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RATE BUREAU
REINSURANCE FACILITY
INSURANCE GUARANTY ASSOCIATION

North Carolina Rate Bureau

July 23, 2014

Honorable Wayne Goodwin
Commissioner of Insurance
North Carolina Department of Insurance
Post Office Box 26387
Raleigh, NC 27611

Re: January 3, 2014 Homeowners Insurance Rate Filing
Revised Filing Pages

Dear Sir:

As we have previously advised the Department, David Lalonde, who originally submitted the testimony on behalf of AIR Worldwide Corporation, has retired, and Robert Newbold has been designated as the AIR witness to replace Mr. Lalonde.

Mr. Newbold's testimony is attached herewith, together with two pages in the filing (E-7 and E-256) where Mr. Newbold's name should be substituted for that of Mr. Lalonde.

As advised, Mr. Newbold's substituted testimony contains no substantive changes to the testimony previously submitted on behalf of AIR.

Very truly yours,

Sue Taylor
Chief Operating Officer

Enclosures

cc: Ms. Sherri L. Hubbard (w/enclosures)

Exhibit RB-5

PREFILED TESTIMONY of ROBERT NEWBOLD

2014 HOMEOWNERS INSURANCE RATE FILING BY THE NORTH CAROLINA RATE BUREAU

1. Q. What is your name and business address?

A. My name is Robert Newbold. My business address is 131 Dartmouth St, Boston, MA 02116.

2. Q. What is your occupation?

A. I am Senior Vice President of AIR Worldwide Corporation, a corporation in Boston, Massachusetts.

3. Q. What is AIR Worldwide Corporation?

A. AIR Worldwide Corporation (AIR) is a scientific leader and respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. AIR is headquartered in Boston with additional offices in North America, Europe, and Asia.

4. Q. How many employees does AIR have?

A. AIR has over 500 employees. Of those over 200 have graduate degrees and over 70 have PhDs. Their disciplines include meteorology, wind engineering, actuarial, computer science and statistics.

5. Q. Could you describe your duties as Senior Vice President of AIR?

A. As Senior Vice President, I am responsible for AIR's Consulting and Client Services Group in the Americas. The Consulting and Client Services group provides model and software support and service to AIR's clients. This includes performing analyses using the AIR models, assisting clients in the interpretation of results generated by the AIR models, and training clients on the most efficient way to interact with AIR's software products and solutions. As Senior Vice President, I am also responsible for all of AIR's internal and external training and education, and I am responsible for regulatory work.

6. Q. What is your educational background?

A. I have a Bachelor of Science in Systems Engineering from the University of Virginia. I have a Master of Science in Information Systems (High Honors) from Boston University, and a Master of Business Administration (High Honors) from Boston University. I have completed the requirements of the AIR Institute Certified Catastrophe Modeler Program to achieve the designation of Certified Catastrophe Modeler (CCM).

The Certified Catastrophe Modeler Program is an educational program offered to AIR's clients. The program includes a week of classroom education focusing on both models and software, as well as providing insight into how the models are created and how results from the models should be interpreted. Over the course of my AIR career, in addition to completing the Program, I have also designed course content and materials, acted as an Instructor, and most recently, I have taken a role of preparing other AIR staff to act as Instructors in the Program.

7. Q. What has been your experience since obtaining your initial degree?

A. I was employed at EDS Corporation from 1996-99 and became Information Analyst. From 1999-2001, I attended Boston University Graduate School of Management in pursuit of two Master's degrees. From 2001-02, I was employed at Deloitte Consulting where I became Senior Risk Consultant.

In 2002 I was employed by AIR Worldwide Corporation. I have now been employed by AIR for nearly 12 years, during which time I have had extensive experience with the AIR models performing the functions described in the Consulting and Client Services Group in the response to Question 5 above.

8. Q. Please describe your technical publications and speaking engagements relating to computer models and insurance.

A. I present regularly at the AIR's Client Conferences on various catastrophe risk management topics involving modeling. Further, I travel often to AIR clients and prospects, and have made numerous presentations directly to individual insurers, reinsurers, investment bankers, rating agencies and regulators.

9. Q. Please describe your experience with respect to the issue of computer modeling of windstorms, including tornadoes, hurricanes, hailstorms and other storms.

A. I have been working with AIR's models since joining the company in 2002. In addition to performing analyses using the model and presenting results to clients, I have been charged by AIR with the responsibility for explaining the model in external settings such as in global investor settings as part of AIR's Securitization practice. I have also presented the model in front of the Florida Commission on Hurricane Loss Projection Methodology's Professional Team, who perform an extensive scientific review of hurricane models on an bi-annual basis.

10. Q. Could you characterize your familiarity with the AIR hurricane model that is used by the North Carolina Rate Bureau in this filing?

A. As described above, I have worked with AIR's hurricane model since 2002. I am familiar with all aspects of AIR's hurricane model. I work closely with members of AIR's staff involved in the development, maintenance and application of AIR's hurricane model. I feel that I am well-suited to the task of testifying about the model as a result of my many years of modeling experience and my knowledge of all of the scientific components of the model and how they interrelate with each other.

11. Q. What has been your relationship with the scientific and technical staff at AIR that has allowed you to gain personal knowledge as to AIR's U.S. Hurricane model?

A. Over many years I have had extensive exposure to the technical details of the model components throughout the processes of development and updating the model. I work closely with internal staff members who utilize the model on a day-to-day basis on behalf of AIR clients. I have also presented the model to the Professional Team of the Florida Commission, which includes meteorologists, wind engineers, programmers and others who develop, implement, enhance and explain AIR's model.

12. Q. What has been your role in explaining the model to regulators?

A. AIR clients using the AIR hurricane model to file insurance rates often receive inquiries from state departments of insurance that include questions on the models used to generate the rates. I have prepared responses to such inquiries for a number of states, including Alabama, Louisiana, South Carolina, Florida, Mississippi and Texas. I have presented the hurricane model to the Massachusetts Office of the Attorney General and the Massachusetts State Rating Bureau in connection with rate filings of the Massachusetts Property Insurance Underwriting Association. I have also offered expert testimony on the AIR hurricane model before the Maryland Insurance Administration.

13. Q. Please describe the types of companies and organizations for which you have consulted in connection with the computer modeling of windstorm losses.

A. More than 400 organizations obtain AIR's services. AIR provides catastrophe risk assessment products and services to primary insurance companies, to reinsurers, to intermediaries, to coastal Beach and FAIR plans and other residual market organizations, to state funds, and to other insurance related organizations. We also provide services to investment banks and investors in catastrophe bonds, as well as to bond rating agencies that analyze and rate those bonds.

14. Q. Please explain what those various entities are.

A. “Primary insurers” are the companies with which the members of the public interact when they purchase homeowners insurance policies that cover hurricanes. The members of the Bureau are primary insurers, and they sell homeowners insurance policies to their policyholders.

“Reinsurers” write insurance to cover primary insurers, and that transaction is called reinsurance. Primary insurers purchase reinsurance in part to ensure that they are able to remain solvent in the case of a major industry catastrophe such as a hurricane, and therefore will be able to meet their obligations to their owners and policyholders. The contractual relationship between the primary insurer and reinsurer is typically called a “reinsurance treaty.”

“Intermediaries” include reinsurance brokers and other experts in catastrophe risk who assist primary insurers in locating reinsurers that are willing to write reinsurance and in negotiating terms and rates with those reinsurers.

“Residual market organizations” are involuntary market mechanisms that have been set up by state law to write insurance in high risk situations where the primary insurers are unable or unwilling to write policies at the rates that can be charged for the risk involved. Catastrophe losses have to be paid by someone, and complex state laws typically provide that losses will be paid by some combination of insurers, reinsurers, policyholders and others. The so-called “Beach” and “FAIR” plans in North Carolina are residual market mechanisms.

"State funds" are similar to residual market organizations in that they arise by state law to write insurance in high risk situations where the primary insurers are unable or unwilling to write policies. State funds typically involve the situation in which the state ultimately assumes responsibility for payment of catastrophe losses, such as the case of Citizens Property Insurance Corporation in Florida.

"Investment banks" are sophisticated financial advisers that, in the context of hurricane modeling, analyze the risk of catastrophes and provide advice and assistance to entities that issue and purchase bonds covering catastrophes. Catastrophe bonds frequently serve as an alternative to reinsurance.

"Investors" are parties that invest in catastrophe bonds in order to gain a financial return. In the event of a catastrophe triggering the bond, they are responsible for covering the financial loss indicated in the bond's agreement.

"Rating agencies" are independent organizations such as AM Best, Moody's, Fitch's and Standard and Poor's that analyze the risk of companies and financial instruments. They rate the level of risk involved in instruments such as catastrophe bonds as well as the solvency of primary insurers, reinsurers and investment banks. Investors and issuers of catastrophe bonds rely upon rating agencies in connection with the issuance and purchase of catastrophe bonds.

15. Q. Have these various entities described above relied upon AIR's hurricane model?

A. Yes, over 400 such entities have relied upon our model and methodology in many different contexts and in many situations over many years.

16. Q. Please explain how primary companies and reinsurers have relied upon your computer simulated hurricane loss estimates?

A. Reinsurers use AIR Software Systems (CATRADER®, CLASIC/2™, CATSTATION™, Touchstone®), which all utilize the same underlying models, such as AIR's hurricane model that was used for this analysis, to estimate expected and potential large losses on the reinsurance treaties that they write with the primary companies. Based on these expected loss estimates as well as other economic and underwriting information, reinsurers develop the rates that they charge for catastrophe reinsurance treaties with primary companies.

Primary companies use our services and software systems to estimate their loss potential to catastrophic events such as hurricanes and earthquakes for multiple reasons. One reason is to estimate catastrophe pure premiums and loss costs in various geographical areas for the purpose of setting rates. They are also interested in estimating large loss potential in order to help them to decide how much catastrophe reinsurance they need to buy to protect their company's solvency and pay losses. Particularly after Hurricane Andrew, which caused numerous primary companies to become insolvent, primary companies want to make sure that they are not overly exposed to a single catastrophic event.

As a practical matter, reinsurers and primary insurers have competing economic interests with regard to the output of the catastrophe models. A model which overstated hurricane exposure would prejudice primary insurers through the elevation of reinsurance costs. A model which understated hurricane exposure would result in reinsurers collecting inadequate premiums for the risk undertaken. AIR's ability to serve clients with such competing economic interests is dependent on the rigorous peer review and ongoing updates to the model with the most recent scientific and meteorological data available, to maximize the accuracy of outputs from all AIR models.

17. Q. What is a reinsurance treaty?

A. It is a contract negotiated between a primary insurer and a reinsurer. These treaties come in many different forms and are negotiated between the parties often using the AIR hurricane model as an input in the negotiations. The different primary companies choose to expose their surplus to very different levels of risk based upon factors such as the areas where they choose to write insurance, the types and numbers of policies that they write in high risk areas, the policy terms that they employ, the lines of insurance that they write, their ability to cover major losses using their own funds, etc. There are several hundred primary companies writing property insurance in North America, and each has a unique "book of business" as to the policies it writes and its exposure to catastrophes. Catastrophes can occur in many forms, including earthquakes, severe thunderstorms (hail, wind, and tornados), winter storms, flood, terrorism and fires, as well as hurricanes.

When primary insurers analyze their book of business, they use AIR models to assist them in determining their exposure to various catastrophes and their reinsurance needs to protect their financial security and ability to pay losses when a catastrophe occurs. Each primary insurer has unique exposure to catastrophes, and each needs to analyze its own exposure and determine its reinsurance program based upon its examination of that exposure and its ability to take on risk.

A primary insurer's reinsurance program can be written to cover a single hurricane or a season of hurricanes. It can involve other wind events such as a tornado outbreak or a winter storm. It can involve an entire season of all wind events including tornadoes, hurricanes, straight line winds, hail, winter storms, etc.

Of course, catastrophes can be caused by events other than wind. For instance, some areas are more prone to earthquake than others, and some primary companies are therefore more exposed to earthquake losses than others. Primary companies may purchase reinsurance coverage for most or all risks, including earthquakes, terrorism, brush fires, volcanic eruption and other perils in addition to wind. This can all be done in the same reinsurance treaty or in separate treaties.

It is often the case that large primary insurers will have treaties with numerous different reinsurers, and they may also rely upon catastrophe bonds as well. Primary companies may purchase reinsurance for a single region such as North America, the United States, the hurricane-prone southeastern United States, the Mid-Western United States, the West Coast of the United States, a single state, etc.

The financial terms of reinsurance treaties and catastrophe bonds can vary widely and depend on the needs, ingenuity and willingness of the parties. The AIR models are a vital tool when the parties are negotiating the terms of reinsurance treaties. A primary company can enter into a reinsurance treaty that covers the company above a stated dollar amount, a concept that is similar to a deductible in a typical homeowners policy. Primary companies generally must purchase reinsurance that is capped such that there will be no reinsurance payments beyond a certain dollar amount that is negotiated between the primary insurer and the reinsurer. Such a cap involves a concept similar to a maximum policy amount in a typical automobile liability insurance policy. A reinsurance treaty can provide for the purchase of reinsurance on a pro-rata or quota-share basis where the reinsurer pays a percentage of the catastrophe losses and the primary insurer retains the remaining percentage. Such a basis is similar to a percentage copayment in some health insurance policies. There are a virtually infinite number of possibilities, and the AIR models provide consistent detailed information on the risk to both parties, allowing the parties to negotiate and reach agreement.

18. Q. Please explain how coastal residual market plans rely upon your model.

A. These plans typically operate in a manner similar to primary companies, and they often purchase reinsurance to cover some of their catastrophe exposure. As with primary insurers, coastal plans use models in analyzing their risk to catastrophic hurricanes and in placing reinsurance or obtaining catastrophe bonds. The coastal boards then use AIR's analyses to decide on levels of surplus to maintain, reinsurance to purchase and sometimes the rates that should be charged to their policyholders. They also use AIR's analyses to advise primary companies and the public as to potential assessments that they may face in the event that a hurricane exceeds the plan's surplus and reinsurance. The same type of analysis is typically performed with respect to state funds. They sometimes rely on intermediaries to provide some or all of these services.

19. Q. Please explain how the investment community relies upon your model.

A. AIR provides hurricane loss estimation services to the investment community in conjunction with various catastrophe bond offerings that are issued. Both issuers and purchasers of catastrophe bonds are typically advised by investment bankers. As with the analysis that underlies the negotiation and pricing of reinsurance treaties, these parties in the investment community use the probabilistic estimates derived from the AIR catastrophe models as the primary basis for pricing and investing in catastrophe bonds. Bond rating agencies provide objective opinions of the bonds using the results of the AIR models, and those ratings in turn affect the price and terms of those bonds that are issued.

20. Q. Have you been asked by the Bureau to prepare an analysis based on AIR's model of hurricane loss potential for the state of North Carolina?

A. Yes.

21. Q. What reports has AIR prepared for the Bureau relating to North Carolina homeowners insurance?

A. We have prepared a report for the Bureau based on an analysis using a simulated sample of 100,000 "years" of potential hurricane experience based on our standard view of the hurricane risk. A copy of our report is attached hereto as Exhibit RB-6A.

We have also prepared a report using a simulated sample of 100,000 "years" of potential hurricane experience that estimates the potential impact of elevated sea surface temperatures (SSTs) in the North Atlantic on hurricane activity (the Warm Sea Surface Temperature or "WSST" catalog simulation). A copy of that report is attached hereto as Exhibit RB-6B.

A simulated "year" in this context represents a hypothetical year of hurricane experience that could happen in the prospective year. For the Bureau we used exposures for 2011, which was the most recent year available. These large samples of simulated loss experience enabled us to estimate hurricane pure premiums and loss costs as well as the probabilities of losses of various magnitudes.

As will be discussed later in my testimony, AIR has also prepared an additional exhibit of estimated hurricane losses based on notional exposures to assist the Bureau in its analysis of homeowners territorial definitions.

22. Q. In the context of Exhibits RB-6A and RB-6B, what is meant by the term "pure premiums"?

A. Pure premiums are calculated by dividing the estimated long run average annual aggregate losses by the number of risks, i.e., the house years. The resulting pure premium values are a measure of the expected value of loss for each individual risk.

23. Q. In the context of those reports, what is meant by the term "loss costs"?

A. Loss costs are calculated by dividing the estimated long run average annual aggregate losses by the insurance in force, i.e., the insurance years plus the liabilities for contents and other coverages. The resulting values are a measure of the expected value of loss for each dollar of insured value.

24. Q. Please describe the approach that AIR used to develop these reports.

A. Our approach is that of a computer simulation model. Specifically, in the CLASIC/2™ software version 15.0, we ran our Standard Atlantic Tropical Cyclone Model, version 14.0.1("AIR hurricane model" or "AIR model" or "the model"). The Bureau provided exposure information used to generate the loss estimates. The exposure file contained information on the number of risks, coverage, policy form group, construction type, year of construction, geography, and amounts of insurance. This data was reviewed for reasonableness and input into the model. The data was geocoded based on the zip code information present in the exposure file. Finally, the model was run, simulating potential future hurricane losses and in the process applying policy conditions. The output of the model contains information such as average annual loss which is used in developing rates.

25. Q. What is the role of modeling in projecting future hurricane losses in the insurance context?

A. Many years ago modeling became a widely accepted method of analyzing the loss potential of future hurricanes in the insurance context. In recent years it has become the method that is almost exclusively used. AIR was the first company to develop probabilistic catastrophe modeling of hurricanes over 25 years ago as an alternative to the "rule of thumb" approaches on which insurance companies previously had to rely for the estimation of potential catastrophe losses from hurricanes. In 1987, AIR introduced to the insurance industry a modeling methodology based on simulation techniques and mathematical approaches that had been long-accepted in a wide variety of scientific disciplines. Since the inception of this new approach, the AIR hurricane model has undergone a comprehensive and continuous process of refinement, enhancement, validation, and review. The current version of the model contained in this filing was recently updated based on a comprehensive process of scientific review that began in 2007 and continued into 2010. It was further updated in 2013 to account for two additional years of historical hurricane activity that were included in the National Hurricane Center's (NHC) HURDAT database.

Prior actuarial techniques had by necessity relied on loss data on past hurricanes to project future losses, but that methodology was inadequate for many reasons. A prime reason is that the period of time for which insurance data was available was not sufficiently long to be representative of the long term climatology of hurricanes. Significant hurricanes are relatively infrequent events, and the sample was too small to have predictive capability. Insurance data for homeowners policies began in the 1960's when that policy was introduced, and there was data for earlier policies dating back only to about 1950. Further, efforts to use the limited insurance loss data from previous decades required complicated and highly inexact assumptions and other factors that must be considered in order to relate such data to current conditions. The usefulness of the limited loss data that did exist was significantly limited because of the constantly changing landscape of insured properties. Property values change significantly over the years, along with the costs of repair and replacement of buildings and contents. Building materials, design and construction practices change, as do the types and costs of personal property located in those buildings. New structures may be more or less vulnerable to catastrophe events than were the old ones. New properties continue to be built in areas of high hazard. Therefore, the limited loss information that was available from recent hurricanes was not suitable for estimating future losses.

While it was widely recognized that insurance loss information from the limited number of historical hurricanes did not provide a complete indication or adequate sample of what may occur in the future, there was no alternative until modeling became feasible. Modeling became feasible with the advent of high speed computerization and the enhancement of detailed scientific knowledge of how hurricanes work based on radar, satellites and other advancements. Numerous scientific advancements led to modeling becoming a widely accepted method of analyzing the risk of hurricanes. Modeling employs the available historical data as to meteorological characteristics of actual hurricanes and then allows for combinations and permutations of the parameters and locations of such historical data in order to model future events in accordance with their probability. Doing so provides a robust picture of the expected average loss potential in North Carolina and other hurricane prone states. During the period when modeling replaced the prior actuarial techniques, AIR has been a scientific leader in the catastrophe modeling industry.

26. Q. Does the AIR model produce an unbiased estimate of expected hurricane losses in North Carolina?

A. Yes. While the AIR model has been developed and updated by AIR's internal team of scientists and engineers, it has also been peer reviewed by independent experts in the relevant scientific and academic fields. Examination of modeled versus historical losses has validated the model and has revealed no systematic bias in terms of overestimation or underestimation. Our model is relied upon by parties with diametrically opposite financial interests, including both primary insurers and reinsurers, and both catastrophe bond issuers and investors in those bonds.

27. Q. Do you know how many years of homeowners insurance data exist for North Carolina?

A. I am advised that data for homeowners insurance exists only back to approximately 1960.

28. Q. What is your opinion as to whether homeowners insurance data for the period from 1960 to 2011 adequately represents the state's likely exposure to hurricanes?

A. In my opinion, that period of insurance loss data is not sufficient to estimate the true hurricane loss potential in North Carolina for numerous reasons. One reason is that hurricanes, particularly intense hurricanes, are low frequency events. The absence or presence of even one Category 4 or 5 hurricane (under the Saffir-Simpson scale) can dramatically influence the loss potential calculated over the short time horizon in which homeowners insurance rates are examined in connection with non-catastrophe causes of loss. There has been one Category 4 storm that has made a landfall in North Carolina since 1900 (Hazel in 1954). However, several others could easily have done so if slightly different weather conditions had been present to steer those storms into North Carolina.

Furthermore, as stated previously, the validity and utility of the historical loss data that does exist is limited because of the constantly changing landscape of insured properties. For instance, since Hurricane Hazel devastated southeastern North Carolina in 1954, there are many more houses at the coast that may have been built according to more modern construction practices and contain different levels of contents. Policy forms in use today provide different coverage than those in 1954. It is highly questionable whether the cost data for repairing and replacing houses and their contents in 1954 can validly be compared with cost levels today.

For these reasons, the best available measure of North Carolina's current exposure to hurricanes can be gained by using a computer simulation model, which is grounded in a longer period of meteorological history and documented science. Modeling reflects the broad range of events that could occur in the next hurricane season, with those events modeled in accordance with their probability.

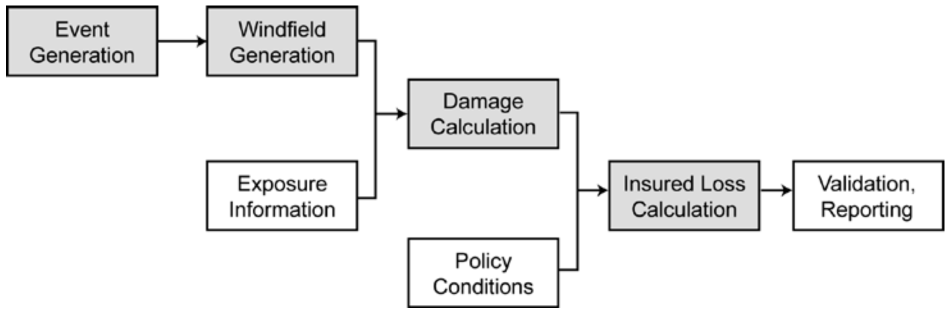
29. Q. What is a computer simulation model?

A. Basically, a computer simulation model is a series of computer programs which describe or model the particular system under study. All of the system's significant variables and interrelationships are included. A high-speed computer then "simulates" the activity of the system and outputs the measures of interest, such as the average expected loss costs.

As is appropriate in probabilistic modeling, AIR's hurricane simulation model incorporates random variables. Numbers are generated from the probability distributions of random variables to assign values to the variables for each model simulation. The probability distributions are usually standard statistical distributions selected on the basis of good fits with empirical data from actual hurricanes and are consistent with and supported by such data and published literature from accepted academic, scientific and governmental sources.

A very large number (100,000) of simulations or iterations of what could happen in the following year are performed in order to derive average loss costs from simulation models. Average values derived from these 100,000 simulations are calculated and put into exhibits RB-6A and RB-6B. Many simulations are necessary so that the output distribution converges to the true distribution and that model-derived estimates are "stable."

The figure below illustrates the component parts of the AIR model (gray boxes). Each component represents both the ongoing efforts of the research scientists and engineers who are responsible for its design and the computer processes that occur as the simulations are run.



30. Q. Is computer modeling commonly used and relied on in meteorology and other fields?

A. Yes. Computer simulation models are universally used and relied upon every day in meteorology and many other fields. They are particularly useful tools for the analysis of complex problems involving the combination of multiple variables whose underlying distributions do not have closed form analytical solutions. In current operational hurricane forecasting practice, experts in the National Hurricane Center (NHC) rely heavily on various kinds of computer models. These models range in complexity from simple statistical models to three-dimensional primitive equation models. The statistical and two-dimensional models are maintained by the Tropical Prediction Center (TPC). The three-dimensional models are maintained by the National Centers for Environmental Prediction's (NCEP) Environmental Modeling Center (EMC), a governmental organization which monitors meteorological conditions.

There are numerous advantages of the computer simulation approach. Such an approach is able to capture the effects on the catastrophe loss distribution of changes over time in population patterns, building codes, amounts insured, construction costs, personal property insured and other factors. Further, since the historical record is limited, the stochastic catalog of events is designed to capture the potential of experiencing loss from events which have not yet happened. These events are nevertheless realistic and possible and are simulated in accordance with their probabilities. Also, simulation models provide a good means to analyze the impact of new scientific understanding.

31. Q. How long have computer simulation models been used in insurance?

A. AIR pioneered the probabilistic catastrophe modeling technology that is used today by the world's leading insurers, reinsurers, regulators and financial institutions. The AIR hurricane model has been in use by clients since 1987.

32. Q. What different sizes of catalogs does AIR have available for hurricane loss estimation?

A. AIR has three different sized catalogs, distinguished by the number of simulated "years" of hurricane activity in the Atlantic Basin. Our catalogs consist of ten thousand, fifty thousand, and one hundred thousand simulated "years." As more simulations are used, the loss estimates become more robust and can be used at an increasingly granular level to provide accurate estimates of hurricane risk.

33. Q. What catalog did you use for your study on North Carolina Homeowners insurance?

We performed two analyses, each using a catalog 100,000 "years" of simulations. The 100,000 year catalog is the most robust catalog, and is commonly used in property insurance rate making. The first analysis is based on a standard view of the hurricane risk. This analysis formed the bases of the prospective hurricane losses employed by the Bureau in its filing.

The second analysis incorporates the impact of warm sea surface temperatures (WSSTs) in the North Atlantic on hurricane activity. This analysis formed the basis of the analyses by Dr. Appel who has noted in his testimony that reinsurers price reinsurance for the forthcoming year based on the existence of warm sea surface temperatures. This comports with my understanding of what reinsurers do.

34. Q. What is a Monte Carlo simulation model and what are its uses?

A. Our approach was based on the Monte Carlo simulation method which is a generally accepted and frequently used mathematical technique. This technique has been used extensively in the fields of operations research, nuclear physics, insurance and many other fields. With the advent of powerful computers that enable many simulations to be run quickly and relatively cheaply, the uses for this technique have expanded greatly.

One of the first uses of a Monte Carlo simulation as a research tool was for work on the atomic bomb during World War II. With the advent of powerful computers, the uses for this technique expanded. Computer simulation models are particularly useful tools for the analysis of problems that involve solutions that are difficult to obtain analytically.

As one noted authority, Law and Kelton, has stated: "Most complex, real-world systems cannot be accurately described by a mathematical model which can be evaluated analytically. Thus, a simulation is often the only type of investigation possible."
The natural hazard loss-producing system involving the analysis of potential hurricanes is one such system.

35. Q. What is a natural hazard simulation model?

A. A natural hazard simulation model is a model of the natural disaster "system." The primary variables are meteorological in nature. As to hurricanes, the AIR research team collects the available scientific data pertaining to the meteorological variables critical to the characterization of hurricanes and therefore to the simulation process. These primary model variables include landfall location, central pressure, radius of maximum winds, gradient wind reduction factor, peak weighting factor, forward speed, and track direction. Data sources used in the development of the AIR hurricane model include the most complete databases available from various agencies of the National Weather Service, including the National Hurricane Center.

Based on a rigorous data analysis of the model variables of all past hurricanes in the data period, AIR researchers develop probability distributions for each of the variables, testing them for goodness-of-fit and robustness. The selection and subsequent refinement of these distributions are based not only on the expert application of standard statistical techniques, but also on well-established scientific principles and the latest scientific studies of how hurricanes behave.

These probability distributions are then used to produce a large catalog of simulated hurricane events. By sampling from the various probability distributions, the model generates simulated “years” of event activity. A simulated year in this context represents a hypothetical year of hurricane experience that could happen in the next hurricane season. The AIR model also allows for the possibility of no hurricane event or of multiple events occurring within a single year. That is, each simulated year may have zero, one, or multiple hurricanes, just as occurs in an actual year. Each of the 100,000 simulated years has an equal probability of occurrence.

By generating 100,000 of these scenario years, the model produces a complete and stable range of potential annual experience of tropical cyclone activity. The pattern and distribution of the simulated years is based upon the pattern of historical years because their derivation is based on a scientific extrapolation of actual historical data. The pattern and distribution represent the broad range of events that could occur in the next hurricane season in accordance with their likelihood of occurrence. Thus, the next season could have no storms affecting North Carolina or multiple storms affecting North Carolina. It could have a Category 1 storm or a rare Category 5 storm. The model simulates these events in proportion to their likelihood based on the underlying science and actual meteorological data as to historical hurricanes.

Once values for each of the important meteorological characteristics have been stochastically assigned, each simulated storm is propagated along its track. Peak wind speeds and wind duration are estimated for each geographical location affected by the storm. Based on peak winds and duration, damages are estimated at each location for different types of structures. Also, policy conditions are applied to estimate the insured losses resulting from each event.

As opposed to purely deterministic simulation models, probabilistic simulation models such as the AIR model enable the estimation of the complete probability distribution of losses from hurricanes. Based on this probability distribution, average annual hurricane losses are derived and provided to the Bureau in the form of loss costs.

36. Q. What are the meteorological data sources that underlie your model?

A. The following are key data sources that underlie the AIR model.

Source	Years of Data
Tropical Cyclone Data Tape for the North Atlantic Basin, HURDAT	1900-2010
NOAA Technical Memorandum NWS NHC-6	1851-2010
Monthly Weather Review	1900-2012
NWS-23	1900-1976
NWS-38	1900-1984
Neumann, Charles J., "Tropical Cyclones of the North Atlantic Ocean, 1871-1998." NCDC, NOAA	1900-1998
National Hurricane Center Preliminary Reports for Specific Hurricanes	1977-2006
National Land Cover Dataset	1999-2001
DeMaria Extended Best Track Dataset	1988-2008

NOAA/AOML/Hurricane Research Division GPS Dropsonde data	2002-2005
http://weather.unisys.com/hurricane/index.html	1900-2012

37. Q. Are all of these sources governmental reports?

A. All are except for the Monthly Weather Review, which is a peer-reviewed journal published by American Meteorological Society; the DeMaria Extended Best Track Dataset, which is an academic dataset maintained by researchers at the University of Colorado; and the Unisys web site which is maintained by Unisys Corporation.

38. Q. Are these sources all generally accepted and relied upon in the meteorological and insurance communities?

A. Yes.

39. Q. Has AIR provided a document that describes the technical aspects of the AIR hurricane model in detail?

A. Yes. Attached as Exhibit RB 6-C is a lengthy document entitled "AIR Hurricane Model for the United States." It explains technical aspects of the AIR model and is incorporated into my testimony.

40. Q. What steps were taken to assure that the meteorological data underlying the model were correctly input into the model?

A. When the meteorological and other data are input into the model, we consistently follow the policy of carefully cross-checking and verifying the numbers for accuracy. We continually review our model and the underlying meteorological data to make sure that the data have been input correctly. We also compare our model-generated data with the actual historical data to make sure that there is a close match. For example, we overlay maps of our simulated wind speeds on maps of the actual wind speeds for actual historical events.

For example, Exhibit RB-6D, pages 1, 2 and 3 consists of three representative maps where we have compared data from actual wind speed measurements of hurricanes that have affected North Carolina with the modeled-generated data to make sure that there is a close match. These maps show the actual wind observations and location points for Hurricanes Charley, Floyd, and Ophelia, overlaid on the modeled wind speed footprint of the same events. Charley made landfall in South Carolina as a Category 1 hurricane after passing through Florida as a Category 4 hurricane. Floyd made landfall in the Cape Fear area as a strong Category 2 storm. Ophelia never made landfall, but bypassed close enough to the North Carolina coast as a Category 1 hurricane to cause damaging winds onshore.

41. Q. Turning to basic meteorological concepts, how do hurricanes form?

A. Hurricanes form when warm ocean water evaporates, is further warmed by the sun, and rises to create a high, thick layer of humid air. This rising of warm, dense air creates an area of low pressure, known as a depression, near the ocean's surface. Surface winds converge to the area of low pressure and, due to the earth's Coriolis force, display a clear cyclonic pattern.

The inward rush of peripheral surface winds toward the central area of low pressure, the rise of warm humid air in the center, and the subsequent outflow away from the system at high altitude, combine to create a self-sustaining heat engine. The warmer the water temperature, the faster the air in the center of the system rises. The faster this air rises, the greater will be the difference between the surface air pressures inside and outside the vortex.

Air flows from areas of relative high pressure to areas of relative low pressure. The greater the difference between peripheral and central pressures, the faster the inflow. When sustained wind speeds reach 40 miles per hour, the depression reaches tropical storm status. When sustained wind speeds reach 74 miles per hour, the storm is designated a hurricane.

42. Q. What is meant by sustained wind speed?

A. The term sustained wind speed refers to the wind speed averaged over a given period of time, such as one or ten minutes, or an hour. Generally for the purpose of this testimony as to hurricanes, a one minute sustained wind speed is used, and surface wind speed is defined as the wind speed at 33 feet (10 meters) above ground. The speed of shorter period gusts or lulls may be considerably higher or lower than the sustained wind speed.

43. Q. What are the categories of hurricanes?

A. Under the Saffir-Simpson Hurricane Wind Scale, there are five categories of hurricanes. These categories are useful to the public in describing the general intensity of storms and in issuing warnings to the public, but they are not relevant to AIR's modeling, which generates a continuous distribution of wind speeds rather than placing hurricanes into categories. Under the Saffir-Simpson scale, hurricanes are categorized according to sustained wind speeds as follows:

Saffir-Simpson Hurricane Wind Scale

Category	Wind Speed (mph)
1	74-95
2	96-110
3	111-129
4	130-156
5	>156

These category definitions were changed by the National Hurricane Center prior to the 2012 hurricane season for ease of calculation between different measures of wind speed. Since modeling uses a continuous distribution, it has not been necessary that these changes in category definition be implemented in the event descriptions in AIR's stochastic catalog, and it should be noted again that the category designations have no bearing on the loss results produced by the model. They are used to categorize one parameter of hurricanes and ignore many more parameters that can also greatly impact the damage caused by hurricanes. Since Saffir-Simpson categories are simply a descriptor for the wind speeds of hurricanes, and there is no change to the underlying wind speeds in AIR's model that are modeled on a continuous distribution, there will be no change to estimated loss costs as a result of the NHC's change to the Saffir-Simpson Category definitions.

The name "hurricane" is commonly employed for tropical cyclones of certain strength in the Atlantic basin. Categories 3, 4 and 5 hurricanes are commonly called "major" hurricanes. It should be noted that various other names and labels are given to tropical cyclones of different intensities when they occur in different parts of the world. For instance, the term "typhoon" is often used in the Pacific basin, and the term "supertyphoon" is used for tropical cyclones that reach maximum sustained 1-minute surface winds of at least 249 km/h, which is the equivalent of a strong Category 4 or Category 5 hurricane in the Atlantic basin.

44. Q. How many hurricanes made landfall in the United States in the historical experience period?

A. A total of 183 hurricanes made landfall in the U.S. during the sample period of 111 years of hurricane experience (1900-2010). A single hurricane may comprise several landfalls. For example hurricane Donna in 1960 had three landfall points including one in North Carolina. When accounting for multiple landfalling events, there were 209 hurricane landfalls in the U.S. during the same period, 25 of which are North Carolina landfalls. By landfall point, I mean the latitude and longitude coordinates of the place where the center of the wind circulation of the hurricane (commonly called the eye) crossed from the ocean to land.

Due to significant advances in satellites and other observational methods, much more is known with certainty about storms in recent years than about storms that occurred many years ago. The tracks and intensities of older storms often have to be pieced together by researchers based on limited data points. Many years ago, there were relatively few locations that measured storm parameters such as wind speed and central pressure, and often the instruments were destroyed in powerful storms. From time to time, governmental and academic researchers have reexamined the underlying data as to past hurricanes. For instance, as part of an organized reanalysis of historical hurricane data performed by government and academic researchers several years ago, it was determined that additional hurricanes had made landfall in North Carolina during the period of 1900-2010, and these storms and their meteorological parameters were therefore added to AIR's historical data base. However, more recent storms like Hurricane Irene or Hurricane Sandy are not yet included in AIR's historical database, because they were not included in the HURDAT database as of August 15, 2011, upon which the current version of the model is based. These storms will be added to the model when more data becomes available as to these storms and the model is updated.

In addition to landfalling hurricanes, scientists have analyzed historical data on the storm tracks of "bypassing" events. In the context of the AIR model, a bypassing event is defined as a hurricane that does not make landfall but causes damaging winds over land. In other words, it is an event where the center of wind circulation does not cross over land but the outlying winds away from the center are strong enough over land to cause damage to structures. Because North Carolina juts out into the Atlantic, bypassing hurricanes are more frequent in North Carolina than many other states. Bypassing hurricanes are generally not counted in the number of landfalling hurricanes; however, hurricanes that make landfall in states other than North Carolina but are strong enough to cause damaging winds in North Carolina as bypassing storms are counted in the number of landfalling hurricanes in U.S.

45. Q. The model results in approximately 58,000 events causing loss in North Carolina during the 100,000 "years" simulated. Does that conform closely with historical meteorological data?

A. Yes. It is important to point out that this number consists of numerous different types of events, many of which are quite small in impact. A small number of those events are "major hurricanes" making landfall in North Carolina and causing significant losses in North Carolina. Historical examples of major hurricanes include Hurricane Hazel, which was a Category 4, and Hurricane Fran, which was a Category 3. Hurricane Floyd was also a large and memorable Category 2 even though it was not a "major" hurricane at landfall in North Carolina. A small number of the approximately 58,000 events are major hurricanes that make landfall elsewhere and then continue on to make an impact in North Carolina. An historical example of this type of event is Hugo, which hit Charleston as a Category 4 before continuing through North Carolina with weakened but still powerful winds. "Famous" historical storms such as Hazel, Fran, Hugo and Floyd caused large losses and deservedly receive a great deal of publicity, but they do not constitute a large percentage of the total number of storms causing loss in North Carolina.

The total number of storms causing loss in North Carolina is predominantly comprised of many other types of events, most of which are small in terms of losses. Some examples of the types of events that can impact North Carolina with relatively modest levels of loss include:

- Storms that make landfall in the Gulf of Mexico and travel north, typically through central or western North Carolina, resulting in minimal wind losses in those areas of North Carolina.
- Storms that make landfall in Florida, Georgia or South Carolina, continue inland and cause losses in various areas throughout North Carolina.
- Storms that make landfall in Florida, go back out to sea and make landfall in North Carolina.
- Storms that bypass North Carolina. These can be of several types. Some are bypassing storms that never make landfall anywhere in the United States. Others can be storms that bypass North Carolina and make landfall in Virginia, New England or some other location to the north of North Carolina. Still others can be storms that made landfall in a state to the south of North Carolina (often in Florida) and then travel north just off the coast of North Carolina.

These examples are not intended to represent the complete list of types of storms that could impact North Carolina, but rather are designed to show the diverse nature of events that result in losses in the state.

In addition, there have been numerous years in which multiple hurricanes caused losses in North Carolina. For instance, in 1955 three storms made a direct landfall in North Carolina, and in 2004 more than three storms made landfall in the Gulf of Mexico or Florida and caused losses in North Carolina as they moved north.

Exhibit RB-6E compares the historical frequency of events that made landfall in North Carolina, that made landfall outside North Carolina and impacted North Carolina inland and that bypassed North Carolina, with the corresponding frequency from the AIR modeled stochastic catalog. As can be seen, there is a close relationship between the model and the historical record, both for the entire period and for the period when warm sea surface temperatures have been in existence. As can be seen, the model simulates fewer hurricanes than have actually affected North Carolina in the historical record.

It is in the very nature of modeling that differences between the model and the historical record are expected. The nature of modeling is to take the limited number of data points in the historical record and apply accepted mathematical distributions to those data points in order to simulate thousands of equally likely events for the following year.

46. Q. What was the most intense hurricane to directly strike North Carolina during the period 1900-2013?

A. Hazel, a Category 4 hurricane, in 1954 was the most intense hurricane to hit North Carolina during this period from a meteorological standpoint. Several other strong hurricanes of intensity similar to Hazel were "near misses" during this period. Of course, North Carolina may experience much more severe storms than Hazel at some point in the future. Hazel was by no means the worst case scenario for the state, even though it was the worst storm during the period during which good records are available.

47. Q. How are bypassing storms handled in the AIR model?

A. As described above, bypassing storms are hurricanes which do not actually make landfall (i.e., where the center of the hurricane eye never actually comes on shore) but which come close enough to the coastline to cause damaging winds over land. For the purpose of categorization, those storms that are identified as North Carolina by-passers are ones that originate in the Atlantic basin and do not make landfall as hurricanes anywhere in the United States. They can, however, make landfall as tropical storms further north along the US coastline and still be counted as bypassing storms.

Recent changes to the AIR model reflect an increase in the number of bypassing storms that have been identified by government and academic researchers, based upon their continuing analysis and reanalysis of the storm frequency in the Atlantic basin. A recent example of a bypassing storm is Hurricane Earl in 2010. Earl had the potential to make a direct landfall in North Carolina. However, in 2010 the location and influence of the so-called "Bermuda High" caused many storm tracks, including Earl, to curve northward without making a landfall. Had conditions been different, Earl could have made a landfall and caused significant loss in North Carolina. There have been numerous other powerful bypassing storms that, if steering currents had been slightly different, could have made landfall in North Carolina and have caused significant losses.

Another example is Hurricane Helene in 1958. Helene was a strong Category 4 hurricane which came very close to making landfall in North Carolina but bypassed the coast. Even though it did not make landfall, it caused damage in some parts of the state in excess of that caused by Hazel four years earlier in those areas.

48. Q. Has AIR produced any comparisons of historical event frequencies to the frequencies that are incorporated in the model?

A. Yes, Exhibit RB-6F to this testimony compares the historical frequency by Saffir-Simpson category of events making landfall in North Carolina to the corresponding frequency from the modeled stochastic catalog. As stated earlier, AIR models a continuous distribution of hurricane wind speeds using a distribution that is based on the actual wind speeds of historical hurricanes, and this procedure does not depend on or employ assumptions as to the Saffir-Simpson categories of past or modeled storms. Analyzing storm data by first placing storms into certain categories and then measuring the number of storms in each such category is not a robust manner to review the validity of the model because the presence or absence of a single storm on the borderline between two categories could affect the review inappropriately; however, even by forcing storms into Saffir-Simpson categories, it can be seen that the AIR model conforms with history using that type of popularized analysis.

As stated above, it is the nature of modeling that the limited amount of historical data can be analyzed and, by the use of mathematical distributions, can be extended to create combinations and permutations that can and will occur but have not occurred in the past. For example, as can be seen from the small bar on Exhibit RB-6F for Category 5 storms, the model simulates a very small number of Category 5 storms even though there has never been a Category 5 storm to strike North Carolina in recorded history. This is appropriate. Scientists know that there is no meteorological reason and no reason in physics that a Category 5 storm cannot strike North Carolina, and there is a mathematical probability that one will strike someday. Academic and governmental sources confirm that a Category 5 storm can strike North Carolina. Accordingly, the model simulates such storms as extremely low probability events even though they have never occurred in the period of time for which consistent historical data has been collected.

49. Q. Are there any climatological factors influencing hurricane frequency and intensity in general and with respect to North Carolina in particular?

A. Yes. There are a number of climate “signals” that are correlated with mechanisms within the earth’s environment that impact hurricane activity in the Atlantic Basin. These include the Atlantic Multidecadal Oscillation (AMO), the El Nino Southern Oscillation (ENSO), the Quasi-Biennial Oscillation (QBO), and the North Atlantic Oscillation (NAO).

The AMO is the oscillation of sea surface temperatures in North Atlantic, which fluctuates over a period of several decades. We are currently in a period of warmer than average sea surface temperatures.

The ENSO is the oscillation of sea surface temperatures in the Eastern Pacific Ocean, which fluctuates over a period of approximately 2.5 to 7 years. “El Nino” conditions result in stronger than average wind shear over the Atlantic Ocean. Wind shear is detrimental to hurricane development. Wind shear is a measure of how much winds vary by height. High wind shear has the effect of preventing hurricane development by disrupting the structure of a tropical cyclone. In contrast to El Nino conditions, “La Nina” conditions are more conducive for hurricane formation due to lower wind shear over the Atlantic.

The QBO is the oscillation in wind directions over the tropics in the upper atmosphere, which fluctuates about every 2 years.

The NAO is the large scale oscillation in atmospheric pressure in the Atlantic Ocean between the subtropical high and the polar low pressure system. The NAO fluctuates over short periods of time, such as days, weeks, or months. The changing location of the high and low pressure systems over the Atlantic has different impacts on hurricane activity in the Atlantic basin. NAO movements can affect steering currents that direct hurricanes to various areas in the Atlantic basin. For instance, the location of the “Bermuda high” can have a significant effect on whether a storm makes landfall along the east coast of the United States.

In addition to these four climate signals, there is always variation in any given hurricane season. The random occurrence of factors such as sandstorms in West Africa, the timing of frontal systems coming across the northern United States and periodic fluctuations in jet stream activity that have been shown to impact the formation, development and landfall of hurricanes in states such as North Carolina.

50. Q. How are these factors incorporated into the AIR model?

A. The four climate signals and other factors are not explicitly accounted for in the standard 100,000 "year" hurricane catalog. The standard catalog is a catalog that is based on the past 111 years of historical hurricane activity which includes multiple observations of each of these climatological signals and oscillations. The 111 year period used in the Standard Catalog captures the effects of all of these factors.

As stated earlier, AIR has developed a WSST hurricane catalog which incorporates the impact of elevated sea surface temperatures (SSTs) in the North Atlantic on hurricane activity. Loss costs from this catalog are contained in Exhibit RB-6B.

A correlation has been drawn between sea surface temperature and hurricane activity in the Atlantic basin. There is an increased probability of hurricane activity during warm periods, and a decreased probability of hurricane activity during cool periods. This correlation is logical because it is known as a matter of physics that warm sea surface temperatures provide the necessary "fuel" for hurricanes. As with many meteorological matters, this correlation is subject to uncertainty and continues to be an area of active research. The WSST Catalog is created by adjusting the frequency and severity of the Standard Catalog based on historical periods of known above-average sea surface temperature.

Exhibit RB-6E shows how the frequency of events in years with warmer than average SSTs differs from the average frequency for the entire historical period in terms of hurricanes affecting North Carolina.

51. Q. Based on this information, what conclusions can be drawn about the probability of hurricane activity in the Atlantic basin in the coming years?

A. As noted above, we are currently in a period of above-average sea surface temperatures. If the warmer than average sea surface temperatures persist into the coming years, the Atlantic hurricane activity is likely to be elevated. While the other three cycles might oscillate to result in either an increased or decreased level of hurricane activity from one season to the next, and while other factors may increase or decrease activity in given years, the SST varies over a much longer period of time and thus results in an overall increased probability of hurricane activity in North Carolina in the coming years.

52. Q. Is the AIR modeling methodology a sound and appropriate method of projecting the prospective hurricane losses used in the filing for homeowners insurance in North Carolina?

A. Yes. AIR's simulation methodology is based on mathematical/statistical models that are derived from and that represent real-world systems. The methodology is founded in and consistent with documented science. As with all models, these representations are not exact; however, simulation methodology is the best available technique for estimating potential hurricane losses and is far superior to referencing actual dollars of losses paid by insurance companies following hurricanes, whether recently or many years ago. The best approach is to consider the longest period of consistently maintained and reported meteorological data available and to use that data to establish the range and probability distributions of events that could occur. That is what AIR's model does for 100,000 iterations, and the results are averaged for the determination of loss costs used by the Bureau.

AIR's standard hurricane catalog incorporates data beginning in 1900, which AIR scientists have concluded is the best and longest period of consistent and reliable data available. While some data is maintained on hurricanes that have occurred prior to 1900, the data is not of the consistency and quality of data following that date.

AIR's analyses using the standard catalog produces the long run average hurricane loss costs for the modeled exposure set. AIR's WSST hurricane catalog also incorporates the best and longest period of data available, with modifiers applied to account for the impact of elevated sea surface temperatures on hurricane activity. The differences in historical hurricane data between periods of warm and cold sea surface temperatures are reflected in the WSST catalog. Analyses using the WSST catalog also yield the average hurricane loss costs, assuming the continuation of elevated sea surface temperatures.

53. Q. What is the sequence in which the AIR model simulates hurricanes affecting the U.S. and North Carolina?

A. For each simulated year, the model first determines the number of landfalls that occur during that year. This frequency variable is based upon and reflects the historical pattern and probability of hurricanes over the long term. In those years in which a landfall occurs, the landfall location is generated using a probability distribution for landfall location. This landfall location also is based upon and reflects the historical probability of landfall locations.

Having simulated the location, values for landfall angle, forward speed, central pressure, radius of maximum wind, gradient wind reduction factor, and peak weighting factor are generated using probability distributions derived from historical data and meteorological knowledge. As a hurricane moves from its landfall location, its track is simulated using probability distributions derived from historical data and meteorological knowledge. This is done by using a Markov procedure with transition probabilities estimated using historical data.

54. Q. How is hurricane frequency modeled?

A. The model uses a negative binomial distribution to generate the number of hurricane landfalls per year. Actual historical data from 1900-2010 is compared to the modeled distribution for the entire Gulf and East Coasts. The modeled distribution fits the historical data very closely. The average number of hurricanes per year making landfall in the U.S. is 1.65. However, considering that a storm may make more than one landfall, the average number of hurricane landfalls is 1.88. Since the negative binomial distribution models individual landfalls, it has a mean of 1.88, reflecting the historical average of hurricane landfalls.

As discussed above, Exhibit RB-6E to this testimony shows comparisons of AIR's modeled event frequency to the corresponding frequency from the historical record for North Carolina.

55. Q. How is landfall location modeled?

A. For the United States, there are 62 potential landfall segments each representing 50 nautical miles of smoothed shoreline along the Gulf and East Coasts, including the Florida Keys. A cumulative distribution of landfall locations within each coastal boundary segment is used to estimate the probability of a hurricane landfall occurring at a point along a segment. Once a segment is chosen in accordance with its probability, the landfall location within that segment is drawn at random from a uniform distribution along that segment; that is, a storm can make landfall anywhere on that segment with equal probability.

56. Q. How is hurricane severity modeled?

A. The AIR hurricane model generates values for the severity variables based on historical meteorological data. There are seven primary variables which account for hurricane severity. These variables are: the minimum central pressure, the gradient wind reduction factor, the peak weighting factor, the radius of maximum winds, the forward speed, the angle at which the storm enters the coast and the track of the storm once on shore. The most recent version of the model reflects new scientific findings as to these variables.

57. Q. What is the central pressure variable?

A. Central pressure is defined as the minimum atmospheric pressure measured in a hurricane. The central pressure distribution is based on the historical database and is determined for each 100-nautical-mile coastline segment, as well as for larger regional segments.

Exhibit RB-6G shows a comparison of the modeled central pressure values in AIR’s stochastic catalog to the same values in the historical catalog for events which make landfall in North Carolina.

There is good agreement for the mean central pressure at landfall. The mean central pressure for North Carolina landfalls is 968.5Mb, which falls within the 95% confidence interval based on the historical record. The 95% confidence interval is a range of values in which we can be 95% sure that the true mean lies, based on the observed historical data. The fact that the modeled mean lies within this range means that there is no statistical reason to suspect that the modeled mean is not the true mean.

58. Q. What is meant by the radius of maximum winds?

A. The radius of maximum winds (Rmax) is the radial distance from the storm’s center, or center of the eye, to the location in the eye wall where the highest cyclonic wind speeds occur. The radius distribution is based on the historical database and is dependent on the central pressure of the storm. The radius of maximum winds also varies after landfall, in accordance with values in the historical data.

There is uncertainty in the historical data since this storm parameter is a difficult parameter to measure. This was particularly true for storms that made landfall during the first half of the 20th century, before reconnaissance flight data or high-resolution radar data become available. The model is based on widely accepted Rmax values and distributions in the scientific literature.

59. Q. What are the gradient wind reduction and peak weighting factors?

A. These two factors are used to translate the flight-level winds to the land surface. The wind speed of a hurricane varies both with the lateral distance from the eye and the vertical distance from the land surface to the flight level. The gradient wind reduction factor varies by distance from the eye of the storm and translates the flight-level winds horizontally to the land surface where buildings are affected by hurricane winds. The peak weighting factor also adjusts the gradient wind reduction factor for the vertical slant in the hurricane eye. These two factors are generated jointly for each modeled storm based on algorithms founded in historical data and accepted meteorological principles.

60. Q. What is forward speed?

A. Forward speed is the speed at which the center of a hurricane moves from point to point along its track. In general, hurricanes pick up speed as they move further north in latitude. The forward speed distribution is based on the historical database of forward speeds at landfall and is determined for each 100-nautical-mile segment

Exhibit RB-6H shows a comparison of the modeled forward speed values in AIR's stochastic catalog to the same values in the historical catalog for events which make landfall in North Carolina.

There is good agreement for the different bands of forward speed at landfall, and in fact the mean forward speed for North Carolina landfalls is 16.2 mph, which falls within the 95% confidence interval based on the historical record. The 95% confidence interval is a range of values in which we can be 95% sure that the true mean lies, based on the observed historical data. The fact that the modeled mean lies within this range means that there is no statistical reason to suspect that the modeled mean is not the true mean.

61. Q. Does the combination of forward speed and wind speed affect the damage caused by a given hurricane?

A. Yes, this is what is referred to as the "asymmetrical effect" of hurricane winds. Hurricane winds move in a counter clockwise direction around the eye of the hurricane, which means that winds on the right side of the hurricane are moving with the forward direction of the storm, thereby combining to create higher wind speeds at locations on the right side of the hurricane. Conversely, the wind speed at any given location on the left side of the storm is reduced by the combined effect of the hurricanes rotational winds being offset by the translational winds. The faster the forward speed of the hurricane, the greater are the effects of this asymmetry. Also, the faster the forward speed, the less time that damaging winds affect a given location.

62. Q. What is the track angle at landfall?

A. Track angle at landfall is the angle between track direction and due north at landfall location. Track angles at landfall in the model reflect the underlying meteorological data.

63. Q. What is the storm track?

A. Storm track is the path the hurricane takes. AIR has developed a procedure to simulate storm tracks, which is described in more detail under question 70 below This procedure allows the tracks to curve and re-curve in the same way and to the same extent that actual historical storms do.

64. Q. Does the latitude of the hurricane make a difference?

A. Yes. Hurricane intensity and frequency vary by latitude. In general, as latitude increases, average hurricane intensity decreases, and we model this effect accordingly. In general, water tends to be cooler in higher latitudes. When a hurricane moves over cooler waters, its primary source of energy (latent heat from warm water vapor) is reduced so that the intensity of circulation decreases, in the absence of outside forces. For this reason, the parameters of the severity variable probability distributions were estimated separately for each of the thirty-one 100-mile coastal segments using state-of-the-art statistical techniques combined with published scientific information. The result is that the model reflects the historical data that hurricanes tend to lose some of their intensity as they move north. Likewise, the model reflects the historical data that hurricanes tend to have higher land speed as they move north.

65. Q. How does the AIR model generate values for the distribution of hurricane central pressures?

A. The AIR hurricane model utilizes central pressure as the primary hurricane intensity variable. Based on the historical data, Weibull distributions are employed so that the parameters are estimated for each of the thirty-one 100-nautical-mile coastal segments, as well as for larger regional segments, with the final distribution being a mixture of the two. The Weibull form was selected based on “goodness-of-fit” tests with actual historical data. The use of the Weibull distribution for storm central pressure is documented in and supported by the scientific literature.

As discussed earlier, Exhibit RB-6G shows a comparison of the modeled central pressure values in AIR's stochastic catalog to the same values in the historical catalog for events which make landfall in North Carolina.

66. Q. How does the AIR model generate values for the radius of maximum winds?

A. The radius of maximum wind (Rmax) is simulated using a regression model that relates the mean radius to central pressure and latitude. The deviations from the mean in this model are simulated from a Normal distribution. The parameters are estimated using the least squares method, and standard diagnostic tests are used to evaluate the adequacy of the fit. The resulting values are bounded based on central pressure to produce a final distribution for the radius. The radius of maximum wind also varies after landfall, following an autoregressive model.

The model is based on Rmax values and distributions that are widely accepted in the scientific literature.

67. Q. How does the AIR model generate values for the gradient wind reduction factor and the peak weighting factor?

A. The model computes the maximum wind speed at upper levels and then adjusts this wind speed to the surface level (10 meters) via a conversion factor. This factor, called the gradient wind reduction factor, represents a model parameter which varies stochastically by storm. For a particular storm it varies by location as a function of the central pressure and distance from Rmax. The peak weighting factor adjusts the gradient wind reduction factor to reflect the vertical slant in the hurricane eye. The peak weighting factor and gradient wind reduction factor are generated jointly using a bounded bivariate normal distribution. These factors are based on accepted meteorological studies and principles.

68. Q. How does the AIR model generate values for forward speed?

A. Probability distributions are estimated for forward speed for each 100-nautical-mile segment of coastline with bounds based on the historical record. Separate distributions are estimated for each of these segments to capture the dependence of this variable upon geographical location, particularly latitude. Based on the historical record, forward speed varies after landfall according to an autoregressive model. The bounds on forward speed are latitude dependent; i.e., storms tend to pick up speed the further north they travel.

As discussed earlier, Exhibit RB-6H shows a comparison between the modeled forward speed values in AIR's stochastic catalog and the same values in the historical catalog for events which make landfall in North Carolina.

69. Q. How does the AIR model generate values for track angle at landfall?

A. Separate distributions are used for different 50-nautical-mile coastal segments to allow for variation in the coastal orientation of each segment. In the historical record, certain coastal segments seem to be characterized by bimodal track angles. To preserve consistency with the historical distribution, the track angle at landfall is modeled using a mixture of two normal distributions. That is, the track angle at landfall is drawn from the first normal distribution with probability p, or it is drawn from the second normal distribution with probability 1-p. The final distributions are bounded based on the historical record, the coastline orientation, geographical constraints, and meteorological expertise.

70. Q. How does the AIR model generate values for storm tracks?

A. Storm tracks are generated by successively drawing track direction and forward speed. AIR uses a Markov chain model with estimated transition matrices to simulate track direction. Our scientists have analyzed historical data on the tracks of more than 1,000 Atlantic tropical cyclones, both those that made landfall and those that did not. Using this data, AIR has created transition matrices from which successive track directions are generated. There are 16 primary directional probabilities. Within each primary direction there is a uniform, continuous probability distribution, resulting in an infinite number of potential track directions. For each of 16 directional probabilities of storm arrival, these matrices specify the probability of a directional change at each time step. Having determined the new track direction, the next track point is determined by drawing forward speed using a procedure that incorporates time series dependence between successive drawings. The methodology produces realistic tracks that represent the full range of diverse storm tracks that have been observed historically across the Atlantic basin and the U.S. mainland in accordance with their historical probability.

In older versions of the AIR hurricane model, storms were terminated after the tracks evolved for 24 hours after making U.S. landfall. In Version 12 of the model and newer versions, including Version 14.0.1, each storm is terminated only when its wind speed along the path decreases to below 40 mph. The number of storms causing loss in North Carolina has therefore increased because of this change, but the potential for damage is more appropriately reflected than before. The dollar value of losses associated with this increased event persistence is not great.

It is also the case that a single landfalling hurricane may produce multiple landfalls or subsequent bypasses. A number of historical storms that have affected North Carolina fall into these categories. Since the AIR model follows each simulated hurricane from inception until dissipation, multiple landfalls and bypassing hurricanes are included in the simulation. The simulated frequency of these events is consistent with their historical frequency by coastal region.

71. Q. How does the AIR model calculate maximum wind speeds?

A. Once values are obtained for all of the severity variables, the maximum sustained wind speed is calculated using generally accepted meteorological formulas. For each simulated event, the model simulates the storm's movement along its track. A complete time profile of wind speeds is developed for each location affected by the storm, thus capturing the effect of duration of wind on structures, as well as the effect of peak wind speed. Calculations of local intensity also take into account the effects of the asymmetric nature of the hurricane windfield, the effects of the storm "filling" or dissipating in intensity over land, the directional effects of surface friction, the gustiness effects of surface friction, the effect of wave height on wind speed, and the relative wind speeds as the distance from the radius of maximum winds increases.

In AIR's continuing effort to reflect scientific advancements, recent versions of the model much more accurately reflect these factors. For instance, Version14.0.1 explicitly computes the effects of land cover on windspeed by wind direction. In previous versions (prior to version 12), the model assumed an average land cover and an average frictional effect, but as a result of the ability to geocode actual land cover characteristics, the model is now much more precise. Thus, less deterioration of wind speeds occurs to storms that make landfall in areas that have nearby low dunes or sounds and other bodies of water, as opposed to areas that have tall trees, hilly or mountainous terrain, or tall buildings. This change means that the model now more accurately reflects the deterioration of storms in various locations in North Carolina based on the actual land cover in those locations.

As mentioned previously, Exhibit RB-6D shows the actual wind observations for Hurricanes Charley, Floyd, and Ophelia, which each affected North Carolina, overlaid on the modeled wind speed footprint of the same events. Hurricane Irene is not included in this exhibit because it is not included in the HURDAT database as of August 2011, and is not yet included in AIR's historical catalog.

Additionally, Exhibit RB-6I shows a comparison of the modeled maximum wind speed values at landfall in AIR's stochastic catalog to the same values in the historical catalog for events which make landfall in North Carolina.

There is good agreement for the different bands of maximum wind speed at landfall, and in fact the mean maximum wind speed for North Carolina landfalls is 96.0 mph, which falls within the 95% confidence interval based on the historical record. The 95% confidence interval is a range of values in which we can be 95% sure that the true mean lies, based on the observed historical data. The fact that the modeled mean lies within this range means that there is no statistical reason to suspect that the modeled mean is not the true mean.

72. Q. You have explained how the AIR model generates values determining the frequency and severity of hurricanes. Now please explain how insured damages are computed?

A. AIR scientists and engineers have developed mathematical functions, called damageability relationships, which describe the interaction between buildings (both their structural and nonstructural components as well as their contents) and the local wind intensity to which they are exposed. Damageability functions have also been developed for estimating time element losses (generally, coverage for loss of use which requires the owner to rent elsewhere). These functions relate the mean damage level as well as the variability of damage to the measure of storm intensity at each location. Because different structural types (ex. frame or masonry) will experience different degrees of damage, the damageability relationships vary according to construction materials and occupancy. The AIR model estimates a complete distribution around the mean level of damage at a given intensity and structural type, and from there the model constructs an entire family of probability distributions. Losses are calculated by applying the appropriate damage function to the replacement value of the insured property.

The AIR damageability relationships incorporate the results of well-documented engineering studies, tests, and structural calculations. AIR employs a team of nine engineers who continually survey the engineering literature and state and/or regional building codes and other sources as to wind engineering. They also consult with other experienced engineers to verify our damage functions, and if necessary, they refine these relationships.

AIR engineers perform post-disaster field surveys and analyses for all U.S. landfalling hurricanes. Additionally, AIR has analyzed billions of dollars of actual insurance claims data from hurricanes in order to validate damageability relationships in the model. The loss information is typically reviewed in numerous manners, including by zip code, coverage and construction.

73. Q. How often has the AIR model been updated and refined since it was originally created?

A. The AIR hurricane model was first developed in 1985. Since that time the model has typically been updated in each year. In some years, routine matters such as the zip code database are the only updates performed. On such occasions, for each new zip code centroid, the following are re-estimated: distance from coastline, elevation, surface terrain, and any other special topographical features.

In other years there can be a large number of model updates. As new data and research about hurricanes become available, such information is also added to the model. The probability distributions for all of the meteorological variables have been re-computed approximately every two or three years to reflect additional years of new hurricane experience. Damageability relationships have been continually reviewed and validated as actual hurricanes have occurred and new loss data has become available.

Other revisions to the model represent one-time refinements to various model components, and these typically are undertaken when significant new data or research becomes available. AIR prides itself on keeping up with the newest developments of science.

During the period of 2009-2010 there was a major and comprehensive update of many components of the model to reflect significant new data and research. These updates were implemented into Version 12 and carried through the newer model versions, including Version 14.0.1. Some of these updates are described in detail throughout this testimony. The 2011-2013 update to Version 14.0.1 represents the most recent of the ongoing model update efforts. Over the years these efforts brought about some significant improvements to the model and its output. As will be discussed below, these changes were extensively thought out, peer reviewed and validated.

74. Q. Has the AIR model been independently peer reviewed?

A. Yes, it has been extensively peer reviewed by independent scientists since it was first created in 1985, and it has been subject to periodic peer review thereafter. Independent reviews of the model have been conducted by many experts in multiple fields, including meteorology, engineering, computer science, insurance, statistics, and finance. As a result of this review and scrutiny, it is correct to state that the AIR hurricane model has been extensively vetted by independent, outside parties as well as AIR's own technical staff.

Meteorological components of the model were reviewed in 1986, 1994, 2009 and 2010. The derivation and application of vulnerability functions used in the model have undergone independent review for each of the past ten years, particularly following hurricane loss reports becoming available after analysis of each hurricane. Computer science reviews have been conducted in 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2010 and 2012 to validate that AIR's modeling software complies with the standards of the Florida Commission on Hurricane Loss Projection Methodology.

75. Q. Please describe the peer review process.

A. As described below, over many years, the AIR model has undergone extensive external review by independent scientists, and it has been examined in scientific literature. It has also been reviewed in depth by independent rating agencies and regulators.

The following are independent peer reviews that have been performed, broken down by the components of the AIR model. As will be noted, peer reviews were particularly extensive as to the 2009-2010 changes that are reflected in this filing.

Meteorology – In 2010 the meteorology component of the model was extensively reviewed by three meteorologists, Dr. Kerry Emanuel, Dr. Peter Black, and Dr. Robb Contreras.

Dr. Black has spent over 40 years conducting hurricane research at NOAA's Hurricane Research Division as a research meteorologist using observations provided by aircraft and satellite platforms. Among many other accomplishments, Dr. Black has been a lead project scientist on various NOAA research aircraft, involving over 400 hurricane eye penetrations in 300 hurricane flights. He has been responsible for conducting investigations of the hurricane boundary layer structure, ocean response to a hurricane, microwave remote sensing of surface winds, hurricane convective clusters, and most recently, hurricane air-sea interaction processes.

Dr. Contreras has spent over sixteen years doing research in academic departments such as the University of Massachusetts, Amherst, the University of Washington, Seattle and UC San Diego. Recently Dr. Contreras has worked as a scientist to implement physical models of signatures, environments, and sensors based on first principles. He has developed physics-based algorithms for robust detection and tracking.

Dr. Kerry A. Emanuel has been a professor at the Massachusetts Institute of Technology since 1997 in both the Program in Atmospheres, Oceans, and Climate and the Center for Meteorology and Physical Oceanography, where he was also the director for eight years. Dr. Emanuel has received numerous awards including The Carl-Gustaf Rossby Research

Medal and the Louis J. Battan Author's Award, from the American Meteorological Society in 2007.

The WSST catalog generation process has also been reviewed by well-respected meteorological experts. The research used to develop the WSST catalog was peer reviewed and published in the American Meteorological Society’s *Journal of Applied Meteorology and Climatology*. In 2010 the WSST catalog generation process was also reviewed by Dr. Kerry Emanuel of MIT, Dr. James Elsner of Florida State University, and Dr. Timothy Hall of the NASA Goddard Institute for Space Studies.

Vulnerability - The vulnerability functions have been reviewed by Dr. Joseph Minor, P.E. in 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2009, by Dr. Marc Levitan in 2009 and by Dr. Carol Friedland in 2009 and 2013.

Dr. Friedland has been engaged in wind and hurricane engineering research, practice, and education for over nine years and in civil engineering and construction for over fourteen years. She is an Assistant Professor in the Department of Construction Management and Industrial Engineering at Louisiana State University. She has been a registered professional engineer since 2003. She has studied wind and hurricane effects on buildings and structures through structural analysis and post-storm investigations. Recent field investigations include documenting performance of buildings and other structures after Hurricanes Isaac, Gustav, Ike, Katrina, and Ivan and the April 2011 tornado outbreaks in Alabama and Mississippi.

Dr. Marc Levitan has been actively engaged in wind and hurricane engineering research, practice, and education for over 27 years. He is currently leading research and development to improve model codes, standards, design guidance, and practices for the construction and rehabilitation of buildings, structures, and lifelines at the National Institute of Standards and Technology. At the time of his review of the model, he was an Associate Professor in the Department of Civil and Environmental Engineering at Louisiana State University. He was the driving force behind the creation of the LSU Hurricane Center. Under his direction for a period of 10 years, that Center became one of the premiere interdisciplinary research facilities, addressing hurricanes and other natural hazards and their impacts on the natural, built, and human environments. He has provided national leadership through: chairing national technical and policy committees; chairing national and international conferences and workshops; serving as President of the American Association for Wind Engineering, and testifying a number of times before Congress and in state legislatures on topics related to wind and hurricane hazards and mitigation. He has several dozen publications in journals, conference proceedings, and other venues.

Computer Science - The software engineering components of the model have undergone independent peer review by Dr. Mark Wolfskehl in 2002, Dr. John Kam in 2003, 2004 and 2005, and by Narges Pourghasemi in 2006, 2007, 2008, 2010 and 2012.

Ms. Pourghasemi has been an independent software consultant for over eight years. She has extensive experience in software engineering, development and testing.

Actuarial - The model underwent an actuarial review in 2010 and 2012 by John Rollins, FCAS, MAAA.

Mr. Rollins is an experienced property-casualty actuary. His qualifications include over twenty-two years of property and casualty insurance experience in a variety of positions including a leading catastrophe modeling firm, Florida property insurers, Florida residual market property insurers, global consulting and software firms, and advisory organizations. He has the highest actuarial qualifications, and has extensive authorship and speaking experience.

76. Q. What are examples of outside reviews that have been performed on behalf of independent third parties?

A. One significant example is the testing conducted by four bond rating agencies in 1996 and 1997 in conjunction with their rating of the USAA catastrophe bond. Those agencies were Duff & Phelps, Fitch, Moody's and Standard & Poor's. Their review was particularly extensive because the USAA catastrophe bond was the first such bond to be assigned a corporate bond rating by all four agencies. The probabilistic estimates derived from the AIR hurricane model formed the primary basis for the assigned ratings.

Over a period of 18 months, AIR staff met with employees and consultants hired by the rating agencies representing many fields, including insurance, statistics, meteorology and finance, to explain the AIR hurricane model in extensive detail. In addition, a number of sensitivity analyses and stress tests were performed at the request of the rating agencies during this period of time.

These tests, performed by outside experts whose primary interest was the protection of prospective investors, confirmed the robustness of the AIR model. Moody's wrote: "Moody's did not simply accept AIR's modeling results at face value. Rather, we followed an examination and calibration procedure, aiming to provide Moody's with a high degree of confidence in the reliability and stability of the simulation results."

Similarly, Fitch wrote in approving the model: “Fitch evaluated the underlying technical integrity of the AIR model on the basis of model specification and model structure.”

Due to the first-time nature of such a large catastrophe bond issuance, the rating agencies very carefully scrutinized model assumptions, data, and methodology. These rating agencies have continued their scrutiny of the model in the course of subsequent catastrophe bond transactions, including every property catastrophe bond transaction that came to market in 2011 and 2012 and every property catastrophe bond transaction that has come to market so far in 2013.

77. Q. What information does AIR provide outside reviewers about its methodology?

A. In the review of the AIR model in 1996 and 1997 by the bond rating agencies, review took place as to the probability distributions used in the model and the estimation methods employed to fit the parameters of those distributions. Also the consultants employed by the bond rating agencies reviewed the mathematical functions used in the model to estimate the interactions between simulated storm parameters. For the validation testing and sensitivity analysis, the rating agencies reviewed model output under various distributional assumptions.

For the meteorology peer reviews in 2010, we provided Dr. Emmanuel, Dr. Black and Dr. Contreras the data sources, the references of data and the published research used, as well as detailed explanations of the actual implementation which AIR scientists used to develop and/or update the model. The review was conducted iteratively so that suggestions and feedback from the peer reviewers early on was incorporated in subsequent model updates.

For their review of the vulnerability component of the model in 2010 and 2012, Dr. Friedland and Dr. Levitan were provided the Florida Commission vulnerability standard submissions and comprehensive detail on all changes to the vulnerability component of the model. The peer review team conducted an extensive review of the damage functions and research used in the development of those functions.

The computer science peer reviewers were provided information on the software development and testing processes, including insights into the software and underlying code to ensure that the software complies with the software standards and requirements established by the Florida Commission, as well as current industry-standard software engineering practices.

AIR provided the 2010 and 2011 actuarial peer reviewer with model software, input data, output files, and work papers used in assembling the response document and forms for the Florida Commission. The review proceeded step by step based on these items.

78. Q. You have mentioned on several occasions that the AIR model has been reviewed by the Florida Commission. Please describe what that Commission is and what AIR has done in connection with that Commission.

A. The Florida Commission was established in 1995 by the Florida legislature with the mission to "assess the effectiveness of various methodologies that have the potential for improving the accuracy of projecting insured Florida losses resulting from hurricanes and to adopt findings regarding the accuracy or reliability of these methodologies for use in residential rate filings." The Commission has established 37 standards that need to be met before a catastrophe model is acceptable for ratemaking purposes in the state of Florida. The AIR hurricane model was the only model approved under the original standards in 1996, and it has consistently been approved under the standards in every subsequent year. Once approved, the model can be used in rate filings in Florida.

In addition, AIR has been working with insurance departments in other states for a number of years in meeting their informational requirements in connection with rate reviews and solvency reviews. No other state legislature has elected to set up and fund a commission that does a comprehensive ongoing review of models as exists in Florida, but it appears that many other states in the hurricane prone southeast rely upon the extensive review and approval process performed in Florida. Some states have performed less extensive and more piecemeal or informal examinations of the AIR model. For instance, representatives of the North Carolina Insurance Department have visited AIR at its headquarters in Boston on several occasions. AIR provided information to a consulting meteorologist retained by the North Carolina Department who visited AIR in Boston in 1993. On two subsequent occasions actuaries from the North Carolina Department traveled to AIR's offices in Boston for a review of the model. Also, AIR responded to numerous questions and provided extensive information to a professor of mathematics from North Carolina State University who was hired by the North Carolina Department to review AIR's methodology. He reviewed the distributions and algorithms underlying AIR's model and how they conformed with historical data and published literature.

79. Q. What sorts of scientists and specialists comprise the Florida Commission's professional team?

A. The Florida Commission's professional team includes two persons from each of the following professions: actuary, computer scientist, statistician, structural engineer, and meteorologist. In each area the Florida Commission requires extensive documentation and explanation of the AIR model prior to approval. It is a very time consuming and expensive undertaking for AIR, but the AIR model has always been approved.

It is important to reiterate that the same model that is certified in Florida is used in North Carolina. Over the years, the Bureau has specifically requested AIR to use model versions that have been approved by the Florida Commission. The loss costs modeled by the model are naturally much lower for North Carolina than for Florida because of the greater level of hazard that Florida is exposed to relative to North Carolina.

80. Q. Does AIR have staff meteorologists, wind engineers, actuaries and software engineers?

A. Yes, as discussed above, AIR has numerous staff meteorologists, wind engineers, actuaries and software engineers.

81. Q. In addition to the outside validation of modeling that you have just described, do AIR's staff scientists internally validate the model on a continuing basis?

A. Yes. AIR scientists and engineers validate the model at every stage of development. We compare model results with actual data from historical events. We ascertain that the simulated event characteristics parallel patterns observed in the historical record and that resulting loss estimates correspond closely to actual claims data provided by clients. Internal peer review is a standard operating procedure and is conducted by the AIR professional staff of scientists and engineers

82. Q. You have described the extensive external and internal review that occurred in the period 2009-2012. Please describe how that review, as well as new data and science led to improvements in the model over what had been available in older Bureau filings.

A. First let me reiterate that the Bureau has specified that AIR use the latest available version of the hurricane model approved by the Florida Commission, and AIR has done so. AIR employs a numbering system to identify different versions of the hurricane model, and it is useful to identify which version of the model was used in older filings. In the 2008 homeowners filing, version 9 of CLASIC/2 and the AIR US Hurricane Model was the latest available version. In the 2012 homeowners filing, version 13 of CLASIC/2 and version 12 of the AIR US Hurricane Model was the latest available version and was used. It incorporated numerous updates that had been made as a result of the extensive external and internal review process that has been described. The current filing uses version 15 of CLASIC/2 and version 14.0.1 of the AIR US Hurricane Model. The main updates to the AIR US Hurricane Model since 2007 are detailed below:

2007 (updates incorporated into version 9):

- Updates to the historical storm set to include storms through 2006
- Revision of the bounds on the distribution governing central pressure in the northeast
- Refinements to the distributions governing the day of hurricane landfall
- Refinements to the damage functions for residential contents
- Updates to secondary risk modifiers for pool enclosures, based on claims data
- Enhancements to the business interruption damage function
- Updates to the demand surge function
- Update to the WSST catalog

2008 (updates incorporated into version 10):

- Updates to ZIP Code databases and population-weighted centroids
- Updates to the historical storm set to incorporate track information from hurricanes through 2007
- Updates to the stochastic catalog, including annual frequency, landfall location and intensity probability distributions.
- Refinements to the inland decay functions

2009 (updates incorporated into version 11):

- Updates to ZIP Code databases and population-weighted centroids
- Updates to the historical storm set to incorporate track information from hurricanes through 2008 for Florida and adjacent states

2010 (incorporated into version 12):

- Significantly more precise risk differentiation based on Geography, Construction, Occupancy, Year Built
- Basin-wide Catalog enables more accurate loss estimates for portfolios spanning over multiple countries
- Model domain includes 29 states to provide complete coverage of inland risk
- Updates to Rmax estimation and addition of Rmax Evolution based on High Resolution Radar Imagery
- Explicit modeling of the influence of wave action on surface roughness

- Refinements in vulnerability relationships and explicit modeling of the evolution of Building Codes

2013 (updates incorporated into version 14.0.1):

- Updates to the Stochastic Catalog based on HURDAT and NOAA Databases valid as of August 2011, which include data from 1900 through 2010

83. Q. Could you please explain in more detail the changes to the wind field and vulnerability components of the model?

A. Recent research in atmospheric science has enabled wind modeling with unprecedented fidelity and accuracy. Improved knowledge of the full 4-D structure of hurricanes – from the temporal evolution of the storm footprint, to the radial wind profile, to the vertical relationship between winds aloft and winds at the surface – was in 2010 integrated into the model to more accurately estimate wind speeds and their distribution.

On the engineering front, the 2010 updates to the model reflect new findings from recent loss experience data, wind engineering studies and damage surveys. The model incorporates the results of a new and exhaustive analysis of the evolution and enforcement of building codes across all states including North Carolina and their impact (as a continuous function of time after the 1990s) on the existing building inventory.

The additional level of detail in both the hazard and vulnerability components of the model enables better differentiation between risks. This differentiation applies to both the location and the structural attributes of properties.

84. Q. With respect to updates to the model that are reflected in –Model Versions 12 and newer, including Version 14.0.1, which is used in this filing, please explain the general effects of those updates on prospective loss costs used in the filing.

A. Different updates had different effects. Also, some of the updates happened to coincide with a period when the Bureau was able to provide more detailed exposure data to AIR for modeling purposes. The combined effect was that loss costs are now more accurately modeled than ever before as a result of these changes. In this connection, let me describe AIR's motivation as to the peer review and resulting updates. The AIR hurricane model has long been considered the industry standard, and AIR desires to maintain that position. To maintain that position, the model must reflect the latest science and engineering research, and take into account recent loss experience.

Over the years leading up to the substantial peer review described above, numerous scientific studies of hurricanes as well as additional and more detailed claims and exposure data became available, and a number of scientific studies of hurricanes had advanced the knowledge of hurricanes significantly in the preceding several years. AIR therefore decided to incorporate those scientific advances in the hurricane model.

We also decided that because so many changes were being considered, we should have the changes peer reviewed by independent experts. A good deal of that peer review has been described earlier in my testimony. Naturally, changes to the model can affect loss costs in different directions. Some of the changes that may have affected loss costs in North Carolina include the following:

- Updates to ZIP Code databases and population-weighted centroids. These updates did not in and of themselves cause significant changes in loss costs in North Carolina, but it should be noted that only in recent years was the Bureau able to provide exposure data by zip code to AIR. Previously, assumptions had to be made as to where houses were located within territories based on AIR's data base. The use of actual exposure data by zip code significantly improved the precision of AIR loss costs. Those loss costs are now more accurate than could be modeled in previous years when simplifying assumptions had to be made because of the absence of detailed data.
- Updates to the historical storm set to incorporate information from the HURDAT database as of August 2011. Over the years, incorporation of this database, which now includes the period 1900-2010, sometimes involved inclusion of additional hurricanes that were determined by governmental sources to have affected North Carolina as well as modified parameters of previously-known hurricanes. The addition of these storms to the data base increased the modeled frequency of North Carolina storms. However, since these storms were relatively weak, they did not have a significant impact on loss costs.
- Updates to the model's wind field formulation. This update incorporated the latest available data and scientific literature, including the latest research on the radial decay of winds from the eye wall to the storm's periphery and the conversion of surface winds from winds aloft. This update improved the model's accuracy as to where damages occur and the extent of those damages.
- Modeling storms longer than 24 hours after landfall. In regard to North Carolina, this improvement in the model meant that more storms that made landfall to the south of North Carolina (such as in the Gulf of Mexico or Florida) are reflected since they typically affect North Carolina more than 24 hours after landfall. Such storms cause relatively modest losses in North Carolina.
- Incorporation of new data from satellites as to ground cover. Such data was incorporated in the wind field calculations. This improvement was significant because there is a large difference in the degradation of hurricane winds

depending on the terrain that they are passing over. For instance, storms passing over forests or mountainous terrain dissipate much more quickly than storms passing over flat or marshy areas. The inclusion of accurate ground cover data meant that areas such as the sounds of North Carolina were no longer assumed to have caused storms to dissipate to the same extent as in past model runs for North Carolina. On the other hand, this change reduced wind speeds in areas of North Carolina with extensive tree cover to reflect the fact that trees reduce wind speeds as storms travel over land.

- Updates to the wind damage functions. Such updates were based on the latest findings from AIR's ongoing analysis of detailed claims data from recent hurricane seasons and have improved the accuracy of modeled losses.
- Introduction and updates to the "year built" (age of home) bands. Such updates capture the evolution of North Carolina's building code, changes in construction practices and materials, and other factors affecting vulnerability over time. It should also be noted that the Bureau is now able to provide exposure data including detailed year built data to AIR. Previously, all locations were assumed to be unknown, and their damageability was based on a state-wide weighted average of year built damageability. The provision by the Bureau of exposure data with actual year built information significantly improved the precision of AIR loss costs. Those loss costs are now more accurate than could be modeled in previous years.
- Enhancements to individual risk modifiers (secondary risk characteristics). Such enhancements reflect newly acquired data and analysis.

85. Q. As relates to the current filing, did AIR receive exposure data from Insurance Services Office on which AIR relied in preparing its analyses?

A. Yes, we received data reflecting the number of earned house years and earned insurance years for 2011 for homeowners policies in North Carolina. It was broken down by categories (Voluntary and Beach Plan), policy form group (owners, tenant, and condominium), zip code, construction class, year built and territory. It was furnished to AIR by Insurance Services Office (ISO), which had compiled the data. AIR routinely receives and relies upon data of this type in the ordinary course of its business of modeling and did so in this instance. AIR routinely reviews such data submissions for consistency and reasonableness and notifies the producer of such data if there are questions as to the data.

86. Q. Can you explain what is displayed on Pages 15-35 of RB-6A?

A. Yes, these pages contain the Project Information and Assumptions Forms (PIAFs) that we prepared before completing our analysis and releasing the reports contained in RB-6A and RB-6B to the Bureau. These contain a summary of the exposures to be modeled as well as the assumptions that are to be used in the course of the analysis.

87. Q. What information is contained on Page 15 and 26 of RB-6A?

A. These pages show the contact information for some key personnel responsible for the project, both at AIR and at the Bureau. They show the version of the software and the model catalogs that are to be used in the analysis. Finally, They show the reports and loss results that we are going to provide to the Bureau.

88. Q. What information is contained on Page 16 and 27 of RB-6A?

A. These pages contain a summary of the exposure data that was provided to us by the Bureau, including the date the data was received, and the total values of various aspects of that data. They then provide information on how the various values have been changed based on the assumptions to be made before carrying out the loss analysis. The first four items under the “Added/Excluded Records” sections display the changes in total insured value that result from applying assumptions for additional coverages to the data that was provided by the Bureau. The last two items describe changes in the number of records, risks, and insured value due to rounding of records in general and specifically from applying the Beach Split treatment that is described in question 109 of this testimony.

89. Q. What information is contained on Page 17 and 28 of RB-6A?

A. These pages provide a summary of the geocoding process that occurs in CLASIC/2. As is frequently the case, there are a number of records in the exposure data which are placed in ZIP codes which are no longer valid based on the US Postal Service ZIP code database at the time the model was last updated. These invalid ZIP codes are re-mapped to current valid ZIP codes based on the US Postal Service database. The number of records matched at a postal level is representative of the records that were not subject to the Beach Split treatment described in question 109 of this testimony. Records geocoded based on population grid points are the records that were subject to the Beach Split treatment described in question 109 of this testimony.

90. Q. What information is contained on Page 18 and 29 of RB-6A?

A. These pages describe the assumptions that are made with regards to replacement value, limits, and deductibles for the various coverages for each line of business individually. For owners (HO) policies, limits were provided for coverage A, and assumptions were made for coverage B, C, and D. For condo (CO) and tenants (TN) policies, limits were provided for coverage C, and assumptions were made for coverage A, B, and D. The Analysis Options sections describe the specific analysis options that were utilized when running our models.

91. Q. What information is contained on Page 19 and 30 of RB-6A?

A. These pages show the number of records which included information on each of the various secondary modifiers that are able to be modeled in CLASIC/2. For this analysis, 87.6% of the records included information on the year the structure was built.

92. Q. What information is contained on Page 20 and 31 of RB-6A?

A. These pages describe in detail the specific assumptions that were made in the process of carrying out the analysis.

93. Q. What information is contained on Page 21 and 32 of RB-6A?

A. These are tables summarizing the total value and number of risks by construction and occupancy for each line of business.

94. Q. What information is contained on Pages 22-24 and 33-34 of RB-6A?

A. These are tables summarizing the total value, number of risks, and average deductible within each territory for each line of business. The information was provided by ISO.

95. Q. What information is contained on Page 25 and 35 of RB-6A?

A. These are tables displaying the total limits factors which are applied to homeowners policies to account for coverage B, C, and D. This methodology is described on Page 18 of RB-6A.

96. Q. Is the information on Pages 15-35 of RB-6A the same information contained in Pages 16-36 of RB-6B?

A. Yes.

97. Q. How is the PIAF used?

A. The PIAF is provided to the Bureau prior to performing the analysis and allows the Bureau the opportunity to examine the data and assumptions that will be used during the course of the AIR analysis to ensure that they comport with the data and assumptions intended to be modeled. The Bureau provides a signed copy back to us so that we can be assured that both parties understand the data and assumptions to be used for the analysis.

98. Q. What use did you make of such data?

A. For each territory, category, policy form group, ZIP code, and construction class, the insurance years were used as the primary insured value (either the building value for owners records or the contents value for the tenant or condominium records). Appropriate adjustments were then applied to account for non-primary coverages (appurtenant structures and contents in the case of the owners forms, building value for the condominium form, and time element for all three forms). Appropriate assumptions were also applied to account for deductibles.

The data was then analyzed in AIR's CLASIC/2™ software application using the model and catalogs referenced previously in order to yield loss estimates. These loss estimates were rolled up to the territory level for reporting purposes.

99. Q. What are the areas of the state with the highest hurricane risk in North Carolina?

A. The highest risk areas are the beach and coastal areas. A hurricane is typically at its maximum force in those areas just as it crosses over land. As it travels inland, the storm dissipates because of the elimination of its primary energy source (heat and moisture from the sea) and because of surface frictional effects.

100. Q. As between portions of the coast of North Carolina, which areas experience the greatest hurricane frequency?

A. The highest frequency of hurricanes occurs in a 100-mile segment which includes Cape Lookout, Cape Hatteras, and Pamlico Sound. The coastline in this area juts out into the Atlantic Ocean where it is exposed as storms move up the coastline. The far northern coast towards Virginia suffers relatively few hurricane landfalls because of the more westerly location of the coastline in this region, but hurricanes frequently come through that area after making landfall to the south.

101. Q. Has AIR examined North Carolina's building code?

A. Yes. AIR engineering experts have undertaken an extensive, peer-reviewed study to understand the large number of building codes and wind standards that exist in hurricane-prone states, specifically including North Carolina. In addition to major code changes, there are continuous changes in vulnerability due to changes in building materials, enforcement, structural aging and upgrading. The model accounts for the spatial and temporal variations in vulnerability for all hurricane states including North Carolina.

102. Q. Are there any changes that you have made to your model just for North Carolina?

A. No. AIR has a single, integrated U.S. hurricane model which reflects historical regional differences in hurricane risk. In the model development and validation process, North Carolina is treated in the same way as all other states in determining regional variations in vulnerability at the state and local level, through examination of both the regional building stock and state and local building regulations, codes and practices. AIR has performed a detailed review of, and continues to monitor, the building codes in North Carolina. AIR's implementation of this information allows its model to accurately estimate the vulnerability of buildings in North Carolina based on the specific nature of the building codes they are subjected to. Additionally, the model adjusts its vulnerability for structures in North Carolina based upon the year in which they were constructed and the codes which were enforced at the time of their construction. While the model looks at each state's building code situation individually, if there were two identical buildings in different states which were both subject to equivalent building codes and enforcement, those two buildings would be subject to the same vulnerability calculation.

As discussed previously, while there is a single hurricane model, each state's prospective losses are computed individually based on the circumstances in that state. While the model version, settings and assumptions used for North Carolina were the same as those accepted by the Florida Commission, Florida's higher vulnerability to losses is not in any way imputed to North Carolina, and losses in Florida are not in any way spread to North Carolina. Florida has higher expected loss costs than North Carolina because it has a greater exposure to hurricanes than North Carolina, but those higher expected losses in

Florida do not have the effect of making expected loss costs higher in North Carolina than they otherwise should be.

Inputs to the model include detailed land cover data that affect the wind speeds being calculated at every location in the modeled portfolio, as well as detailed building code examinations for every state which adjust the vulnerability of buildings based on the year of construction and location. The land cover data used in the model reflects, in detail, the currently existing land cover in North Carolina, and the building code information used in the model reflects the actual building codes and practices of North Carolina. The model reflects both the fact that different building code standards apply in different regions of North Carolina and the fact that the building code standards have changed at various times over the years.

Although the model can take into consideration the effects of storm surge and individual building characteristics, these components of the model were not employed at the direction of the Bureau. Modeled loss costs would have been higher if the Bureau had elected to instruct AIR to run the storm surge component. In the case of the Bureau's exposures, the storm surge component would reflect the fact that in the claims settlement process some damage from storm surge losses (which are not covered under homeowners policies) may nevertheless be paid as covered wind losses following a hurricane because storm surge losses sometimes cannot be distinguished from wind losses in the claim settlement process. While this phenomenon has been studied, validated, and can be easily modeled, the Bureau chose not to run the model with this component enabled.

103. Q. What is demand surge and how is it calculated in the AIR model?

A. The results were provided with aggregate demand surge as directed by the Bureau. Demand surge according to actuarial standards is defined as a sudden and usually temporary increase in the cost of materials, services and labor due to the increased demand for them following a catastrophe. Historical evidence from major catastrophic events in past 20 or more years shows that, after a major event, increased demand for materials and services to repair and rebuild damaged property can put pressure on prices, resulting in temporary inflation. This phenomenon is often referred to as demand surge and it results in increased losses to the insurers.

After Hurricane Andrew in 1992, AIR developed a rudimentary demand surge function to allow companies the capability to assess the potential impact on losses due to demand surge. In order to develop an initial demand surge function, AIR reviewed several studies on the impact on prices of material and labor after Hurricane Andrew and the Northridge Earthquake. It was commonly accepted that the demand surge from a Hurricane Andrew sized event ($15.5 billion) was 8-12 %.

AIR continued to review the impact that catastrophic events have had on material and labor prices. We found that in 1989 Hurricane Hugo, for example, caused a significant temporary impact on personal incomes in the construction industry in South Carolina. Analyses performed after the 2004 hurricane season in Florida revealed that demand surge had a significant impact on insured losses. Among other findings, empirical data specifically revealed that roof rebuilding costs increased substantially in the period following the hurricane season, and losses resulting from the additional living expense provisions in the policy (referred to as the “time element” which reflects the need of the policyholder to find alternative lodging after a house has been damaged) were significantly impacted due to the increased amount of time it took to repair damages from the multiple events.

104. Q. Was demand surge used for the analyses you performed for the Bureau?

A. Yes, demand surge was used for both analyses (standard and WSST).

105. Q. How is the demand surge factor calculated, and how is it applied?

A. Demand surge effects do not occur following the majority of hurricanes, and the demand surge component of the model reflects this fact. Small hurricane events are not accompanied by demand surge. AIR’s demand surge function relates the level of demand surge to the amount of industry loss. Each event is assigned demand surge factors by coverage based on the amount of industry loss caused by the given event, as well as by other events that occur close to the given event in both time and space. AIR’s demand surge begins at an industry loss amount of $5.5 billion. The demand surge factors are applied to losses from the specific exposure set to calculate the loss with demand surge.

106. Q: What is the estimated impact of the application of demand surge on the loss estimates for the Bureau?

A. To quantify the impact of demand surge on the Bureau portfolio, AIR performed a high-level analysis without demand surge in addition to the detailed analysis that was used to generate the results for the Bureau. These analyses showed that there is an increase of 5.7% in gross losses when demand surge is applied.

107. Q. Now let me ask you several questions concerning Exhibit RB-6A to your pre-filed testimony. What is the significance of the figure from the column called "Loss Cost (Per 100)" on pages 11 to 14 of Exhibit RB-6A?

A. The figures show the estimated loss costs per $100 of exposure, including contents and all other coverages.

108. Q. On page 7 of Exhibit RB-6A entitled "Exposure Information and Assumptions," there is reference to "insurance-years by category, ZIP code, line of business, construction class, and territory." Please explain these terms.

A. The term "insurance-years" refers to the insured values under homeowners policies. The source of this data is ISO. The data were provided by each of the elements listed. Category refers to the categories of Voluntary and Beach Plan. The line of business refers to the owners, condominium, or tenant forms. The construction classes provided are Frame, Masonry, Masonry Veneer, Superior, and Aluminum or Plastic siding over frame.

109. Q. On the same page there is reference to "Beach Split ZIP Codes." Please explain this term and its relevance to the modeled losses contained in Exhibit RB-6A.

A. A "Beach Split ZIP Code" is a zip code which is split between two different Bureau territories, where one of the territories intersecting the zip code is categorized as a beach territory. The Beach Split ZIP Code treatment is used to improve the modeled loss estimates for coastal territories in those situations. AIR's determination of prospective loss costs is more accurate as a result of implementing this treatment.

In understanding this treatment, it is important to understand how the model works with respect to the geographic placement of risks. When a risk is analyzed in CLASIC/2, its geocode placement determines the relative severity of each simulated event. Items such as elevation, proximity to the coast and land cover are determined based on the geocode coordinates assigned to the location. If a risk contains only zip code information rather than address information, CLASIC/2 will assign geocode coordinates corresponding to the zip code centroid and will use the average physical characteristics for the zip code to estimate loss.

The information provided to AIR for the Bureau analysis is now at the zip code level, which allows for greater precision in modeling loss costs than could be accomplished in filings prior to the 2011 dwelling filing and the 2012 homeowners filing. The ability to use more detailed data has created a desire to be even more accurate, and it was for this reason that AIR uses the split zip procedure. In several instances coastal area zip codes fall across the boundary between the Beach territory (i.e. Territory 110 or 120) and the inland coastal territories (Territory 130, 140, 150, or 160). In these cases, without refinement, modeled loss costs for the zip code would be the same whether the territory was beach or inland, when in reality, houses located on or closer to the beach have higher loss costs than equivalent exposures inland, and vice versa. The Beach Split ZIP Code treatment improves the modeled loss estimates for these zip codes by distributing the risks to uniform grid points across the area of the zip code falling in each of the territories. In so doing greater accuracy and fairness are promoted.

110. Q. Page 8 of Exhibit RB-6A shows the long term average annual aggregate losses by territory. Please explain what is shown on this page and how it was computed.

A. Page 8 displays the average annual aggregate loss for each territory. This figure is the sum of all losses caused by all simulated events, divided by the number of simulation years for each territory. It represents the long run average annual hurricane loss potential by territory. As can be seen, the territory with the highest average annual aggregate loss is territory 140. This fact is a function of the large number of homeowners policies in that territory as well as the territory's high exposure to hurricanes.

111. Q. What does the table on page 9 of Exhibit RB-6A show?

A. It shows the distribution of exposures and average annual losses by territory. Obviously, coastal territories account for a much higher percentage of losses than exposures because there is a greater hurricane hazard nearer the coast. For instance, the table on page 9 demonstrates that territory 340 in the western part of the state has 17.83%of the statewide insurance in force, but accounts for only 5.81%of total annual hurricane losses. Territory 120 on the beach, on the other hand, accounts for only 0.59% of the statewide insurance in force, but its average annual hurricane loss is 7.61% of the statewide total annual hurricane losses.

112. Q. What is the source of the insured values, risk count and average annual loss on pages 11 to 14 of Exhibit RB-6A?

A. The source of the insured values and Risk Count shown on pages 11 to 14 is provided on pages 22 to 24 and 33 to 34 of Exhibit RB-6A (the PIAFs), and page 8 is the source of the average annual loss.

113. Q. What do the last two columns on pages 11 to 14 of Exhibit RB-6A show?

A. They show the estimated hurricane pure premiums and loss costs per $100 of exposure by territory, both overall for all lines (Exhibit 3) and individually for each policy form group (Exhibits 4 to 6). As can be seen from these exhibits, loss costs are highest in territories 110 and 120 and are high in territories 130, 140 and 160.

114. Q. On page 11 of Exhibit RB-6A, please explain the significance of the number "1,625.16" for territory 110 in the column entitled "Pure Premium."

A. The number $1,625.16 is the amount, exclusive of expenses and provisions for profit and contingencies, that on average needs to be collected each year to cover the long run average hurricane loss potential on each risk on homeowners policies in territory 110. By comparison, only $15.67 needs to be collected to cover that same potential in territory 390.

115. Q. Do the explanations set forth above for Exhibit RB-6A also follow for similar pages in Exhibit RB-6B?

A. Yes. The exhibits and explanations follow the same format. The loss costs and pure premiums in Exhibit RB-6B reflect those appropriate to the view of risk that incorporates the impact of the current elevated sea surface temperatures (SSTs) in the North Atlantic on hurricane activity.

116. Q. In 2011, Hurricane Irene passed through eastern NC and hence caused losses from Hurricane damage. Has AIR been able to do any detailed validation of Hurricane Irene as yet?

A. No. As of the date of preparation of this prefiled testimony in November of 2013, AIR has not yet been able to perform any validation on Hurricane Irene due the lack of necessary claims data resulting from the storm and due to the fact that the meteorological parameters of this storm were not included in the 2011 HURDAT database at the time the model was being updated. Due to this lack of information, Hurricane Irene is not yet in AIR's Historical Storm Catalog. Loss validation information for Hurricane Irene is only available at an aggregate level, meaning on an industry level. It is anticipated that a more detailed validation can be done when state specific claims and exposure data from the event are available. AIR is in the process of collecting this information, but it is not yet clear when this will be completed. Aside from this, AIR did perform a damage survey along coastal North Carolina and Virginia after Hurricane Irene passed. Findings from this survey will be compared to claims and loss data after it becomes available.

117. Q. The current filing proposes revised territory definitions as well as revised rates. Did AIR perform any assistance in support of the Bureau's analysis of revised territory definitions?

A. Yes. The Bureau set up a task force to review territory definitions and contacted AIR in the Fall of 2012 for consultation and assistance as to the best manner in which to employ modeling of various wind events to review territorial definitions. The latest available data consisted of the data underlying the Bureau's October 1, 2012 homeowners rate filing. It was concluded that the best manner to examine differing wind exposure across the state, while removing the impact of exposure differences across the state, was to create a "notional" dataset and run AIR models based on the assumption of uniform exposures across the state. Doing so enabled a better review and comparison of the varying risk across the state from wind events. Assuming a uniform exposure set across the state permitted the Bureau to examine regional variations in hazard without the analysis being complicated by the distribution of the actual exposures in the state. It is important to isolate these effects, because the exposure distribution can and will change over time, and the territories should reflect regional differences in risk even after exposure distribution changes.

118. Q. How was the analysis adjusted after the North Carolina Department of Insurance raised objections to the revised territory definitions?

A. The bureau made changes to the filed territory definitions and provided AIR with updated exposure for all records. AIR performed a second analysis for those records which were impacted by the differences in territory definitions using both the standard and WSST catalogs. The losses as presented in RB-6A and RB-6B reflect the losses based on the combination of results from the unchanged territories as well as the new results for territories with updated definitions.

119. Q. Are the data, information and numbers used in the AIR hurricane model true and accurate to the best of your knowledge, information and belief?

A. Yes. The AIR research team collects the available scientific data pertaining to the meteorological variables critical to the characterization of hurricanes and therefore to the simulation process. Data sources used in the development of the AIR hurricane model include the most complete databases available from various agencies of the National Weather Service, including the National Hurricane Center. All data is cross-verified. If data from different sources conflict, a detailed analysis and the use of expert judgment is applied to prepare the data for modeling purposes. Furthermore, to the extent possible, we cross-check and verify the numbers that go into the AIR model as well as the numbers that come out of the model. To the best of my knowledge, information and belief, the data that we use are the most reliable and accurate data that is publicly available.

120. Q. Are the Exhibits to your pre-filed testimony true and accurate to the best of your knowledge, information and belief?

A. Yes.

121. Q. Do you have an opinion as to whether your model is a reasonable method of projecting the prospective hurricane losses used in the filing to set rates for homeowners insurance in North Carolina that are not excessive, inadequate or unfairly discriminatory, and if so what is that opinion?

A. Yes, I have an opinion. It is a reasonable, consistent, and reliable method of doing so. The prospective hurricane losses in the AIR reports and used in the filing are reasonable and appropriate projections of insured hurricane losses on the policy forms reviewed.

122. Q. Is AIR willing to allow the Insurance Commissioner and/or any personnel from the North Carolina Department of Insurance to visit your offices in Boston and examine any areas of the model that they wish?

A. Yes, subject only to a non-disclosure agreement that will protect the proprietary and confidential information possessed by AIR Worldwide from being used by our competitors, we welcome the Commissioner and/or any associates or consultants appointed by him to again visit our offices, where they can examine any information related to the model that they would like. With the encouragement and permission of AIR, we understand that the Bureau offered the Department the opportunity to make such a visit in the summer of 2012. This offer was also extended in connection with the Dwelling hearing in 2011. If the Commissioner or his Department would like to arrange such a visit, we ask that they contact the Bureau to organize a date and time that is convenient for all parties. We strongly encourage the Commissioner and Department to do so to help educate them on the benefits and validity of the use of hurricane modeling in ratemaking for North Carolina.

NORTH CAROLINA
HOMEOWNERS INSURANCE

ADJUSTMENTS TO PREMIUMS, LOSSES, LOSS ADJUSTMENT EXPENSES,
EXPENSES AND EXPOSURES

Adjustments made to premiums, losses, loss adjustment expenses, and expenses are set forth below. See also the prefiled testimony of R. Curry, B. Donlan and R. Newbold.

Losses reported to ISO, ISS, and NISS are adjusted to the $250 base deductible level by application of loss elimination ratios. These factors are applied on a record-by-record basis and vary by cause of loss and policy form.

Losses were developed to an ultimate basis through the application of loss development factors. The derivation and application of loss development factors is described in the response to 11 NCAC 10.1105(3).

Non-hurricane wind losses for the owners forms have been smoothed using an "excess wind" procedure.

Additionally, due to the volatile nature and the catastrophic potential of hurricane losses, actual hurricane losses have been removed from the data and replaced with expected hurricane losses produced by a model designed by AIR Worldwide.

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See prefiled testimony of R. Curry, B. Donlan and R. Newbold.