.715
			Ordinary	0.516	0.502	0.379	0.367	0.748	0.716	0.598	0.567	0.507	0.500	0.382	0.375	0.701	0.679	0.578	0.559
			Basic	0.414	0.398	0.271	0.256	0.600	0.571	0.423	0.393	0.420	0.413	0.295	0.288	0.547	0.531	0.417	0.402
			Hurricane	0.338	0.321	0.193	0.177	0.577	0.549	0.398	0.368	0.362	0.356	0.242	0.234	0.526	0.511	0.397	0.382
		Clips	None	0.515	0.503	0.372	0.362	0.785	0.756	0.655	0.635	0.537	0.533	0.411	0.407	0.765	0.747	0.659	0.649
			Ordinary	0.438	0.424	0.290	0.277	0.642	0.614	0.502	0.478	0.464	0.458	0.338	0.333	0.628	0.613	0.518	0.508
			Basic	0.361	0.345	0.209	0.192	0.498	0.472	0.349	0.321	0.390	0.384	0.266	0.259	0.491	0.480	0.378	0.367
			Hurricane	0.315	0.297	0.169	0.149	0.482	0.455	0.332	0.303	0.356	0.350	0.236	0.229	0.476	0.465	0.361	0.350
		Single Wraps	None	0.504	0.493	0.371	0.361	0.748	0.726	0.654	0.636	0.534	0.530	0.410	0.407	0.747	0.735	0.658	0.649
			Ordinary	0.429	0.415	0.290	0.276	0.613	0.590	0.502	0.479	0.460	0.456	0.338	0.333	0.615	0.604	0.517	0.508
			Basic	0.353	0.337	0.208	0.191	0.478	0.454	0.350	0.322	0.387	0.382	0.266	0.259	0.483	0.474	0.376	0.366
			Hurricane	0.314	0.296	0.169	0.149	0.464	0.439	0.332	0.304	0.356	0.350	0.236	0.228	0.470	0.460	0.361	0.350
		Double Wraps	None	0.499	0.488	0.367	0.357	0.741	0.719	0.647	0.630	0.528	0.524	0.406	0.403	0.740	0.728	0.651	0.643
			Ordinary	0.424	0.411	0.287	0.273	0.607	0.584	0.497	0.474	0.456	0.451	0.335	0.329	0.609	0.598	0.512	0.502
			Basic	0.350	0.333	0.206	0.189	0.474	0.449	0.346	0.318	0.383	0.378	0.263	0.256	0.478	0.469	0.373	0.362
			Hurricane	0.311	0.293	0.167	0.147	0.459	0.434	0.329	0.301	0.352	0.346	0.234	0.226	0.465	0.455	0.358	0.347
	B	Toe Nails	None	0.570	0.560	0.478	0.469	0.847	0.814	0.751	0.721	0.546	0.539	0.456	0.449	0.801	0.773	0.707	0.683
			Ordinary	0.448	0.437	0.365	0.356	0.680	0.652	0.565	0.539	0.439	0.432	0.366	0.360	0.621	0.599	0.540	0.521
			Basic	0.326	0.315	0.253	0.243	0.513	0.490	0.378	0.357	0.333	0.324	0.276	0.270	0.441	0.425	0.374	0.360
			Hurricane	0.237	0.225	0.168	0.158	0.489	0.466	0.353	0.332	0.258	0.249	0.219	0.213	0.417	0.401	0.352	0.339
		Clips	None	0.404	0.391	0.269	0.251	0.671	0.643	0.469	0.440	0.421	0.414	0.324	0.316	0.630	0.611	0.482	0.468
			Ordinary	0.311	0.295	0.208	0.192	0.496	0.468	0.347	0.319	0.347	0.338	0.272	0.265	0.486	0.469	0.383	0.370
			Basic	0.218	0.198	0.148	0.133	0.321	0.293	0.224	0.199	0.273	0.263	0.220	0.213	0.342	0.327	0.284	0.272
			Hurricane	0.155	0.131	0.119	0.103	0.297	0.269	0.211	0.185	0.238	0.226	0.204	0.197	0.325	0.310	0.273	0.261
		Single Wraps	None	0.323	0.302	0.230	0.201	0.546	0.518	0.391	0.355	0.383	0.374	0.308	0.299	0.543	0.528	0.447	0.434
			Ordinary	0.252	0.230	0.180	0.156	0.403	0.374	0.297	0.263	0.319	0.309	0.261	0.252	0.425	0.410	0.360	0.348
			Basic	0.181	0.158	0.131	0.111	0.260	0.230	0.202	0.172	0.255	0.245	0.213	0.205	0.306	0.291	0.274	0.262
			Hurricane	0.149	0.123	0.118	0.100	0.243	0.212	0.191	0.161	0.236	0.224	0.202	0.195	0.291	0.277	0.264	0.251
		Double Wraps	None	0.293	0.263	0.225	0.193	0.439	0.408	0.383	0.346	0.373	0.364	0.305	0.296	0.495	0.484	0.442	0.429
			Ordinary	0.229	0.200	0.176	0.150	0.330	0.297	0.291	0.257	0.311	0.301	0.258	0.250	0.392	0.380	0.357	0.344
			Basic	0.165	0.136	0.127	0.106	0.220	0.185	0.199	0.168	0.248	0.237	0.211	0.203	0.290	0.275	0.271	0.260
			Hurricane	0.148	0.121	0.115	0.097	0.207	0.172	0.188	0.158	0.233	0.222	0.200	0.193	0.276	0.262	0.261	0.249
	C	Toe Nails	None	0.568	0.558	0.478	0.469	0.846	0.812	0.753	0.723	0.543	0.536	0.454	0.447	0.799	0.771	0.707	0.682
			Ordinary	0.446	0.435	0.364	0.355	0.679	0.651	0.566	0.541	0.436	0.428	0.365	0.358	0.617	0.596	0.539	0.521
			Basic	0.323	0.313	0.251	0.242	0.512	0.489	0.379	0.358	0.328	0.321	0.275	0.270	0.436	0.421	0.372	0.359
			Hurricane	0.235	0.224	0.169	0.159	0.486	0.464	0.352	0.332	0.251	0.244	0.218	0.213	0.411	0.397	0.350	0.338
		Clips	None	0.400	0.388	0.266	0.248	0.666	0.637	0.460	0.429	0.411	0.403	0.319	0.311	0.619	0.598	0.468	0.451
			Ordinary	0.304	0.290	0.206	0.190	0.487	0.461	0.340	0.312	0.337	0.329	0.268	0.261	0.474	0.458	0.373	0.359
			Basic	0.208	0.192	0.146	0.132	0.307	0.285	0.219	0.195	0.263	0.255	0.218	0.212	0.329	0.317	0.278	0.267
			Hurricane	0.141	0.124	0.117	0.102	0.283	0.261	0.205	0.182	0.226	0.218	0.203	0.196	0.312	0.300	0.267	0.256
		Single Wraps	None	0.305	0.280	0.220	0.187	0.526	0.496	0.360	0.308	0.357	0.345	0.298	0.286	0.511	0.492	0.417	0.395
			Ordinary	0.236	0.215	0.173	0.148	0.384	0.357	0.275	0.234	0.300	0.289	0.254	0.244	0.400	0.384	0.340	0.322
			Basic	0.168	0.150	0.126	0.108	0.241	0.218	0.191	0.159	0.242	0.233	0.209	0.201	0.288	0.276	0.263	0.249
			Hurricane	0.134	0.114	0.114	0.098	0.223	0.200	0.180	0.150	0.223	0.214	0.200	0.193	0.275	0.263	0.254	0.240
		Double Wraps	None	0.249	0.200	0.211	0.169	0.361	0.298	0.340	0.270	0.333	0.313	0.294	0.281	0.418	0.392	0.408	0.382
			Ordinary	0.195	0.156	0.166	0.132	0.274	0.226	0.259	0.201	0.281	0.265	0.250	0.239	0.338	0.317	0.330	0.308
			Basic	0.141	0.115	0.120	0.096	0.187	0.153	0.178	0.133	0.229	0.217	0.206	0.197	0.258	0.243	0.252	0.234
			Hurricane	0.130	0.107	0.110	0.089	0.174	0.143	0.168	0.126	0.219	0.208	0.196	0.188	0.248	0.233	0.243	0.226
Concrete			None	0.136	0.136	0.136	0.136	0.182	0.182	0.182	0.182	0.212	0.212	0.212	0.212	0.255	0.255	0.255	0.255
			Ordinary	0.111	0.111	0.111	0.111	0.148	0.148	0.148	0.148	0.172	0.172	0.172	0.172	0.207	0.207	0.207	0.207
			Basic	0.085	0.085	0.085	0.085	0.114	0.114	0.114	0.114	0.133	0.133	0.133	0.133	0.159	0.159	0.159	0.159
			Hurricane	0.077	0.077	0.077	0.077	0.102	0.102	0.102	0.102	0.119	0.119	0.119	0.119	0.143	0.143	0.143	0.143

These results show significant differences in one- and two-story houses and for shingle[3] and tile roof coverings. The effect of building height is significant because the wind loads increase rapidly with height above the ground. Tile roof covers are more expensive than shingle roof covers and are also more vulnerable to damage from debris impacts, requiring expensive replacement. While additional work is clearly needed to perform further research and additional validation of these effects, these results are the best developed structural system interactions that we have at this time to develop the HSRS.

Figure 2-7 shows a scatter plot of the Terrain B relativities and Figure 2-8 shows a scatter plot of Terrain C relativities. In these figures, house number corresponds to each row in the loss relativity tables. There are a total of 100 rows in Tables 2-1 and 2-2 (Terrain B) and 100 rows in Tables 2-3 and 2-4 (Terrain C). There are 16 columns of data (each column is plotted with a different symbol) for a total of 1600 points in each plot. The periodic spikes in relativity for house numbers 1, 17, 33, 49, 65, and 81 corresponds to the toe nailed roof-to-wall connections with no opening protection. The range of relativities is (0.109 to 1.00) for Terrain B and (0.077 to 1.00) for Terrain C.

These plots show a large mass of houses in the range of relativities from 0.2 to 0.6. The weaker houses plot at the top of the figures. The effect of mitigating the weaker houses can be seen by how few points are at the top end of the figure. As shutters are added and other components strengthened, the relativities drop to the central portion of the vertical range. These effects can be traced in the tables. By improving certain components on a weak house and finding the appropriate cell, you can see noticeable reductions in relativity.

The unweighted probability distributions of loss relativities for each terrain are plotted in Figure 2-9. There is slightly more spread in the results for Terrain C, as the coefficient of variation (standard deviation divided by the mean) is about 10% larger. When the data is ranked, the order of houses is also different for the two terrains, which indicates that separate relativities are needed. This is an unweighted plot in the sense that it does not reflect the distribution of the building stock (see Reference 1 for discussion of building stock and average rating factors.)

2.5 Short-Term Adjustments to Secondary Factors

The secondary factors used in the 2002 loss relativity study [1] provide the basis for the secondary factors used in the HSRS. These secondary factors were originally developed as multiplicative factors (K_i) to the loss relativities. The multiplicative adjustment is applied by the equation:

$$R = \prod_i K_i \tag{2-1}$$

where K_i is the secondary factor multiplier. Hence, if there are multiple secondary factors, they are applied by multiplying all the factors sequentially to achieve a total adjustment to the basic relativities.

[3] Please interpret "shingle" roof covers in this document to be any "non-tile" roof covering. That is, tile roof coverings are treated as a distinct class and all other roof coverings are referred to herein as "shingle" or "non-tile".

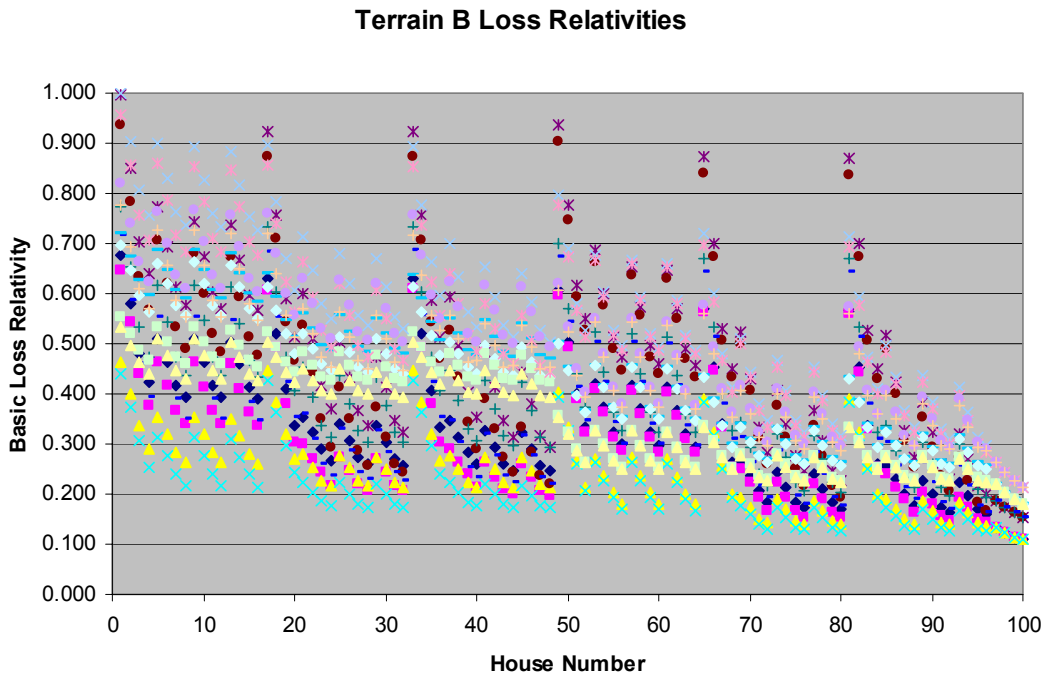


Figure 2-7. Terrain B Basic Loss Relativities.

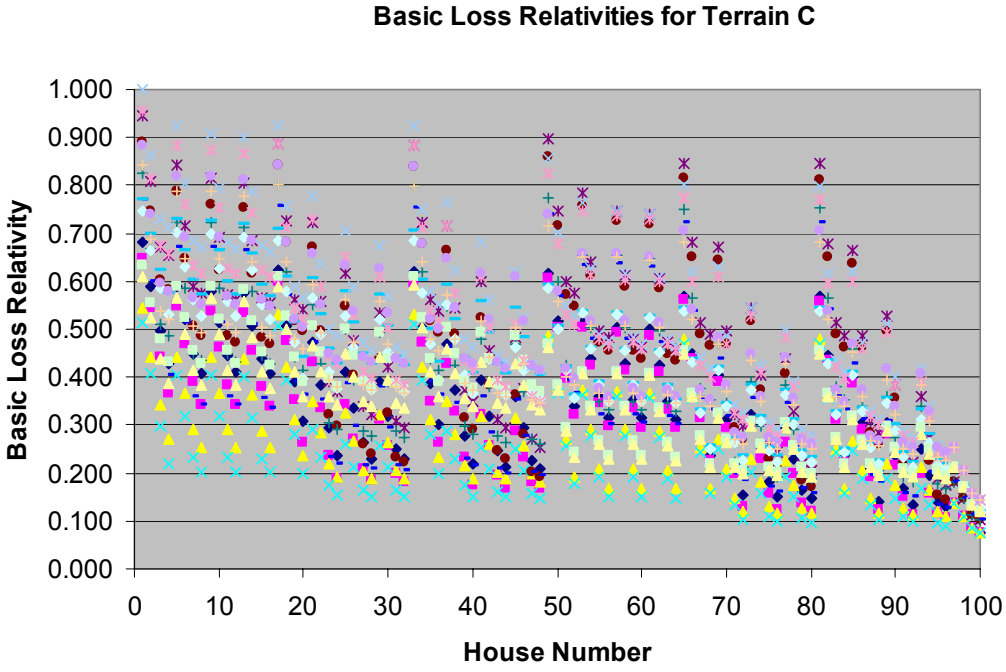


Figure 2-8. Terrain C Basic Loss Relativities.

A problem with the secondary factor approach is that the effect of the secondary factors is not actually a uniform multiplier over all the combination of house features in the relativity tables. That is, the effect of the secondary factor actually depends on the particular house features. However, to keep the basic relativity tables a reasonable size in Reference 1, secondary

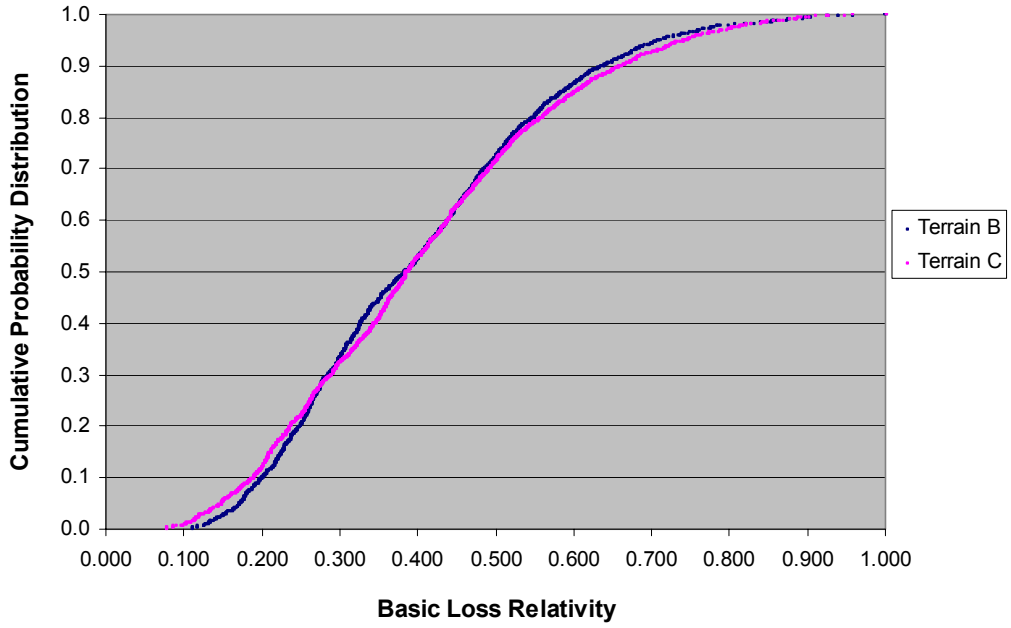


Figure 2-9. Unweighted Probability Distribution of Loss Relativities.

factors were introduced for variables that were felt to have a smaller effect than the primary variables. In this work, we use the same approach for secondary factors that was developed in Reference 1.

A few adjustments to these 2002 factors are warranted based on generally accepted building performance factors recognized in recent hurricanes. These adjustments to the 2002 secondary factors are based on wind engineering judgment. A fundamental update to the loss relativities and the use of secondary factors is needed to better quantify these effects in future updates to the HSRS.

Table 2-5 summarizes the secondary factors used in the HSRS. The first seven factors are directly from Reference 1. We adjusted the factors as follows:

1. For dimensional lumber deck (Deck D), masonry walls, reinforced masonry walls, and unbraced gable ends, we decreased the multipliers by 0.01. The decrease is based on the fact that the secondary factors in Reference 1 were applied to compressed relativities and a 2% deductible. For ground-up relativities without any compression, the secondary factor adjustments need to be increased slightly to show a comparable effect. The secondary factors used for HSRS are shown in the fourth column in Table 2-5.
2. For all openings protected, the secondary factor adjustment is decreased by 0.02. This decrease is based on similar logic as discussed under item 1 and also on the fact that protecting large openings, such as garage doors was not treated separately in Reference 1.

Table 2-5. Secondary Factors for HSRS

No.	Secondary Factor Description	Loss Relativity Multiplier (K_i)		Comments
		Reference 1	HSRS	
1	Dimensional Lumber Deck	0.96	0.95	1 point reduction
2	Masonry Walls	0.98	0.97	1 point reduction
3	Reinforced Masonry Walls	0.95	0.94	1 point reduction
4	Opening Coverage – All Openings	0.98	0.96	2 point reduction, considering garages and large openings
5	Unbraced Gable End	1.02	1.03	1 point increase
6	Foundation Restraint	Ter B 1.38, Ter C 1.54	Ter B 1.10, Ter C 1.20	Reduced to reflect unanchored foundations vs house on "blocks"
7	Reinforced Concrete Roof Deck Integrate with Concrete or Reinforced Masonry Walls Opening Protection: None / Basic / Hurricane	Ter B: 0.44 / 0.38 / 0.36 Ter C: 0.32 / 0.20 / 0.18	See Tables 2-2 and 2-4	Factors 1, 2, 3, and 5 do not apply for reinforced concrete roof deck integrated with reinforced concrete or masonry walls
8	Enhanced Roof Deck	-	0.99	New 0.99 used in HRR
9	Soffits	-	1.02	New
10	Vinyl Siding	-	1.02	New
11	Window, Door, and Skylight Water Leak Potential[1]:	-		New
	Total Number of Openings			
	a. All Window Types Except Casement and Fixed		No Shutter / Shutter	
	≤ 5	-	1.020 / 1.010	
	6 to 10	-	1.040 / 1.020	
	11 to 20	-	1.070 / 1.035	
	21 to 30	-	1.100 / 1.050	
	31 to 40	-	1.130 / 1.065	
	≥ 41	-	1.160 / 1.080	
	b. Casement and Fixed			
	≤ 5	-	1.012 / 1.007	
	6 to 10	-	1.024 / 1.014	
	11 to 20	-	1.042 / 1.025	
	21 to 30	-	1.060 / 1.036	
	31 to 40	-	1.078 / 1.047	
	≥ 41	-	1.096 / 1.058	

[1] Each sliding glass door is counted as 4 openings in determining the total number of openings. All other openings (doors, windows and skylights) are counted as one each.

3. For foundation restraint, we reduced the effect from the factors developed in Reference 1. This reduction is based on the fact that the analysis of foundation restraint in Reference 1 was based on a house sitting on blocks. The analysis considered sliding (off of the supporting blocks) and overturning failure modes. However, the MSFH inspection form (Appendix B) does not gather information on this type of foundation. The MSFH inspection focuses on anchorage attachment to slab and stem-wall foundations. We therefore adjusted the relativities to reflect the fact that overturning failures are not generally possible for these types of foundations.

These adjustments are based on engineering judgment and should be updated in the next loss relativity study.

4. The reinforced concrete roof deck factors in Reference 1 apply to reinforced concrete roof decks integral with reinforced concrete or masonry walls. The factors in Reference 1 were developed for one-story buildings. We extended these factors to two-story buildings and different roof cover types. The results are given in the basic relativity tables.
5. A new factor is applied for "code-plus" wood roof deck. Roof deck material is considered "code plus" if the deck is constructed with 5/8 inch thick (or thicker) plywood. The HRR used a factor of 0.99 and we apply a similar factor in the HSRS. We note that in the next update to the HSRS, code-plus roof decks need to be determined through a combination of deck thickness and fastener pull out resistance (thicker decks should have longer nails, else a thicker deck with the same length nails as a thinner deck actually has less attachment strength).
6. Soffits have been a long neglected component of the building envelope. Field surveys confirm the premature failure of soffits. Soffits also allow for water penetration into the attic and wall cavity. We apply a judgment factor of 1.02 for any house with soffits.
7. Vinyl siding is an exterior wall covering that has been observed to be vulnerable to failure in windstorms. We apply an engineering judgment factor of 1.02 for houses with vinyl siding wall covers.
8. Windows and doors are highly vulnerable to water leaks in hurricanes. The pressure differential across these openings tends to force water into cracks that exist between the moving and stationary parts of the window or door. Water moves from the outside of the building to the inside of the building or into the wall cavity. Part of this problem is due to the fact that the building codes only require leakage testing of components to 15% of the design pressure. Field observations also confirm that windows and doors leak in hurricanes. We used wind engineering judgment to develop the factors in Table 2-5. The leakage factor is assumed to be linear in the number of openings (windows, doors, and skylights). Each opening (window, door, garage door, skylight) counts as a single opening except that sliding glass doors are counted as four openings. The factor reaches a maximum of 1.16 for houses with 41 or more openings and no shutters. If the windows are shuttered, the effect of the shutters is to reduce the amount of water that reaches the opening because the shutter acts as a rain screen. Considering these effects, we reduced the leakage factors for shuttered openings (0.6 for casement/fixed windows and 0.5 for all others), as can be seen in Table 2-5. The leakage rates are expected to be less for casement and fixed windows, due to the fact that fixed windows have no moving parts and casement windows operate in such a way that they leak less when subjected to positive pressure on the windward side of the house.

These secondary factors are applied by using Eqn. 2-1 to the basic loss relativities in Tables 2-1 through 2-4.

3. HSRS METHODOLOGY

3.1 Introduction

Rating a home on its ability to resist hurricane wind effects requires the development of a measurement scale. The loss relativity tables and secondary factors in Section 2 provide the "foundation" to measure a home in terms of its potential to resist physical damage and economic loss. A rating scale founded in loss relativities has many desirable features, not the least of which is that the Florida insurance discount system for wind mitigation features is also based on loss relativities.

The transformation from loss relativities to a home rating scale can be accomplished in many ways according to how the rating will be used by the State. There are many desirable uses of such a rating, including:

1. Promoting homeowner awareness of the existing wind resistive features of his/her home.
2. Promoting homeowner awareness of how the rating changes with wind mitigation improvements to the structure.
3. Allowing potential home buyers to see potential rating differences among homes with different construction and wind mitigation features.

These potential types of uses of an HSRS scale suggest that the scale must have a basic ordinal property, or the ability to rank the data. That is, houses with ratings of 55, 80, 17, and 42 can be ranked in order of wind loss mitigation desirability from best to worst as 80, 55, 42, and 17. We know that a house with a rating of 80 is better than a house with a rating of 55, which is better than a house rated 42, which is better than a house rated 17. Hence the measurement scale must at least be ordinal (and not nominal).

Other well known measurement scales beyond ordinal include interval scales (such as temperature) and ratio scales (such as weight and length). Interval scales do not have a natural zero, whereas ratio scales do. We can say that loss costs, as a theoretical measure, can be viewed as a ratio scale since a building with a loss cost of zero is theoretically possible.[4] Hence, a building with a loss cost of $2 (per thousand) is five times "better" than a building with a loss cost of $10, since we can "ratio" the numbers.

The transformation from loss costs as the measure of wind resistance of a building to a home structure rating is identical to the methodologies used in the field of decision theory. In decision analysis, one is concerned with making choices among alternatives, each with potential different levels of risk [14,15,16]. The alternatives are measured by values (generally economic values) and decision maker desires to maximize the expected value. The values are measured by "utility", which is the ability to satisfy the decision maker's wants within his/her limited resources of time, effort and money.

[4] Such a building would have absolutely no losses for the entire range of possible hurricane wind effects.

A key requirement in decision making is that transitivity holds between preferences for outcomes (i.e., that the outcomes can be ranked). Von Neumann and Morgenstern [17] proved that the standard method for developing utility functions for decision makers yielded an interval scale[5]. While this background may not seem germane to developing an HSRS, it is important in a general sense in that we can use well-known approaches in decision analysis to transform loss relativities to "utilities," which are measured on an arbitrary interval scale (such as a HSRS that goes from 1 to 100).

A final point on the use of a single scale to rate homes is simply that a great deal of information on the home is condensed into a single dimension. It is important to realize that, while a lot of information is condensed into a single number, one should not assume that the number means more than it actually measures. For example, loss relativities are measures of long term averages of building losses. Loss relativities are not measures of how different buildings are expected to perform in a Category 1 hurricane or any other single storm. They constitute an integrated measure that considers the statistical distribution of storm intensities, frequencies, wind directions, and tracks over a long period. For a single hurricane event, it is possible that a house with a rating of 60 may have higher relative losses than a neighboring house with a rating of 50. Such differences in damage and loss for a particular storm may be due to many factors, including the predominate wind direction in that storm relative to building orientation, differences in true aerodynamic roughness versus building code assigned roughness, roof cover condition, etc. Also, a single house rating scale based on loss relativities obviously cannot be used to make decisions on evacuation, since the scale does not measure in-home structural shelter features. These examples are intended to emphasize that a single scale should not interpreted to mean more than its physical meaning, which is the estimated ability of the house to resist damage and loss over many potential hurricane events.

Section 3.2 discusses key attributes of different potential home structure rating systems. Section 3.3 presents a HSRS approach based on location, terrain, and building code and Section 3.4 discusses the transformation from loss relativities to HSRS scores.

3.2 Attributes of a Home Structure Rating System

There are many possible ways to devise a HSRS that is founded in loss relativities. Three key attributes that could be considered in the development of a state-wide HSRS include:

1. **Building Vulnerability:** Measures structural vulnerability to hurricane damage and loss.
2. **Location and Terrain:** Considers location and terrain.
3. **Building Code**. Considers the building code requirements at that location.

Another attribute could include an emphasis on scoring the practical mitigation potential of an existing house, given that certain house features aren't readily mitigated. For example, a 2-story building is naturally more vulnerable to wind damage than a 1-story building, but is it not practical to mitigate a 2-story building by removing the second floor. It is also not generally cost effective to change the roof shape of an existing house. Hence, subsets of the above attributes

[5] Mathematical operations, such as expected values can be performed on the transformed utilities and still preserve the ranking of decision preferences.

could be created such that the scores are normalized by specific house types (such as number of stories and roof shape). These subsets may result in a more readily understandable scale, but one would then have to provide a separate rating to reflect the differences between the subsets.

Table 3-1 summarizes three possible HSRS scoring systems that include, respectively: Attribute 1, Attributes 1 and 2, and Attributes 1, 2, and 3. The first system is the one selected for the HRR used in the MSFH pilot study. The HRR is a location-independent scoring system that is based on loss relativities.

Table 3-1. Possible HSRS Scoring Attributes

System Attribute	1. Measures structural vulnerability to damage and loss	2. Measures structural vulnerability and location	3. Measures structural vulnerability, location, normalized to building code
Interpretation	1a. By house only 1b. Considers only structure 1c. Does not consider location 1d. Does not consider terrain 1e. Does not consider building code	2a. By house and location 2b. Scales over entire State 2c. Locations in lower wind zones receive high scores regardless of house features 2d. Interpretation is state-wide 2e. Mitigation scores may not change in low hazard counties 2f. Useful for determining where to allocate inspections, grants	3a. By house, location, and building code 3b. Interpretation allows the direct comparison of house vulnerability within each windspeed zone in the State, considering terrain and building code requirements for that wind zone. 3c. Interpretation is local, not state-wide 3e. Separate measures must be used to prioritize inspection and grant location
Example	HRR (pilot study)		HSRS

We believe that the best approach for the HSRS is the third system in Table 3-1; that is, a system that considers location, terrain, and building code. This approach considers location by the design wind zones in the Florida Building Code and is described in the following section.

3.3 HSRS Based on Wind Zone Location, Terrain, and the Florida Building Code

The Florida Building Code windspeed design map provides the most consistent way to treat location and building code (see Figure 3-1) in a state-wide HSRS. The design windspeeds in the FBC are based on the ASCE 7 design windspeed map. The contours correspond approximately to 100 year return period hurricane winds[6], which means that a point on a windspeed contour has about a 1% chance each year of experiencing peak gust windspeeds greater than or equal to contour windspeed. The windspeeds in Figure 3-1 are peak gust windspeeds in open terrain at 10 meters above the ground surface. These winds are converted to wind loads by considering surface roughness (Terrain) and building height and shape. Wind loads are heavily dependent on surface roughness and, hence, terrain exposure is captured in the HSRS.

[6] The contour was actually developed as the 500 return period winds divided by the square root of the load factor. This calculation results in approximately 100 year return period winds for Florida locations.

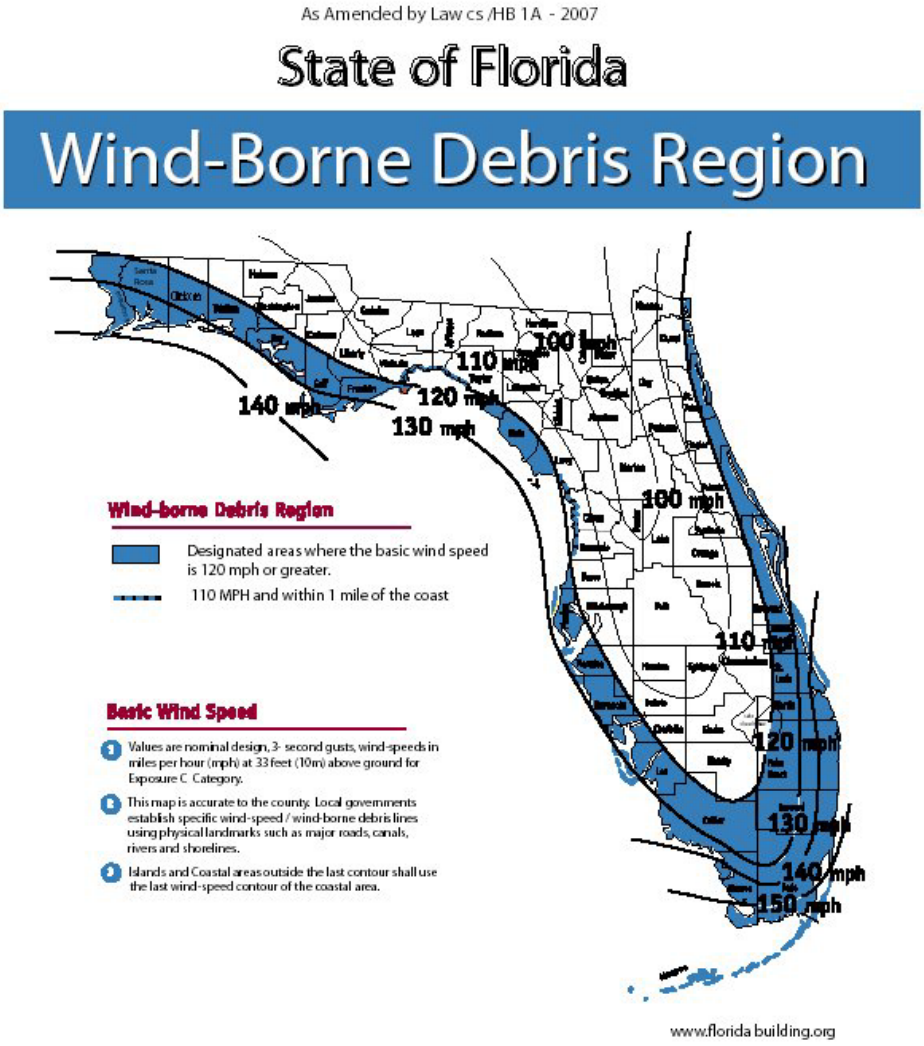


Figure 3-1. Florida Wind-Borne Debris Map.

Each house in the MSFH program requires that the design windspeed and location be identified as part of the inspection and homeowner reporting process. Since each county in Florida has determined exactly where the wind zones change within their county, the MSFH wind zone determination may not exactly reproduce the exact county wind zone delineation. However, the MSFH wind zone determination provides a reasonably accurate method to identify wind zone for purposes of developing a rating score. The MSFH inspection information is used to assign location-dependent windspeed and terrain as part of the HSRS rating process.

The loss relativities in Tables 2-1 through 2-4 cover a range of building features. In order to reference the loss relativities to wind zone, we need to determine the code-minimum wind mitigation features for FBC designed houses in each wind zone. By determining what the design features are for a wind zone, we can determine the reference design relativity for use in transforming relativity to HSRS score (over a range of 1 to 100).

The designs of new code houses according to the 2001 FBC (note that the 2001 FBC was adopted on March 1, 2002 and, hence, houses permitted after that date would be "code-built" for purposes of the HSRS) are summarized in Appendices E and F of Reference 1. For this project we have used this design information to determine the reference design house and, hence, the reference design house loss relativity for each Florida wind zone. The reference design house was selected to be a two-story gable roof shape house with tile roof cover. This building type was selected since: (1) the losses for a two-story house are greater than the losses for an identical (in terms of wind mitigation features) one-story house; (2) a house with a gable roof has higher average losses than the same house with a hip roof; and (3) houses with tile roof covers generally have higher loss costs than houses with shingle roof covers. Hence, the reference design house provides an upper bound case of design relativity from among the loss relativities in References 1 and 2.

The design reference house was then estimated for each wind zone according to the basic wind mitigation features in Tables 2-1 through 2-4. We interpolated on roof deck connection strength so that the minimal design resistance of the roof deck connections was accurately treated in the reference to a design relativity for each wind zone.

3.4 Transforming Loss Relativities to HSRS Scores

As briefly described in Section 3.1, we use basic decision theory concepts 14,15,16] to make the transformation from loss costs relativities to HSRS scores[7].

Figure 3-2 illustrates several possible ways to make the transformation from the horizontal axis (loss relativity) to the vertical axis (HSRS score). A linear transformation from loss relativity (r) to score provides the simplest mathematical approach. A linear transformation, for purposes of interpreting an HSRS score could be described as a risk-neutral utility function.[8] Also shown are a "risk-averse" utility function and a "risk-taker" utility function. The risk-averse function has a shape that reflects the fact that the decision maker desires to avoid risk. In this case, the avoidance of risk corresponds to achieving high scores only for very strong and "code-plus" houses. The risk-taker function corresponds to the case where the decision maker is more than willing to take risks. This decision maker prefers not to spend additional effort, time or money to secure a more hurricane-resistant home. Thus, the utility function for a risk-taker produces HSRS score that are not sensitive over the range of relativities for strong houses.

From the State's perspective, a risk-taking utility function would clearly not be in the best interest of its citizens and would work against mitigation by scoring low loss cost houses (strong buildings with good hurricane resistance) and mid loss cost houses (mid buildings with some hurricane resistance) roughly the same. This effect can be seen in Figure 3-2 since the risk-taking utility function is flat over large regions of low relativity. Hence, we are left with a risk-neutral

[7] Measure of risk preferences follows from von Neuman's probabilistic theory of utility and the discussion herein are very general.

[8] Strictly, risk neutrality here would mean that that person is only willing to invest in home improvements if the expected payoff in dollars exceeds the cost of the improvements. This determination also requires considering the time value of money, which goes beyond our current development of the HSRS. Our intent, however, is simply to discuss the shape of the function that transforms loss relativities to HSRS scores in the context of risk preferences from the State's desire to promote mitigation.

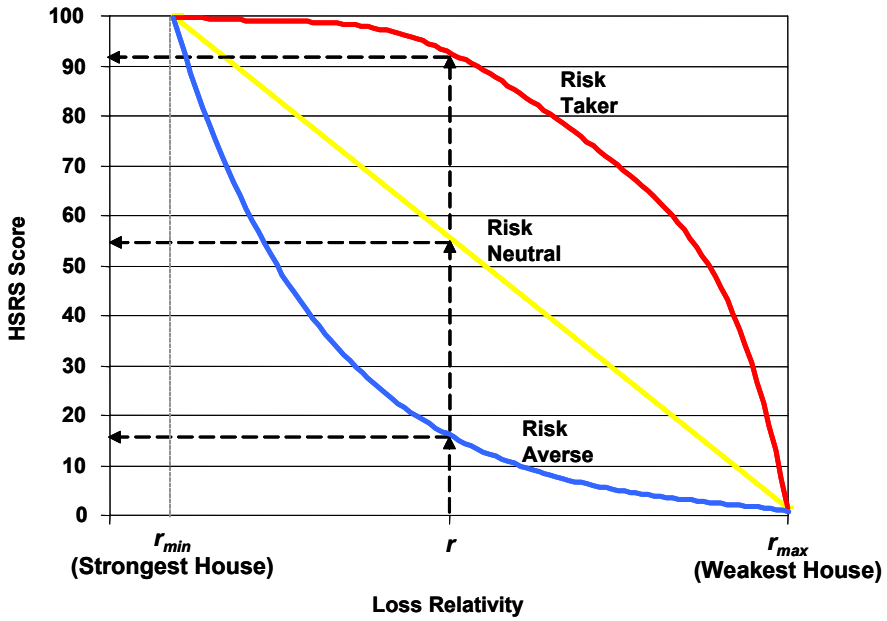


Figure 3-2. Transforming Loss Relativities to HSRS Scores.

or a risk-averse utility function as possibilities. Both of these are reasonable options. The scores produced by the HRR in the pilot study could be considered as kind of a risk-neutral utility function in that it treats all reductions in relativity in a linear fashion in determining the house score.

A key attribute in basing HSRS on home wind-zone location, terrain, and building code is the need to have a consistent interpretation of the score for the selected design house (the two-story gable with tile roof covering). That is, it would be desirable to select a score on the HSRS that can be consistently interpreted across wind zones and terrains. Obviously, if we use a linear (risk-neutral) utility function, we cannot also set a reference value independently of the lower and upper bound scores. Since 1 is the lowest HSRS score and 100 is the highest HSRS score, we have no further opportunity to select a reference score and still have a linear interval scale for the HSRS[9]. Hence, the desire to have at least one consistent interpretation point on the HSRS scale requires us to consider a risk-averse utility function.

Utility Functions for HSRS. The obvious choice for a nonlinear utility function is a risk-averse utility function with the general shape as indicated in Figure 3-2. An often used utility function is

$$U = 1 - \exp(-cx) \quad , \tag{3-1}$$

where U = utility, c is a risk aversion constant, and x is the amount of money considered. By generalizing Eqn. 3-1 and adding a linear term, we have

$$\text{HSRS} = K \exp\left[C(r - r_{min})\right] + b\, r \quad , \tag{3-2}$$

[9] Recall that for an interval scale, there are only two "free" choices (in this case 1 and 100). In a ratio scale there is only 1 free choice, since a ratio scale has a natural zero.

where K, C, r_{min}, and b are constants and r = loss relativity. To determine the constants for each wind zone, we use the following equations:

1. ***Maximum HSRS Score***. At $r = r_{min}$, HSRS =100, which produces

$$100 = K + b\, r_{min}. \tag{3-3}$$

2. ***HSRS Score for Design Home***. At $r = r_{des}$, HSRS = HSRS*, yielding

$$\text{HSRS*} = K \exp\left[C(r_{des}-r_{min})\right] + b\, r_{des} \ . \tag{3-4}$$

3. ***Minimum HSRS Score.*** At $r = r_{max}$, HSRS = 1, which produces

$$1 = K \exp\left[C(r_{max}-r_{min})\right] + b\, r_{max} \ . \tag{3-5}$$

For each wind zone, we know r_{des}. Once we decide on HSRS*, we have 3 equations and 3 unknowns (K, C, and b). These nonlinear equations are solved iteratively. We note that Eqn. 3-2 is linear when $C = 0$ and has increasing curvature (risk aversion) as C becomes more negative.

Design House Reference Scores in Terrains B and C. The following reference scores (HSRS*) for the design house in each wind zone have been used:

1. **Terrain B**: HSRS* = 50
2. **Terrain C**: HSRS* = 40.

A reference score of 50 was selected for Terrain B, which represents suburban exposures. This score for the two-story gable tile roof house provides sufficient room for the range of building code houses and code plus construction. Two-story hips will score better, as do shingle roof covers and one-story code design homes. The range of movement in code-built homes is from about 50 to 90 for Terrain B. Code plus homes will score higher, all the way up to a top score for one-story concrete buildings with opening protection.

Terrain C exposures primarily include barrier islands and homes within 1500 feet of the coast.[10] Due to the higher windspeeds associated with reduced aerodynamic roughness in Terrain C, a home in Terrain C has higher loss costs than the same home in a Terrain B exposure. The increase in loss costs varies from about 15% to about 180% increase, depending on the house. However, for the respective design houses in high wind zones, the difference in loss costs from Terrain B to Terrain C are about 20% to 45%. To reflect this increased vulnerability of the same house in Terrain C vs B, we chose to use the design house Terrain C reference score of 40. By using a different reference score in Terrain C vs B, we are able to reflect in a single scale a reasonable difference in the ability of the same house in the two terrains to withstand hurricane wind effects.

Table 3-2 provides the HSRS utility function parameters (K, C, b*)* that result from solving Eqns. 3-3 through 3-5 with the appropriate r_{des} for each wind zone. The Terrain B results for the HVHZ are included only for completeness.

[10] Homes adjacent to large bodies of water or other open spaces may also have a Terrain C exposure. However, the way the current Terrain is assigned in MSFH, it is likely that all inland homes will be assigned a Terrain B exposure. Further refinement of terrain assignment to homes may occur in the next update of the HSRS.

Table 3-2. HSRS Utility Functions

Windspeed (mph)	Terrain	r_{min}	r_{des}	r_{max}	K	C	b
100	B	0.102	0.656	1.367	103.12	-0.698	-30.522
110	B	0.102	0.607	1.367	102.22	-0.954	-21.718
120	B	0.102	0.343	1.367	100.13	-2.854	-1.272
130	B	0.102	0.328	1.367	100.09	-3.045	-0.88
140	B	0.102	0.323	1.367	100.07	-3.124	-0.685
150	B	0.102	0.319	1.367	100.06	-3.189	-0.587
HVHZ: Broward (140)[1]	B	0.102	0.31	1.367	100.04	-3.326	-0.391
HVHZ: Miami-Dade (146)[1]	B	0.102	0.307	1.367	100.03	-3.37	-0.293
100	C	0.072	0.740	1.492	101.12	-1.01	-15.51
110	C	0.072	0.731	1.492	101.07	-1.043	-14.818
120	C	0.072	0.276	1.492	99.96	-4.521	0.554
130	C	0.072	0.269	1.492	99.96	-4.671	0.554
140	C	0.072	0.264	1.492	99.96	-4.797	0.554
150	C	0.072	0.262	1.492	99.96	-4.856	0.554
HVHZ: Broward (140)	C	0.072	0.253	1.492	99.96	-5.076	0.554
HVHZ: Miami-Dade (146)	C	0.072	0.251	1.492	99.96	-5.139	0.554

[1] Included for completeness only.

Plots of HSRS Utility Functions. The resulting utility functions are shown in Figure 3-3 and 3-4. These indicate a high degree of risk aversion in the high risk locations (like the 120, 130, 140, and 150 mph wind zones) and lesser degree of risk aversion for lower risk locations (like 100 and 110 mph wind zones).

Terrain C utility functions generally have more curvature than B. All of these functions have monotonically increasing HSRS scores for decreasing relativity (stronger houses). The derivatives of these functions are increasing negative and hence the negative slope is rising fastest as the score approaches 100.

The risk-averse shape of the HSRS utility functions means that as houses are mitigated to high standards, including code-plus standards, the HSRS score will increase faster and faster as the vulnerability (and loss relativity) reduces. The beauty of the risk-averse shape of the utility functions is that we do not have a large part of the HSRS scale (1 to 100) devoted to weak and very weak houses. We have more room for code, code-plus, and future (improved) building code scores at the upper end of the scale.

3.5 Computing HSRS Scores

The approach to produce an HSRS score is simply:

1. The MSFH inspection provides the information to select the appropriate basic relativity from Tables 2-1 through 2-4.
2. The Secondary Factors are determined from the inspection data and applied to compute the updated relativity per Eqn. 2-1.
3. From the wind zone and terrain information from the MSFH checklist, the HSRS score is computed from Eqn. 3-2 with the appropriate K, C, b, and r_{des} parameters from Table 3-2.

These equations have been programmed and tested in DBDDS.

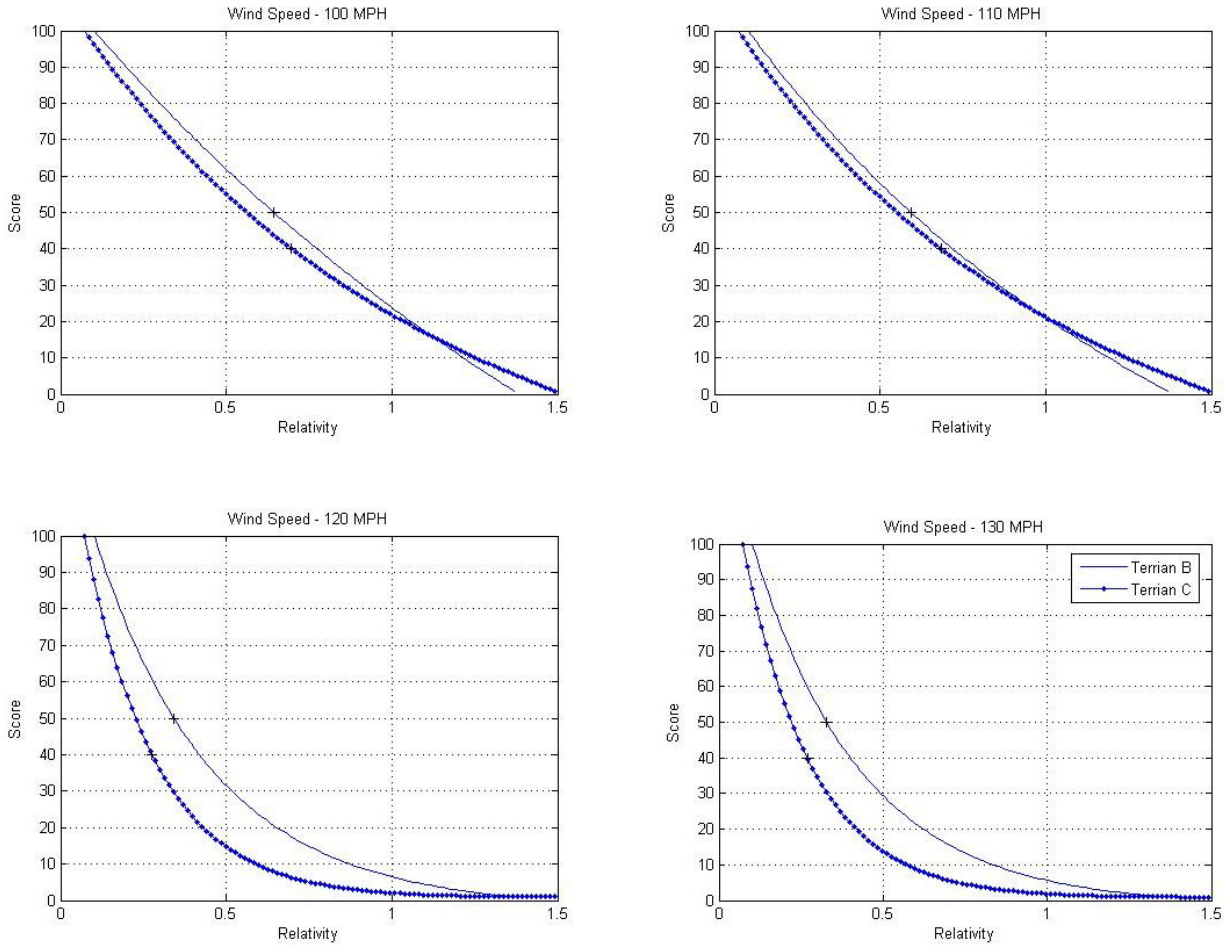


Figure 3-3. HSRS Utility Functions for 100, 110, 120, and 130 mph Wind Zones.

Figure 3-5 summarizes the HSRS methodology to rate a house in Florida based on visual inspection features. The MSFH inspection produces information on the wind zone, terrain, house construction features, and house structure mitigation features. These data, along with the homeowner's insurance company, goes into the DBDDS database. The database looks up the basic loss relativity and adjusts the loss relativity based on secondary factors. The adjusted relativity is used to compute the HSRS score using Eqn. 3-2 with the appropriate wind zone and terrain parameters from Table 3-2.

The insurance discount for the house is determined from the inspection data and the insurance company's rate filing, which includes the mitigation discounts. The insurance discounts are captured in the DCA's MIDB database, which has been copied into DBDDS.

The outputs of this process are the HSRS scores for the existing house and for each improvement plan produced in the homeowner report. The insurance discounts are also estimated for the homeowner's current insurance company for the existing house and each improvement plan.

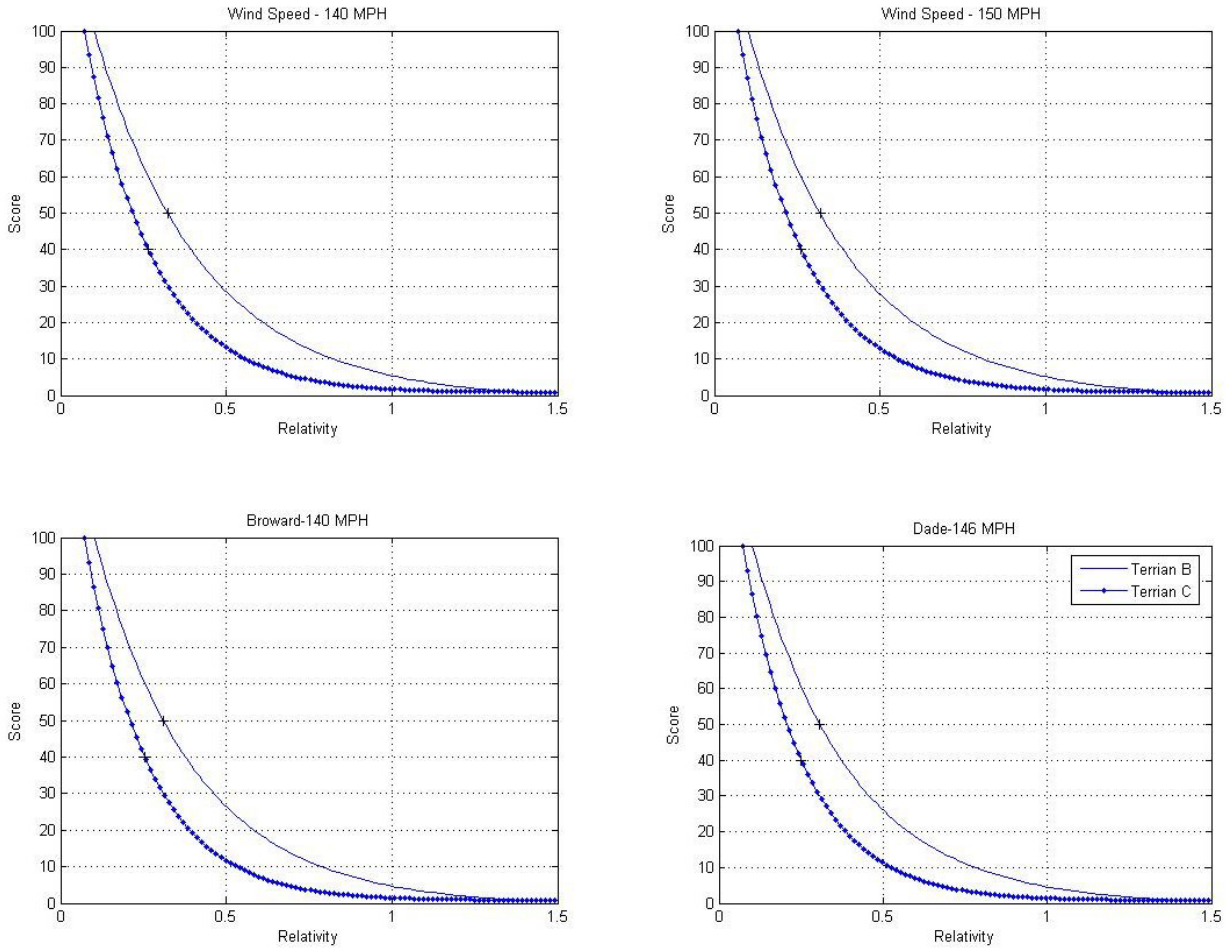


Figure 3-4. HSRS Utility Functions for 140 and 150 mph, Miami-Dade, and Broward Wind Zones.

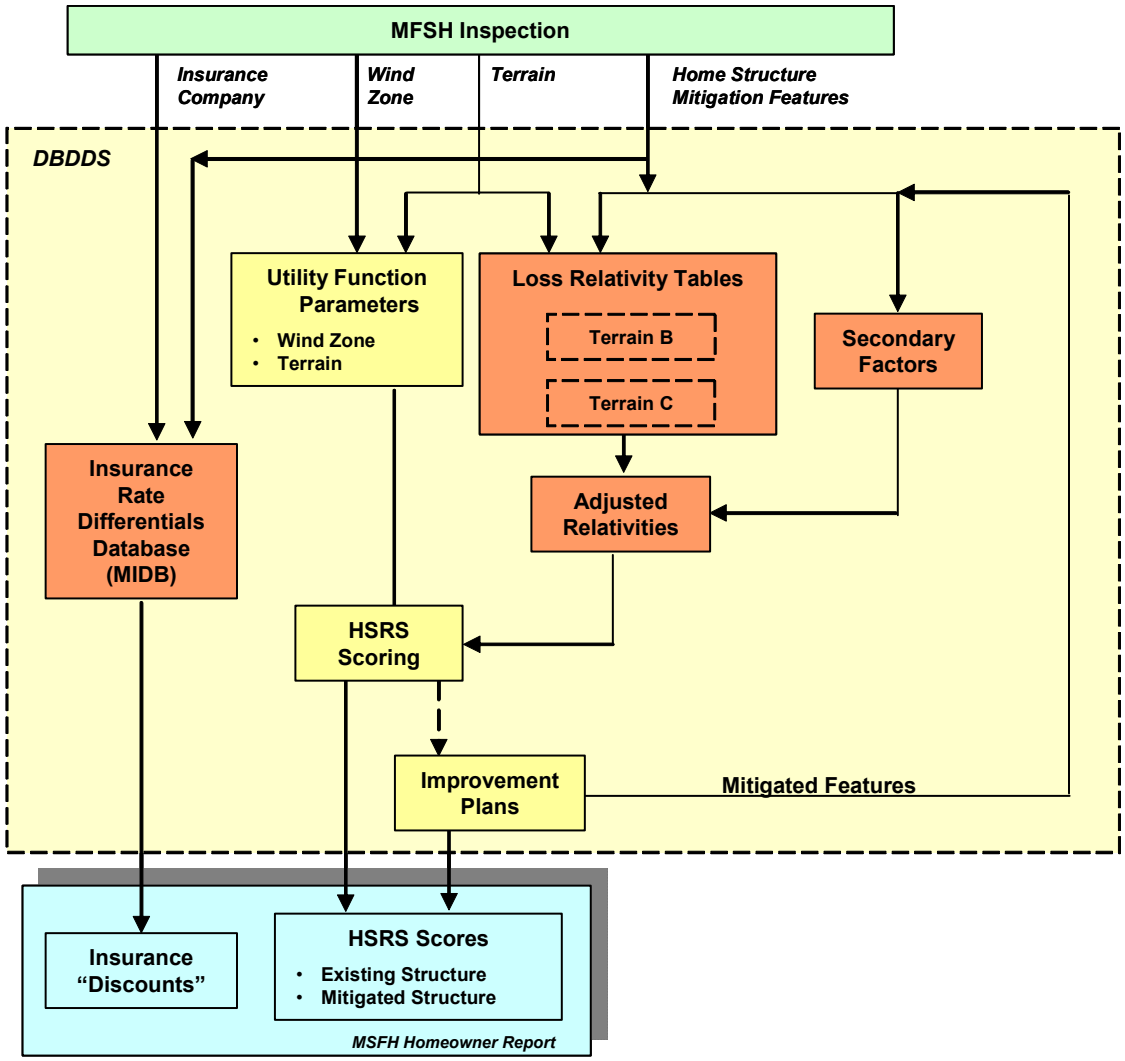


Figure 3-5. HSRS Methodology.

4. TESTING AND IMPLEMENTATION OF THE HSRS

4.1 General

The HSRS was developed in a research mode and implemented in a FORTRAN computer code. The basic loss relativity tables were incorporated as a database and the operations on that database were programmed in the developmental code.

The MSFH program developed and used DBDDS to produce the Hurricane Resistance Ratings (HRR) for each inspected home. Under this project, we assumed that the DBDDS will remain the platform for implementation of the HSRS.

As part of this project, we performed testing of the HSRS at three levels. These levels included:

1. ***Basic Testing***. Development of scores for a matrix of houses in the FORTRAN computer code.
2. ***Unit Testing***. Development of scores in an HSRS updated version of DBDDS and comparison of these scores to those obtained in the Basic Testing. This unit testing therefore provided direct comparisons of the FORTRAN and DBDDS versions of the HSRS.
3. ***System Testing***. System testing involved running the HSRS version of DBDDS against the database of houses inspected during the MSFH pilot program.

The results of this testing are described in Subsections 4.2 through 4.4. Subsection 4.5 discusses implementation steps.

4.2 Basic Testing

In the development of the HSRS, we used a set of 68 houses for each terrain to test and compare results. These houses included:

1. The so-called reference house (relativity of one) in Ref. 1. The reference house is a one-story gable, roof deck B, clips, non-FBC roof cover, no SWR, no opening protection, and Secondary Factors = 1.0914.
2. The design house in each of the eight wind zones. The design house is a two-story, FBC tile roof, gable shape with Secondary Factors = 1.0914. The opening protection, roof-to-wall connection, and roof deck attachment for each wind zone are based on the designs in Reference 1, extrapolating as needed.
3. The one-story shingle and tile roof cover versions of the design house and the two-story shingle roof cover version. These variations produce another 24 houses.
4. Weakest house one- and two-story versions with shingles and tiles and mitigated versions of the weakest house, producing 8 houses in this set.
5. Mitigated reference houses (one- and two- story, shingles and tiles), producing 4 houses in this set of cases.

6. Hip versions of the reference house, mitigated, and minimal mitigated (shutters only) cases, yielding 12 additional houses.
7. Strongest houses with and without concrete roof, one- and two-stories, shingle and tile roof covers, producing 8 houses.

These sets of houses produce 68 houses with different mitigation features for the basic testing.

4.2.1 Terrain B Results

Table 4-1 provides the details on these houses and the HSRS score for each by wind zone for Terrain B. The table contains 68 × 8 = 544 scores. For completeness, we produced results for Broward and Miami-Dade HVHZ counties for Terrain B, although those counties are specified as Terrain C in the Florida Building Code.

Design Houses. Figure 4-1 plots the HSRS score for the State's eight wind zones, where design winds less than 100 mph are plotted as one category. The plotted values correspond to the Table 4-1 diagonal values that match the wind zone and the design houses in rows 2-9, 11-18, 20-27, and 29-36. We see that the two-story tile design house scores from 51 to 57. While these scores are close to 50 (the HSRS* constraining value in Eqn. 3-4), they are not exactly 50 due to the fact that the scores are based on the closest cell in the loss relativity tables, which have only 3 deck attachments (vs a continuum of deck attachment strengths). Hence, the scores are slightly greater than the 50 for the actual interpolated minimal designs. The greatest difference is for the 110 mph wind zone, where the minimal deck attachment is about half way between Deck A and Deck B. For purposes of these tests, we assumed the house would always be built to the stronger attachment (rather than some odd nail spacing). Hence, we see that the weakest of the design houses (the two-story with tile roof cover) will generally score in the low fifties throughout the State. The strongest of the design houses, the one-story shingle) scores about 80 in each Terrain B wind zone.

In the lower wind zones in Figure 4-1, we note that the one-story tile design house scores better than the one-story shingle. This difference is a result of the relativities for the design houses in these wind zones. Tile roof covers are heavier than shingles. The added weight helps to keep the roof on the house in cases where the roof deck attachment is minimal and the roof-to-wall connection is also minimal. As the strength of these connections increase (and/or as shutters are added to the house), the benefit of the tile weight is offset by the cost of replacing damaged tiles and the loss relativity for tile roof covers is higher in higher wind zones. The loss relativities for these buildings reflect these complicated interactions of variables, which is needed in a total building rating system.

Reference Houses. Figure 4-2 plots the HSRS scores for the shingle roof cover reference houses (Rows 19, 28, 53 and 56 in Table 4-1) in each wind zone. The one-story hip scores the best in each zone, as expected. Note that the scores decrease as each house is located in more severe wind zones. This behavior shows that the HSRS is working as intended. The reference houses are near the design requirements of the 100 and 110 mph zones, but less than the requirements in the 120 mph and above wind zones.

Table 4-1. Terrain B HSRS Scores – Basic Tests

No.	Terrain B House Description	Sec Fact	Ter	Stories	Rf cover	Roof Shape	SWR	Op Pro	Rf-Wall	Rf Dk	FBC Rf	HSRS Score by Wind Zone							
												<=100 mph	110 mph	120 mph	130 mph	140 mph	150 mph	Broward	Miami-Dade
1	Ref House 1 tile	1.0914	B	1	tile	gable	no	no	clip	B	no	54	50	23	21	20	19	18	18
2	Design House-1-100	1.0914	B	1	tile	gable	no	no	clip	B	yes	74	71	46	44	43	42	41	40
3	Design House-2-110	1.0914	B	1	tile	gable	no	no	clip	B	yes	74	71	46	44	43	42	41	40
4	Design House-3-120	1.0557	B	1	tile	gable	no	yes	wrap	C	yes	83	81	62	60	59	58	57	57
5	Design House-4-130	1.0557	B	1	tile	gable	no	yes	dble wrp	C	yes	83	81	62	60	59	58	57	57
6	Design House-5-140	1.0557	B	1	tile	gable	no	yes	dble wrp	C	yes	83	81	62	60	59	58	57	57
7	Design House-6-150	1.0557	B	1	tile	gable	no	yes	dble wrp	C	yes	83	81	62	60	59	58	57	57
8	Design House-7-Bro	1.013472	B	1	tile	gable	no	yes	dble wrp	C	yes	84	82	63	62	61	60	59	59
9	Design House-8-Dade	1.013472	B	1	tile	gable	no	yes	dble wrp	C	yes	84	82	63	62	61	60	59	59
10	Ref House 2 tile	1.0914	B	2	tile	gable	no	no	clip	B	no	41	37	14	12	12	11	10	10
11	Design House-1-100	1.0914	B	2	tile	gable	no	no	clip	B	yes	58	54	27	24	24	23	22	21
12	Design House-2-110	1.0914	B	2	tile	gable	no	no	clip	B	yes	58	54	27	24	24	23	22	21
13	Design House-3-120	1.0557	B	2	tile	gable	no	yes	wrap	C	yes	79	77	55	52	52	51	50	49
14	Design House-4-130	1.0557	B	2	tile	gable	no	yes	dble wrp	C	yes	79	77	55	52	52	51	50	49
15	Design House-5-140	1.0557	B	2	tile	gable	no	yes	dble wrp	C	yes	79	77	55	52	52	51	50	49
16	Design House-6-150	1.0557	B	2	tile	gable	no	yes	dble wrp	C	yes	79	77	55	52	52	51	50	49
17	Design House-7-Bro	1.013472	B	2	tile	gable	no	yes	dble wrp	C	yes	81	78	57	55	54	53	52	51
18	Design House-8-Dade	1.013472	B	2	tile	gable	no	yes	dble wrp	C	yes	81	78	57	55	54	53	52	51
19	Ref House 1 shingle	1.0914	B	1	shingle	gable	no	no	clip	B	no	73	69	44	42	41	40	39	38
20	Design House-1-100	1.0914	B	1	shingle	gable	no	no	clip	B	yes	82	79	58	56	56	55	54	53
21	Design House-2-110	1.0914	B	1	shingle	gable	no	no	clip	B	yes	82	79	58	56	56	55	54	53
22	Design House-3-120	1.0557	B	1	shingle	gable	no	yes	wrap	C	yes	93	92	82	81	81	80	80	79
23	Design House-4-130	1.0557	B	1	shingle	gable	no	yes	dble wrp	C	yes	93	92	82	81	81	80	80	79
24	Design House-5-140	1.0557	B	1	shingle	gable	no	yes	dble wrp	C	yes	93	92	82	81	81	80	80	79
25	Design House-6-150	1.0557	B	1	shingle	gable	no	yes	dble wrp	C	yes	93	92	82	81	81	80	80	79
26	Design House-7-Bro	1.013472	B	1	shingle	gable	no	yes	dble wrp	C	yes	94	93	84	83	83	82	82	81
27	Design House-8-Dade	1.013472	B	1	shingle	gable	no	yes	dble wrp	C	yes	94	93	84	83	83	82	82	81
28	Ref House 2 shingle	1.0914	B	2	shingle	gable	no	no	clip	B	no	50	46	20	18	17	17	16	15
29	Design House-1-100	1.0914	B	2	shingle	gable	no	no	clip	B	yes	57	53	25	23	23	22	21	20
30	Design House-2-110	1.0914	B	2	shingle	gable	no	no	clip	B	yes	57	53	25	23	23	22	21	20
31	Design House-3-120	1.0557	B	2	shingle	gable	no	yes	wrap	C	yes	89	88	73	72	71	71	70	69
32	Design House-4-130	1.0557	B	2	shingle	gable	no	yes	dble wrp	C	yes	89	88	73	72	71	71	70	69
33	Design House-5-140	1.0557	B	2	shingle	gable	no	yes	dble wrp	C	yes	89	88	73	72	71	71	70	69
34	Design House-6-150	1.0557	B	2	shingle	gable	no	yes	dble wrp	C	yes	89	88	73	72	71	71	70	69
35	Design House-7-Bro	1.013472	B	2	shingle	gable	no	yes	dble wrp	C	yes	90	89	75	74	73	73	72	71
36	Design House-8-Dade	1.013472	B	2	shingle	gable	no	yes	dble wrp	C	yes	90	89	75	74	73	73	72	71
37	Weakest House - 1 story-shingles	1.367	B	1	shingle	gable	no	no	toe nail	A	no	30	27	8	7	7	7	6	6
38	Mit Weak House-D deck, code plus rf, all open	1.0042573	B	1	shingle	gable	yes	yes	dble wrap	C	yes	94	93	84	83	83	83	82	82
39	Weakest House- 2 story shingles	1.367	B	2	shingle	gable	no	no	toe nail	A	no	1	1	1	1	1	1	1	1
40	Mit Weak House-D deck, code plus rf, all open	1.0042573	B	1	shingle	gable	yes	yes	dble wrap	C	yes	90	89	76	74	74	73	72	72
41	Weakest House - 1 story-tiles	1.367	B	1	shingle	gable	no	no	toe nail	A	no	26	23	7	6	6	5	5	5
42	Mit Weak House-D deck, code plus rf, all open	1.0042573	B	1	shingle	gable	yes	yes	dble wrap	C	yes	85	83	65	63	63	62	61	60
43	Weakest House- 2 story tiles	1.367	B	2	shingle	gable	no	no	toe nail	A	no	1	1	1	1	1	1	1	1
44	Mit Weak House-D deck, code plus rf, all open	1.0042573	B	1	shingle	gable	yes	yes	dble wrap	C	yes	82	80	59	57	56	56	54	54
45	Case 1 Mit Ref House 1 tile-shutters, D deck	1.002915	B	1	tile	gable	yes	yes	clip	C	yes	85	82	64	62	61	61	59	59
46	Case 10 Mit Ref House 2 tile	1.002915	B	2	tile	gable	yes	yes	clip	C	yes	78	75	52	50	49	49	47	47
47	Case 19 Mit Ref House 1 shingle	1.002915	B	1	shingle	gable	yes	yes	clip	C	yes	94	93	84	83	82	82	81	81
48	Case 27 Mit Ref House 2 shingle	1.002915	B	2	shingle	gable	yes	yes	clip	C	no	94	93	84	83	82	82	81	81
49	Ref Hip 1 tile	1.0914	B	1	tile	hip	no	no	clip	B	no	61	57	29	27	26	26	24	24
50	Mit Ref Hip 1 tile	1.002915	B	1	tile	hip	yes	yes	clip	C	yes	88	86	70	68	68	67	66	66
51	Ref Hip 2 tile	1.0914	B	2	tile	hip	no	no	clip	B	no	47	43	18	16	16	15	14	14
52	Mit Ref Hip 2 tile	1.002915	B	2	tile	hip	yes	yes	clip	C	yes	81	78	57	55	54	53	52	52
53	Ref Hip 1 shingle	1.0914	B	1	shingle	hip	no	no	clip	B	no	80	78	56	54	53	52	51	50
54	Mit Ref Hip 1 shingle	1.002915	B	1	shingle	hip	yes	yes	clip	C	yes	97	97	92	92	92	91	91	91
55	Ref Hip 2 shingle	1.0914	B	2	shingle	hip	no	no	clip	B	no	63	60	32	30	29	29	27	27
56	Mit Ref Hip 2 shingle	1.002915	B	2	shingle	hip	yes	yes	clip	C	yes	91	90	77	76	76	75	74	74
57	Min Mit Ref Hip 1 tile (shutters only)	1.002915	B	1	tile	hip	no	yes	clip	B	no	69	66	39	37	36	35	34	33
58	Min Mit Ref Hip 2 tile (shutters only)	1.002915	B	2	tile	hip	no	yes	clip	B	no	62	58	31	28	28	27	26	25
59	Min Mit Ref Hip 1 shingle (shutters only)	1.002915	B	1	shingle	hip	no	yes	clip	B	no	88	87	72	70	70	69	68	68
60	Min Mit Ref Hip 2 shingle (shutters only)	1.002915	B	2	shingle	hip	no	yes	clip	B	no	79	77	54	52	52	51	49	49
61	Strong 1 tile House-No conc Rf	0.846048	B	1	tile	hip	yes	yes	dble wrap	C	yes	91	90	78	77	76	76	75	75
62	Strong 1 tile House- Conc Rf	0.950208	B	1	tile	hip	yes	yes	na	na	na	93	92	82	81	81	80	80	80
63	Strong 2 tile House-No conc Rf	0.846048	B	2	tile	hip	yes	yes	dble wrap	C	yes	86	84	67	65	64	64	63	62
64	Strong 2 tile House- Conc Rf	0.0950208	B	2	tile	hip	yes	yes	na	na	na	90	88	75	73	73	72	71	71
65	Strong 1 shingle House-No conc Rf	0.846048	B	1	shingle	hip	yes	yes	dble wrap	C	yes	100	99	99	99	99	99	99	99
66	Strong 1 shingle House- Conc Rf	0.0950208	B	1	shingle	hip	yes	yes	na	na	na	100	100	100	100	100	100	100	100
67	Strong 2 shingle House-No conc Rf	0.846048	B	2	shingle	hip	yes	yes	dble wrap	C	yes	96	96	90	89	89	89	88	88
68	Strong 2 shingle House- Conc Rf	0.0950208	B	2	shingle	hip	yes	yes	na	na	na	96	95	88	88	87	87	86	86

Figure 4-3 shows this same behavior to a more pronounced degree for the reference houses with tile roof covers (Rows 1, 10, 49, and 51 in Table 4-1). The scores drop dramatically as the same house is located in more severe wind zones. We see that the two-story gable tile reference house in Figure 4-3 has a score of 10 to 12 in the high wind zone locations, whereas the design two-story gable tile has a score of 51-53 in these same locations. Hence, these plots illustrate that the scoring system is behaving as expected with respect to house features and how those mitigation features compare to a 2001 code-built house in each wind zone.

Weakest and Strongest. Figure 4-4 plots the strongest (Rows 66 and 68) and weakest houses (Rows 41 and 43) for each wind zone. The strongest house scores from 100 to 99 as the wind zone increases and the weakest house scores one in all wind zones. The strong two-story concrete house does not score quite as well as the one-story building.

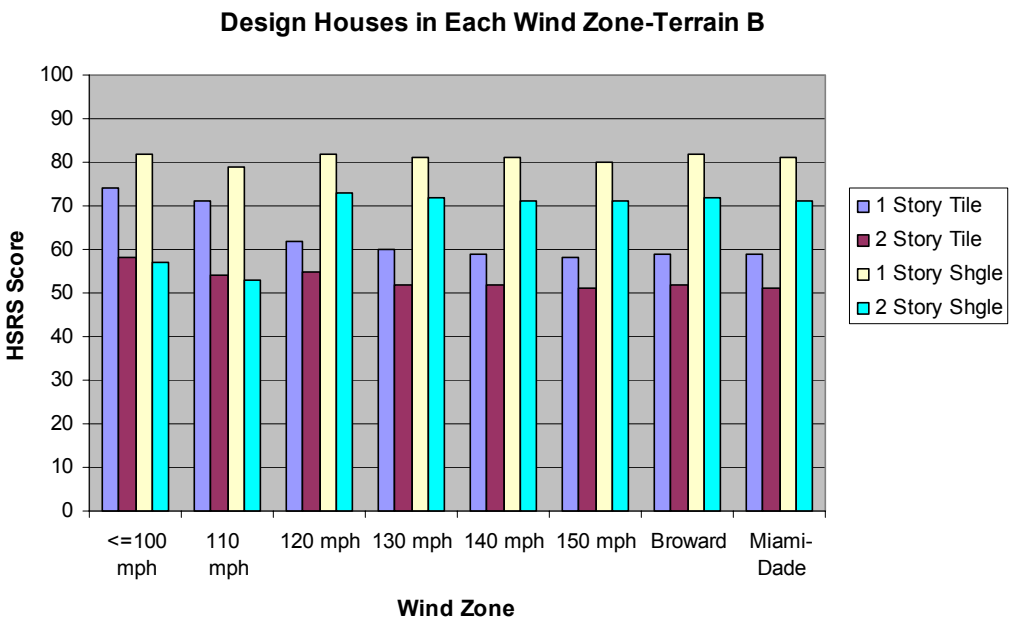


Figure 4-1. Terrain B Design Gable Houses.

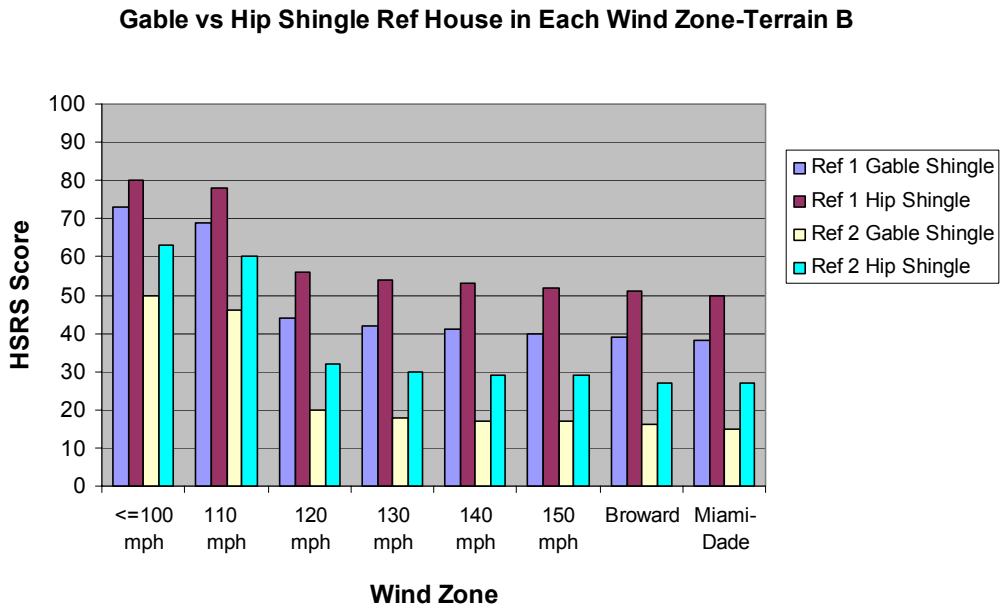


Figure 4-2. Terrain B Shingle Reference Houses

Mitigation of Reference Houses. The mitigation cases for the reference houses in Table 4-1 includes the following upgrades:

1. Re-nail Roof Deck to Level D
2. Add Secondary Water Resistance

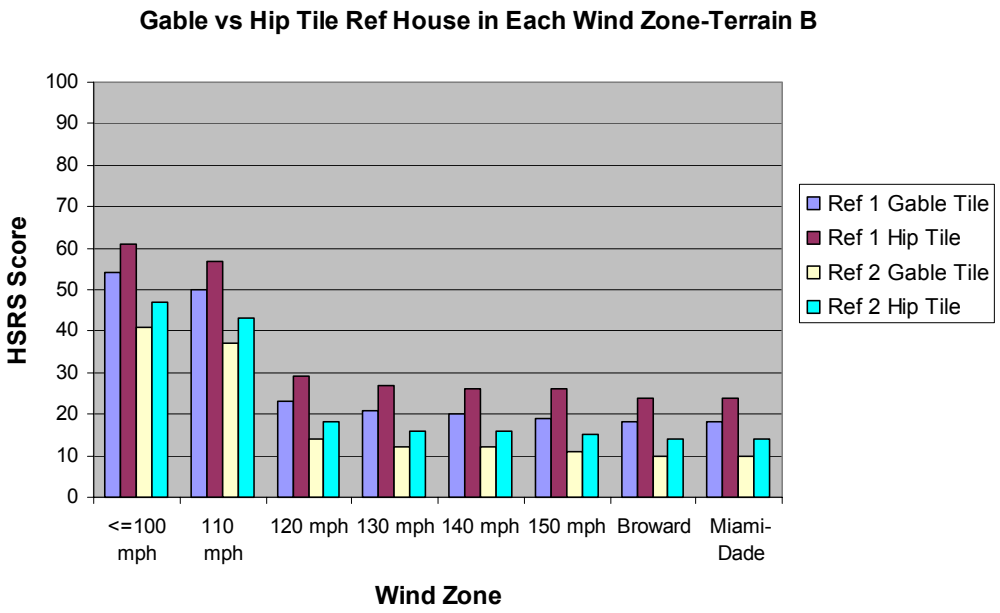


Figure 4-3. Terrain B Tile Reference Houses.

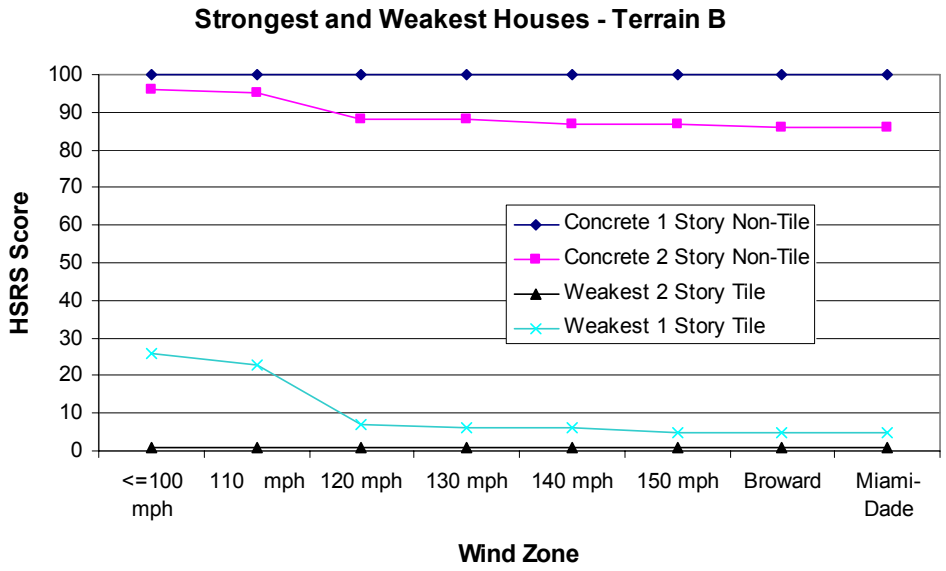


Figure 4-4. Terrain B Strongest and Weakest Houses.

3. New FBC Roof Cover
4. Add Hurricane Opening Protection on all Glazed Openings (not all openings)

Figure 4-5 plots the unmitigated and mitigated scores of the shingle roof cover reference houses in each wind zone. For the one-story, there is a 20 point increase in the 100 and 110 mph zones and about a 40 point increase in the more severe wind zones. The fact that the increase in score is more dramatic in the higher wind zones reflects the fact that the one-story reference house scores better in the lower wind zones and the level of mitigation is significant. The two-story building

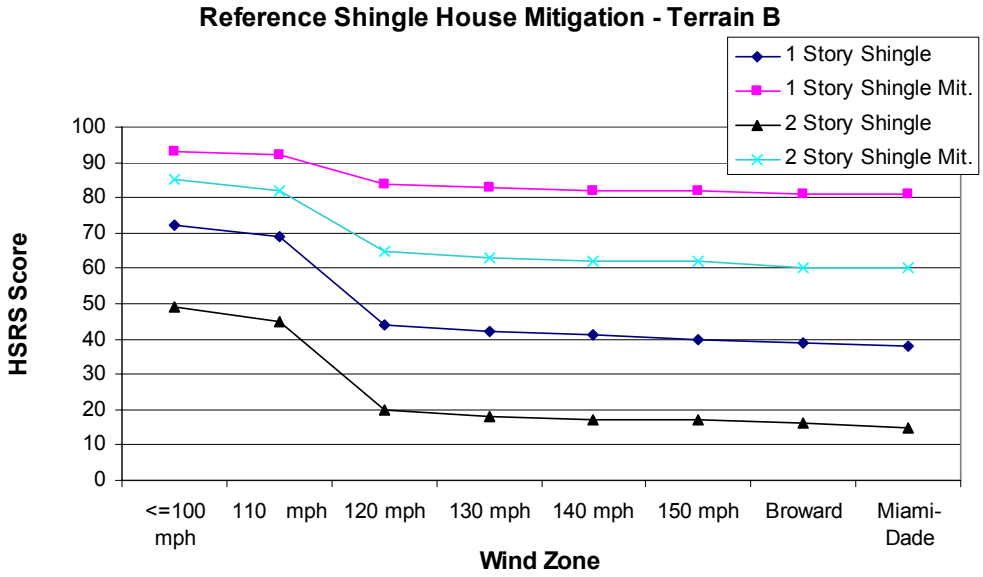


Figure 4-5. Terrain B – Mitigation of Reference Shingle House.

has a similar behavior, but somewhat less pronounced difference between the wind zones since the two-story is more vulnerable in all wind zones.

Figure 4-6 shows similar results for the mitigation of the reference tile roof houses. We see a notable change in score for the mitigated tile houses, as we did for the shingle house.

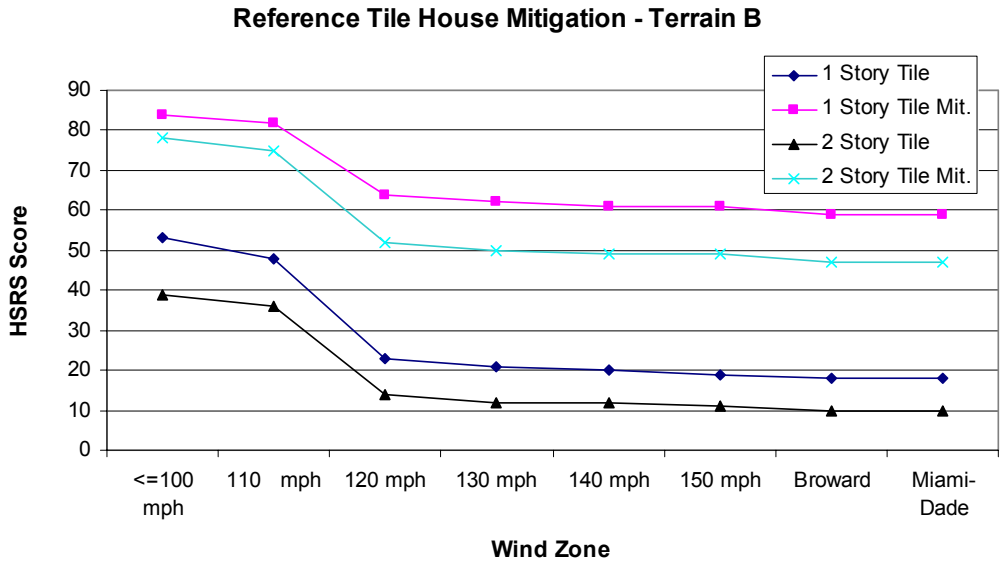


Figure 4-6. Terrain B – Mitigation of Reference Tile House.

4.2.2 Terrain C Results

Table 4-2 provides the HSRS scores for the basic set of 68 houses in Terrain C. The behavior of the HSRS scores is similar to that for Terrain B.

Table 4-2. Terrain C HSRS Scores – Basic Tests

No.	Terrain C House Description	Sec Fact	Ter	Stories	Rf cover	Roof Shape	SWR	Op Pro	Rf-Wall	Rf Dk	FBC Rf	HSRS Score by Wind Zone							
												<=100 mph	110 mph	120 mph	130 mph	140 mph	150 mph	Broward	Miami-Dade
1	Ref House 1 Tile	1.0914	C	1	Tile	Gable	no	no	clip	B	no	46	45	7	7	6	6	5	5
2	Design House-1-100	1.0914	C	1	Tile	Gable	no	no	clip	B	yes	61	61	18	17	16	16	14	14
3	Design House-2-110	1.0914	C	1	Tile	Gable	no	yes	clip	C	yes	61	61	18	17	16	16	14	14
4	Design House-3-120	1.0557	C	1	Tile	Gable	no	yes	dble wrp	C	yes	83	82	49	48	47	46	45	44
5	Design House-4-130	1.0557	C	1	Tile	Gable	no	yes	dble wrp	C	yes	83	82	49	48	47	46	45	44
6	Design House-5-140	1.0557	C	1	Tile	Gable	no	yes	dble wrp	C	yes	83	82	49	48	47	46	45	44
7	Design House-6-150	1.0557	C	1	Tile	Gable	no	yes	dble wrp	C	yes	83	82	49	48	47	46	45	44
8	Design House-7-Bro	1.013472	C	1	Tile	Gable	no	yes	dble wrp	C	yes	84	83	51	50	49	49	47	47
9	Design House-8-Dade	1.013472	C	1	Tile	Gable	no	yes	dble wrp	C	yes	84	83	51	50	49	49	47	47
10	Ref House 2 Tile	1.0914	C	2	Tile	Gable	no	no	clip	B	no	33	33	3	3	3	3	2	2
11	Design House-1-100	1.0914	C	2	Tile	Gable	no	no	clip	B	yes	44	43	7	6	6	5	5	5
12	Design House-2-110	1.0914	C	2	Tile	Gable	no	no	clip	C	yes	44	43	7	6	6	5	5	5
13	Design House-3-120	1.0557	C	2	Tile	Gable	no	yes	dble wrp	C	yes	79	79	43	41	40	40	38	38
14	Design House-4-130	1.0557	C	2	Tile	Gable	no	yes	dble wrp	C	yes	79	79	43	41	40	40	38	38
15	Design House-5-140	1.0557	C	2	Tile	Gable	no	yes	dble wrp	C	yes	79	79	43	41	40	40	38	38
16	Design House-6-150	1.0557	C	2	Tile	Gable	no	yes	dble wrp	C	yes	79	79	43	41	40	40	38	38
17	Design House-7-Bro	1.013472	C	2	Tile	Gable	no	yes	dble wrp	C	yes	81	80	45	43	43	42	40	40
18	Design House-8-Dade	1.013472	C	2	Tile	Gable	no	yes	dble wrp	C	yes	81	80	45	43	43	42	40	40
19	Ref House 1 Shingle	1.0914	C	1	Shingle	Gable	no	no	clip	B	no	56	56	14	13	12	12	11	10
20	Design House-1-100	1.0914	C	1	Shingle	Gable	no	no	clip	B	yes	63	62	19	18	17	17	16	15
21	Design House-2-110	1.0914	C	1	Shingle	Gable	no	no	clip	C	yes	63	62	19	18	17	17	16	15
22	Design House-3-120	1.0557	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	92	75	74	73	73	72	72
23	Design House-4-130	1.0557	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	92	75	74	73	73	72	72
24	Design House-5-140	1.0557	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	92	75	74	73	73	72	72
25	Design House-6-150	1.0557	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	92	75	74	73	73	72	72
26	Design House-7-Bro	1.013472	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	93	76	76	75	75	74	74
27	Design House-8-Dade	1.013472	C	1	Shingle	Gable	no	yes	dble wrp	C	yes	93	93	76	76	75	75	74	74
28	Ref House 2 Shingle	1.0914	C	2	Shingle	Gable	no	no	clip	B	no	37	36	4	4	4	4	3	3
29	Design House-1-100	1.0914	C	2	Shingle	Gable	no	no	clip	B	yes	41	40	5	5	5	4	4	4
30	Design House-2-110	1.0914	C	2	Shingle	Gable	no	no	clip	C	yes	41	40	5	5	5	4	4	4
31	Design House-3-120	1.0557	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	87	87	60	59	59	58	57	56
32	Design House-4-130	1.0557	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	87	87	60	59	59	58	57	56
33	Design House-5-140	1.0557	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	87	87	60	59	59	58	57	56
34	Design House-6-150	1.0557	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	87	87	60	59	59	58	57	56
35	Design House-7-Bro	1.013472	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	88	88	62	61	61	60	59	59
36	Design House-8-Dade	1.013472	C	2	Shingle	Gable	no	yes	dble wrp	C	yes	88	88	62	61	61	60	59	59
37	Weakest House - 1 Story-Shingles	1.4916	C	1	Shingle	Gable	no	no	toe nail	A	no	23	23	2	2	2	2	1	1
38	Mit Weak House-D deck, code plus rf, all open	1.0042573	C	1	Shingle	Gable	yes	yes	dble wrap	C	yes	93	93	77	76	76	75	74	74
39	Weakest House- 2 Story Shingles	1.4916	C	2	Shingle	Gable	no	no	toe nail	A	no	4	4	1	1	1	1	1	1
40	Mit Weak House-D deck, code plus rf, all open	1.0042573	C	1	Shingle	Gable	yes	yes	dble wrap	C	yes	88	88	63	62	61	61	59	59
41	Weakest House - 1 Story-Tiles	1.4916	C	1	Shingle	Gable	no	no	toe nail	A	no	16	16	1	1	1	1	1	1
42	Mit Weak House-D deck, code plus rf, all open	1.0042573	C	1	Shingle	Gable	yes	yes	dble wrap	C	yes	85	85	54	53	52	52	50	50
43	Weakest House- 2 Story Tiles	1.4916	C	2	Shingle	Gable	no	no	toe nail	A	no	1	1	1	1	1	1	1	1
44	Mit Weak House-D deck, code plus rf, all open	1.0042573	C	1	Shingle	Gable	yes	yes	dble wrap	C	yes	82	82	48	47	46	46	44	44
45	Case 1 Mit Ref House 1 tile-shutters, D deck	1.002915	C	1	Tile	Gable	yes	yes	clip	C	yes	84	84	52	51	50	49	48	47
46	Case 10 Mit Ref House 2 tile	1.002915	C	2	Tile	Gable	yes	yes	clip	C	yes	76	75	36	35	34	33	31	31
47	Case 19 Mit Ref House 1 shingle	1.002915	C	1	Shingle	Gable	yes	yes	clip	C	yes	94	94	79	79	78	78	77	77
48	Case 27 Mit Ref House 2 shingle	1.002915	C	2	Shingle	Gable	yes	yes	clip	C	no	79	79	43	41	40	40	38	38
49	Ref Hip 1 Tile	1.0914	C	1	Tile	Hip	no	no	clip	B	no	53	53	12	11	10	10	9	9
50	Mit Ref Hip 1 Tile	1.002915	C	1	Tile	Hip	yes	yes	clip	C	yes	86	86	57	56	55	55	53	53
51	Ref Hip 2 Tile	1.0914	C	2	Tile	Hip	no	no	clip	B	no	42	41	6	5	5	5	4	4
52	Mit Ref Hip 2 Tile	1.002915	C	2	Tile	Hip	yes	yes	clip	C	yes	80	80	43	42	41	41	39	39
53	Ref Hip 1 Shingle	1.0914	C	1	Shingle	Hip	no	no	clip	B	no	68	68	25	24	23	22	21	21
54	Mit Ref Hip 1 Shingle	1.002915	C	1	Shingle	Hip	yes	yes	clip	C	yes	97	96	87	87	87	87	86	86
55	Ref Hip 2 Shingle	1.0914	C	2	Shingle	Hip	no	no	clip	B	no	50	49	9	9	8	8	7	7
56	Mit Ref Hip 2 Shingle	1.002915	C	2	Shingle	Hip	yes	yes	clip	C	yes	88	87	61	60	59	59	57	57
57	Min Mit Ref Hip 1 Tile (shutters only)	1.002915	C	1	Tile	Hip	no	yes	clip	B	no	68	68	25	24	23	23	21	21
58	Min Mit Ref Hip 2 Tile (shutters only)	1.002915	C	2	Tile	Hip	no	yes	clip	B	no	63	63	19	18	18	17	16	16
59	Min Mit Ref Hip 1 Shingle (shutters only)	1.002915	C	1	Shingle	Hip	no	yes	clip	B	no	87	86	58	57	56	56	55	54
60	Min Mit Ref Hip 2 Shingle (shutters only)	1.002915	C	2	Shingle	Hip	no	yes	clip	B	no	77	76	37	36	35	35	33	33
61	Strong 1 Tile House-No conc Rf	0.846048	C	1	Tile	Hip	yes	yes	dble wrap	C	yes	90	90	68	67	66	66	64	64
62	Strong 1 Tile House- Conc Rf	0.950208	C	1	Tile	Hip	yes	yes	na	na	na	95	95	83	83	82	82	81	81
63	Strong 2 Tle House-No conc Rf	0.846048	C	2	Tile	Hip	yes	yes	dble wrap	C	yes	87	86	59	58	57	56	55	54
64	Strong 2 Tile House- Conc Rf	0.0950208	C	2	Tile	Hip	yes	yes	na	na	na	93	93	75	74	74	73	72	72
65	Strong 1 Shingle House-No conc Rf	0.846048	C	1	Shingle	Hip	yes	yes	dble wrap	C	yes	100	100	99	99	99	99	99	99
66	Strong 1 Shingle House- Conc Rf	0.0950208	C	1	Shingle	Hip	yes	yes	na	na	na	100	100	100	100	100	100	100	100
67	Strong 2 Shingle House-No conc Rf	0.846048	C	2	Shingle	Hip	yes	yes	dble wrap	C	yes	96	96	86	85	85	85	84	84
68	Strong 2 Shingle House- Conc Rf	0.0950208	C	2	Shingle	Hip	yes	yes	na	na	na	97	97	89	89	89	89	88	88

The average difference in score for Terrain C vs Terrain B is minus 10 points. That is, for the same house location in both terrain, the Terrain B location will score an average of 10 points higher than a Terrain C location. We note that there are several cases where the Terrain C houses score better than Terrain B houses. However, these cases occur less than 6.6% of the time for the 544 cases in Tables 4-1 and 4-2. There are no cases where the Terrain C house outscores its equivalent Terrain B house by more than 4 points.

Figure 4-7 illustrates how the design houses are scored. The two-story tile scores near 40 points in all wind zones, as expected from the constraint that the design house score is 40. Differences are due to the same effects as described for Terrain B.

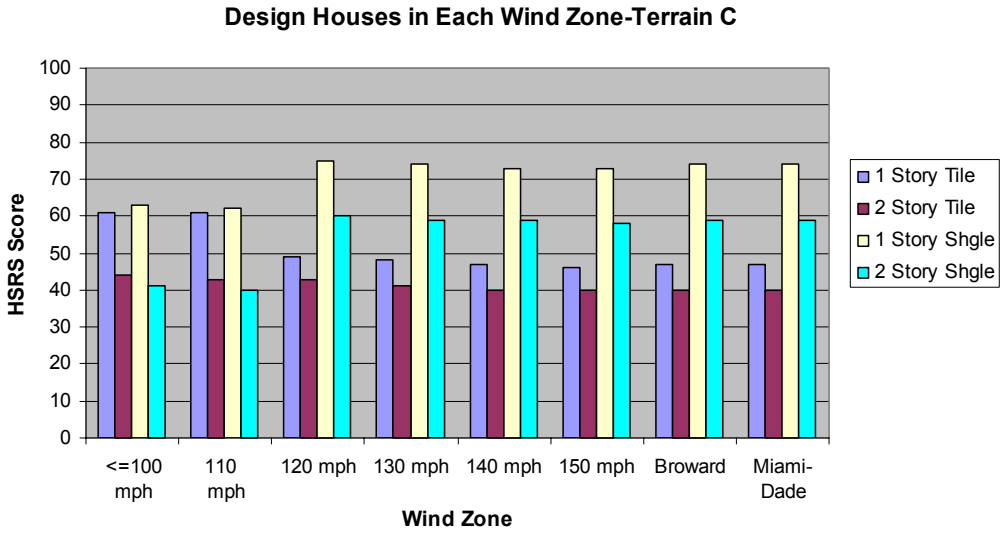


Figure 4-7. Terrain C Design Gable Houses.

The reference house with shingle roof cover scores are plotted in Figure 4-8 and the tile roof covers are plotted in Figure 4-9. We see a dramatic drop in scores for the reference house beginning in the 120 mph wind zone for Terrain C. The drop is more severe than that seen in Figure 4-2 because the open exposure in Terrain C has dramatically higher loads on the buildings and the need for shutters is stronger than in Terrain B.

The strongest and weakest house plots in Figure 4-10 are similar to those in Figure 4-4. There is a slightly greater drop in the two-story concrete house in terms of score than seen in Terrain B.

The effects of mitigating the reference houses are shown in Figures 4-11 and 4-12. We see a larger increase in score due to mitigation because the unmitigated reference house scores significantly lower in Terrain C. The scores for the mitigated reference houses are somewhat less than the mitigated scores for the same house in Terrain B. Again, the wind loads in Terrain C are greater than Terrain B and the mitigation example does not include roof to wall connection upgrade. In general, the houses in C require significant mitigation to achieve scores in the 80s.

4.2.3 Summary Range of Scores for Design Houses

In addition to the gable roof shape 2001 code design houses in Tables 4-1 and 4-2, we produced HSRS scores for their counterpart hip roof shape design houses in each wind zone. These results are summarized in Table 4-3 along with the gable results from the previous tables.

Pairs of numbers in the rows of Table 4-3 can be used to determine ranges of scores for different types of 2001 code design houses. For example, a one story shingle roof cover 2001 code house in 120 mph Terrain B scores between 82 and 88, depending on the shape of the roof. The same house with a tile roof cover scores between 62 and 67.

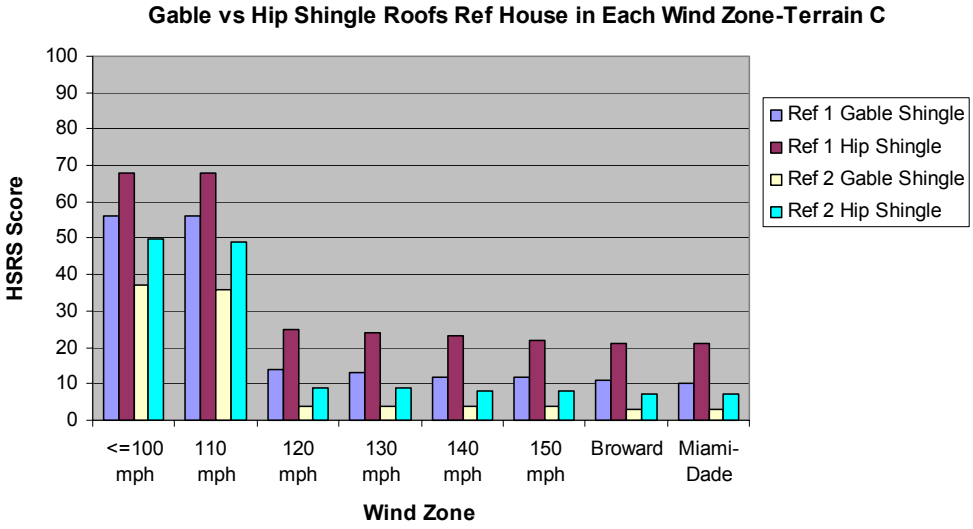


Figure 4-8. Terrain C Shingle Reference Houses.

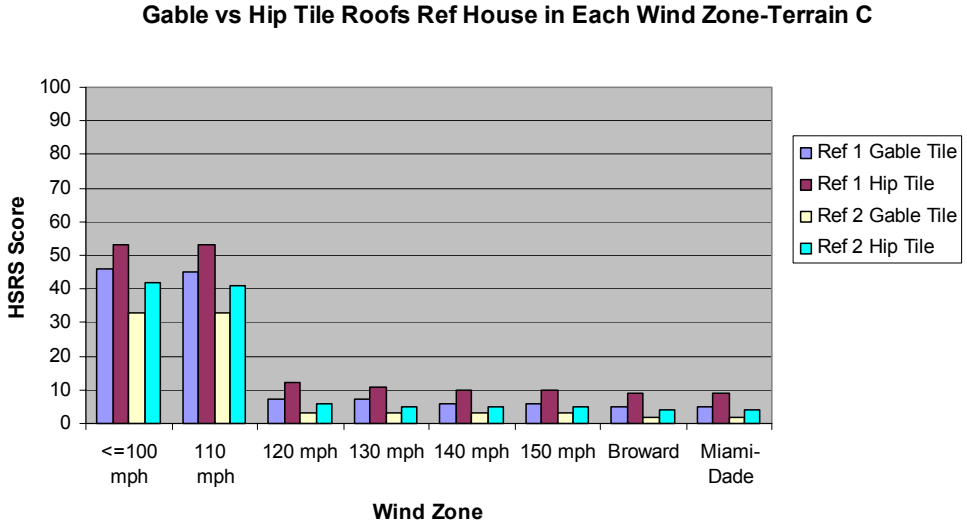


Figure 4-9. Terrain C Tile Roof Reference Houses.

In the right hand columns of the tables, overall ranges for the design homes are given for each wind zone. For example, the overall range for the 120 Terrain B wind zone is 55 to 88, whereas the 120 Terrain C wind zone is 43 to 82. The far right pair of columns show a nominal representation of ranges, which is 50 to90 for Terrain B and 40 to 80 for Terrain C. These nominal ranges are illustrated in Figure 4-13.

Another possible set of uses for the HSRS results in Table 4-3 is that these scores and range of scores could be used in the presentation of results to a homeowner. The score for a code-built version of the homeowner's house type could be included as a reference score in the homeowner report.

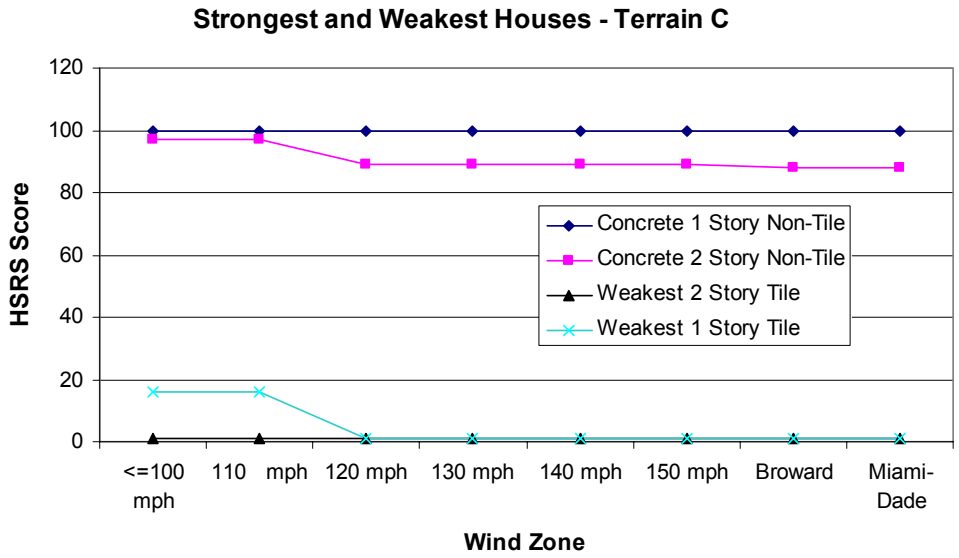


Figure 4-10. Terrain C Strongest and Weakest Houses.

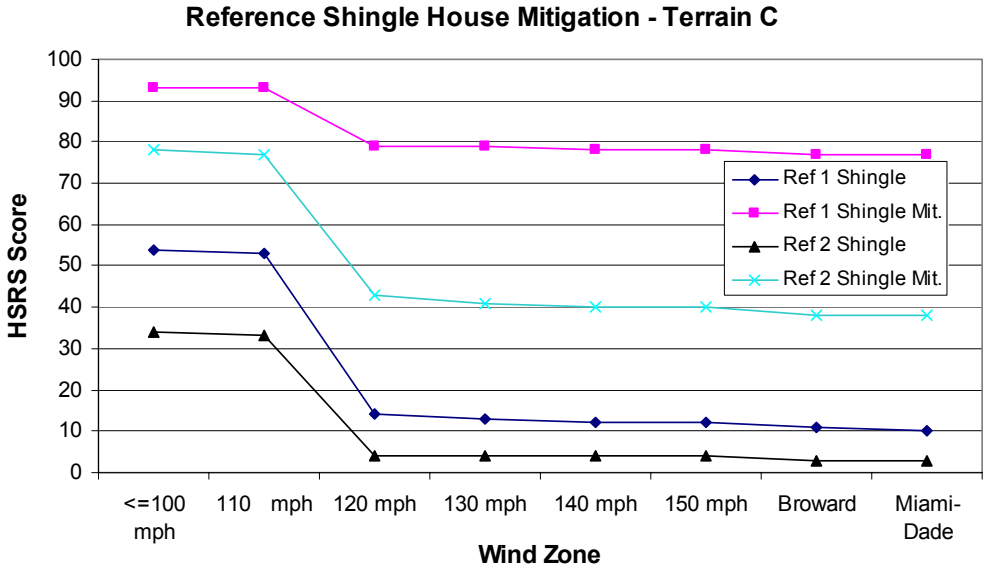


Figure 4-11. Terrain C – Mitigation of Reference Shingle House.

All of these design houses have FBC roof covers and for the two story houses, there is much smaller difference in the effects of roof shape for design homes with well constructed roof decks, roof to wall connections and new-code roof covers.

Additional research is needed to further update and validate the differences among key house construction features, including:

1. One Story and Two or More Stories
2. Gable vs Hip Roof Shape
3. Shingle and Tile roof Covers

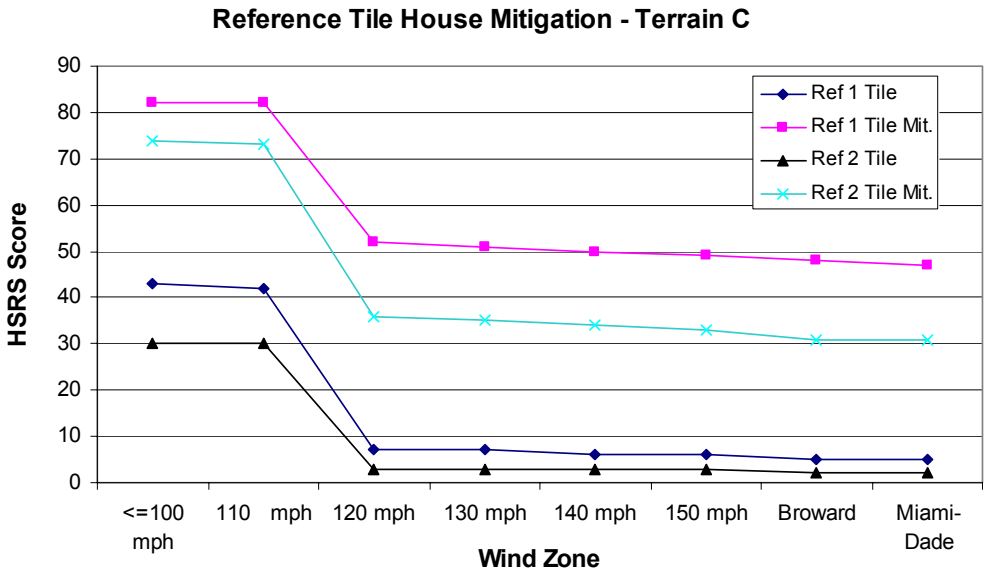


Figure 4-12. Terrain C – Mitigation of Reference Tile Houses.

Table 4-3. Summary Range of Scores for Design Houses

Range of Scores for Design Houses

Terrain	Wind Zone	Two-Story				One-Story				Overall Range		Simplified Range	
		Tile		Shingle		Tile		Shingle					
		Gable	Hip	Gable	Hip	Gable	Hip	Gable	Hip	Min	Max	Min	Max
B	100	58	67	57	74	74	80	82	89	57	89	50	90
	110	54	63	53	71	71	77	79	88	53	88	50	90
	120	55	56	73	74	62	67	82	88	55	88	50	90
	130	52	54	72	73	60	66	81	88	52	88	50	90
	140	52	53	71	72	59	65	81	87	52	87	50	90
	150	51	52	71	72	58	64	80	87	51	87	50	90
	Broward[1]	52	53	72	73	59	65	82	88	52	88	50	90
	Miami-Dade[1]	51	52	71	73	59	65	81	88	51	88	50	90
	Overall Min-Max	51	66	56	74	58	79	79	89	51	89	50	90
C	100	44	56	41	57	61	71	63	76	41	76	40	80
	110	43	55	40	56	61	70	62	76	40	76	40	80
	120	43	44	60	62	49	55	75	82	43	82	40	80
	130	41	42	59	61	48	53	74	82	41	82	40	80
	140	40	41	59	61	47	53	73	81	40	81	40	80
	150	40	41	58	60	46	52	73	81	40	81	40	80
	140 HVHZ	40	42	59	61	47	53	74	82	40	82	40	80
	146 HVHZ	40	41	59	61	47	52	74	82	40	82	40	80
	Overall Min-Max	40	53	37*	62	46	68	59	82	37	82	40	80

[1] Terrain B given for completeness only.

4.3 Unit Testing

Following the development of the HSRS documented in previous sections, we updated the MSFH pilot program DBDDS to produce a HSRS DBDDS. The pilot program DBDDS produced a hurricane resistance rating (HRR) score. The updated DBDDS operates similar to the pilot program, except it produces a HSRS score instead of an HRR score.

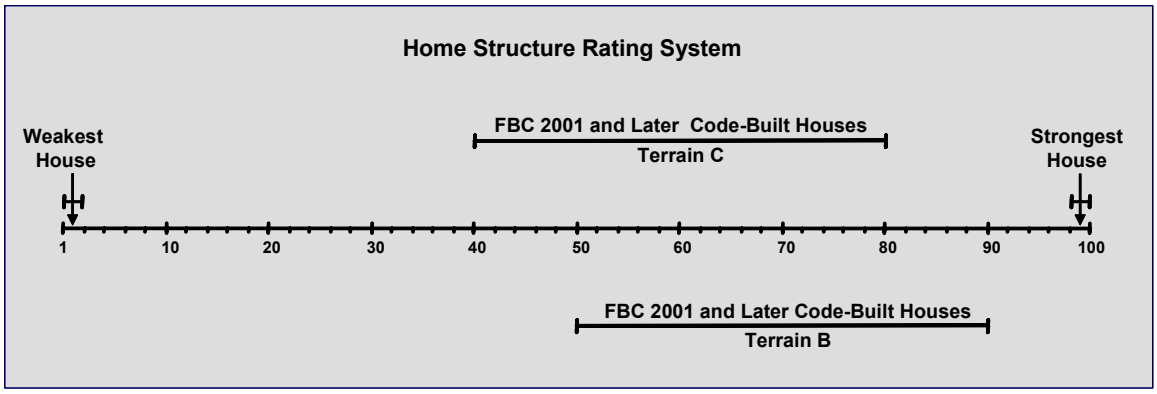


Figure 4-13. Nominal Ranges HSRS Score for Code-Built Houses.

The OIR requested that we perform unit testing of the new DBDDS. Unit testing refers to testing the HSRS DBDDS to ensure that it computes HSRS scores consistent with the results discussed above, which were produced using the a FORTRAN program. The HSRS database and algorithms were therefore encoded into the DBDDS SQL Server database.

The unit testing was performed on the 1,088 combinations of houses, wind zones, and Terrain, summarized in Tables 4-1 and 4-2. We produced the HSRS scores in DBDDS and compared those scores to those produced by the developmental FORTRAN program. The results indicate that 100% of the time the integer scores are within ±1 point; that is, there is never more than a one point difference between any of the 1,088 comparison cases. Ninety-two percent of the time there is no difference between the integer scores. The small, one point differences for 7% of the cases are due to differences in round off for the two different computer programs.

Based on these results, we conclude that the HSRS DBDDS is scoring houses as it should and is consistent with the HSRS methodology documented above.

4.4 System Testing

The OIR requested that we perform system testing of the HSRS DBDDS against actual house inspection data. The DFS sent ARA data for 8,596 inspected houses from the MSFH pilot program database (DBDDS). We augmented this data with an additional 4,866 houses from the ARA and JVI MSFH inspections. For purposes of testing the HSRS DBDDS with the inspection house data, the total number of house inspections and mitigation analysis results included in the system testing is 13,462. Figures 4-14 and 4-15 show the location of the houses from this data set plotted by zip code.

This system testing included two objectives:

1. Evaluate HSRS scores for the existing house and for mitigated versions of the house, per the three DBDDS mitigation plans.
2. Compare the HSRS scores to the HRR scores to gain an understanding of the differences.

These comparisons were performed by comparing HSRS scores and HRR scores for each existing house and the three mitigation plans.

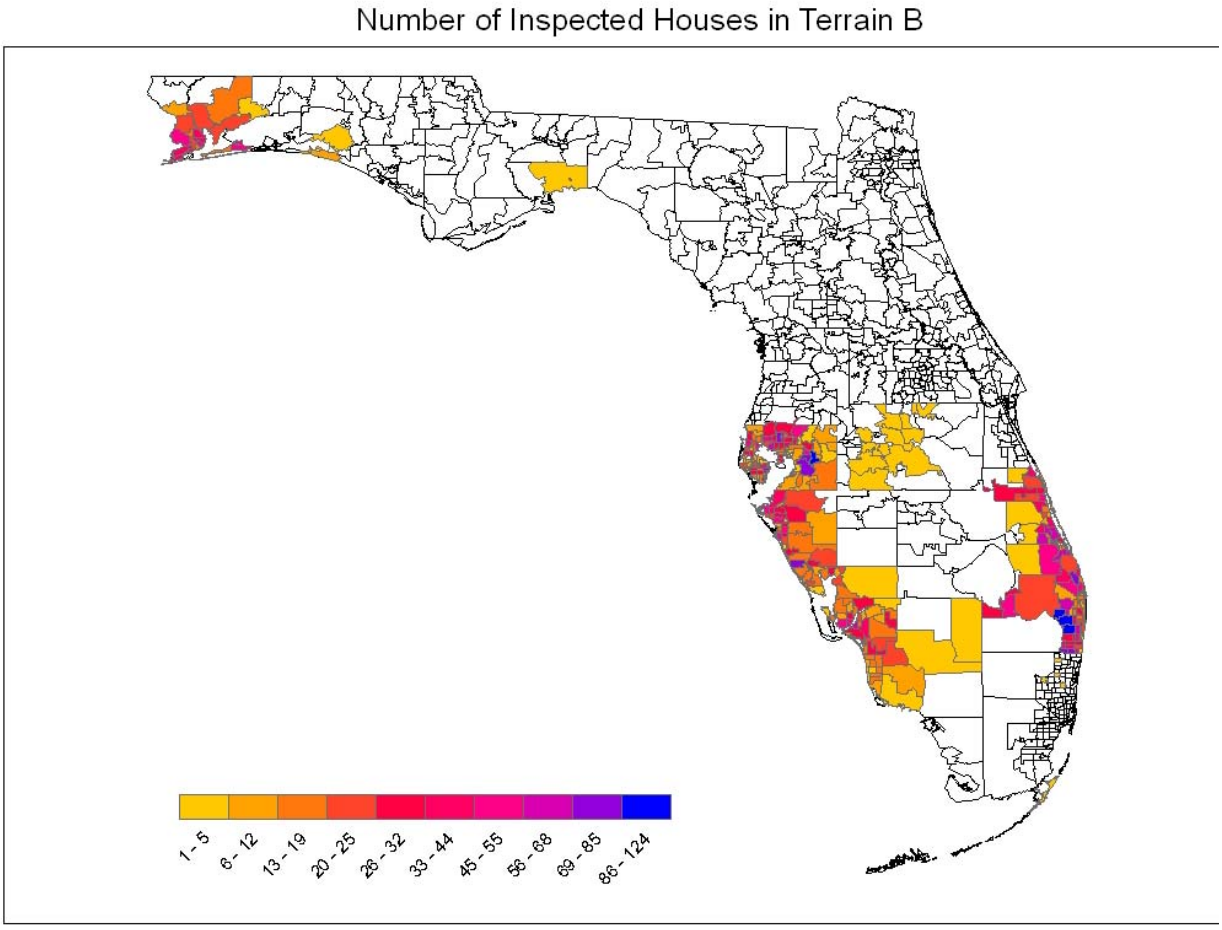


Figure 4-14. Location of Terrain B Houses in HSRS Testing.

The mitigation plans were developed in the two approaches in a similar fashion:

1. The HRR DBDDS used the change in HRR score divided by the cost of the improvement plan to select the top three mitigation plans. The top three plans were then ranked by changed in HRR score and presented in the homeowner report.
2. The new HSRS DBDDS uses the negative of the change in relativity divided by the cost of the improvement plan to select the top three mitigation plans. The top three plans are ranked by the change in HSRS score.

The HSRS approach to rank the mitigation plans is therefore similar to the HRR approach since the negative in the change in relativity is a positive value and represents a measure of positive loss reduction (the benefit).

4.4.1 Comparisons of HSRS and HRR

Table 4-3 summarizes some of the basic Terrain B statistics, broken out by State wind zone location. In the 110 mph wind zone, the average HSRS scores are higher than the HRR scores for the existing house and the three improvement plans. In higher windspeed zones, the HRR scores are higher than HSRS. The fundamental differences in the two scales is illustrated in

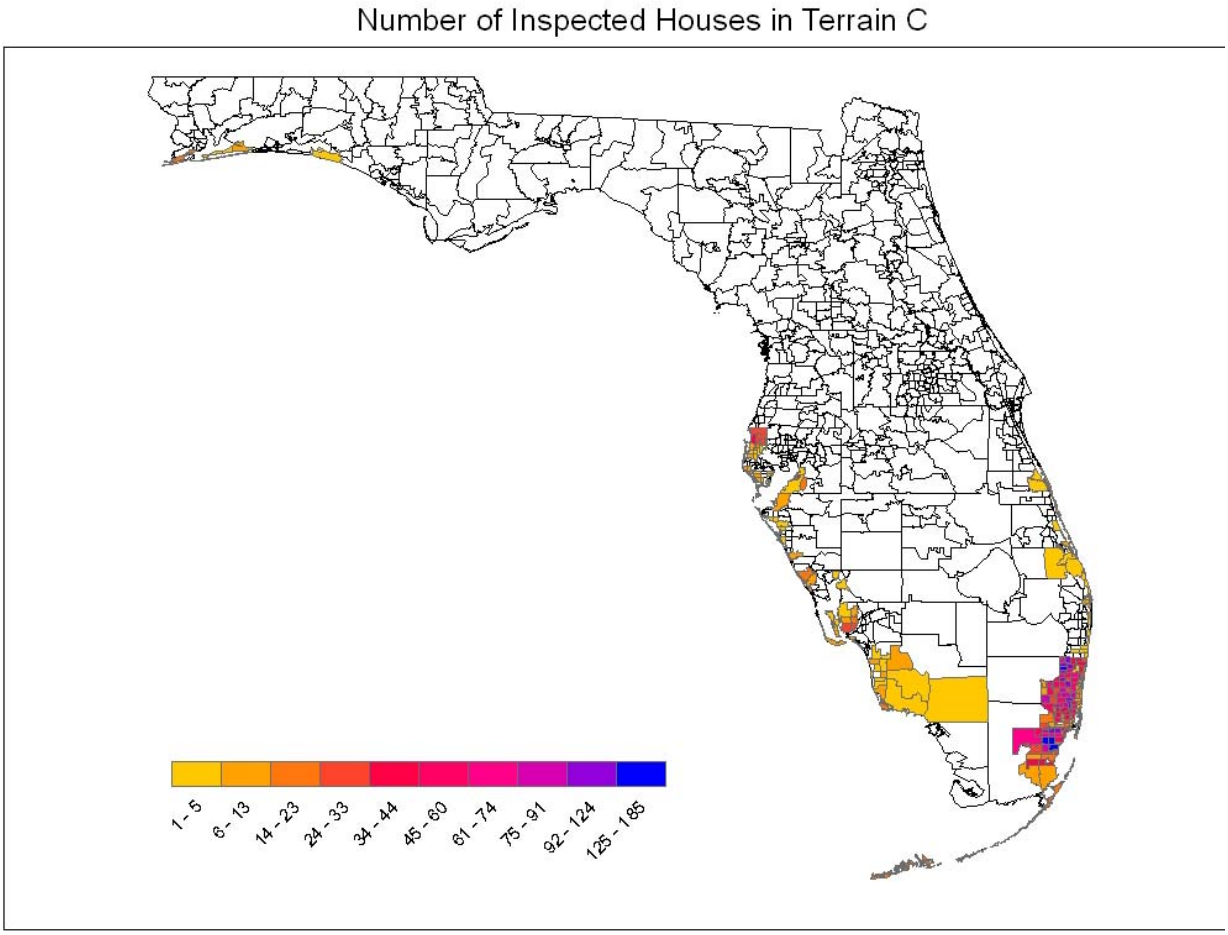


Figure 4-15. Location of Terrain C Houses in HSRS Testing.

Figure 4-16. The HSRS scores each house relative to the reference design house in that wind zone whereas the HRR scores the houses regardless of location and terrain. For weak windspeed locations the HSRS scores in Terrain B are higher since the design requirements are appropriately less, whereas in more severe wind locations the HSRS are lower, based on the design code in those locations.

The Mitigation (Improvement) Plans in DBDDS are termed Plans A, B, and C. Plan C is the plan with the highest resulting score. From Table 4-3, we see that the HSRS for Terrain B houses produces no Plan C scores that are less than 10.

The Terrain C results are given in Table 4-4 and the mean scores are plotted in Figure 4-17. The average HSRS scores are lower for all wind zones. The average change in score for the mitigation plans as a percent of the original score is higher for HSRS, but still remain lower than for HRR. Recall that the HSRS reference score in Terrain C is 40, which reflects the higher expected losses for buildings in Terrain C. Since the HRR is terrain and location independent, its scores do not reflect the higher risk of damage in Terrain C locations.

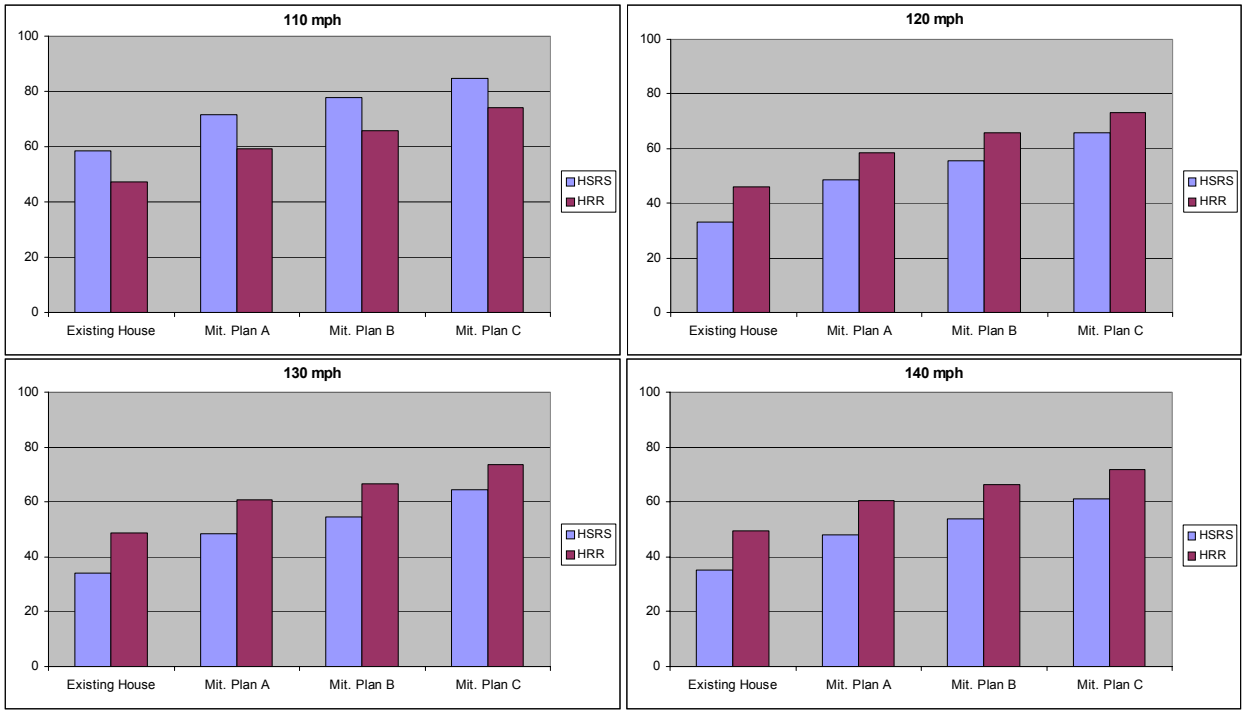


Figure 4-16. HSRS vs HRR Terrain B Mean Scores.

Table 4-4. Wind Zone Statistics of HSRS and HRR Scores for Houses Located in Terrain C

Wind Speed Zone (mph)	Terrain	Test Statistic	HSRS				HRR			
			Existing House	Mit. Plan A	Mit. Plan B	Mit. Plan C	Existing House	Mit. Plan A	Mit. Plan B	Mit. Plan C
120	Terrain C	Average	11.92	22.89	32.40	50.69	44.18	56.35	62.46	71.09
		Stdev	8.57	15.02	17.79	21.88	16.05	16.54	16.25	15.65
		Min	1	1	3	5	0	7	22	30
		Max	58	79	82	91	79	91	89	93
		Number of Houses	209				810			
		Houses with Mit. Plan C Score <10				4				0
130	Terrain C	Average	13.13	25.42	35.99	50.76	45.87	58.72	65.72	72.60
		Stdev	12.54	17.27	19.45	22.27	17.50	16.86	15.77	15.06
		Min	1	2	2	4	6	21	23	33
		Max	82	84	90	93	87	89	89	92
		Number of Houses	311				311			
		Houses with Mit. Plan C Score <10				6				0
140	Terrain C	Average	12.15	21.44	34.31	47.15	45.31	57.22	64.84	70.68
		Stdev	10.07	13.59	19.04	21.90	16.68	15.91	15.25	14.60
		Min	1	2	3	4	8	21	24	32
		Max	56	63	87	90	80	86	90	93
		Number of Houses	236				236			
		Houses with Mit. Plan C Score <10				7				0
150	Terrain C	Average	20.07	33.78	34.88	47.65	53.32	66.89	70.24	75.61
		Stdev	19.24	26.29	19.56	19.17	20.99	17.85	13.23	11.90
		Min	1	2	4	7	11	21	34	40
		Max	83	91	90	92	89	97	90	91
		Number of Houses	94				94			
		Houses with Mit. Plan C Score <10				3				0
146- Dade	Terrain C	Average	13.43	24.48	30.63	41.06	43.47	53.16	57.59	62.46
		Stdev	12.95	19.34	18.40	21.94	17.37	17.46	16.63	17.30
		Min	1	1	1	2	0	5	14	20
		Max	90	92	89	93	92	100	90	93
		Number of Houses	2978				2978			
		Houses with Mit. Plan C Score <10				59				0
140 - Broward	Terrain C	Average	12.88	23.28	30.55	39.74	43.91	54.36	59.15	63.90
		Stdev	12.07	18.05	18.66	21.22	17.25	16.76	16.15	16.20
		Min	1	1	2	2	0	7	21	23
		Max	82	96	89	91	96	100	90	93
		Number of Houses	2665				2665			
		Houses with Mit. Plan C Score <10				39				1

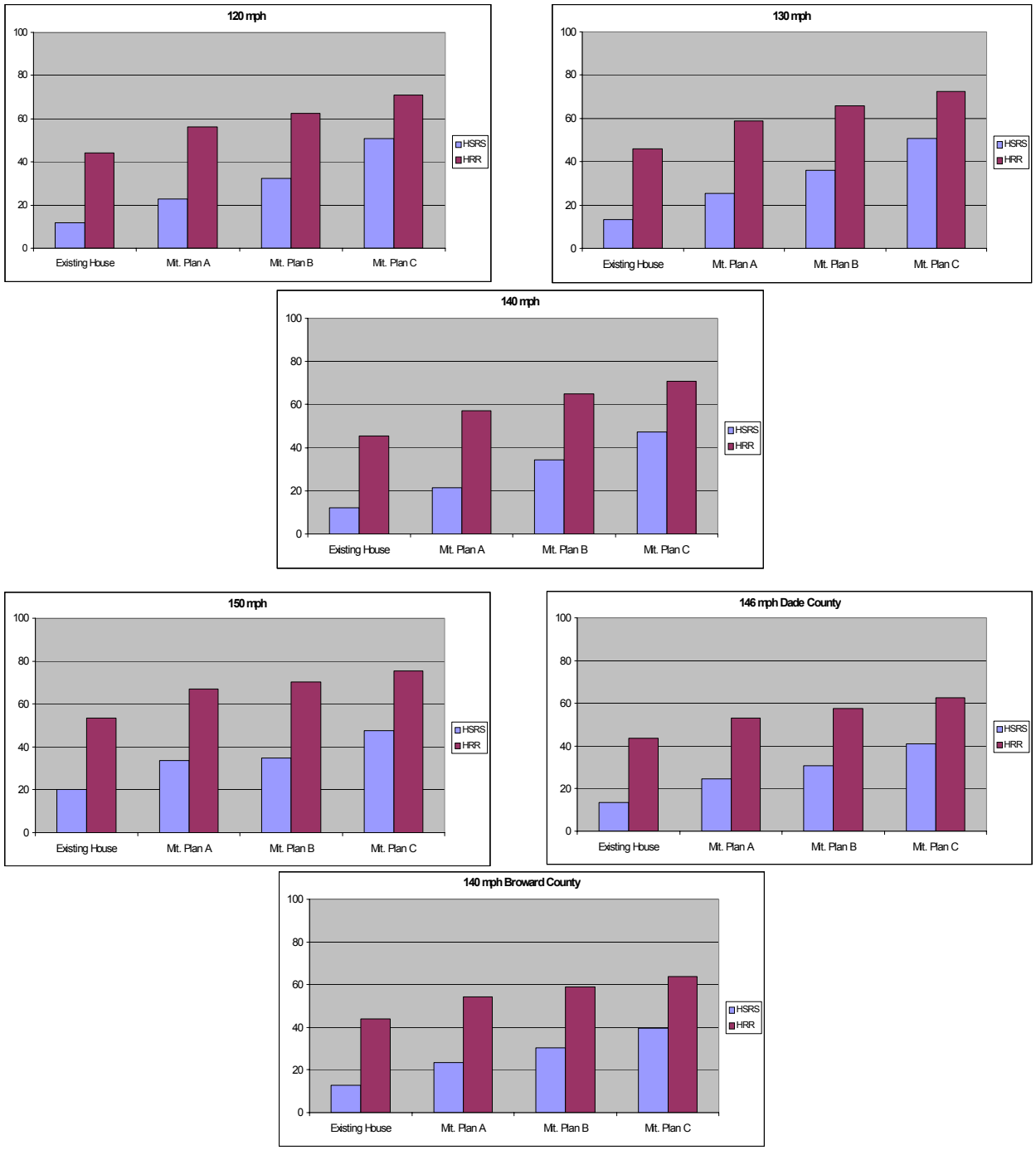


Figure 4-17 HSRS vs HRR Terrain C Mean Scores.

The Mitigation Plan scores in Table 4-4 for Terrain C show that the HSRS occasionally produces a Plan C score less than 10. The frequency of this score is less than 2% in each Terrain C wind zone. We recommend further enhancements to the DBDDS to produce additional Mitigation Plans so that the homeowner can at least understand what further improvements are needed to mitigate the house to a higher level.

The difference in the two home rating systems is significant. Comparing the two is like comparing "apples and oranges" since they are based on different scales of performance. One is independent of terrain, location, and building code and the other includes all three factors. The HRR almost always scores higher than the HSRS in Terrain C and in high wind zone locations.

Table 4-5 shows that the HRR scores higher about 96% of the time for the MSFH houses (existing) and scores higher about 77% of the time for the Mitigation Plan C. The differences in the two systems are most notable for weak homes in Terrain C high wind zones.

A trade-off in the selection of HSRS* as 50 in Terrain B and 40 in Terrain C is that we have some low scores for relatively weak two-story tile roof houses. This is the result of the flat shape in the risk-averse utility function in the region of high relativities.

Table 4-5. Frequency of Time HRR > HSRS

	Frequency HRR > HSRS	Percentage of Total
Existing House	12,902	95.9
Mit. Plan A	12,288	91.3
Mit. Plan B	10,954	81.4
Mit. Plan C	10,422	77.4

4.4.2 Scatter Plot Comparisons

Scatter plots of HSRS vs HRR have been produced as an additional way to check the system in terms of scoring anomalies and/or data errors. Visual comparisons of the HSRS and HRR scores are illustrated in Figures 4-18 and 4-19 for Terrain B and in Figures 4-20 through 4-22 for Terrain C. These plots compare the respective scores by wind zone and mitigation improvement plan.

The Terrain B 110 mph plots in Figure 4-18 show that the HSRS scores are almost always higher that the HRR scores. Beginning at 120 mph, the HRR scores are generally higher.

In Figure 4-19, the shape of the HSRS utility function becomes more apparent. Since HRR is a linear function of 1-r, the curvature of the HSRS utility functions can be seen by turning the page counterclockwise 90 degrees and viewing the plot.

The Terrain C results in Figures 4-20 through 4-22 clearly show the utility function shape of the HSRS.

4.5 Implementation of HSRS

The implementation of the HSRS into the DFS MSFH production mode will require, at a minimum, the following steps:

1. Integration of the ARA modified DBDDS into the DFS DBDDS.
2. Testing of the integrated DBDDS to ensure that the integrated HSRS produces the same scores as the ARA tested version of DBDDS.

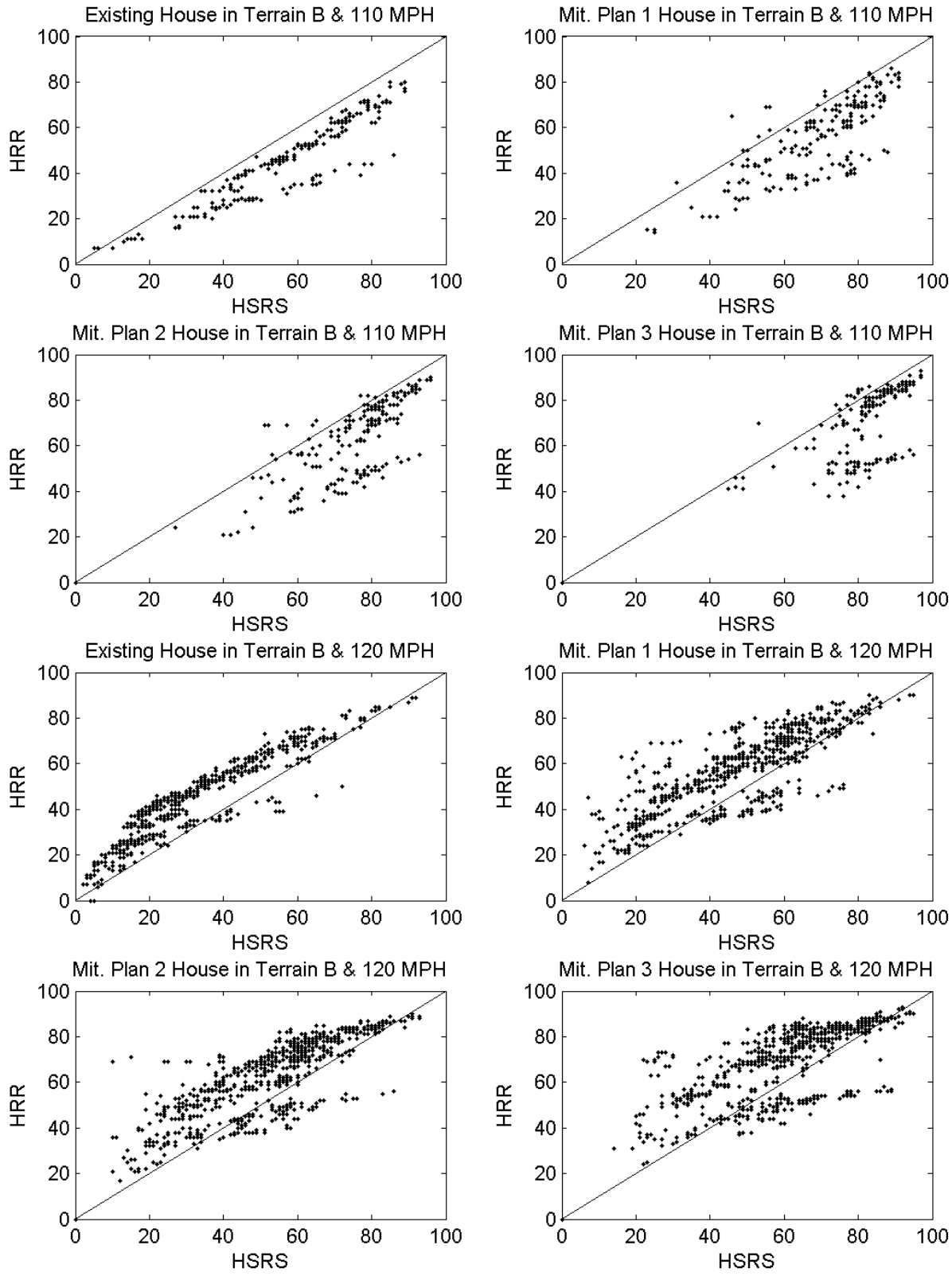


Figure 4-18. Scatter Plots of HSRV vs HRR for Terrain B – 110 to 120 mph.

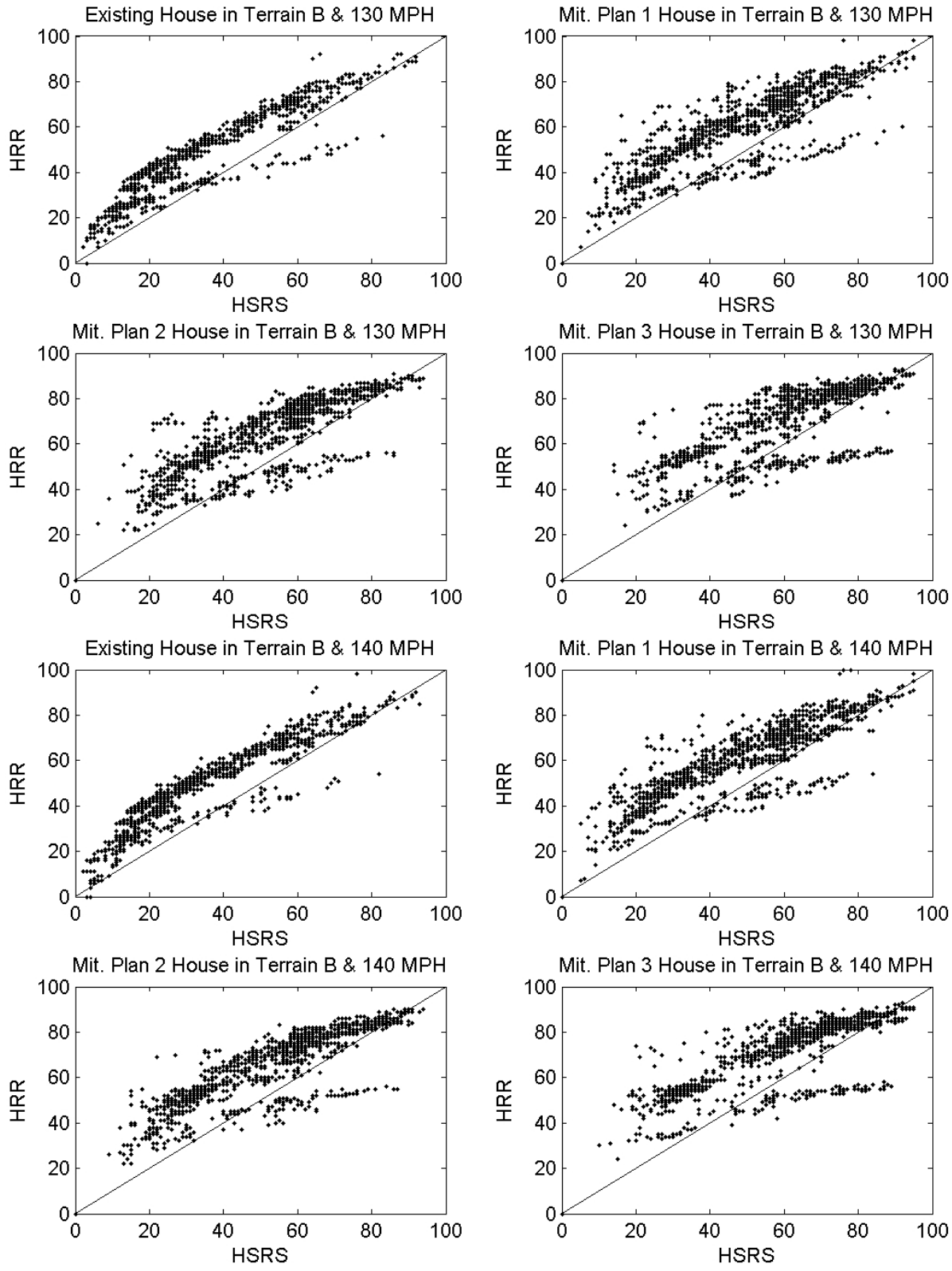


Figure 4-19. Scatter Plots of HSRV vs HRR for Terrain B – 130 to 140 mph.

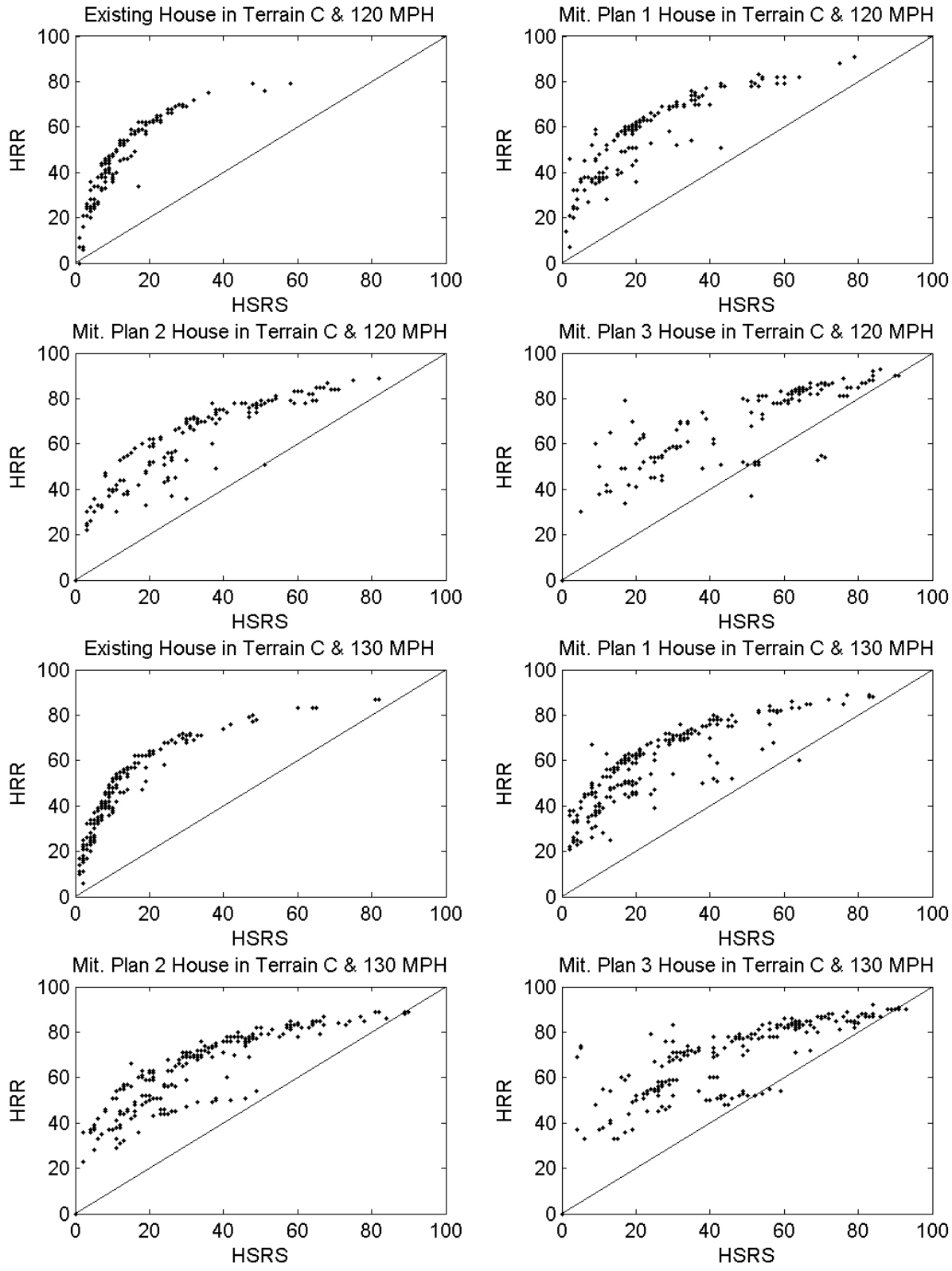


Figure 4-20. Scatter Plots of HSRV vs HRR for Terrain C – 120 to 130 mph.

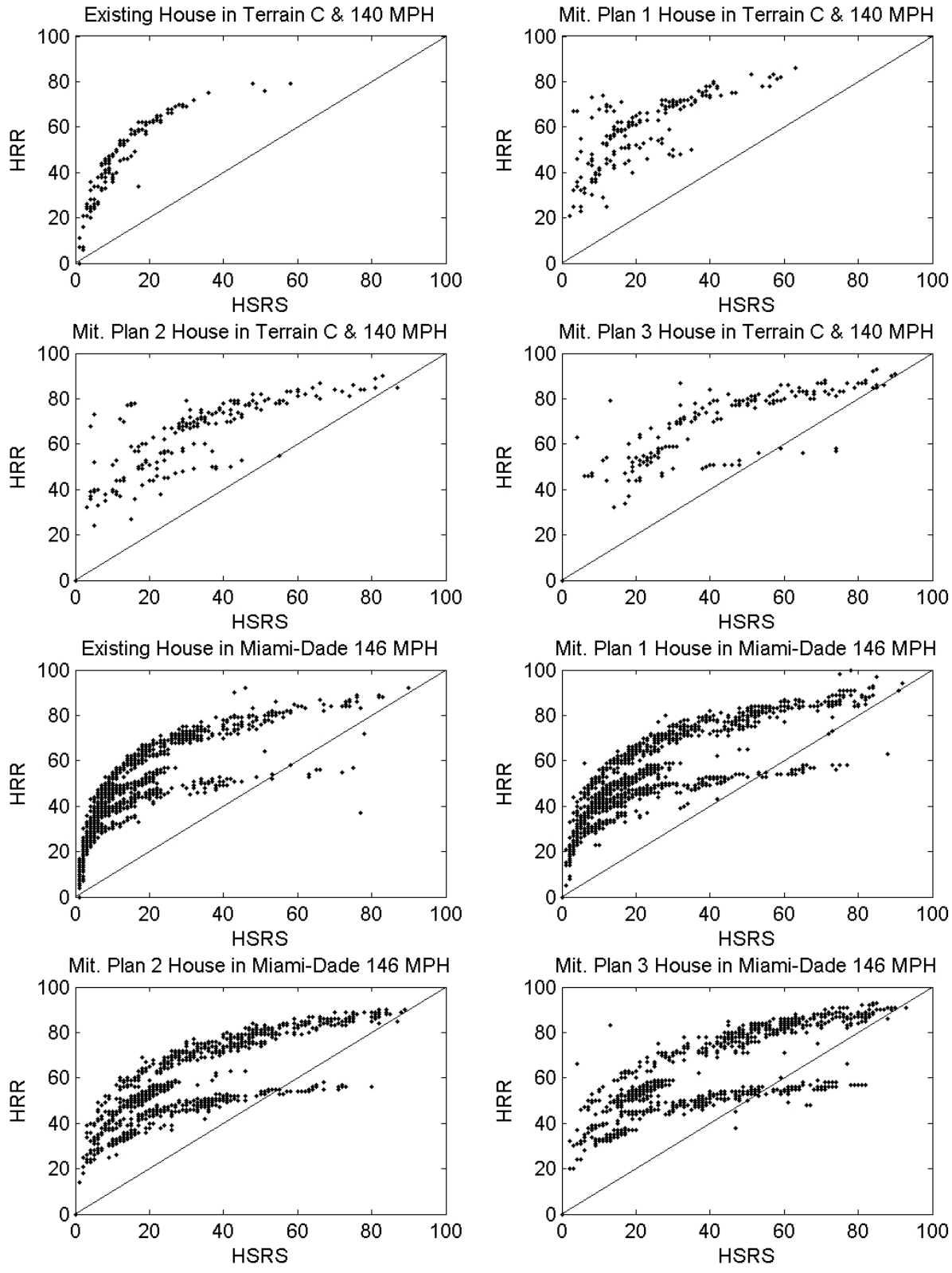


Figure 4-21. Scatter Plots of HSRV vs HRR for Terrain C – 140 and Miami-Dade.

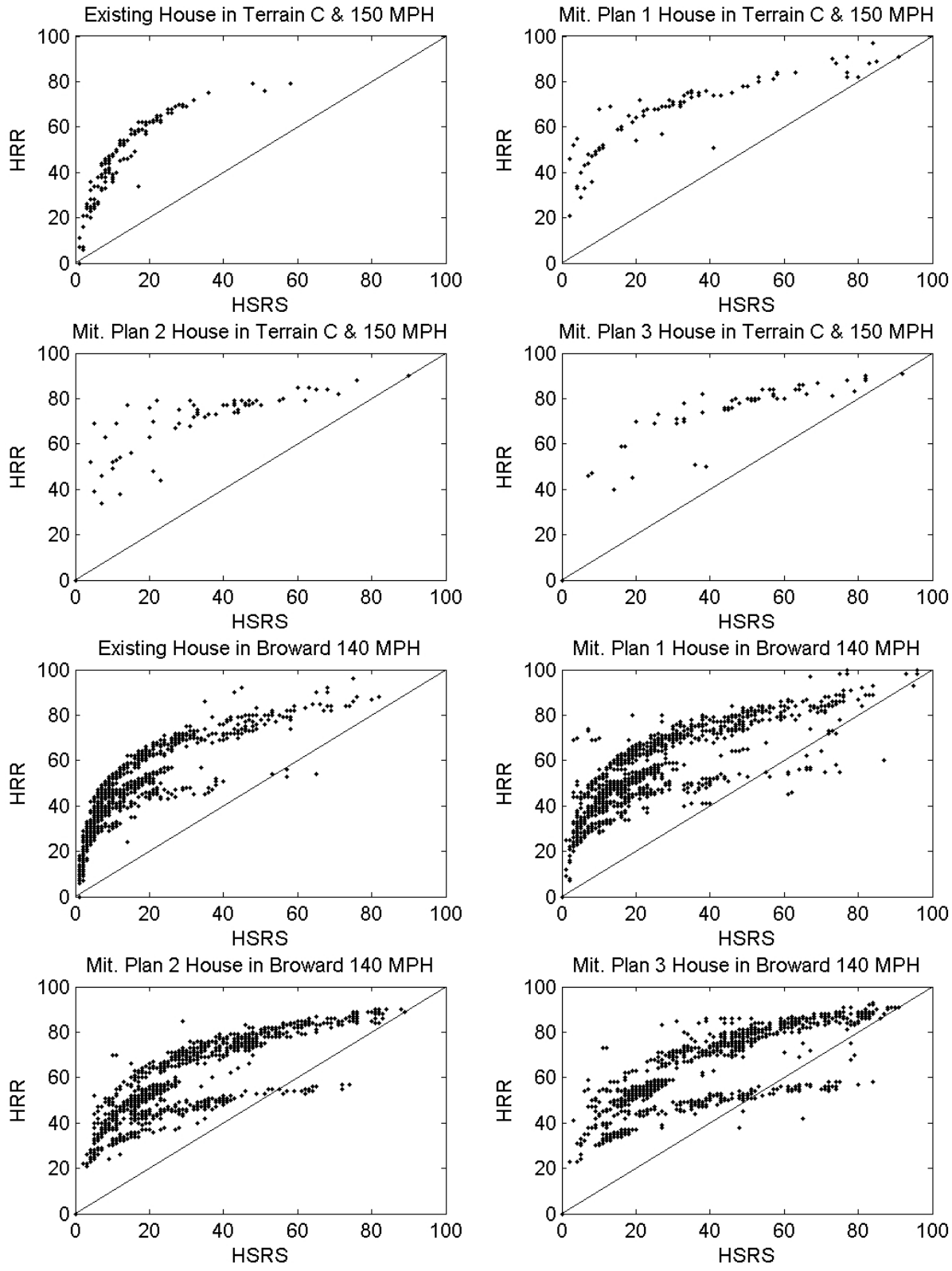


Figure 4-22. Scatter Plots of HSRV vs HRR for Terrain C – 150 and Broward.

3. Updating the MSFH website and other materials regarding the discussion of the HSRS rating.

No changes to the inspection checklist are required to accommodate this initial version the HSRS.

The first two items involve the integration of the HSRS DBDDS into the DFS computer systems and into the MSFH production mode. The draft language for homeowner report is presented in Section 4.5.1. The third item regards changes to the website and other materials that describe the rating scale and how to interpret it. The Item 3 changes are outside the scope of this project, which has focused on methodology development and integrating the HSRS into DBDDS.

4.5.1 Updating the Homeowner Report for the HSRS Scale

The language in the MSFH homeowner report that discusses the interpretation of the rating is on page 2. The homeowner scores are given on page 2 for the existing home and on page 3 for the various improvement plans. The HSRS rating numbers fit into the same locations in the current HRR homeowner report (both the HRR and HSRS scores cover essentially the same range (HRR goes from 0 to 100 and HSRS goes from 1 to 100).

As part of ARA's scope to deliver an updated DBDDS, we updated the language on page 2 of the report that discussed the interpretation of the score. Following is a summary of the changes made in the discussion on page 2.

Descriptive Text for Interpreting the HRR Score. The current paragraph on page 2 of the homeowner report includes the following language on interpreting the HRR score.

Understanding your home's hurricane wind resistance rating

The hurricane wind resistance ratings provided in this report are estimated numbers on a scale of 0 to 100. The ratings are designed to provide a general indication of how well your home is expected to perform over a broad range of hurricanes with different intensities and wind directions. Homes built to Florida's current strictest building code requirements will have ratings near 100 while the weakest homes will have ratings approaching zero.

Your home's current hurricane wind resistance rating is estimated to be 41.

It is important to realize that the ratings in this report only consider a practical number of inspection features and do not treat the location of the home within Florida. New research to improve the rating system is now underway which may result in adjustments to the rating scale.

The HRR text has 140 words.

Draft Form of Replacement Text for Interpreting the HSRS Score. Following is the draft replacement text we have put in the HSRS DBDDS:

Understanding your home's hurricane wind rating

The ratings provided in this report are based on the Home Structure Rating System (HSRS), which is a newly developed scale to provide a relative measure of the ability of a Florida home to withstand hurricane wind effects. The rating reflects your home's structural features, location, and the Florida Building Code requirements for your location. The rating is a number between 1 and 100, where 100 corresponds to the strongest, code-plus construction.

Your home's current hurricane wind rating is estimated to be 41.

It is important to realize that the rating is intended to provide only a relative measure of how well your home is expected to perform over a wide range of potential wind speeds and wind directions. The rating is approximate and is based on a limited number of visible inspection features. Research to improve the rating system is underway and future adjustments are likely as our understanding of hurricane wind effects continues to improve.

The replacement HSRS text has 163 words, but still easily fits on page 2 without causing an overrun.

In the rest of the homeowner report, the only change we made was to replace "hurricane wind resistance rating" with "hurricane wind rating". This change was made to reflect the fact that the HSRS rating includes resistance, location, and building code, whereas the HRR considers only resistance.

A copy of an HRR homeowner report is given in Appendix C. A draft version of the same report with the HSRS wording changes on pages 2 and 3 is also given in Appendix C. The suggested wording changes are included in the delivered version of HSRS DBDDS. However, we recommend that these draft changes be reviewed as part of the total HSRS implementation process.

5. SUMMARY AND RECOMMENDATIONS

5.1 General

A short-term research project has been conducted to develop a rating system for the hurricane wind resistance of single-family homes in Florida. The requirements for this project are given in Chapter 2006-12, Section 39 of the Laws of Florida. Basically, the requirements indicate that the OIR, in consultation with a designated Advisory Board, shall develop a program that will provide an objective rating system that will allow homeowners to evaluate the relative ability of Florida properties to withstand the wind load from a sustained severe tropical storm or hurricane. The rating system should be designed in a manner that is easy to understand for the property owner, based on proven readily verifiable mitigation techniques and devices, and able to be implemented based on a visual inspection program.

This project uses research performed in 2001 and 2002 on loss relativities of single family homes (1,2,3) to provide the foundation for the Home Structure Rating System (HSRS). Minor updates to the data have been undertaken in this report and have been discussed with the Advisory Board.

Sections 5.2 through 5.5 summarize the key results of the work. Section 5.6 includes the implementation recommendations.

5.2 Home Rating Factors

The primary wind resistive building features considered in the HSRS and the number of levels for each factor include:

1. Roof Shape (Hip and Other)
2. Secondary Water Resistance (Yes or No)
3. Roof Cover (post FBC 2001 or not)
4. Roof Deck Attachment (Three levels of attachment strength)
5. Roof-Wall Connection (Four levels of connection strength)
6. Opening Protection (Three levels of protection for wind-borne debris)
7. Number of Stories (Two levels, one story and two or more stories)
8. Roof Covering Type (Tile and non-tile)

Eleven secondary factors are also considered:

1. Dimensional Lumber Deck
2. Masonry Walls
3. Reinforced Masonry Walls
4. Opening Coverage
5. Unbraced Gable End

6. Foundation Restraint
7. Reinforced Concrete Roof Deck Integral with Reinforced Concrete or Reinforced Masonry Walls
8. Enhanced Roof Deck
9. Soffits
10. Vinyl Siding
11. Window, Door, and Skylight Water Leak Potential

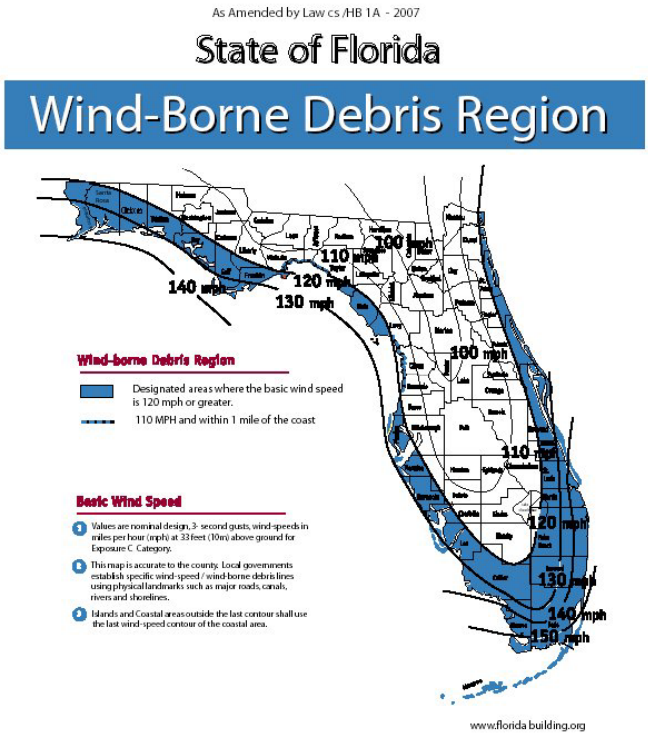
These rating factors are used to determine the loss relativity, which is a single measure of the relative ability of the house to withstand hurricane wind effects as an integrated structural system. The loss relativity is determined from tables that have been normalized by the highest loss cost of the weakest house. A low loss relativity means that a house is expected to have relatively low loss costs from hurricane winds and a high loss relativity corresponds toa house with expected high loss costs. The basic loss relativity tables are based on 0% deductible and reflect a minor adjustment on the Secondary Water Resistance Factor. The tables are based on research done in 2001 and 2002.

The basic rating tables include a total of 3,200 loss relativities (1,600 for Terrain B locations and 1,600 for Terrain C locations). The secondary factors are applied in a sequential multiplicative fashion to adjust the basic house relativity. The final adjusted relativity is the fundamental input measure that determines the HSRS score for each wind zone and terrain.

5.3 Home Structure Rating System

This initial HSRS has been developed to provide an objective measure of the relative ability of a Florida home to withstand wind effects from sustained severe tropical windstorms and hurricanes. This rating system is based on an inspection procedure that uses readily verifiable (visual) methods to determine the building's construction and wind mitigation features.

The rating system produces a score between 1 and 100, with 1 being the score for a very weak structure and 100 the score for a very strong, code-plus structure. The system was designed to allow room in the top portion of the scale for building code improvements over time and for implementation of code-plus mitigation techniques. The scale produces the greatest relative change in score for code and code-plus construction.



Objective Measures. The system includes the following measures to determine the score:

1. A set of basic construction and wind damage mitigation features;
2. The home's location in Florida, as determined by its Florida Building Code wind zone location;
3. A set of wind resistive features relative to a Florida Building Code (2001 version, adopted 3-1-2002) home, built in that specific wind zone location; and
4. A simplified terrain exposure of the home, which considers coastal locations (Terrain C) and inland suburban locations (Terrain B).

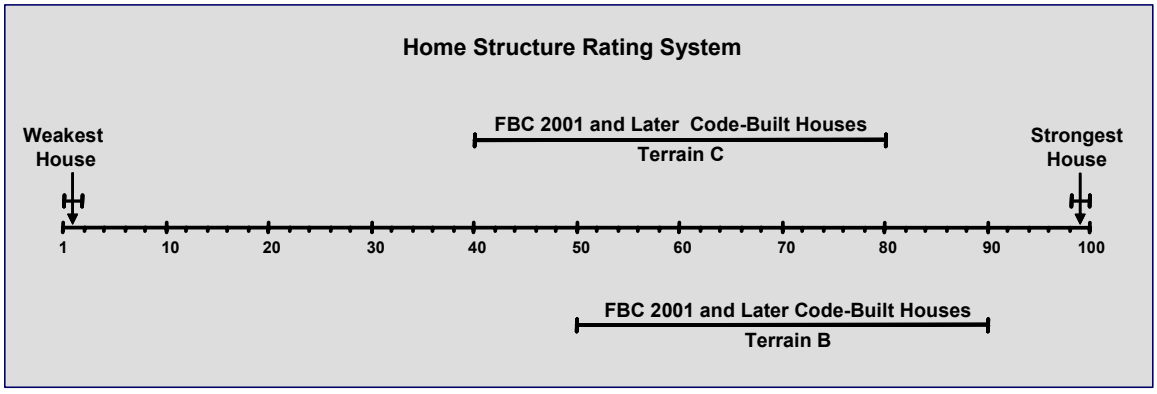
The score within each of Florida's "wind zones" is based on eight primary and eleven secondary inputs from these four groups of measures. The score does not reflect structures that may be attached to the home, such as screen enclosures or carports.

Score Interpretation. The HSRS score is founded in loss cost relativities. It measures the home's relative ability to withstand hurricane wind effects as an integrated structural system, including: roof covering, roof shape, roof deck, roof-to-wall, wall, wall-to-foundation, openings, and other components. A weakness in one or more of these building envelope components has a measurable affect on the score.

The HSRS was designed to be interpreted in a reasonably consistent manner throughout the State:

1. Within each of the wind zones in the State, the score for a FBC 2001 (and later) code-built home lies within a scoring range of 40 to 90.
2. FBC 2001 and later code construction with one or more code-plus improvements will always produce a score within or greater than the design range.
3. Effective loss mitigation improvements to a house, from among the 19 primary and secondary features, always produce higher scores.
4. A house in a Terrain B wind zone location scores higher than the same house in a Terrain C location within the same wind zone.

The range of score for FBC 2001 and later code-built homes is illustrated in the following figure.



Hence, a house with a score of 50 can be interpreted consistently, regardless of the wind zone location. In more severe wind zones (such as 120 mph and above), a house will need to have stronger construction features to achieve a good score than the same house in a milder wind zone (such as 100 mph).

The HSRS rating is not intended to be used or interpreted as a simplified stand-alone insurance rating measure. The HSRS scale was developed using loss relativities with a nonlinear risk-averse scoring function to promote wind mitigation of homes. While insurance rate differentials are determined from the same home inspection information as the HSRS rating, the determination of insurance rate differentials for wind mitigation features is more complicated than can be represented by a two-digit score. As the HSRS and insurance rate differentials further evolve, and as long as the HSRS is founded in loss cost relativities, there the rating score and insurance rate differentials should be reasonably correlated.

5.4 Testing of the HSRS

Testing of the HSRS was performed at three levels: Basic, Unit, and System. The Basic Testing involved producing HSRS scores for 1,088 combinations of different houses, wind zones, and terrains. These results produced reasonable scores and showed improved scores for mitigated houses. The scores behave consistently across wind zones and reflect the building code requirements within each zone.

The Unit Test involved testing the HSRS in the DBDDS for the same 1,088 cases analyzed in the basic tests. These tests confirmed that the programmed version of HSRS in the DBDDS performed consistently with the developmental FORTRAN code used to both develop the HSRS and to produce the Basic scores.

The System Testing involved testing the HSRS DBDDS against actual house inspection data from the MSFH pilot program. A total of 13,462 house inspections were used to produce HSRS scores for the existing house and the mitigation improvement plans. In addition, the MSFH pilot program HRR DBDDS version was run against these same houses (in order to compare HRR and HSRS scores). The HSRS scores are generally lower than the HRR scores, but result in a higher range of scores for code and code-plus construction. The HSRS scores consistently produce scores for FBC 2001 and later code-built houses in Terrain B between 50 and 90 and between 40 and 80 for Terrain C locations.

The testing confirms that the HSRS scores are performing in a reasonable manner and provide a consistent range of scores across wind zones, based on the home's construction and wind damage mitigation features. The HSRS scores increase monotonically with increasing mitigation of the building.

5.5 Limitations

While this initial HSRS has many desirable features, it also has many limitations. It is based largely on research done in the 2001-2002 period for single-family, site-built houses. The current HSRS rating system should not be applied to manufactured housing or multifamily structures. While the methodology is based on significant prior research, the relative scores are limited by our basic knowledge, estimation methods, and numerous uncertainties. Care must be

taken to ensure that the score is interpreted as a relative, best-estimate measure that is subject to further refinement and improvement. Much additional data exists now to improve the estimation of building performance and to validate the relative differences in construction and damage mitigation features, including new-code construction. The HSRS scale will need to evolve with improved methodologies and recognize further improvements in the building code. The ratings of homes will therefore need periodic updating to best reflect the structure's ability to withstand hurricane wind effects. A rough guess on the accuracy of a house's relative position on the HSRS scale is about ±10 points.

5.6 Implementation Recommendations

The implementation of the HSRS into the MSFH production mode requires:

1. Integration of the ARA modified DBDDS into the DFS DBDDS.
2. Testing of the integrated DBDDS on the DFS computer system to ensure that it produces the same scores as the testing performed under this project.
3. Updating the MSFH website and other materials regarding the interpretation of the home rating.

Wording changes to the homeowner report are given in Section 4.5.1 and have been implemented in the HSRS DBDDS.

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APPENDIX A: HRR DOCUMENTATION

A.1 HRR Background and Concept

In order to compare improvement plans objectively, a rating system was developed to measure the resistance of Florida homes to hurricane winds. The result is a location-independent Hurricane Resistance Rating (HRR) that can be used to quantify the existing ability of a home to resist hurricane winds as well as the potential increased resistance that can be gained through retrofitting.

The rating system is designed to use the data collected during the MSFH inspections to determine an HRR between 0 and 100 with 0 representing the weakest house and 100 representing the strongest. The rating scale developed is based largely on previous research conducted by the Florida Department of Community Affairs, insurance rate filings for Florida homes, and engineering judgment. Figure A-1 presents a flowchart of how a home's HRR is calculated.

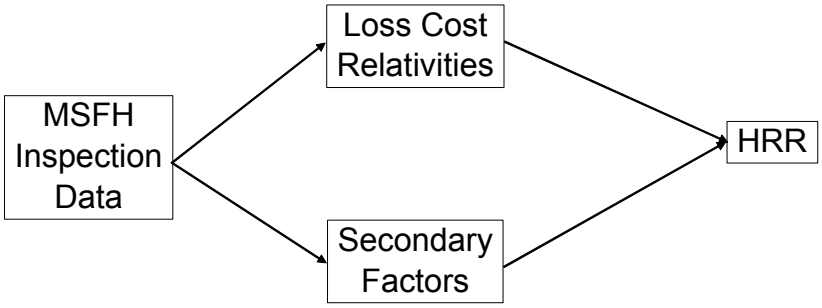


Figure A-1. Flowchart of Hurricane Resistance Rating Calculation.

It should be noted that this rating system is part of a pilot project and will likely be changed in the future to account for future research and increased understanding of how residential construction is affected by hurricane winds and wind-driven rain. It is not unreasonable for homes that today score in the 90s to score in the 70s in future versions of this rating scale.

A.2 My Safe Florida Home Inspection Data

Data gathered through the inspection process are used to determine the in situ construction and condition of each home in the program. This assessment is the input to determining each home's HRR. The *My Safe Florida Home* inspection documents the following features of each home which are used in the computation of HRR:

- Year built
- Number of stories
- Foundation type and restraint
- Roof shape
- Roof covering type and year installed
- Window, door and skylight debris protection ratings

- Wall construction type
- Roof deck type, thickness, and attachment
- Number of missed fasteners in roof deck attachment
- Presence of secondary water barrier
- Type of roof-to-wall connection
- Gable end bracing and sheathing type

Additional details on determining lookup values based on the data gathered by the *My Safe Florida Home* inspection checklist appears in Appendix A.

A.3 Loss Cost Relativities

In 2002, the Florida Department of Community Affairs published a report entitled "Development of Loss Relativities for Wind Resistive Features of Residential Structures" (Twisdale et. al, 2002). The loss cost relativities presented in this report formed the basis for insurance discounts for wind resistive features recommended by the Florida Department of Financial Services Office of Insurance Regulation (OIR). These relativities are based on the following features of Florida homes:

- Roof cover code (pre- or post-Florida Building Code)
- Roof deck material (wood or concrete)
- Roof deck fasteners and spacing (6d or 8d nails, field and edge spacing)
- Roof-to-wall connection (none, clips, single or double wrap straps)
- Glazed opening protection (none, basic, or hurricane level)
- Roof shape (hip or not hip)
- Secondary water resistance

Following the publication of this report, the United Service Automobile Association (USAA) insurance filing (FLFDS 2003a) followed the same methodology as the DCA study but included additional classification by roof cover type (tile or non-tile), and number of stories (1 or 2+).

Also, the Citizens Property Insurance Corporation insurance filing (FLFDS 2003b) considered the additional classification of Ordinary level of opening protection which was assigned a loss cost relativity equal to the average of the relativities for Hurricane level protection and no protection for each case.

As a result of this review of relativities and insurance filings, the USAA filing was chosen as the base for the creation of the Hurricane Resistance Rating scale. However, before transformation of the loss cost relativities to HRRs, the USAA filing was adjusted to include the ordinary level for window protection as calculated in the Citizens filing. Several secondary factors that were introduced in the original DCA study were also considered and are discussed in the following section.

A.4 Secondary Factors

The DCA report (Twisdale et. al. 2002) also included several secondary factors that could be applied to the loss relativities to account for additional features that were not included in the primary features. The secondary factors recommended in the report address:

- Unbraced gable ends
- Unreinforced masonry walls
- Reinforced masonry walls
- Unrestrained foundations
- All doors protected (in addition to all glazed openings)
- Roof decks with additional uplift capacity (dimensional lumber decks and decks fastened with screws)

In addition to these secondary factors, two additional secondary factors were developed to cover improved roof deck materials (5/8" or thicker plywood) and new code-plus roof covering materials. These factors were based on professional judgment from FLASH and ARA.

A.5 Transformation of Relativities to HRR

The loss cost relativities from the USAA filing (FLFDS 2003a) were then renormalized to the weakest house. In other words, each loss cost relativity was divided by the highest loss cost relativity in the tables. The house with the highest loss cost relativity is a two-story, gable roof , pre-FBC tile roof covering house with toe-nailed roof-to-wall connections, a plywood roof deck with 6d nails, no window protection and no secondary water barrier. Following normalization, the weakest house now has a relativity of 1 and the strongest house has a relativity near zero.

These normalized relativities are then transformed to a 0 to 100 Hurricane Resistance Rating scale where the weakest house receives a 0 and the strongest a 100. This transformation also takes into account the effect of the secondary factors so that the strongest house, after application of the secondary factors (such as reinforced masonry walls, all doors hurricane protected and superior roof deck), will have a value near, but not greater than, 100. The resulting transformation of the normalized loss cost relativities to a base Hurricane Resistance Rating (HRR_B) takes the form:

$$HRR_B = 93.65 * (1-r)$$

where:

HRR_B = Base Hurricane Resistance Rating

r = normalized relativity

A home's final HRR is calculated by multiplying the base HRR by each appropriate secondary factor:

$$HRR = HRR_B * SF_1 * SF_2 * \ldots SF_n$$

where:

HRR = Hurricane Resistance Rating

SF_i = Secondary Factor associated with the house

Tables A-1 through A-4 present the base Hurricane Resistance Ratings (HRR_B) that make before application of any secondary factors. Table A-5 shows the secondary factors developed for the rating system. The HRR for a given home can be calculated by looking up the appropriate base HRR from Tables A-1 through A-4 and multiplying the result by all applicable secondary factors from Table 2-5.

Table A-1. Base Hurricane Resistance Ratings (HRR_B) Before Application of Secondary Factors (SF) for One-Story Homes with Non-FBC Equivalent Roofs

				1 Story Shingle				1 Story Tile			
				Other Roof Shape		Hip Roof Shape		Other Roof Shape		Hip Roof Shape	
Roof Cover Code	Roof Deck Attachment	Roof-Wall Connection	Opening Protection	No SWR	SWR	No SWR	SWR	No SWR	SWR	No SWR	SWR
Non-FBC Equivalent Roof Cover	A	Toe Nail	None	33	36	49	51	19	22	34	36
			Basic	50	55	65	69	32	35	45	48
			Hurricane	56	61	70	74	35	39	48	51
			Ordinary	44	49	60	63	27	30	41	44
		Clips	None	44	48	59	62	24	26	38	40
			Basic	56	61	70	75	33	37	47	50
			Hurricane	59	65	73	77	36	39	48	52
			Ordinary	51	56	66	70	30	33	43	46
		Single Wrap	None	45	49	59	62	24	27	38	40
			Basic	56	62	70	75	34	37	47	50
			Hurricane	59	65	73	77	36	39	49	52
			Ordinary	52	57	66	70	30	33	43	46
		Double Wrap	None	45	49	59	62	24	27	38	40
			Basic	56	62	70	75	34	37	47	50
			Hurricane	59	65	73	77	36	39	49	52
			Ordinary	52	57	66	70	30	33	43	46
	B	Toe Nail	None	38	40	50	52	25	27	36	38
			Basic	58	61	67	70	41	44	48	50
			Hurricane	65	68	73	76	45	48	51	53
			Ordinary	51	54	61	64	35	38	43	45
		Clips	None	54	58	66	70	34	37	43	46
			Basic	69	73	75	79	45	49	51	53
			Hurricane	73	77	77	80	47	51	52	54
			Ordinary	63	68	71	75	40	44	48	50
		Single Wrap	None	60	66	68	74	36	40	44	48
			Basic	71	76	76	80	46	50	51	54
			Hurricane	73	79	77	81	47	51	52	54
			Ordinary	67	72	72	77	42	46	48	51
		Double Wrap	None	62	69	68	74	37	41	44	48
			Basic	72	78	76	80	46	50	51	54
			Hurricane	73	79	77	81	47	51	52	54
			Ordinary	68	74	72	78	42	46	48	51
	C	Toe Nail	None	38	40	50	52	26	28	36	38
			Basic	59	61	67	70	41	44	48	50
			Hurricane	65	68	73	76	46	49	51	53
			Ordinary	52	54	61	64	36	38	43	45
		Clips	None	55	58	66	70	35	38	44	47
			Basic	70	74	75	79	46	49	51	54
			Hurricane	74	78	77	80	48	51	52	54
			Ordinary	64	68	72	75	42	45	48	51
		Single Wrap	None	61	67	68	75	38	42	44	48
			Basic	73	77	76	80	47	51	51	54
			Hurricane	75	79	77	81	48	52	52	55
			Ordinary	68	73	73	78	43	47	48	51
		Double Wrap	None	64	73	69	76	39	45	45	48
			Basic	74	79	76	81	48	51	51	54
			Hurricane	75	80	77	81	48	52	52	55
			Ordinary	70	77	73	78	44	48	48	52

Table A-2. Base Hurricane Resistance Ratings (HRR_B) Before Application of Secondary Factors (SF) for One-Story Homes with FBC Equivalent Roofs and One-Story Homes with Concrete Roof Decks

				1 Story Shingle				1 Story Tile			
				Other Roof Shape		Hip Roof Shape		Other Roof Shape		Hip Roof Shape	
Roof Cover Code	**Roof Deck Attachment**	**Roof-Wall Connection**	**Opening Protection**	**No SWR**	**SWR**	**No SWR**	**SWR**	**No SWR**	**SWR**	**No SWR**	**SWR**
FBC Equivalent Roof Cover	A	Toe Nail	None	38	40	53	54	41	41	54	55
			Basic	57	58	71	72	55	55	67	67
			Hurricane	63	64	76	78	59	59	70	70
			Ordinary	51	52	65	66	50	50	62	62
		Clips	None	50	51	65	66	46	46	59	59
			Basic	63	65	76	78	57	58	69	69
			Hurricane	67	68	79	80	60	60	70	71
			Ordinary	58	60	72	73	53	53	65	65
		Single Wrap	None	52	53	65	66	46	47	59	59
			Basic	64	65	76	78	57	58	69	69
			Hurricane	67	68	79	80	60	60	70	71
			Ordinary	59	60	72	73	53	54	65	65
		Double Wrap	None	52	53	65	66	47	47	59	59
			Basic	64	65	77	78	57	58	69	69
			Hurricane	67	68	79	80	60	60	70	71
			Ordinary	59	61	72	73	53	54	65	65
	B	Toe Nail	None	42	43	54	55	45	46	55	56
			Basic	63	64	72	73	62	62	68	68
			Hurricane	70	71	78	79	66	67	71	72
			Ordinary	56	57	66	67	56	56	63	64
		Clips	None	60	61	72	73	56	56	65	65
			Basic	75	76	81	82	67	67	72	72
			Hurricane	79	81	82	83	69	69	72	73
			Ordinary	69	71	77	78	62	63	69	69
		Single Wrap	None	67	69	75	77	59	59	66	66
			Basic	78	80	82	83	68	68	72	72
			Hurricane	80	82	83	84	69	70	72	73
			Ordinary	73	75	79	80	64	65	69	70
		Double Wrap	None	70	72	75	78	60	60	66	66
			Basic	79	81	82	83	68	69	72	72
			Hurricane	80	82	83	84	69	70	73	73
			Ordinary	75	77	79	81	64	65	69	70
	C	Toe Nail	None	42	43	54	55	46	46	55	56
			Basic	64	64	72	73	62	62	68	68
			Hurricane	70	71	78	79	67	67	71	72
			Ordinary	56	57	66	67	56	57	63	64
		Clips	None	60	61	72	74	57	57	65	65
			Basic	76	77	81	82	67	68	72	72
			Hurricane	80	81	82	83	69	70	73	73
			Ordinary	70	71	77	79	63	64	69	69
		Single Wrap	None	68	70	76	78	60	61	66	67
			Basic	79	80	82	83	69	69	72	73
			Hurricane	81	82	83	84	70	70	73	73
			Ordinary	75	76	79	81	65	66	69	70
		Double Wrap	None	73	76	76	79	62	63	66	67
			Basic	81	82	82	84	69	70	72	73
			Hurricane	81	83	83	84	70	71	73	73
			Ordinary	77	80	80	81	66	67	70	70
Concrete Roof Deck			None	87	87	87	87	87	87	87	87
			Basic	92	92	92	92	92	92	92	92
			Hurricane	93	93	93	93	93	93	93	93
			Ordinary	90	90	90	90	90	90	90	90

Table A-3. Base Hurricane Resistance Ratings (HRR_B) Before Application of Secondary Factors (SF) for Two-Story Homes with Non-FBC Equivalent Roofs

				2 Story Shingle				2 Story Tiles			
				Other Roof Shape		Hip Roof Shape		Other Roof Shape		Hip Roof Shape	
Roof Cover Code	Roof Deck Attachment	Roof-Wall Connection	Opening Protection	No SWR	SWR	No SWR	SWR	No SWR	SWR	No SWR	SWR
Non-FBC Equivalent Roof Cover	A	Toe Nail	None	11	15	23	27	0	3	10	13
			Basic	37	43	51	58	24	29	35	39
			Hurricane	39	45	53	60	26	30	36	40
			Ordinary	25	30	38	43	13	17	23	27
		Clips	None	21	26	33	37	7	10	15	18
			Basic	45	52	57	64	28	33	37	42
			Hurricane	46	54	58	66	30	34	38	43
			Ordinary	34	40	45	51	19	22	27	30
		Single Wrap	None	24	29	33	37	9	11	15	18
			Basic	46	54	57	64	29	33	37	41
			Hurricane	48	55	58	66	30	34	38	43
			Ordinary	36	42	45	51	19	23	27	30
		Double Wrap	None	25	29	33	36	9	11	16	18
			Basic	46	54	57	64	29	33	37	41
			Hurricane	48	55	58	66	30	34	38	43
			Ordinary	36	42	45	51	19	23	27	30
	B	Toe Nail	None	16	19	25	28	6	9	13	16
			Basic	46	50	57	61	36	39	40	43
			Hurricane	48	52	59	63	38	41	42	45
			Ordinary	32	36	42	45	22	25	27	30
		Clips	None	32	36	48	54	20	23	29	34
			Basic	61	67	68	74	43	47	46	50
			Hurricane	63	68	69	75	44	48	47	51
			Ordinary	48	52	59	65	32	36	38	42
		Single Wrap	None	42	48	52	61	26	30	31	36
			Basic	66	72	69	76	45	50	46	51
			Hurricane	67	73	70	77	46	51	47	51
			Ordinary	55	61	61	69	36	41	39	44
		Double Wrap	None	49	57	53	62	29	34	31	37
			Basic	68	75	70	76	46	51	46	51
			Hurricane	69	77	71	77	47	52	47	51
			Ordinary	59	67	62	69	38	43	39	44
	C	Toe Nail	None	17	20	25	28	7	9	14	16
			Basic	46	50	57	61	36	39	40	43
			Hurricane	49	52	59	63	38	41	42	45
			Ordinary	33	36	42	46	22	25	28	31
		Clips	None	33	37	48	55	21	24	30	35
			Basic	63	67	69	74	44	48	46	50
			Hurricane	65	69	70	75	46	49	47	51
			Ordinary	49	53	59	65	33	37	39	43
		Single Wrap	None	44	49	54	64	28	33	32	39
			Basic	68	73	70	77	47	51	47	51
			Hurricane	69	74	71	77	48	52	48	52
			Ordinary	56	62	62	71	38	43	40	46
		Double Wrap	None	54	65	55	67	33	40	33	40
			Basic	71	78	71	78	49	53	47	52
			Hurricane	72	78	72	79	49	54	48	53
			Ordinary	63	72	63	73	41	47	40	46

Table A-4. Base Hurricane Resistance Ratings (HRR_B) Before Application of Secondary Factors (SF) for Two-Story Homes with FBC Equivalent Roofs and Two-Story Homes with Concrete Roof Decks

				2 Story Shingle				2 Story Tiles			
				Other Roof Shape		Hip Roof Shape		Other Roof Shape		Hip Roof Shape	
Roof Cover Code	Roof Deck Attachment	Roof-Wall Connection	Opening Protection	No SWR	SWR	No SWR	SWR	No SWR	SWR	No SWR	SWR
FBC Equivalent Roof Cover	A	Toe Nail	None	15	18	27	29	17	19	28	30
			Basic	43	45	58	60	45	46	56	57
			Hurricane	45	47	61	63	47	48	57	58
			Ordinary	30	32	44	46	32	33	43	44
		Clips	None	26	28	38	39	26	27	36	36
			Basic	53	55	65	67	50	51	59	60
			Hurricane	54	56	66	69	51	52	60	61
			Ordinary	40	42	52	54	39	39	48	49
		Single Wrap	None	30	31	38	39	28	28	36	36
			Basic	54	56	65	67	51	51	59	60
			Hurricane	56	58	66	68	52	52	60	61
			Ordinary	43	44	52	54	40	40	48	49
		Double Wrap	None	30	31	38	39	28	29	36	36
			Basic	54	56	65	67	51	51	59	60
			Hurricane	56	58	66	69	52	52	60	61
			Ordinary	43	45	52	54	40	40	48	49
	B	Toe Nail	None	20	22	29	31	22	24	31	32
			Basic	50	52	62	63	53	54	59	60
			Hurricane	53	54	64	65	55	56	61	61
			Ordinary	36	38	47	48	39	40	46	47
		Clips	None	36	38	55	57	38	39	50	51
			Basic	67	69	75	76	61	62	66	67
			Hurricane	69	71	76	77	63	64	67	67
			Ordinary	53	54	65	67	50	51	58	59
		Single Wrap	None	48	50	61	64	45	46	53	54
			Basic	72	74	76	78	64	65	66	67
			Hurricane	73	75	77	79	65	66	67	68
			Ordinary	61	63	69	72	55	56	60	61
		Double Wrap	None	57	59	62	64	49	50	53	54
			Basic	75	78	77	79	65	66	67	67
			Hurricane	76	79	77	79	66	67	67	68
			Ordinary	67	69	70	72	58	59	60	61
	C	Toe Nail	None	20	22	29	31	22	24	31	32
			Basic	50	52	62	63	54	54	59	60
			Hurricane	53	54	64	65	56	56	61	61
			Ordinary	36	38	46	48	39	40	46	47
		Clips	None	37	39	55	58	38	40	51	52
			Basic	68	69	75	77	62	63	66	67
			Hurricane	70	71	76	78	64	64	67	68
			Ordinary	53	55	66	68	51	52	59	60
		Single Wrap	None	50	51	63	67	47	48	54	56
			Basic	73	75	77	79	65	66	67	68
			Hurricane	75	76	78	80	66	67	68	69
			Ordinary	62	64	71	73	57	58	61	62
		Double Wrap	None	63	67	65	69	54	56	55	56
			Basic	77	80	78	81	67	68	68	69
			Hurricane	78	80	79	81	68	69	68	69
			Ordinary	71	74	72	75	61	62	62	63
Concrete Roof Deck			None	82	82	82	82	82	82	82	82
			Basic	89	89	89	89	89	89	89	89
			Hurricane	90	90	90	90	90	90	90	90
			Ordinary	86	86	86	86	86	86	86	86

Table A-5. Secondary Factors (SF) Used to Modify Base Hurricane Resistance Rating

Description	Secondary Factor
Unbraced Gable Ends	0.98
Unreinforced Masonry Walls	1.02
Reinforced Masonry Walls	1.05
Unrestrained Foundation	0.65
All Doors & Glazed Openings Protected	1.02
Dimensional Lumber/Screwed Roof Deck	1.04
Code Plus Roof Deck (>= 5/8" Plywood)	1.01
Code Plus Roof Covering	1.01

APPENDIX B: MSFH SURVEY CHECKLIST

This appendix contains Version 10.1 of the survey checklist.

SR Number:_____

My Safe Florida Home Survey Checklist

Section A Inspector Information

Date Assigned: _____ WCE: _____ Date Inspected: _____

Inspector: _____ Inspection Company: _____

Start time: _____ Finish Time: _____

Dates of Attempted Calls: 1st _____ 2nd _____ 3rd _____

Section B Owner Information

Owner's Name: _____ Contact Person: _____

Property Address: _____ Home Phone: _____

City: _____ Work Phone: _____

County: _____ Cell Phone: _____

Zip Code: _____ E-Mail Address: _____

Insurance Co: _____ Policy Number: _____

Section C General Building Information

Year Built	Number of Stories	Foundation	Foundation Restraint
☐ Year Known	☐ 1 Story	☐ Pier/Piling	☐ Anchor Bolts
☐ Year Estimated	☐ 2 Story	☐ Slab on Grade	☐ Cut Nails
	☐ 3 Story	☐ Stem wall	☐ Rebar
	☐ 4 Story		☐ None

WCE Office to Complete the following information

Wind Speed ☐ Exposure Cat *B* *C* (Circle one) WBDR *No* *Yes* (Circle one)

Section D Signature

I acknowledge that (inspector name) _____ ID Number _____ inspected the home at the address shown above and no damage was caused to the home and/or any property.

I also acknowledge that I received the DFS Homeowner Tips Guide or the FLASH Tips flyer.

Printed Name: Date:

Signature:

Section E Codes

Window Type	
Single Hung	SH
Double Hung	DH
Horizontal Sliding	HS
Awning / Jalousie	AW
Casement	CS
Fixed glass	FG

Door Type	
Single Hinged (out swing)	SO
Double Hinged (out swing)	DO
Single Hinged (in swing)	SI
Double Hinged (in swing)	DI
Sliding Glass	SG
Garage (Single)	GS
Garage (Double)	GD

Protection Codes:	
Hurricane	H
Basic	B
Ordinary	O
NOT RATED (pre 1994)	NR
None	X

SR Number:_____

Front Elevation

Section F-1 Exterior Roof Information

Roof Shape

☐	Gable	☐	Hip	☐	Flat
☐	Gambrel	☐	Mansard	☐	Other

Roof Complexity

☐	Simple Roof Shape
☐	Moderate Roof Shape
☐	Complex Roof Shape

Roof Covering (Front Elevation Only)

☐	Shingles	☐	Tile	**Year installed:**	☐ Year Known
☐	Wood	☐	Metal		☐ Year Estimated
☐	Other				

Section G-1 Window Openings

Number	Quantity	Window Type	Floor	Opening in Inches		Protection	
				Width	Height	Code	Yr. Installed
1							
2							
3							
4							
5							
6							
7							

Section H-1 Doors

Number	Quantity	Door Type	Floor	Opening in Inches		Protection		Glazed	
				Width	Height	Code	Yr. Installed	Yes	No
1									
2									
3									
4									

Section I-1 Skylights

Quantity	Daylight/Buck		Protection	
	Width	Height	Code	Yr. Installed

Section J-1 Gable Ends (all dimensions in inches)

Quantity	Height	Bottom Chord Width	Vent-inches	
			Width	Height

Section K-1 Wall Cladding (circle floor)

	Aluminum Siding	*1*	*2*	*3*	*4*		Stucco	*1*	*2*	*3*	*4*
	Vinyl Siding	*1*	*2*	*3*	*4*		Brick Veneer	*1*	*2*	*3*	*4*
	Wood Siding	*1*	*2*	*3*	*4*		Painted Block	*1*	*2*	*3*	*4*

Other	*1*	*2*	*3*	*4*	

Section L-1 Wall Construction (circle floor)

	Concrete Block Un-Reinforced	*1*	*2*	*3*	*4*		Solid Concrete	*1*	*2*	*3*	*4*	
	Concrete Block Reinforced	*1*	*2*	*3*	*4*		Wood/Light Metal Frame	*1*	*2*	*3*	*4*	

Section M-1 Reinforcement Check: (check 3- 5 locations for entire house)

Not Applicable ☐ Left Corner ☐ Window/Door ☐ Right Corner ☐

Section N-1 Carport

(Circle Applicable)

None *Built-In*

Attached *Detached*

Number of Cars: _____

Section O-1 Porches

(Exclude Pool Screen Enclosure)

(Circle Size and Type)

Size	**Type**
Small	*Open*
Medium	*Screened*
Large	*Enclosed*

Section P-1 Soffits

Overhang (inches)	**Horizontal Length** (linear feet)

Type

☐ Solid/Wood/Other

☐ Vinyl/Aluminum

☐ None

SR Number:_____

Right Elevation

Section F-2 Exterior Roof Information

Roof Shape

☐	Gable	☐	Hip	☐	Flat
☐	Gambrel	☐	Mansard	☐	Other

Roof Complexity

☐ Simple Roof Shape
☐ Moderate Roof Shape
☐ Complex Roof Shape

Section G-2 Window Openings

Number	Quantity	Window Type	Floor	Opening in Inches		Protection	
				Width	Height	Code	Yr. Installed
1							
2							
3							
4							
5							
6							
7							

Section H-2 Doors

Number	Quantity	Door Type	Floor	Opening in Inches		Protection		Glazed	
				Width	Height	Code	Yr. Installed	Yes	No
1									
2									
3									
4									

Section I-2 Skylights

Quantity	Daylight/Buck		Protection	
	Width	Height	Code	Yr. Installed

Section J-2 Gable Ends (all dimensions in inches)

Quantity	Height	Bottom Chord Width	Vent	
			Width	Height

Section K-2 Wall Cladding (circle floor)

	Aluminum Siding	*1*	*2*	*3*	*4*		Stucco	*1*	*2*	*3*	*4*	
	Vinyl Siding	*1*	*2*	*3*	*4*		Brick Veneer	*1*	*2*	*3*	*4*	Other *1 2 3 4*
	Wood Siding	*1*	*2*	*3*	*4*		Painted Block	*1*	*2*	*3*	*4*	

Section L-2 Wall Construction (circle floor)

	Concrete Block Un-Reinforced	*1*	*2*	*3*	*4*		Solid Concrete	*1*	*2*	*3*	*4*	
	Concrete Block Reinforced	*1*	*2*	*3*	*4*		Wood/Light Metal Frame	*1*	*2*	*3*	*4*	

Section M-2 Reinforcement Check: (check 3- 5 locations for entire house)

Not Applicable ☐ Left Corner ☐ Window/Door ☐ Right Corner ☐

Section N-2 Carport

(Circle Applicable)

None *Built-In*

Attached *Detached*

Number of Cars: _____

Section O-2 Porches

(Exclude Pool Screen Enclosure)

(Circle Size and Type)

Size	Type
Small	*Open*
Medium	*Screened*
Large	*Enclosed*

Section P-2 Soffits

Overhang (inches)	Horizontal Length (linear feet)

Type
☐ Solid/Wood/Other
☐ Vinyl/Aluminum
☐ None

SR Number:_____

Back Elevation

Section F-3 Exterior Roof Information

Roof Shape

☐	Gable	☐	Hip	☐	Flat
☐	Gambrel	☐	Mansard	☐	Other

Roof Complexity

☐ Simple Roof Shape
☐ Moderate Roof Shape
☐ Complex Roof Shape

Section G-3 Window Openings

Number	Quantity	Window Type	Floor	Opening in Inches		Protection	
				Width	Height	Code	Yr. Installed
1							
2							
3							
4							
5							
6							
7							

Section H-3 Doors

Number	Quantity	Door Type	Floor	Opening in Inches		Protection		Glazed	
				Width	Height	Code	Yr. Installed	Yes	No
1									
2									
3									
4									

Section I-3 Skylights

Quantity	Daylight/Buck		Protection	
	Width	Height	Code	Yr. Installed

Section J-3 Gable Ends (all dimensions in inches)

Quantity	Height	Bottom Chord Width	Vent	
			Width	Height

Section K-3 Wall Cladding (circle floor)

	Aluminum Siding	*1*	*2*	*3*	*4*		Stucco	*1*	*2*	*3*	*4*	
	Vinyl Siding	*1*	*2*	*3*	*4*		Brick Veneer	*1*	*2*	*3*	*4*	Other *1* *2* *3* *4*
	Wood Siding	*1*	*2*	*3*	*4*		Painted Block	*1*	*2*	*3*	*4*	

Section L-3 Wall Construction (circle floor)

	Concrete Block Un-Reinforced	*1*	*2*	*3*	*4*		Solid Concrete	*1*	*2*	*3*	*4*
	Concrete Block Reinforced	*1*	*2*	*3*	*4*		Wood/Light Metal Frame	*1*	*2*	*3*	*4*

Section M-3 Reinforcement Check: (check 3- 5 locations for entire house)

Not Applicable ☐ Left Corner ☐ Window/Door ☐ Right Corner ☐

Section N-3 Carport

(Circle Applicable)

None *Built-In*

Attached *Detached*

Number of Cars: _____

Section O-3 Porches

(Exclude Pool Screen Enclosure)

(Circle Size and Type)

Size	Type
Small	*Open*
Medium	*Screened*
Large	*Enclosed*

Section P-3 Soffits

Overhang (inches)	Horizontal Length (linear feet)

Type

☐ Solid/Wood/Other
☐ Vinyl/Aluminum
☐ None

SR Number:_____

Left Elevation

Section F-4 Exterior Roof Information

Roof Shape

☐	Gable	☐	Hip	☐	Flat
☐	Gambrel	☐	Mansard	☐	Other

Roof Complexity

☐ Simple Roof Shape
☐ Moderate Roof Shape
☐ Complex Roof Shape

Section G-4 Window Openings

Number	Quantity	Window Type	Floor	Opening in Inches		Protection	
				Width	Height	Code	Yr. Installed
1							
2							
3							
4							
5							
6							
7							

Section H-4 Doors

Number	Quantity	Door Type	Floor	Opening in Inches		Protection		Glazed	
				Width	Height	Code	Yr. Installed	Yes	No
1									
2									
3									
4									

Section I-4 Skylights

Quantity	Daylight/Buck		Protection	
	Width	Height	Code	Yr. Installed

Section J-4 Gable Ends (all dimensions in inches)

Quantity	Height	Bottom Chord Width	Vent	
			Width	Height

Section K-4 Wall Cladding (circle floor)

	Aluminum Siding	*1*	*2*	*3*	*4*		Stucco	*1*	*2*	*3*	*4*
	Vinyl Siding	*1*	*2*	*3*	*4*		Brick Veneer	*1*	*2*	*3*	*4*
	Wood Siding	*1*	*2*	*3*	*4*		Painted Block	*1*	*2*	*3*	*4*

Other *1* *2* *3* *4*

Section L-4 Wall Construction (circle floor)

	Concrete Block Un-Reinforced	*1*	*2*	*3*	*4*		Solid Concrete	*1*	*2*	*3*	*4*
	Concrete Block Reinforced	*1*	*2*	*3*	*4*		Wood/Light Metal Frame	*1*	*2*	*3*	*4*

Section M-4 Reinforcement Check: (check 3- 5 locations for entire house)

Not Applicable ☐ Left Corner ☐ Window/Door ☐ Right Corner ☐

Section N-4 Carport

(Circle Applicable)

None *Built-In*

Attached *Detached*

Number of Cars: _____

Section O-4 Porches

(Exclude Pool Screen Enclosure)

(Circle Size and Type)

Size	Type
Small	*Open*
Medium	*Screened*
Large	*Enclosed*

Section P-4 Soffits

Overhang (inches)	Horizontal Length (linear feet)

Type

☐ Solid/Wood/Other
☐ Vinyl/Aluminum
☐ None

SR Number:_____

Section Q Roof Deck

Materials

- [ ] No Access
- [ ] Plywood
- [ ] OSB
- [ ] Planks/Dimensional Lumber
- [ ] Concrete
- [ ] Deck over Battens
- [ ] Battens
- [ ] Metal Deck
- [ ] Other

Roof Slope: _____ /12

Deck Thickness

(Nominal)

- [ ] No Access
- [ ] 3/8"
- [ ] 7/16"
- [ ] 1/2"
- [ ] 5/8"
- [ ] 3/4"
- [ ] =>1"
- [ ] Other

Roof Deck Attachment

- [ ] No Access
- [ ] Staples
- [ ] 6d Nail
- [ ] 8d Nail
- [ ] 10d Nail
- [ ] Screws (=> #8 x 2.5")

- [ ] Spray Foam Adhesive
- [ ] Construction Adhesive

Average # of missed nails in 4' of structure:

[ ] 0 [ ] 1 [ ] 2 [ ] 3 [ ] 4+

Spacing

- [ ] > 6"/12"
- [ ] 6"/12"
- [ ] 6"/6"

Section R Roof Structure Materials

- [ ] No Access
- [ ] Rafters
- [ ] Wood Trusses
- [ ] Light Metal Trusses

Spacing: *12" 16" 24" >24"*
(Circle one)

Section S Secondary Water Barrier

- [ ] Exterior
- [ ] Interior
- [ ] None

How verified: *Photos* *Documents* *Other*
(Circle Applicable)

Spray Foam Adhesive: Y [ ] N [ ]

If none, is there > than 4 feet of height? Y [ ] N [ ]

Section T Roof to Wall Connection

No Access	Severe Corrosion	3 or More Nails	Every Truss/Rafter	Within 1.5" of Trusses
[ ]	Y [ ] N [ ]	Y [ ] N [ ]	Y [ ] N [ ]	Y [ ] N [ ]

[ ] None [ ] Toe Nail [ ] Clips [ ] Single Wrap [ ] Double Wrap [ ] Unknown

If Unknown, Explain why: _____

Section U Gable End Wall Construction

Gables 4 feet or more in height:	Count:
No Access	
Not Braced - Cathedral Ceiling	
Not Braced - Flat Ceiling	
Braced Gables:	
Balloon	
Deck/Diaphragm	
Diagonal Bottom or X Bracing	
Horizontal Continuous	
Masonry Cathedral	
Masonry Flat Ceiling	
Gables less than 4 feet in height:	
Total number of ALL Gables:	

(Total must equal # of gables listed on four elevations)

Gable Wall Sheathing (check type)

- [ ] Plywood
- [ ] OSB
- [ ] Planks
- [ ] Non-wood / Insulation
- [ ] None
- [ ] Masonry

Section V Building Footprint Area

Plan View of House (for calculating building footprint area)

Total Building Footprint Area = _____ sq. ft.

APPENDIX C: EXAMPLE MSFH "HOME INSPECTION REPORTS"

This appendix contains two example reports. The first report represents a Version 1.0 HRR report. The second report corresponds to a Version 2.0 HSRS report.

The differences in the two reports are documented in Section 4.5

Home Inspection Report

for [NAME]

Mailing Address:
[ADDRESS]
[City], [STATE] [ZIP]

Property Location:
[ADDRESS]
[City], [STATE] [ZIP]

Dear Homeowner,

At your request, the State of Florida has paid for an inspection of your home by a qualified wind mitigation inspector. The purpose of this report is to identify specific actions that you can take to strengthen your home against hurricane winds. Please use this report as a resource to make your home as hurricane-resistant as possible. Because the *My Safe Florida Home* program has limited funds, receiving this report does not guarantee your eligibility or approval for a grant to make the improvements recommended in this report.

This report provides you with:

- Your home's current level of resistance to hurricane winds
- Specific improvements that will increase your home's hurricane wind resistance
- The estimated costs of improvements
- Your potential savings on homeowner's wind insurance premiums
- Guidelines on securing bids from licensed contractors to perform the recommended improvements

To help you get the most out of your report, an easy to understand *Inspection Report User's Guide* has been included along with your report. Please refer to this User's Guide for answers to questions you may have about your inspection report and the *My Safe Florida Home* program.

Thank you for your participation in the My Safe Florida Home program.

Sincerely,

My Safe Florida Home program

Section 1: Home Inspection Report

Understanding your home's hurricane wind resistance rating

The hurricane wind resistance ratings provided in this report are estimated numbers on a scale of 0 to 100. The ratings are designed to provide a general indication of how well your home is expected to perform over a broad range of hurricanes with different intensities and wind directions. Homes built to Florida's current strictest building code requirements will have ratings near 100 while the weakest homes will have ratings approching zero.

Your home's current hurricane wind resistance rating is estimated to be 34.

It is important to realize that the ratings in this report only consider a practical number of inspection features and do not treat the location of the home within Florida. New research to improve the rating system is now underway which may result in adjustments to the rating scale.

Your house has the following beneficial features that contribute to its current hurricane wind resistance rating:

- One story
- Non-tile roof covering
- Reinforced masonry wall construction
- Restrained foundation

Please contact your homeowner's insurance agent or insurance company to find out if you are eligible for windstorm loss reduction credits or discounts for these features and to determine how to apply for them.

Why you should consider strengthening your home

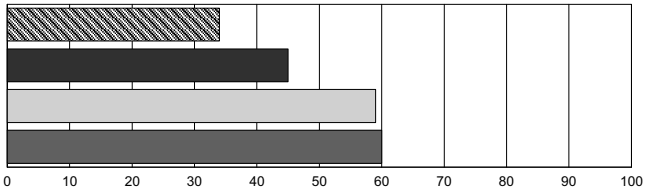
Taking steps to increase your hurricane wind rating will:

- Make your house safer, providing increased levels of protection for you and your family.
- Reduce the likelihood of future property losses.
- Reduce the likelihood of damage to irreplaceable possessions.
- Reduce the likelihood of being displaced from your home following a storm.
- Possibly make you eligible to receive discounts on windstorm insurance.
- Reduce the likelihood of having to pay the deductible portion of windstorm insurance. Your current windstorm deductible is $0.
- Possibly increase in the resale value of your house.

The following chart shows your home's current wind rating. It also shows the wind rating you could achieve if you implement any of the up to three Recommended Improvement Plans developed as a result of your recent home inspection (denoted as Plans A, B and C). The details of these plans are included in Sections 1 and 2 of this report and in the contractor bid sheets provided in Appendix A.

Each improvement plan offers a combination of hurricane-resistance features. Based on the combination of features in each plan, the chart below details how much it is estimated to cost you to implement that plan and the possible discount or credit you may qualify for on the winstorm portion of your insurance premium.

Hurricane Wind Rating



	Rating	Estimated Cost	Estimated Discount
CURRENT	34	$0	0%
PLAN A	45	$1,248	17%
PLAN B	59	$2,813	22%
PLAN C	60	$3,313	22%

By making all of the improvements recommended in Improvement Plan C, you can increase your home's rating by as much as 26 points to a total rating of 60.

Making your home stronger - Improvement options considered in this report

There are seven wind-resistance improvements covered by the *My Safe Florida Home* program. The recommended improvements developed for your home will fall within these seven improvement categories. For additional information about these seven improvements, please refer to the *Inspection Report User's Guide.*

The seven improvements are:

Improvement 1) Improving the strength of your roof deck attachment. For example, if your roof consists of shingles nailed to plywood sheets, the inspection may reveal that the plywood sheets are not adequately nailed to your roof trusses, and that additional nails and/or longer nails need to be added to reduce the possibility of the plywood from being blown off in a hurricane.

NOTE: There are two options for implementing Improvement 1. They are:

1a. Interior roof deck attachment (installed on the underside of the roof via the attic)
1b. Exterior roof deck attachment (installed when home is being re-roofed)

Improvement 2) Creating a secondary water barrier to prevent water intrusion. For example, using strips of "peel and stick-on" material that covers the joints between the plywood sheets on your roof to reduce leakage until repairs can be made if a hurricane blows off your roof covering.

NOTE: There are two options for implementing Improvement 2. They are:

2a. Interior secondary water barrier (installed on the underside of the roof via the attic)
2b. Exterior secondary water barrier (installed betweent the roof deck and roof cover)

Improvement 3) Upgrading roof covering. For example, upgrading to stronger hurricane-resistant roof shingles, attached with properly sized and properly applied roofing nails, to reduce the susceptibility of your roof shingles blowing off in a hurricane.

Improvement 4) Bracing gable-end walls. This is usually done inside your attic to decrease chances that gable end walls will fail under hurricane wind loads.

Improvement 5) Reinforcing roof-to-wall connections. For example, installing metal tie-down clips that attach roof rafters to walls to decrease chances that all or a portion of your roof will simply lift off your house during a hurricane.

Improvements 6 & 7) Window protection (6) and door protection (7). For example, installing hurricane-rated window shutters or replacing a standard garage door with a hurricane-rated garage door. Protection of gable end wall vents, if present, is also recommended under this improvement.

There are three options for implementing Improvements 6 & 7. They are:

Improvement 6a/7a. Standard - This improvement is the lowest-cost option for protecting windows, doors and other openings. On a one-story house, this improvement would provide temporary structural panels for each opening that would need to be installed each time a serious storm threatened the home. On a two-story house, this improvement would typically be a combination of panel shutters (first floor) and permanently attached shutters (second floor).

Improvement 6b/7b. Permanently attached - Protective devices that are always attached to the house and only need to be deployed when a hurricane is approaching.

Improvement 6c/7c. Permanently deployed - These are protective devices such as impact-rated glass windows and doors that require no installation when a hurricane is approaching. Some homeowners may want to upgrade from standard opening protection to permanently attached or permanently deployed protection as a matter of convenience. Section 2 of your report lists the estimated costs associated with this option.

NOTE: Improvements 6 & 7 are combined because it is recommended that they be undertaken together.

THE RECOMMENDED IMPROVEMENTS FOR YOUR HOME WILL FALL WITHIN THE SEVEN CATEGORIES SHOWN ABOVE. Please use these categories as a reference when reviewing the recommended improvements for your home outlined in this report. For additional information about these seven improvement categories, please refer to the *Inspection Report User's Guide.*

Recommended Improvement Plans for Your House

Based on the results of your home inspection, the recommended improvement plans for your house are outlined in the table below. For each improvement plan, the table provides the new hurricane wind rating after the improvements are completed, the estimated cost of the improvements, and the estimated annual wind insurance premium savings. The chart also shows which of the seven Improvements are included in your recommended Improvement Plans.

Plan	Improvement(s) (See Appendix A for Details)	Hurricane Wind Rating	Estimated Cost**	Estimated Annual Premium Savings*	
				Percent	Dollars
	Current condition of house	34	$0	0%	$0
A	Reinforce roof-to-wall connection Recommended Improvement 5	45	$1,248	17%	$289
B	Window and door protection Recommended Improvement 6a7a	59	$2,813	22%	$374
C	Brace gable ends Recommended Improvement 4 Window and door protection Recommended Improvement 6a7a	60	$3,313	22%	$374

* Estimated annual premium savings are based on your current insurance company's (CITIZENS PROPERTY INSURANCE CORPORATION) windstorm loss reduction credits and your current base wind premium of $1,702 per year. Possible discounts are estimates and do not factor in future rate changes.

** A breakdown of estimated costs for each improvement plan is provided in Section 2 of this report.

Note on Insurance Premiums and Potential Discounts

Payment for insurance is usually called a "premium". In the case of homeowner's insurance, the premium is divided into at least two parts on most comprehensive policies. One part of the premium is for winstorm damage -- the type that occurs during a hurricane. The other part of the premium covers such perils as fire and theft. These details should be spelled out on your insurance policy's "declaration page".

Any discount for making your house stronger will **only** be applied to the **windstorm** portion of your premium.

Section 2: Estimated Improvement Costs & Contractor Bid Summary

IMPORTANT:
Do not show this page to the contractors when requesting cost estimates

Use the following table to compare contractor bids. Please note that the bids you receive may be substantially different than the *My Safe Florida Home* estimates due to the current availability and cost of materials and labor in your area, installation details that are specific to your house, and other factors. You should make your final decision based on the actual bids rather than the estimates given in this report. This table includes cost details for the recommended improvement plans outlined on the previous pages. It also outlines alternative improvement methods you can consider as substitutes for elements within your recommended plans. Additionally, the chart outlines additional improvements that can help make your home more hurricane resistant.

IN	Description of Improvement	Estimated Cost	Bid 1	Bid 2	Bid 3
	Recommended Improvements				
	Plan A				
5	Reinforce roof-to-wall connection	$1,248			
	TOTAL	**$1,248**			
	Plan B				
6a7a	Window & door protection - standard	$2,813			
	TOTAL	**$2,813**			
	Plan C				
4	Brace gable ends	$500			
6a7a	Window & door protection - standard	$2,813			
	TOTAL	**$3,313**			
	Alternative Improvements				
6b7b	Window & door protection - perm. attached	$5,060			
6c7c	Window & door protection - perm. deployed	$12,150			
	Additional Improvements				
1a	Roof deck attachment - interior	$2,250			
1b	Roof deck attachment - exterior	$80			
2a	Secondary water barrier - interior	$0			
2b	Secondary water barrier - exterior	$497			
3	Upgrade roof covering	$640			
IN	= Improvement Number				

IMPORTANT: The footnotes below provide helpful detail on the improvements outlined in the table above. Please refer to them to gain a better understanding of your options in strengthening your home. For additional information about these improvements, please refer to the *Inspection Report User's Guide* included with your report.

Footnote # 2a When an interior foam adhesive roof deck attachment is installed in a home, a secondary water barrier is also achieved. Therefore, no cost is shown for the interior secondary water barrier improvement (Improvement Category 2a).

Footnote # 1b, 2b

If you are planning to re-roof your house within the next three years due to normal deterioration with age, there is a more cost effective way to achieve improved roof performance. Instead of implementing improvements 1a (roof deck attachment - interior) and 2a (secondary water barrier - interior), it is generally more cost effective to re-roof your home now and substitute the following improvements:

Improvement 1b (roof deck attachment - exterior)
Improvement 2b (secondary water barrier - exterior)
Improvement 3 (upgrade roof covering) (See footnote # 3)

Footnote # 3 Since re-roofing your home is considered a normal part of home maintenance, the basic cost of re-roofing your home is not eligible for matching grants from the *My Safe Florida Home* program. However, if you re-roof your home with a roof covering that exceeds the minimum building code requirements, you are eligible for matching grants for the difference in the cost between the upgraded or "code-plus" roof covering and the standard or "code-minimum" roof covering. (Code Minimum is defined as products meeting FBC minimum of ASTM D3161 requirements and Code Plus is products meeting FBC ASTM D 7158 Class H shingles. For Tile roofs, code minimum is considered Adhesive Set tile and Code Plus is tile fastened to the roof deck with 2 stainless steel screws. The use of Upgraded Underlayment -- using a synthetic underlayment instead of number 15 or 30 felt -- should be included in Code Plus installations). The estimated cost (shown above) for Improvement 3 reflects the estimated cost difference between the minimum allowed roof covering and a code-plus roof covering.

Footnote # 6b/7b, 6c/7c

The use of permanently attached or permanently deployed opening protection was not recommended only because lower cost opening protection options are available. To qualify for an opening protection matching grant, all openings (windows, hinged doors, sliding glass doors, garage doors, skylights, and gable end vents) must be protected using Florida Building Code approved products.

Footnote # 4 Your home has one or more gable ends that cannot be braced due to limited access to this part of your home, however, your home also has one or more unbraced gable ends that can be braced. Bracing only the accessible gable ends is a good idea and the cost associated with this improvement is eligible for matching grant funding, even though it will not result in a higher Hurricane Resistance Rating or insurance credits.

Section 3: 10-Point Checklist for Using this Report

**** IMPORTANT HOMEOWNER INSTRUCTIONS ****

☐ 1. Review the suggested plans for improving your home's hurricane wind rating. These improvement plans are designed to help you obtain the best level of wind resistance for your money.

☐ 2. Consider the estimated costs, remembering that actual costs will vary based on location, availability of materials and labor, installation details, and other factors.

☐ 3. Select one of the three recommended improvement plans, or create your own improvement plan by selecting one or more of the recommended, alternative, or additional improvements identified in Section 2 of this report.

☐ 4. Request bids from three or more licensed contractor(s) using the contractor bid sheets in Appendix A and compare the bids using the table in Section 2. You have the option of requesting bids from licensed general contractors to do all of this work. You may also request seperate bids from specialty contractors licensed to do each type of work required in your chosen improvement plan.

☐ 5. Select a contractor or contractors. IMPORTANT: Actual bids will vary from the amounts shown Sections 1 and 2. You should make your final decision based on the actual bids rather than the estimates given in this report. Log onto www.mysafefloridahome.com to review a list of contractors interested in performing mitigation improvements by county.

☐ 6. Before signing any contracts, confirm that each selected contractor will obtain all necessary permits, has proper worker's compensation insurance, will perform the work in accordance with the specifications provided in Appendix A, and is aware of the certifications required upon completion of the work.

☐ 7. The contractor bid sheets and improvement specifications provided on the following pages are to be used when you request bids from contractors to perform any of the work identified in this report. After you have decided on the specific improvements that you want to make to your home, make up to 3 copies of the appropriate contractor bid sheets in Appendix A and ask each bidding contractor to complete these forms.

☐ 8. To ensure improvements comply with state and local building codes, make sure the contractor agrees to follow the guidelines included in the Contractor Bid Sheets in Appendix A.

☐ 9. Ask your insurance company or insurance agent for their wind certification forms and instructions on how to obtain possible windstorm loss reduction credits or discounts for any improvements you make to your home.

☐ 10. Visit www.mysafefloridahome.com and www.flash.org for more information on making your home safer.

Appendix A: Contractor Bid Sheets

for
[NAME]
[ADDRESS]
[City], [STATE] [ZIP]

**** IMPORTANT CONTRACTOR INSTRUCTIONS ****

The following bid sheets have been prepared for the homeowner as the result of a free inspection performed by the My Safe Florida Home program. These bid sheets are pre-populated with data collected during the home inspection to assist contractors in providing cost estimates. Contractors are asked to provide their bids for specified work using the attached forms to help homeowners best evaluate bids from multiple contractors. The *My Safe Florida Home* program has identified seven key improvements that will enhance a home's ability to withstand a hurricane. Homeowners are only eligible for matching funds through the *My Safe Florida Home* program for improvements that fall within these seven categories, which include:

Improvement 1) Improving the strength of your roof deck attachment.

Improvement 2) Creating a secondary water barrier to prevent water intrusion.

Improvement 3) Upgrading roof covering.

Improvement 4) Bracing gable-end walls.

Improvement 5) Reinforcing roof-to-wall connections.

Improvements 6 & 7) Window protection (6) and door protection (7).

NOTE: Improvements 6 & 7 are combined because it is recommended that they be undertaken together.

NOTE: Only those bid sheets for the Improvements presented in Section 2 as Recommended, Alternative, or Additional for your home are included in this section.

Improvement 1a: Roof Deck Attachment - Interior **Bid Requested:** ☐

Improvement 2a: Secondary Water Barrier - Interior

Company:_____ MSFH ID:_____

Printed Name:_____ Date:_____

Signature:_____

Apply Adhesive to Roof Decking and Rafters	**Quantity**	**Cost**
A spray-on adhesive shall be applied to the underside of the roof sheathing from the attic such that a positive bond between the joists and the sheathing is formed. The applied adhesive shall have a minimum uplift capacity of 260 psf for a 4x8 ft panel as determined by laboratory testing. The 260 psf value refers to the mean value of the test results. Joints between sheathing pieces will also be sprayed with adhesive to prevent water infiltration in the event of roof covering losses. The adhesive should be applied continuously to within at least one foot of the eaves. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Interior Roof Area = **1,500** SF	_____

Improvement 1b: Roof Deck Attachment - Exterior **Bid Requested: ☐**

Improvement 2b: Secondary Water Barrier - Exterior

Company:_____ MSFH ID:_____

Printed Name:_____ Date:_____

Signature:_____

Re-nail Roof Sheathing & Add Secondary Water Barrier	Quantity	Cost
Work is to be performed after existing roof covering has been removed to the decking level. Replace damaged sheathing, re-nail the sheathing, and/or install a secondary water barrier following the requirements specified below.	Exterior Roof Area = **1,600** SF	_____
Replace Damaged Sheathing Any damaged roof sheathing is to be replaced and attached to the roof trusses/rafters using the specifications given in the Florida Building Code with one exception; nail fastener spacing will not exceed 6 inches on center for all roof zones in all wind zones. Deck fasteners will be 8d ring shank nails. Within 4 feet of any gable end, nail spacing will be reduced to 4 inches on center. **Re-nail Sheathing** All roof sheathing is to be re-nailed using the specifications given in the Florida Building Code with one exception; nail fastener spacing will not exceed 6 inches on center for all roof zones in all wind zones. Existing fasteners and new fasteners may be used to satisfy this requirement. New fasteners will be 8d ring shank nails. Within 4 feet of any gable end, nail spacing will be reduced to 4 inches on center. The contractor will verify that the new fasteners have properly penetrated the rafter/truss by visua examination inside the attic. Fasteners that miss the framing in whole or in part will be removed and re-nailed. *If hired, contractor must supply properly completed documentation for this work to the homeowner.* **Secondary Water Barrier** Prior to application of underlayment, all joints between plywood sheets will be taped with a self-adhering polyethylene or rubberized asphalt underlayment that has a minimum width of 6 inches. This self-adhering product shall be applied in accordance with the manufacturer's instructions for wood application. This product will have adherence strength suitable so that it remains attached to the roof deck and provides a secondary water barrier if the roof cover underlayment tears or fails in a hurricane. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*		

Improvement 3: Upgraded Roof Covering **Bid Requested: ☐**

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

Install Upgraded Code-Plus Roof Covering	**Quantity**	**Cost**
For shingle roofs, Code Minimum is defined as products meeting the FBC minimum of ASTM D3161 requirements, and Code Plus is defined as products meeting ASTM D7158 Class H. For tile roofs, Code Minimum is considered adhesive set tile, and Code Plus is tile fastened to the roof deck with 2 stainless steel screws. The use of Upgraded Underlayment -- using a synthetic underlayment instead of number 15 or 30 felt -- should be included in Code Plus installations. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Exterior Roof Area = **1,600** SF	_____
Install Standard Code-Minimum Roof Covering		
Install a new roof covering per the manufacturer's installation instructions using FBC-compliant products. For shingles, six nails are required for each shingle. For mechanically attached tiles, the manufacturer's directions are to be followed. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*		_____
Difference in Cost		
Homeowners are only eligible to receive matching grant funds for the cost difference between code-plus and code-minimum shingles or tiles. Please subtract standard cost from upgraded cost and show that figure in this box to assist the homeowner in identifying the portion of your re-roofing eligible for matching funds.		_____

Improvement 4: Brace Gable Ends **Bid Requested:** ☐

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

Brace All Gable End Walls 4 ft or Greater in Height	Quantity	Cost
The objective of this improvement is to brace the bottom chord of the gable end truss or gable end wall. Top chord bracing is accomplished through the use of properly connected roof sheathing, and is not the objective of this improvement. For homes with flat ceilings, bracing of the bottom chord may be accomplished by following the prescriptive requirements described on Page 9-10 of the "A Homeowner's Guide to Hurricane Retrofit" booklet published by the Institute for Business and Home Safety. You can obtain this guide online at www.ibhs.org. Otherwise, for cathedral, vaulted, or other unusual situations, evaluation of the existing wall and bracing should be reviewed by a Professional Engineer. An allowance for inspection by a Professional Engineer should be included in the cost estimates provided to the homeowner, where appropriate. Contractors should indicate in their bids for bracing gable ends whether an allowance for inspection by a professional engineer is included in the price. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Number of Gable End Walls to Brace = _____	_____

Improvement 5: Reinforce Roof-to-Wall Connections **Bid Requested:** ☐

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

Reinforce Roof-to-Wall Connections	**Quantity**	**Cost**
Install roof-to-wall straps or clips in accordance with the requirements of the Florida Building Code and the manufacturer's instructions. An allowance should be made in the cost estimate for a licensed engineer to inspect the existing connections and specify measures for the installation of new connections. If code-compliant straps already exist on some connections, they do not need to be replaced. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Estimated Number of Straps to Install = **48**	_____

Improvements 6 & 7: Window and Door Protection **Bid Requested:** ☐

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

GENERAL REQUIREMENTS: Opening protection must satisfy the Florida Building Code standards for both impact resistance and pressure resistance. Opening protection must be installed as per the manufacturer's specifications. The contractor will ensure that all local standards and requirements are met. Products that meet the Florida Building Code requirements must be used in order to receive windstorm insurance credits or discounts.
In the cost analysis for window protection, removable storm panels have been assumed for first floor openings and accordion shutters have been assumed for second floor openings, but other Florida Building Code approved protective devices, including impact resistant units, can be used. The number and area of openings presented below represent only those openings not already Hurricance level protected.

	Quantity	Cost
Install Window Protection		
See general requirements. ADDITIONAL REQUIREMENTS: If the structure is already equipped with shutter protection or the equivalent thereof, non-compliance with the current Florida Building Code standards should be verified before replacement with new products. *If hired, contractor must supply properly completed documentation for this work to the homeowner..*	Number of Windows = **7** Area = **180** SF	_____
Upgrade Entry Doors		
See general requirements. ADDITIONAL REQUIREMENTS: At least one door must meet the Florida Building Code requirements for a means of escape when all of the opening protection is deployed on the house. All remaining entry doors will be equipped with shutter devices meeting Florida Building Code requirements. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Replace **0** Door(s) Shutter **2** Single Door(s) Shutter **0** Double Door(s)	_____ _____ _____

****** END OF BID SHEETS ******

Home Inspection Report

for [NAME]

Mailing Address:
[ADDRESS]
[City], [STATE] [ZIP]

Property Location:
[ADDRESS]
[City], [STATE] [ZIP]

Dear Homeowner,

At your request, the State of Florida has paid for an inspection of your home by a qualified wind mitigation inspector. The purpose of this report is to identify specific actions that you can take to strengthen your home against hurricane winds. Please use this report as a resource to make your home as hurricane-resistant as possible. Because the *My Safe Florida Home* program has limited funds, receiving this report does not guarantee your eligibility or approval for a grant to make the improvements recommended in this report.

This report provides you with:

- Your home's current level of resistance to hurricane winds
- Specific improvements that will increase your home's hurricane wind resistance
- The estimated costs of improvements
- Your potential savings on homeowner's wind insurance premiums
- Guidelines on securing bids from licensed contractors to perform the recommended improvements

To help you get the most out of your report, an easy to understand *Inspection Report User's Guide* has been included along with your report. Please refer to this User's Guide for answers to questions you may have about your inspection report and the *My Safe Florida Home* program.

Thank you for your participation in the My Safe Florida Home program.

Sincerely,

My Safe Florida Home program

Section 1: Home Inspection Report

Understanding your home's hurricane wind rating

The ratings provided in this report are based on the Home Structure Rating System (HSRS), which is a newly developed scale to provide a relative measure of the ability of a Florida home to withstand hurricane wind effects. The rating reflects your home's structural features, location, and the Florida Building Code requirements for your location. The rating is a number between 1 and 100, where 100 corresponds to the strongest, code-plus construction.

Your home's current hurricane wind rating is estimated to be 25.

It is important to realize that the rating is intended to provide only a relative measure of how well your home is expected to perform over a wide range of wind speeds and wind directions. The rating is approximate and is based on a limited number of visible inspection features. Research to improve the rating system is underway and future adjustments are likely as our understanding of hurricane wind effects continues to improve.

Your house has the following beneficial features that contribute to its current hurricane wind rating:

- One story
- Non-tile roof covering
- Single wrap roof-to-wall connection
- Reinforced masonry wall construction
- Restrained foundation

Please contact your homeowner's insurance agent or insurance company to find out if you are eligible for windstorm loss reduction credits or discounts for these features and to determine how to apply for them.

Why you should consider strengthening your home

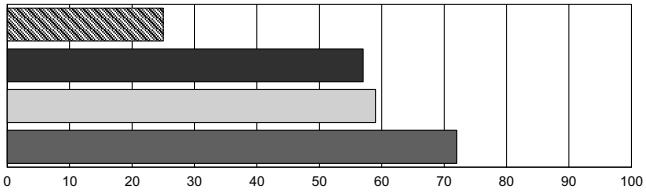
Taking steps to increase your hurricane wind rating will:

- Make your house safer, providing increased levels of protection for you and your family.
- Reduce the likelihood of future property losses.
- Reduce the likelihood of damage to irreplaceable possessions.
- Reduce the likelihood of being displaced from your home following a storm.
- Possibly make you eligible to receive discounts on windstorm insurance.
- Reduce the likelihood of having to pay the deductible portion of windstorm insurance. Your current windstorm deductible is 2% of $413,100 or $8,262.
- Possibly increase in the resale value of your house.

The following chart shows your home's current wind rating. It also shows the wind rating you could achieve if you implement any of the up to three Recommended Improvement Plans developed as a result of your recent home inspection (denoted as Plans A, B and C). The details of these plans are included in Sections 1 and 2 of this report and in the contractor bid sheets provided in Appendix A.

Each improvement plan offers a combination of hurricane-resistance features. Based on the combination of features in each plan, the chart below details how much it is estimated to cost you to implement that plan and the possible discount or credit you may qualify for on the winstorm portion of your insurance premium.

Hurricane Wind Rating



	Rating	Estimated Cost	Estimated Discount
CURRENT	25	$0	9% - 17%
PLAN A	57	$5,850	28% - 32%
PLAN B	59	$6,975	28% - 32%
PLAN C	72	$12,691	34% - 38%

By making all of the improvements recommended in Improvement Plan C, you can increase your home's rating by as much as 47 points to a total rating of 72.

Making your home stronger - Improvement options considered in this report

There are seven wind-resistance improvements covered by the *My Safe Florida Home* program. The recommended improvements developed for your home will fall within these seven improvement categories. For additional information about these seven improvements, please refer to the *Inspection Report User's Guide.*

The seven improvements are:

Improvement 1) Improving the strength of your roof deck attachment. For example, if your roof consists of shingles nailed to plywood sheets, the inspection may reveal that the plywood sheets are not adequately nailed to your roof trusses, and that additional nails and/or longer nails need to be added to reduce the possibility of the plywood from being blown off in a hurricane.

NOTE: There are two options for implementing Improvement 1. They are:

1a. Interior roof deck attachment (installed on the underside of the roof via the attic)
1b. Exterior roof deck attachment (installed when home is being re-roofed)

Improvement 2) Creating a secondary water barrier to prevent water intrusion. For example, using strips of "peel and stick-on" material that covers the joints between the plywood sheets on your roof to reduce leakage until repairs can be made if a hurricane blows off your roof covering.

NOTE: There are two options for implementing Improvement 2. They are:

2a. Interior secondary water barrier (installed on the underside of the roof via the attic)
2b. Exterior secondary water barrier (installed betweent the roof deck and roof cover)

Improvement 3) Upgrading roof covering. For example, upgrading to stronger hurricane-resistant roof shingles, attached with properly sized and properly applied roofing nails, to reduce the susceptibility of your roof shingles blowing off in a hurricane.

Improvement 4) Bracing gable-end walls. This is usually done inside your attic to decrease chances that gable end walls will fail under hurricane wind loads.

Improvement 5) Reinforcing roof-to-wall connections. For example, installing metal tie-down clips that attach roof rafters to walls to decrease chances that all or a portion of your roof will simply lift off your house during a hurricane.

Improvements 6 & 7) Window protection (6) and door protection (7). For example, installing hurricane-rated window shutters or replacing a standard garage door with a hurricane-rated garage door. Protection of gable end wall vents, if present, is also recommended under this improvement.

There are three options for implementing Improvements 6 & 7. They are:

Improvement 6a/7a. Standard - This improvement is the lowest-cost option for protecting windows, doors and other openings. On a one-story house, this improvement would provide temporary structural panels for each opening that would need to be installed each time a serious storm threatened the home. On a two-story house, this improvement would typically be a combination of panel shutters (first floor) and permanently attached shutters (second floor).

Improvement 6b/7b. Permanently attached - Protective devices that are always attached to the house and only need to be deployed when a hurricane is approaching.

Improvement 6c/7c. Permanently deployed - These are protective devices such as impact-rated glass windows and doors that require no installation when a hurricane is approaching. Some homeowners may want to upgrade from standard opening protection to permanently attached or permanently deployed protection as a matter of convenience. Section 2 of your report lists the estimated costs associated with this option.

NOTE: Improvements 6 & 7 are combined because it is recommended that they be undertaken together.

THE RECOMMENDED IMPROVEMENTS FOR YOUR HOME WILL FALL WITHIN THE SEVEN CATEGORIES SHOWN ABOVE. Please use these categories as a reference when reviewing the recommended improvements for your home outlined in this report. For additional information about these seven improvement categories, please refer to the *Inspection Report User's Guide.*

Recommended Improvement Plans for Your House

Based on the results of your home inspection, the recommended improvement plans for your house are outlined in the table below. For each improvement plan, the table provides the new hurricane wind rating after the improvements are completed, the estimated cost of the improvements, and the estimated annual wind insurance premium savings. The chart also shows which of the seven Improvements are included in your recommended Improvement Plans.

Plan	Improvement(s) (See Appendix A for Details)	Hurricane Wind Rating	Estimated Cost**	Estimated Annual Premium Savings*	
				Percent	Dollars
	Current condition of house	25	$0	9% - 17%	$112 - $212
A	Roof deck attachment - interior Recommended Improvement 1a Secondary water barrier - interior Recommended Improvement 2a	57	$5,850	28% - 32%	$350 - $400
B	Roof deck attachment - interior Recommended Improvement 1a Secondary water barrier - interior Recommended Improvement 2a Brace gable ends Recommended Improvement 4	59	$6,975	28% - 32%	$350 - $400
C	Roof deck attachment - interior Recommended Improvement 1a Secondary water barrier - interior Recommended Improvement 2a Window and door protection Recommended Improvement 6a7a	72	$12,691	34% - 38%	$425 - $475

* Estimated annual premium savings are based on your current insurance company's (STATE FARM FLORIDA INSURANCE COMPANY) windstorm loss reduction credits and your current base wind premium of $1,250 per year. Possible discounts are estimates and do not factor in future rate changes.

** A breakdown of estimated costs for each improvement plan is provided in Section 2 of this report.

Note on Insurance Premiums and Potential Discounts

Payment for insurance is usually called a "premium". In the case of homeowner's insurance, the premium is divided into at least two parts on most comprehensive policies. One part of the premium is for winstorm damage -- the type that occurs during a hurricane. The other part of the premium covers such perils as fire and theft. These details should be spelled out on your insurance policy's "declaration page".

Any discount for making your house stronger will **only** be applied to the **windstorm** portion of your premium.

Section 2: Estimated Improvement Costs & Contractor Bid Summary

IMPORTANT:
Do not show this page to the contractors when requesting cost estimates

Use the following table to compare contractor bids. Please note that the bids you receive may be substantially different than the *My Safe Florida Home* estimates due to the current availability and cost of materials and labor in your area, installation details that are specific to your house, and other factors. You should make your final decision based on the actual bids rather than the estimates given in this report. This table includes cost details for the recommended improvement plans outlined on the previous pages. It also outlines alternative improvement methods you can consider as substitutes for elements within your recommended plans. Additionally, the chart outlines additional improvements that can help make your home more hurricane resistant.

IN	Description of Improvement	Estimated Cost	Bid 1	Bid 2	Bid 3
	Recommended Improvements				
	Plan A				
1a	Roof deck attachment - interior	$5,850			
2a	Secondary water barrier - interior	$0			
	TOTAL	**$5,850**			
	Plan B				
1a	Roof deck attachment - interior	$5,850			
2a	Secondary water barrier - interior	$0			
4	Brace gable ends	$1,125			
	TOTAL	**$6,975**			
	Plan C				
1a	Roof deck attachment - interior	$5,850			
2a	Secondary water barrier - interior	$0			
6a7a	Window & door protection - standard	$6,841			
	TOTAL	**$12,691**			
	Alternative Improvements				
1b	Roof deck attachment - exterior	$263			
2b	Secondary water barrier - exterior	$1,019			
3	Upgrade roof covering	$6,986			
6b7b	Window & door protection - perm. attached	$11,725			
6c7c	Window & door protection - perm. deployed	$24,112			
IN	= Improvement Number				

IMPORTANT: The footnotes below provide helpful detail on the improvements outlined in the table above. Please refer to them to gain a better understanding of your options in strengthening your home. For additional information about these improvements, please refer to the *Inspection Report User's Guide* included with your report.

Footnote # 2a When an interior foam adhesive roof deck attachment is installed in a home, a secondary water barrier is also achieved. Therefore, no cost is shown for the interior secondary water barrier improvement (Improvement Category 2a).

Footnote # 1b, 2b

If you are planning to re-roof your house within the next three years due to normal deterioration with age, there is a more cost effective way to achieve improved roof performance. Instead of implementing improvements 1a (roof deck attachment - interior) and 2a (secondary water barrier - interior), it is generally more cost effective to re-roof your home now and substitute the following improvements:

Improvement 1b (roof deck attachment - exterior)
Improvement 2b (secondary water barrier - exterior)
Improvement 3 (upgrade roof covering) (See footnote # 3)

Footnote # 3 Since re-roofing your home is considered a normal part of home maintenance, the basic cost of re-roofing your home is not eligible for matching grants from the *My Safe Florida Home* program. However, if you re-roof your home with a roof covering that exceeds the minimum building code requirements, you are eligible for matching grants for the difference in the cost between the upgraded or “code-plus” roof covering and the standard or “code-minimum” roof covering. (Code Minimum is defined as products meeting FBC minimum of ASTM D3161 requirements and Code Plus is products meeting FBC ASTM D 7158 Class H shingles. For Tile roofs, code minimum is considered Adhesive Set tile and Code Plus is tile fastened to the roof deck with 2 stainless steel screws. The use of Upgraded Underlayment -- using a synthetic underlayment instead of number 15 or 30 felt -- should be included in Code Plus installations). The estimated cost (shown above) for Improvement 3 reflects the estimated cost difference between the minimum allowed roof covering and a code-plus roof covering.

Footnote # 6b/7b, 6c/7c

The use of permanently attached or permanently deployed opening protection was not recommended only because lower cost opening protection options are available. To qualify for an opening protection matching grant, all openings (windows, hinged doors, sliding glass doors, garage doors, skylights, and gable end vents) must be protected using Florida Building Code approved products.

Section 3: 10-Point Checklist for Using this Report

**** IMPORTANT HOMEOWNER INSTRUCTIONS ****

☐ 1. Review the suggested plans for improving your home's hurricane wind rating. These improvement plans are designed to help you obtain the best level of wind resistance for your money.

☐ 2. Consider the estimated costs, remembering that actual costs will vary based on location, availability of materials and labor, installation details, and other factors.

☐ 3. Select one of the three recommended improvement plans, or create your own improvement plan by selecting one or more of the recommended, alternative, or additional improvements identified in Section 2 of this report.

☐ 4. Request bids from three or more licensed contractor(s) using the contractor bid sheets in Appendix A and compare the bids using the table in Section 2. You have the option of requesting bids from licensed general contractors to do all of this work. You may also request seperate bids from specialty contractors licensed to do each type of work required in your chosen improvement plan.

☐ 5. Select a contractor or contractors. IMPORTANT: Actual bids will vary from the amounts shown Sections 1 and 2. You should make your final decision based on the actual bids rather than the estimates given in this report. Log onto www.mysafefloridahome.com to review a list of contractors interested in performing mitigation improvements by county.

☐ 6. Before signing any contracts, confirm that each selected contractor will obtain all necessary permits, has proper worker's compensation insurance, will perform the work in accordance with the specifications provided in Appendix A, and is aware of the certifications required upon completion of the work.

☐ 7. The contractor bid sheets and improvement specifications provided on the following pages are to be used when you request bids from contractors to perform any of the work identified in this report. After you have decided on the specific improvements that you want to make to your home, make up to 3 copies of the appropriate contractor bid sheets in Appendix A and ask each bidding contractor to complete these forms.

☐ 8. To ensure improvements comply with state and local building codes, make sure the contractor agrees to follow the guidelines included in the Contractor Bid Sheets in Appendix A.

☐ 9. Ask your insurance company or insurance agent for their wind certification forms and instructions on how to obtain possible windstorm loss reduction credits or discounts for any improvements you make to your home.

☐ 10. Visit www.mysafefloridahome.com and www.flash.org for more information on making your home safer.

Appendix A: Contractor Bid Sheets

for
[NAME]
[ADDRESS]
[City], [STATE] [ZIP]

**** IMPORTANT CONTRACTOR INSTRUCTIONS ****

The following bid sheets have been prepared for the homeowner as the result of a free inspection performed by the My Safe Florida Home program. These bid sheets are pre-populated with data collected during the home inspection to assist contractors in providing cost estimates. Contractors are asked to provide their bids for specified work using the attached forms to help homeowners best evaluate bids from multiple contractors. The *My Safe Florida Home* program has identified seven key improvements that will enhance a home's ability to withstand a hurricane. Homeowners are only eligible for matching funds through the *My Safe Florida Home* program for improvements that fall within these seven categories, which include:

Improvement 1) Improving the strength of your roof deck attachment.

Improvement 2) Creating a secondary water barrier to prevent water intrusion.

Improvement 3) Upgrading roof covering.

Improvement 4) Bracing gable-end walls.

Improvement 5) Reinforcing roof-to-wall connections.

Improvements 6 & 7) Window protection (6) and door protection (7).

NOTE: Improvements 6 & 7 are combined because it is recommended that they be undertaken together.

NOTE: Only those bid sheets for the Improvements presented in Section 2 as Recommended, Alternative, or Additional for your home are included in this section.

Improvement 1a: Roof Deck Attachment - Interior **Bid Requested:** ☐

Improvement 2a: Secondary Water Barrier - Interior

Company:_____ MSFH ID:_____

Printed Name:_____ Date:_____

Signature:_____

Apply Adhesive to Roof Decking and Rafters	**Quantity**	**Cost**
A spray-on adhesive shall be applied to the underside of the roof sheathing from the attic such that a positive bond between the joists and the sheathing is formed. The applied adhesive shall have a minimum uplift capacity of 260 psf for a 4x8 ft panel as determined by laboratory testing. The 260 psf value refers to the mean value of the test results. Joints between sheathing pieces will also be sprayed with adhesive to prevent water infiltration in the event of roof covering losses. The adhesive should be applied continuously to within at least one foot of the eaves. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Interior Roof Area = **3,900** SF	_____

Improvement 1b: Roof Deck Attachment - Exterior **Bid Requested: ☐**

Improvement 2b: Secondary Water Barrier - Exterior

Company:_____ MSFH ID:_____

Printed Name:_____ Date:_____

Signature:_____

Re-nail Roof Sheathing & Add Secondary Water Barrier	Quantity	Cost
Work is to be performed after existing roof covering has been removed to the decking level. Replace damaged sheathing, re-nail the sheathing, and/or install a secondary water barrier following the requirements specified below.	Exterior Roof Area = **4,500** SF	_____
Replace Damaged Sheathing Any damaged roof sheathing is to be replaced and attached to the roof trusses/rafters using the specifications given in the Florida Building Code with one exception; nail fastener spacing will not exceed 6 inches on center for all roof zones in all wind zones. Deck fasteners will be 8d ring shank nails. Within 4 feet of any gable end, nail spacing will be reduced to 4 inches on center. **Re-nail Sheathing** All roof sheathing is to be re-nailed using the specifications given in the Florida Building Code with one exception; nail fastener spacing will not exceed 6 inches on center for all roof zones in all wind zones. Existing fasteners and new fasteners may be used to satisfy this requirement. New fasteners will be 8d ring shank nails. Within 4 feet of any gable end, nail spacing will be reduced to 4 inches on center. The contractor will verify that the new fasteners have properly penetrated the rafter/truss by visua examination inside the attic. Fasteners that miss the framing in whole or in part will be removed and re-nailed. *If hired, contractor must supply properly completed documentation for this work to the homeowner.* **Secondary Water Barrier** Prior to application of underlayment, all joints between plywood sheets will be taped with a self-adhering polyethylene or rubberized asphalt underlayment that has a minimum width of 6 inches. This self-adhering product shall be applied in accordance with the manufacturer's instructions for wood application. This product will have adherence strength suitable so that it remains attached to the roof deck and provides a secondary water barrier if the roof cover underlayment tears or fails in a hurricane. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*		

Improvement 3: Upgraded Roof Covering **Bid Requested: ☐**

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

Install Upgraded Code-Plus Roof Covering	**Quantity**	**Cost**
For shingle roofs, Code Minimum is defined as products meeting the FBC minimum of ASTM D3161 requirements, and Code Plus is defined as products meeting ASTM D7158 Class H. For tile roofs, Code Minimum is considered adhesive set tile, and Code Plus is tile fastened to the roof deck with 2 stainless steel screws. The use of Upgraded Underlayment -- using a synthetic underlayment instead of number 15 or 30 felt -- should be included in Code Plus installations. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Exterior Roof Area = **4,500** SF	_____
Install Standard Code-Minimum Roof Covering		
Install a new roof covering per the manufacturer's installation instructions using FBC-compliant products. For shingles, six nails are required for each shingle. For mechanically attached tiles, the manufacturer's directions are to be followed. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*		_____
Difference in Cost		
Homeowners are only eligible to receive matching grant funds for the cost difference between code-plus and code-minimum shingles or tiles. Please subtract standard cost from upgraded cost and show that figure in this box to assist the homeowner in identifying the portion of your re-roofing eligible for matching funds.		_____

Improvement 4: Brace Gable Ends **Bid Requested:** ☐

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

Brace All Gable End Walls 4 ft or Greater in Height	Quantity	Cost
The objective of this improvement is to brace the bottom chord of the gable end truss or gable end wall. Top chord bracing is accomplished through the use of properly connected roof sheathing, and is not the objective of this improvement. For homes with flat ceilings, bracing of the bottom chord may be accomplished by following the prescriptive requirements described on Page 9-10 of the "A Homeowner's Guide to Hurricane Retrofit" booklet published by the Institute for Business and Home Safety. You can obtain this guide online at www.ibhs.org. Otherwise, for cathedral, vaulted, or other unusual situations, evaluation of the existing wall and bracing should be reviewed by a Professional Engineer. An allowance for inspection by a Professional Engineer should be included in the cost estimates provided to the homeowner, where appropriate. Contractors should indicate in their bids for bracing gable ends whether an allowance for inspection by a professional engineer is included in the price. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Number of Gable End Walls to Brace = _____	_____

Improvements 6 & 7: Window and Door Protection **Bid Requested:** ☐

Company: _____ MSFH ID: _____

Printed Name: _____ Date: _____

Signature: _____

GENERAL REQUIREMENTS: Opening protection must satisfy the Florida Building Code standards for both impact resistance and pressure resistance. Opening protection must be installed as per the manufacturer's specifications. The contractor will ensure that all local standards and requirements are met. Products that meet the Florida Building Code requirements must be used in order to receive windstorm insurance credits or discounts.
In the cost analysis for window protection, removable storm panels have been assumed for first floor openings and accordion shutters have been assumed for second floor openings, but other Florida Building Code approved protective devices, including impact resistant units, can be used. The number and area of openings presented below represent only those openings not already Hurricance level protected.

	Quantity	Cost
Install Window Protection		
See general requirements. ADDITIONAL REQUIREMENTS: If the structure is already equipped with shutter protection or the equivalent thereof, non-compliance with the current Florida Building Code standards should be verified before replacement with new products. *If hired, contractor must supply properly completed documentation for this work to the homeowner..*	Number of Windows = **18** Area = **362** SF	_____
Upgrade Entry Doors		
See general requirements. ADDITIONAL REQUIREMENTS: At least one door must meet the Florida Building Code requirements for a means of escape when all of the opening protection is deployed on the house. All remaining entry doors will be equipped with shutter devices meeting Florida Building Code requirements. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Replace **0** Door(s) Shutter **3** Single Door(s) Shutter **0** Double Door(s)	_____ _____ _____

Upgrade Garage Doors		
See general requirements. In the cost analysis, replacement of the existing garage door has been assumed; however shuttering devices meeting the general requirements can be used. *If hired, contractor must supply properly completed documentation for this work to the homeowner.*	Number of 1 Car Units = **0** Number of 2 Car Units = **1** Area = **144** SF	_____

****** END OF BID SHEETS ******

Appendix B

Updating Loss Relativities for Florida's Insurance Credit System for Hurricane Wind Loss Mitigation Construction Features and Integration into a Statewide Home Structure Rating System

White Paper

Updating Loss Relativities for Florida's Insurance Credit System For Hurricane Wind Loss Mitigation Construction Features and Integration into a Statewide Home Structure Rating System

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1.0 Background

The state of Florida had adopted a strategy of hurricane loss mitigation through: (1) building code improvements for new homes, and (2) strengthening of existing homes. When the Florida Building Code was enacted in 2001, the state adopted an insurance discount system that includes rate differentials for residences that have construction features which help reduce losses in windstorms. Recently, the state has also initiated the My Florida Safe House program which provides grant assistance to homeowners to perform wind mitigation construction improvements to their homes. As part of this program, the state is requiring a Home Structure Rating System (HSRS) that can be used to accurately rate residences in the state for hurricane risk vulnerability.

Loss relativities and structure ratings are technically and fundamentally intertwined. Loss relativities are based on insurance loss costs (average annual losses per $1,000 of building replacement value), which consider house wind resistance (vulnerability) as well as hurricane wind risk, location, and terrain. The resulting relativities can be normalized many different ways to produce a risk consistent rating system over any desired scale (say 0 to 100). The two fundamental elements, load (wind hazard) and resistance (house "strength") combine to form the classical structural reliability formulation, which is the basis for modern structure performance analysis and is inherently included in building code rationale.

A complicating factor is the number of factors and complicated building performance interactions that need to be addressed for a robust, statewide, and public rating system. For example, there are 576 primary loss relativity cells in the 2001 loss relativity matrices for existing homes. Yet, this number doesn't include important features and doesn't reflect the continually improving building code. In addition, there are also technical limits on modeling losses and political issues on what to include and how best to present a rating system to the public. For example, should the public be presented with all three major elements of the rating system (house vulnerability, hurricane wind risk, and the resulting total rating) or just a single rating (say, the vulnerability piece or the total rating)? How should the fact the current buildings still have performance problems (water penetration through leaky components, roof cover performance, etc.) be reflected in the rating? There are many other technical issues, as discussed below, which need to be addressed to improve the assessment of home building

performance (losses) and evolve a robust, statewide rating system. A multi-phased research effort is needed to systematically address these issues and maintain an accurate basis for insurance rate differentials and rating of buildings. Both must evolve over a period of time while maintaining a sound fundamental basis to ensure public confidence in the rating. Education of the public is also a needed element since the loss relativities and rating system reflect the integration of the total wind hazard and many building components. In any single storm, a house with a higher (better) rating may not necessarily out perform one with a lower rating. In fact, it is possible for a house with a higher rating to actually perform worst that a house with a lower rating in a single storm due to wind direction, orientation of house, and wind speed, terrain, wind-borne debris sources, and building feature differences. Hence, a critical need is to produce detailed house evaluations of a good sample of homes following each hurricane and to publish such results to promote understanding and continued improvement of the rating system and the building codes.

Loss Relativities and Insurance Mitigation Credits. The state of Florida requires that insurance companies offer insurance credits for residential construction features that reduce the potential for loss in hurricane winds. Research was funded by the Florida Department of Community Affairs in 2001 and 2002 to develop "loss relativities" for residential construction features. Loss relativities measure how the "average annual losses" and insurance "loss costs" differ for buildings with different wind-resistive construction features. They provide a practical way for insurance rates to reflect the fact that well-built buildings will experience reduced losses from hurricane wind hazards. Two final reports were produced that documented the results of the research and provided guidance for the insurance industry (1, 2). The Florida Office of Insurance Regulation reviewed these data and issued Informational Memoranda as an aid to help insurers comply with the requirement for insurance credits. The OIR compressed (or reduced) the credits that were estimated in the research by 50% to reflect the limitations of modeling and data, the lack of information on how existing structures were built, and the lack of actual experience data on how new code buildings might perform. [1]

Florida's hurricane wind risk is significant, representing approximately ½ of the nation's average annual hurricane wind losses. Insurance rates are high in Florida, reflecting the high hazard risk and the actual losses that result from landfalling hurricanes. For the built environment, improved wind resistance and construction mitigation provide the only way to reduce risk. Insurance incentives based on loss relativities provide a direct way to economically incentivize loss mitigation. An accurate insurance credit system is critical to insurance companies, the construction industry, and individual homeowners.

The loss relativities developed in 2001-2002 were the first attempt nationally to develop a true loss classification system for single family homes and "commercial-residential buildings", which are condos and town homes with 5 or more units. The

[1] On October 3, 2006, the Florida Cabinet adopted Rule 690-170.79 requiring that any rate filings submitted after January 1, 2007 must use the discounts without compression unless supported by detailed alternative studies.

analysis included structures built to the 2001 Florida Building Code and existing structures, built in previous construction eras. Building models were developed for different construction features and building values. The analysis considered 17 Terrain B locations and 14 Terrain C locations in the state. Roof shape, secondary water resistance, opening protection, roof-wall connection, roof deck attachment, and roof cover were the primary classification variables that came out of the research for single family homes. The loss relativity table has 288 entries for primary variables for each of two terrains. There were seven other secondary adjustments to the relativities, including dimensional lumber deck, masonry walls, reinforcement, concrete roof deck, opening protection level, gable end bracing, and foundation restraint. Similarly, new code construction treated design wind speed, high velocity hurricane zone, wind borne debris region, location, terrain, opening protection, and enclosed or partially enclosed design. The work for commercial-residential buildings considered building code construction era, building height class, wall construction, terrain, roof shape, opening protection, design wind speed, and other variables.

Home Structure Rating System (HSRS). The Florida legislature passed legislation requiring the development of an "*objective rating system that will allow homeowner to evaluate the relative ability of Florida properties to withstand the wind load from a sustained severe tropical storm or hurricane. The rating system will be designed in a manner that is easy to understand for the property owner, based on proven readily verifiable mitigation techniques and devices and able to be implemented based on a visual inspection program.*" A report on the system must be delivered by March 31, 2007 and an operational plan for statewide implementation.

2.0 Objective

The objective of this white paper is to present concepts for a multi-phased approach that develops the initial rating system and includes additional phases of work as part of an operational plan for statewide implementation.

1. Updates the loss relativities for more comprehensive and accurate insurance loss mitigation rate differentials.
2. Suggests a loss relativity integrated framework for the HSRS.

Several phases of work are suggested:

1. Short Term (By March 2007)
2. Mid Term (By March 2008)
3. Long Term and Sustained Effort (Annual updates thereafter)

The dates of these periods are flexible and could be modified to better reflect hurricane season data analysis and data incorporation.

The research and validation efforts would involve the University of Florida, ARA, IBHS, and other entities. Field and lab work are a major need to support and improve the modeling and analysis of losses in a structural reliability framework.

3.0 Approach - Short Term

The short term approach produces the initial rating system. This phase attempts to evaluate key issues with the 2001 loss relativity research, since that is the current basis for house performance and a natural starting point for a rating system. We first discuss some of the key limitations of Reference 1, in light of the approach used and new knowledge since 2001, and then present suggestions for the short term.

Limitations of the Initial Loss Relativity Studies. The single family study included the following limitations:

1. It did not consider:
    a. Building height—only 1 story homes were modeled
    b. Tile roof covers—only shingle roof covers were modeled
    c. Porches and carports—(garages were modeled for some of the homes, but these features likely need a separate rating factor)
    d. Skylights
    e. Wood panel shutter options
    f. Water leakage in hurricanes through non-breached glazed openings, doors, soffits, and/or vents
    g. Tree fall on homes and the resulting losses
    h. Building spacing variation
2. The final approach:
    a. Consolidated all relativities into a statewide average set, thereby averaging over differences that might be useful in a more refined approach, particularly for a statewide house rating system.
    b. Produced relativities based on 2% deductible. HSRS should be based on the total loss potential, regardless of the risk-bearing entity (homeowner, insurer, etc).
    c. Naturally considered the 2001 FBC code and does not reflect further improvements to the code, nor was there any data on actual new code building performance on which to validate the proposed relativities.
    d. Separately normalized the relativities for Terrains B and C by the loss costs of each terrain. This means that the differences in loss costs were not included in a single unified set of relativities. Also, did not consider real terrains vs. building code terrains.
    e. Presented relativities for new code houses that are normalized to location and wind zone. Use of these relativities in a rating system needs to be carefully integrated to maintain consistency.
    f. Averaged the relativities for secondary factors, such as wall type, door protection, foundation restraint, and gable end bracing. This, of course, keeps the approach simple, but too much may be lost in terms of an accurate home rating system.

g. Modeled building interference effects representative of a single subdivision spacing.
h. Treated whole roof failures (roof to wall connection) in a simplistic manner (total uplift load compared to total uplift capacity for each wing of the house). Should be improved to model progressive failure and hence produce a more realistic set of relativities and ratings.
i. Treated bending failures of walls, but did not treat shear failures of walls.
j. Used a single new code shingle throughout the state, regardless of location.
k. Did not consider roof cover condition or age. Did not consider tile roofs and tile fastening systems, such as adhesives, screws, clips, etc.
l. Did not consider garages as either compartmented or non-compartmented from the house (the ability of a failed garage door to pressurize the attic of the living space).
m. Used a judgment-based tempering approach to account for non-modeled components, such as gutter, siding, chimneys, vents, etc. Tempering needs to be updated through detailed analysis of insurance loss data.

Suggestions for Short Term. The short term work should focus on issues related to the basic HSRS. We need to:

1. Run a new set of houses at different locations in the state and understand differences in statewide relativities for the same house, but in different locations. Determine if regionalization of relativities and hence ratings is needed for a statewide rating system.
2. Use the wind tunnel test results for two-story homes to adjust relativities for multistory houses.
3. Use the new and old code building surveys and FCMP data to assess reasonableness of relativities based on Florida hurricanes of 2004. Use this to develop adjustment factors for use in interim for the rating system. This would include interim factors for tile roofs.
4. Develop a tempering scheme to reflect non-modeled features and performance issues.
5. Finalize the theoretical framework for the rating system and present examples, with the above new work, for committee consideration.

A complete systematic update of the relativities is not possible in this time frame, but the selected analyses above would be used to develop a much improved mitigation rating scheme for the near term.

4.0 Approach - Mid Term

The mid-term work includes new research as the next step to completely update the loss relativities. This work would incorporate new data and produce a totally updated loss relativity analysis for single family (and, ideally commercial-residential construction). It would begin where the short term work left off with a systematic approach to:

1. Incorporate new research information into the analysis process :
    a. Building performance in recent Florida hurricanes
    b. Wind tunnel test data
        i. Roof pressures
        ii. Soffits and walls
    c. Wind borne debris and impact test data
    d. FCMP data for model validation
    e. Available "wall of wind" results
2. Analyze additional model buildings with the 2002 construction features, plus:
    a. Two and three story homes
    b. Tile and possibly other roof covers
    c. Unvented attics
    d. More detailed gable end conditions
3. Use latest hurricane hazard modeling
4. Incorporate more realistic terrain modeling.
5. Evaluate building code improvements since 2002 and assess any significant code enhancements on potential loss relativities.
6. Analyze new and existing construction for the added wind resistive features listed above at multiple locations in Florida, and for multiple terrains. Perform sensitivity studies to develop primary and secondary rating features for loss relativities.
7. Regionalize loss relativities into the states wind zones, and hence improve rating system.
8. Develop updated designs for each wind zone according to the latest approved version of the Florida Building Code.
9. Develop terrain dependent ratings to go with regional ratings and relativities. Evaluate different building spacing from new wind tunnel tests.
10. Include first order water penetration through leaky openings, soffits, and vents. Conduct additional full scale experiments on wind driven rain. This work would provide an initial measure for reducing losses from water intrusions through windows, doors, vents, and other leak-prone components in buildings.
11. Include new code house relativities as part of the regional relativity tables for consistent interpretation.
12. Include new validation with insurance loss data.
13. Update statewide building stock models based on statewide inspection data and estimate insurance offset adjustments for the discount program. Perform detailed damage and loss studies for any 2007 Florida hurricanes.

This phase will produce a totally updated loss relativity report for insurance discount purposes and suggested updates to the house rating system and inspection program.

Optional Tasks for Mid-Term. Two optional tasks are identified**.**

a. **New Code Single Family Building Relativity Loss Validation**. This task focuses on the analysis of insurance loss data for new building code houses (houses built after the 2002 Florida Building Code was adopted) for recent Florida hurricanes. We would analyze losses at a claim folder (house by house level) for a representative statistical sample of houses in various peak gust wind speed locations for selected hurricanes. This analysis will be coupled with the physical damage/vulnerability modeling of the selected buildings to provide a key validation for loss relativity based insurance credits. This work will provide for critical validation, in terms of dollar losses and will leverage the building code performance surveys (University of Florida) that have tended to show that new construction performed better that existing construction. This task would therefore take the validation to the level of dollar losses, which is the basis for loss relativity differentials in a mitigation rating system.

b. Commercial-Residential Loss Relativity Development and Validation. This task is similar to the single family work, except it would be done for commercial-residential buildings. Commercial-residential buildings include condominiums and town-home buildings with more than 5 units. There are over a million such units in Florida. The loss estimates and loss relativities for these residential occupancies have historically not been as well validated as single family homes. Detailed insurance claim information would be sought for approximately 30 large commercial-residential buildings that experienced 2004 or 2005 hurricane losses. The damage and loss for each building would be developed in detail. Three dimensional computer models of each building would be developed for purposes of simulating the building performance. The appropriate hurricane wind trace would be developed for each building for the building damage and loss simulations. Site visits would be taken to gather additional information as needed for the validation analysis. These cases would provide a unique database for commercial residential validation. In addition, validating cases for loss allocation between building owner (e.g. condo association) and individual unit owner will be included. The validation will address both physical damage and insured losses.

6.0 Approach - Long Term

Long term work would address new areas and also update and maintain the relativities based on new experiments and damage surveys of building performance. Key issues would likely include:

1. Whole roof performance
2. Wall performance
3. Roof covering inspection and condition analysis, including newer roof covers.
4. Improved tempering of results
5. Improved annual building stock analysis and offset adjustments
6. Damage surveys
7. Insurance loss experience analysis

An annual updating of the rating system and relativities would be produced, along with rule for re-rating existing homes to the latest rating system. This would feed into a statewide database of rated structures.

Optional Task for Long-Term. It is desirable to extend the system to commercial buildings to minimize the economic impact of hurricanes on the state.

a. Commercial Building Loss Relativity, Validation, and Mitigation

Commercial buildings do not currently fall into the legislative requirement for insurance credits in the State of Florida. However, the State's economy depends on commercial businesses to continue to operate following hurricanes. Business interruption can become a significant economic liability to Florida. This project would therefore represent a new research effort aimed at commercial building occupancies. The objective is to put forth a new set of loss relativities that considers building occupancy type (financial, medical, retail, manufacturing, lodging, transportation, etc) in terms of content valuations and business interruption losses.

Building and loss estimation models for commercial buildings have been developed by ARA for FEMA in the development of the HAZUS hurricane model. The building classes include low rise, mid rise, and high rise structures with different roof shapes, building frame construction, roof deck construction, and roof cover type. Over 1,000 commercial type building models were developed for the HAZUS work, which included shingle, built-up, and membrane roof covers. Very limited validation of the loss estimation methodology was performed.

Improvements to the building performance models would address many areas. Updated windborne debris models would be included, including mixed (small and large missiles) windborne debris models for low rise commercial buildings. The HAZUS work would be adapted to building code era (as was done for the commercial-residential loss relativity research). Important modeling improvements would include flashing attachment, parapets, roof top equipment, amount of storefront

glazing, and business interruption. Business interruption is a major issue for commercial building owners in Florida and the amount of business interruption depends on the type of business, or business occupancy class.

Mitigation strategies need to be developed for commercial owners, including: improved roof deck and roof covers: rooftop equipment; glazing protection; roll-up garage doors; and other large openings. Backup generators may also be another strategy to mitigate business interruption.

Loss data from insurers, such as Citizens, will play a major role in validation of loss relativities for commercial buildings. The Florida storms of 2004 and 2005 provide a wealth of information on commercial building performance.

7.0 Summary

Mitigating losses in existing and new code buildings is the only viable option for reducing hurricane impacts in the state. Rating every house in the state is a practical goal and loss relativities provide the mechanism to integrate house rating systems to insurance credits and differentials. Mitigation and inspection programs are underway that will use a rating system to communicate between insurers and homeowners. The current rating system needs to be updated to make it more comprehensive and more accurate. Significant amounts of new data have become available over the past 5 years and provide a basis for a scientifically-developed update. Annual updates thereafter will ensure validation, refinement, public confidence in the system, and will help promote a market for mitigation.

Commercial buildings are an important part of Florida's economy and there is very little information available for owners to understand their risk and mitigation options. A separate optional long term task is outlined that would develop loss relativities for commercial building occupancies.

References

1. Applied Research Associates, Inc., "Development of Loss Relativities for Wind Resistive Features of Residential Structures," Prepared for Florida Department of Community Affairs, Tallahassee, Florida, March, 2002.
2. Applied Research Associates, Inc., "Development of Loss Relativities for Wind Resistive Features for residential Buildings with Five or More Units," Prepared for Florida Department of Community Affairs, Tallahassee, Florida, August, 2002.

Appendix C

Legislation and Laws Relevant to the HSRS

Section 39. (1) The Office of Insurance Regulation, in consultation with the Department of Community Affairs, the Department of Financial Services, the Federal Alliance for Safe Homes, the Florida Insurance Council, the Florida Home Builders Association, the Florida Manufactured Housing Association, the Risk and Insurance Department of Florida State University, and the Institute for Business and Homes Safety, shall study and develop a program that will provide an objective rating system that will allow homeowners to evaluate the relative ability of Florida properties to withstand the wind load from a sustained severe tropical storm or hurricane.

(2) The rating system will be designed in a manner that is easy to understand for the property owner, based on proven readily verifiable mitigation techniques and devices, and able to be implemented based on a visual inspection program. The Department of Financial Services shall implement a pilot program for use in the Florida Comprehensive Hurricane Damage Mitigation Program.

(3) The Department shall provide a report to the Governor, the President of the Senate, and the Speaker of the House of Representatives by March 31, 2007, detailing the nature and construction of the rating scale, its effectiveness based on implementation in a pilot program, and an operational plan for statewide implementation of the rating scale.

Section 40. The Financial Services Commission shall adopt a uniform home grading scale to grade the ability of a home to withstand the wind load from a sustained severe tropical storm or hurricane. The commission shall coordinate with the Office of Insurance Regulation, the Department of Financial Services, and the Department of Community Affairs in developing the grading scale, which must be based upon and consistent with the rating system required by chapter 2006-12, Laws of Florida. The commission shall adopt the uniform grading scale by rule no later than June 30, 2007.