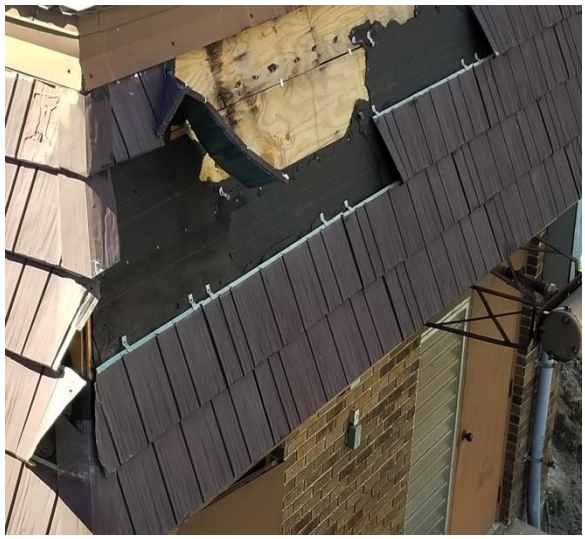
RICOWI, Inc.

Roofing Industry Committee on Weather Issues, Inc.

Wind Investigation Report



Hurricane Michael

October 25-26, 2018

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PREFACE

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RICOWI Wind Investigation
Hurricane Michael, Florida

ABSTRACT

The Roofing Industry Committee on Weather Issues, Inc. (RICOWI, Inc.) investigates and reports on the field performance of low-slope and steep-slope roofing systems after major hurricanes (sustained winds of 95 mph or greater) make landfall in populated areas of the continental United States.

RICOWI, Inc. deployed teams to investigate conditions of roofs in the areas impacted by Hurricane Michael in the Gulf Coast landfall regions of Florida and surrounding areas. This report covers the investigations of October 25-26, 2018.

Information on the damage encountered, including photos and specific information, is included in this unbiased report.

INTRODUCTION

INVESTIGATION PROTOCOL

In previous years, RICOWI, Inc. sent teams to investigate the condition of roofs in the areas impacted by Hurricanes Charley, Ivan, Katrina, Ike and Irma. Reports on these extreme weather events have been published and are available at www.ricowi.com. The valuable information gained from prior investigations helped guide the investigation of roof damage from Hurricane Michael.

RICOWI deploys teams to hurricane damaged areas if they meet the following criteria: sustained wind speeds of 95 mph or greater at landfall in the continental United States as well as demonstrate significant damage to populated areas.

Generally, team members are wind engineers, roofing material specialists, insurance analysts, structural engineers, and/or roofing consultants. Some teams included roofing contractors or other interested parties who aided in arranging inspections or in providing access and equipment.

A refresher wind investigation training workshop was held on October 25, 2018. Investigators were provided information on damage modes, gathering and recording information, and safety training. Members were assigned to the teams based on their expertise. Each team had four positions: (1) report writer, (2) photographer, (3) data recorder, and (4) sample collector. In some instances, positions were combined. All team members acted as observers, combining their expertise and observations to maximize the data obtained. In addition to manufacturing members, each team was balanced by including members of the insurance industry, consulting firms, or other non-manufacturer associations.

Clearance letters were requested from the investigation site cities. Local law enforcement officials were also notified.

RICOWI team briefings were held each day, with collected information reviewed each evening.

EXECUTIVE SUMMARY

Hurricane Michael:

Michael made landfall on October 10, 2018 as a Category 5 event. This storm was the worst case scenario for Mexico Beach, Florida, and its surroundings near Panama City. It was the third-strongest hurricane on record, in terms of pressure, to make landfall in the United States, and had the strongest winds since Hurricane Andrew made landfall in 1992. Economists predict Michael will cost $25 billion.

Limited Investigation

Due to the extensive damage, winds that were at or above wind design code requirements in the Panama City area, accommodations were limited. RICOWI decided that a mini-WIP (smaller scale) investigation would be more prudent. Four teams of four professionals in each team were deployed on October 25 and 26, 2018. Although heavy rain restricted investigations on Oct. 25, the teams believed they had adequately covered the territory and types of roofs that were typical for the Panama City, FL Area. Prior to the deployment NOAA aerial photos were used to select the areas to be investigated.

A key goal was to inspect roofs of varying ages to ascertain if the code enhancements since 2000 were effective in reducing roof damage. The inspections clearly supported the conclusion that newer roofs performed much better in hurricane winds. Nearly all of the inspections and street surveys were in areas that the ARA wind maps define as having winds between 120 and 140 mph, 3 second gust wind speeds. These wind speeds would have destroyed most roofs installed before 2000 and many installed before 2009. Although teams inspected many damaged and leaking roofs, catastrophic damage was less than expected and many roofs were quickly repaired to limit further water intrusion.

Low-Slope Roofs

Although the current code provisions appear to be adequate for low-slope roofs, edge system failure continues to be the key initiation point for damages on low-slope roofs. Appendix B of ANSI/SPRI/FM 4435/ES-1 2017 provides the design pressures for edge systems. Although the basic requirements of ES-1 have been in the IBC since 2003, many systems are still installed that do not comply. Almost all low-slope roof failures begin at the windward edge and a system design that has been available for membrane roofs since before 2004 could reduce or prevent much damage. This enhancement is known as a “peel stop”. A peel stop installed at the bottom of a parapet or at a gravel stop edge on any type low-slope roof can limit the progression of damage from the edge of the roof. When the peel stop is absent, edge failure will frequently spread across the roof, lifting and peeling adhered membranes or pulling fasteners on mechanically attached systems.

Although metal roofs are not required to meet ES-1 in IBC, metal systems were also damaged due to lack of adequate edge securement. Peel stops are not used with metal roofs.

Damage and/or dislodgement to the exterior parapet/roof edge façade was encountered on several low-slope roofs. This involved several types of systems, indicating that the securement did not meet the wind loads that were applied in Hurricane Michael. When the façade was dislodged or damaged, the underside of the roof or roof membrane was pressurized, resulting in lifting and in some cases tearing.

One of the most significant windstorm related problems with low-slope roofs of all types is punctures and tears. Punctures and tears are most often caused by rooftop equipment and/or appurtenances becoming dislodged and then tumbling across the roof. Similarly, wind-blown projectiles from the ground, the air, trees, or nearby roofs can cut, puncture, and displace roof components. Although the rooftop units were typically fastened with as many fastening points as designed, fasteners either pulled out or tore the metal housing. Engineers designing these units need to consider them as solid objects with the full designed wind loads being applied, and should consider the lever effect on the fasteners and the structure to which they are fastened.

Steep-Slope Roofs

Newer steep roofs of all types performed better than older roofs. Resilience was noted in all types of roofs, but if a building became pressurized due to a wall, door or window failure, the roof and other portions of the building could be damaged. There were many examples of roofs with only superficial damage. Metal roofs had installation issues with fasteners not being attached to anything solid and wall failures that resulted in roof pressurization and dislodgement. Many newer asphalt shingled roofs had only limited damage. There were older asphalt shingled roofs that were installed using the racking method. These roofs lost shingles and were often severely damaged. On newer roofs where the starter course was not enhanced with sealant, it was the only course missing, or this lapse led to progressive damage. Ridges on all types of steep roofs were most vulnerable, indicating that attention to ridge and eave installation detailing is most important for windstorm resistance.

Are the updated codes effective?

A scale from 1 to 6 was utilized to rate the performance of a roofing system, where a 6 is the most damage and 1 is very little damage (See Figures 1 and 2). A rating of 3 or greater indicates a roof that is leaking and in need of significant repairs. In Figure 1, 16% of the inspected roofs over 10 years old were rated zero to two, indicating they did not have significant damage.

Damage Rating	%
6	42
5	21
4	5
3	16
2-0	16

Figure 1: Roofs over 10 years old

84% of the inspected roofs over 10 years old were or were likely to be leaking.

Damage Rating	%
6	5
5	14
4	14
3	14
0-2	55

Figure 2: Roofs Less than 10 years old

This is contrasted by 45% of the inspected roofs less than 10 years old that had significant damage and were or were likely to be leaking.

Overall 63% of roofs inspected were, or were likely to be leaking.

Eleven asphalt shingle roofs were inspected. 63% were likely to be leaking. 45% of the asphalt roofs inspected were over ten years old.

Only five modified bitumen and built up roofs were inspected, all of which were over 16 years old, and all but one of which were likely to be leaking.

Eleven steep-slope metal roofs were inspected, 62% that were or were likely to be leaking. 54% of the steep metal roofs were over ten years old.

There were six adhered single ply roofs inspected, with 50% that were or were likely to be leaking. One adhered single ply leaking roof was over 16 years old. The other two leaking adhered single-ply roofs were seven and eight years old.

Ten mechanically attached single ply roofs were inspected, with 70% that were or were likely to be leaking. Four of the mechanically attached single ply roofs inspected were over ten years old.

ASPHALT SHINGLE INVESTIGATION SITES

Inspection #	3.1.1
Team #	3
Date	10/25/18
Primary Building Use	Residence
Building Latitude	30º12’39.80” N
Building Longitude	85º57’48” W
Front of Building Faces	East
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Open grassland
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	22
Roof Age	16+
Source	Google
Building Width	52.5
Building Length	42.5
Building Height	20
Eave Height ft.	8.5
Slope	Low-slope > 3 1/2 to 5/12
Shingle Type	Standard 3 tab.
Fasteners	Nails
Fasteners per shingle	4
Valleys	Closed Cut (lapped}
Underlayment Exposed after storm	Yes
Underlayment Type	#15 felt
Deck	Plywood
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	3
Location of Roof Damage	Field, Near Soil Pipes, Ridge Vents, Off Ridge vents, Soffit vent, Ridge
Type of Damage	Shingles Dislodged
Damage initiation	generally, shingles racking, too few & poorly spaced fasteners
Describe Damage	Metal eave and rake flashing OK, but underlying fascia covering missing in places, ridge vents OK, but attached shingles missing
Damaged Area	More than 25% but less than 50%
Deck attachment	Unknown, but clips present
Number of perimeter fasteners per linear foot of deck section	

3.1.1 Overview of front showing racked shingles

Typical Nailing, nails in sealant strip and missing from one end of shingle

3.1.1 Shingles missing from all sides

Back side roof

Inspection #	3.1.2
Team #	3
Date	10/25/18
Primary Building Use	Residential
Building Latitude	30º12’40.50” N
Building Longitude	85º57’47.88” W
Front of Building Faces	East
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Open grassland
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	22
Roof Age	1-3
Source	Owner
Building Width	42
Building Length	55
Building Height	18
Eave Height ft.	8.5
Slope	Low-slope > 3 1/2 to 5/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	6
Valleys	Closed Cut (lapped}
Underlayment Exposed after storm	Yes
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	OSB
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	1
Location of Roof Damage	Corner, Ridge Vents
Type of Damage	Shingles Dislodged, very minimal, a few shingles near one portion of rolled up vented ridge and a few windward corners
Damage initiation	See above—can’t tell, either a small portion of ridge, or shingles around, a few windward corners, but very limited
Describe Damage	
Damaged Area	

Deck attachment	Can't tell
Number of perimeter fasteners per linear foot of deck section	

3.1.2 Overview indicating very limited damage

Missing ridge shingles

3.1.2 Corner shingles torn

Rear of residence

Inspection #	3.1.3
Team #	3
Date	10/25/18
Primary Building Use	Residential
Building Latitude "	30º12’18.54” N
Building Longitude "	85º57’35.64” W
Front of Building Faces	West
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Short Side
Building Age	24
Roof Age	12-16
Source	Data - From Source
Building Width	44
Building Length	56
Building Height	18
Eave Height ft.	8
Slope	Moderate .5/12 to 9/12
Shingle Type	Standard 3 tab.
Fasteners	Nails
Fasteners per shingle	6
Valleys	Closed Cut (lapped}
Underlayment Exposed after storm	Yes
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	OSB
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	5
Location of Roof Damage	Entire Roof, Corner, Eave, Rake Edge, Ridge Vents, Off Ridge vents, Soffit vent, Ridge, think garage door implosion contributed
Type of Damage	Shingles Dislodged, Structural Deck Failure
Damage initiation	Deck, garage door implosion or explosion, perhaps even end wall
Describe Damage	Whole deck failure over garage
Damaged Area	More than 50%

Deck attachment	Odd combination of staples and some nails, into 24" spaced rafters
Number of perimeter fasteners per linear foot of deck section	

3.1.3 Overview:

Shingles with 7 nails

3.1.3 Synthetic Felt claiming to be compliant with ASTM 226

Strange non-code compliant nailing of sheathing

Inspection #	3.1.4
Team #	3
Date	10/25/18
Primary Building Use	Residence
Building Latitude "	30º12’18.95” N
Building Longitude "	85º57’33.73” W
Altitude (At Ground)	7
Front of Building Faces	West
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	24
Roof Age	12-16
Source	Data - From Source
Building Width	41
Building Length	50
Building Height	20
Eave Height ft.	8.5
Slope	Moderate 5/12 to 9/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	6
Valleys	Closed Cut (lapped}
Underlayment Exposed after storm	Yes
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	OSB
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	2
Location of Roof Damage	Corner, Ridge Vents, Ridge, some damage due to "Florida room" patio flipping onto and over roof
Type of Damage	Shingles Dislodged
Damage initiation	Hard to tell, except for physical due to patio impact
Describe Damage	
Damaged Area	More than 25% but less than 50%

Deck attachment	Odd combo of nails and staples
Number of perimeter fasteners per linear foot of deck section	

3.1.4 Overview

Typical

3.1.4 Nailing

Missing ridge

Inspection #	3.2.1
Team #	3
Date	10/26/18
Primary Building Use	Residence
Building Latitude "	30º22’37.05” N
Building Longitude "	85º58’22.14” W
Altitude (At Ground)	41
Front of Building Faces	North
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	2018
Roof Age	1
Source	Data - From Source
Building Width	45
Building Length	62
Building Height	30
Eave Height ft.	9
Slope	Moderate .5/12 to 9/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	6
Valleys	Woven
Underlayment Exposed after storm	Yes
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	OSB
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	4
Location of Roof Damage	Corner, Eave, Field, Ridge Vents
Type of Damage	Shingles Dislodged, fascia vinyl
Damage initiation	Hard to tell, corner, hip/ridge eave, some misc. field
Describe Damage	Most windward
Damaged Area	More than 25% but less than 50%

Deck attachment	
Number of perimeter fasteners per linear foot of deck section	

3.2.1 Front, Unusual area where shingles are dislodged

Back side limited damage

Inspection #	3.2.2
Team #	3
Date	10/29/18
Primary Building Use	Residence
Building Latitude "	30º22’34.47” N
Building Longitude "	85º58’16.56” W
Front of Building Faces	North
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	1
Roof Age	43103
Source	Data - From Source
Eave Height ft.	9
Slope	Moderate .5/12 to 9/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	6
Valleys	Woven
Underlayment Exposed after storm	Yes
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	OSB
Ventilation	Soffits
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	4
Location of Roof Damage	Corner, Eave, Field, Ridge, garage door 2 bays, several windows cracked, ac and platform tipped,
Type of Damage	Shingles Dislodged
Damage initiation	Corner also ridge field eave, but can't tell which first,
Describe Damage	Shingles dislodged
Damaged Area	More than 25% but less than 50%
Deck attachment	
Number of perimeter fasteners per linear foot of deck section	

3.2.2 Overview

Starter row of shingles dislodged

9.2.2 Dislodged shingles

Starter Row missing

Inspection #	3.2.3
Team #	3
Date	10/26/18
Primary Building Use	Residence
Building Latitude "	30º22’43.13” N
Building Longitude "	85º58’52.38” W
Altitude (At Ground)	46
Front of Building Faces	North
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	8
Roof Age	8-12
Source	Data - From Source
Building Width	48
Building Length	54
Building Height	25
Eave Height ft.	8.5
Slope	Moderate .5/12 to 9/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	6
Valleys	Woven
Underlayment Exposed after storm	No
Underlayment Type	Synthetic (plastic- PE-PP etc.)
Deck	Other
Ventilation	Soffits, Ridge
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	1
Location of Roof Damage	Off Ridge vents
Type of Damage	Shingles Dislodged
Damage initiation	Off ridge vent, but very minor, some impact but, minor
Describe Damage	Vinyl fascia
Damaged Area	Less than 10%

Deck attachment	Limited Fasteners
Number of perimeter fasteners per linear foot of deck section	

3.2.3 Overview

Overview: One broken shingle

3.2.3 Broken Shingle - nailing

Broken ridge cap shingle

Inspection#	3.2.7
Eave Height ft.	10
Slope	Moderate 5/12 to 9/12
Shingle Type	2-ply laminated
Peak Height	30
Fasteners	Nails
Fasteners per shingle	6
Valleys	Open (metal)
Underlayment Exposed after storm	No
Underlayment Type	Self-adhered
Deck	Plywood
Ventilation	
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	0
Location of Roof Damage	AC unit securely attached to solid concrete,
Type of Damage	Note, there is also flat panel through fastened steel with no damage
Damage initiation	None
Describe Damage	None, construction methods in this development seemed very high end for mid-range priced current homes
Damaged Area	
Deck attachment	
Number of perimeter fasteners per linear foot of deck section	


3.2.7 Front View


Back View

Inspection #	4.1.3
Team #	4
Date	10/25/18
Primary Building Use	single family residential
Building Latitude "	30º08’09” N
Building Longitude "	72º80’84” W
Front of Building Faces	West
Zip	32408
Exposure Category	C
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Short Side
Building Age	20 years built in 1998
Roof Age	16+
Source	Best Guess
Building Width	30
Building Length	40
Building Height	20

4.1.3 Structural Damage

It appears the fastening of the sheathing to the rafters was inadequate. The uplift forces on the roofing underlayment may have pulled the sheathing off the rafters.

4.1.3 Nails pulled out of sheathing

Nails pulled out.

Note: Two roof types were installed on this building. Both are included in this report.

Inspection #	4.1.5
Team #	4
Date	10/25/18
Primary Building Use	Multi-family residential
Building Latitude "	30º14’6”
Building Longitude "	85º75’8”
Front of Building Faces	South Southwest
Zip	32408
State	FL
Exposure Category	D C from the North? C from the South West
Primary upwind terrain	Buildings Taller
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Long Side
Building Age	35+ Built 1982
Roof Age	8-12
Source	Best Guess
Building Width	90'
Building Length	30'
Building Height	24'
Eave Height ft.	8
Slope	Moderate .5/12 to 9/12
Shingle Type	2-ply laminated
Fasteners	Nails
Fasteners per shingle	4
Valleys	
Underlayment Exposed after storm	No
Underlayment Type	Other
Deck	Other
Ventilation	Soffits
Hip/Ridge Shingles	Standard
Solar Equipment on Roof	No
Damage Assessment	1
Location of Roof Damage	Field
Type of Damage	Shingles Dislodged
Damage initiation	Field
Describe Damage	Wind uplift at field
Damaged Area	Less than 10%
Deck attachment	Unknown

Number of perimeter fasteners per linear foot of deck section	0
Inspection #	4.1.5
Eave Height ft.	8
Slope	Moderate >51/2 to 9/12
System Type	Architectural Through Fastened
Unfinished Metal	Aluminum
Painted	Aluminum
Installation	Screws
Fastener Spacing	3
Corner or perimeter enhancement	None
Valleys	None
Underlayment	Exposed No
Underlayment Type	Other
Deck	Unknown
Ventilation	Soffits
Damage Assessment State Rank	1.Dents Punctures
Location of Roof Damage	Eave, Rake Edge, Field
Type of damage	Metal Edge, impact
Damage Initiation	Metal edge and field
Describe Damage	Uplift tore off metal edging and debris damaged field
Nails or fasteners per linear foot of sheathing perimeter	Unknown
Deck attachment	Unknown

4.1.5 Interesting set of several roof types

Only obvious damage is to soffit section on through fastened roof

Overview

Overview

BUILT UP ROOF (BUR) INVESTIGATION SITES

Inspection #	1.1.2
Team #	1
Date	October 25 2018
Primary Building Use	Department Store
Building latitude "	30º18’60.08” N
Building Longitude "	85º64’78.38” W
Front of Building Faces	North
Zip	32405
Exposure Category	C
Primary upwind terrain	Smooth (parking lot etc.), Buildings -Smaller, Buildings - Similar Height, Buildings Taller
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	16+
Roof Age	16+
Roof Age	Data - From Source
Building Width	300 ft.
Building Length	516 ft.
Building Height	
System	Built up roof (BUR)
Surface	Granular Surfaced
Number of Plies	
Membrane Attachment	Coal Tar
Membrane Attached to:	Lightweight Insulating Concrete
Insulation Type	No insulation
Insulation Thickness	Not applicable
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge Thickness	24 ga.
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	24"
Solar Equipment	None
Damage Assessment State Rank	2
Location of Damage	Metal Edge, Field
Type of Damage	Corner or edge peel, Metal edge, Aggregate Scour
Extent of Damage Detail Ranking	3
Damage Initiation	Edge, only damage

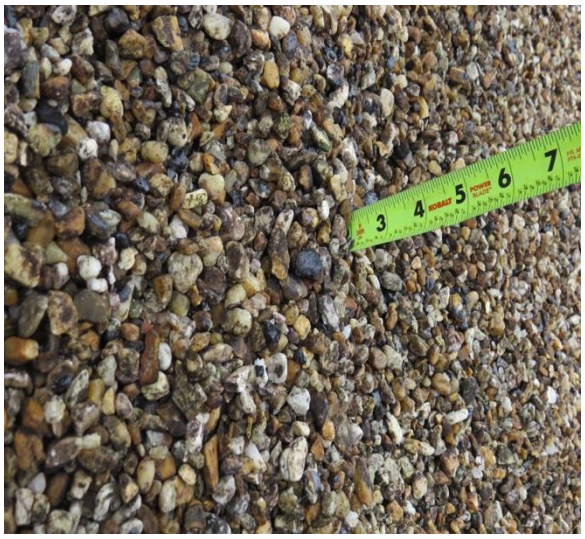
Describe damage in detail. discuss all references to "other"	Edge metal on front side of building (windward side) had mixed attachment of nails and screws. Nails were 6" on center over plywood. Screws were 24" on center over wood nailer (2x4). Expansion joint failure. On the backside (leeward side) of building, nails were 36" on center and failed. Edge metal failed. Aggregate blown 6' from edge.
Parapet height	36"
Roof Width	300 ft.
Roof Length	516 ft.
Total Roof Area, Square feet	155,000 ft.
Area damaged	More than 25 % but less than 50%

1.1.2 Overview

Coping dislodged

Coping fastening

Pea Gravel at divider



1.1.2 Depth of pea gravel at divider

Missing wall covering

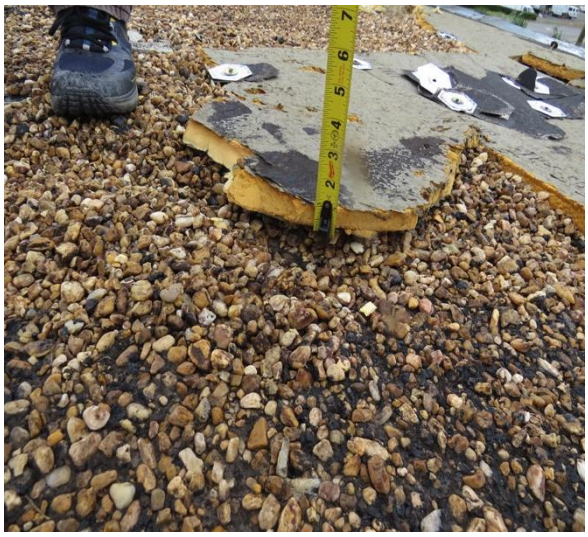
Parapet wall covering missing

Coping

Inspection #	1.1.3
Team #	1
Date	October 25 2018
Primary Building Use	Auto Shop
Building Latitude "	30º18;51..34” N
Building Longitude "	85º65’0553” W
Front of Building Faces	East
Zip	32405
Exposure Category	B
Primary upwind terrain	Smooth (parking lot etc.), Buildings -Smaller, Buildings - Similar Height, Buildings Taller
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	
Roof Age	16+
Source	GIS
System	Modified Bitumen
Surface	Smooth Surfaced
Number of Plies	One ply
Membrane Attachment	Fully Adhered using asphalt
Membrane Attached to:	Polyisocyanurate Foam
Insulation Type	Polyisocyanurate Foam
Insulation Thickness	1"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge Thickness	Not determined
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	Not Determined
Solar Equipment	None
Damage Assessment State Rank	6
Location of Damage	Entire Roof, Corner, Metal Edge, Field
Type of Damage	Corner or edge peel, Metal edge
Extent of Damage Detail Ranking	5
Damage Initiation	Corner metal failure, edge metal and wood removed.
Describe damage in detail. discuss all references to "other"	Modified bitumen was not fully adhered. New roof was installed on top of old gravel roof. Two layers of perlite were compressed. Corrosion of steel deck and deck peeled at edge.
Parapet height	None
Roof Width	48'
Roof Length	120'

Total Roof Area, Square feet	5760 sq ft
Area damaged	More than 50%

1.1.3 Roof profile with modified bitumen mopped to1" Iso that was mechanically fastened to perlite that was strip mopped to the metal roof deck



1" Iso, showing fasteners at corners

Fastener used to attach Iso to perlite through original gravel surfaced built up roof (BUR)

Overview of deteriorated system

1.1.3 Original perlite was strip mopped to the deck with irregular pattern

Deck was rusted through indicating earlier leaks

Inspection #	1.1.6
Team #	1
Date	October 25 2018
Primary Building Use	Bank Offices
Building Latitude "	30º18’96.8” N
Building Longitude "	85º65’82.27” W
Front of Building Faces	South
Zip	32405
Exposure Category	C
Primary upwind terrain	Open grassland, Smooth (parking lot etc.), Buildings -Smaller
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	
Building Age	16+
Roof Age	16+
Roof Age	GIS
System	Modified Bitumen
Surface	Granular Surfaced
Number of Plies	One
Membrane Attachment	Fully Adhered using asphalt
Membrane Attached to:	Directly to 3-ply BUR roof
Insulation Type	Polyisocyanurate Foam
Insulation Thickness	3"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge Thickness	18 gauge
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	8"
Solar Equipment	None
Damage Assessment State Rank	5
Location of Damage	Entire Roof
Type of Damage	Corner or edge peel, Metal edge, Complete displacement of Perlite cover board.
Extent of Damage Detail Ranking	6
Damage Initiation	Insufficient attachment of the perlite cover board to the metal deck.
Describe damage in detail. discuss all references to "other"	Modified bitumen, BUR, and perlite completely displaced around fasteners across entire roof.
Parapet height	7'
Roof Width	184
Roof Length	130

Total Roof Area, Square feet	24500
Area damaged	More than 50%

1.1.6 Intact Roof

43” High parapet

1.1.6 Puncture damage to parapet

Debris damaged parapet

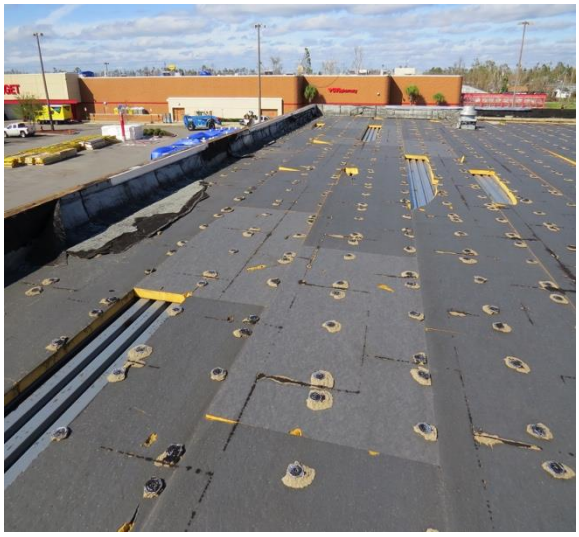
Inspection #	1.2.6
Team #	1
Date	October 26 2018
Primary Building Use	Store
Building Latitude "	30º19’05.21” N
Building Longitude "	85º64’63.91” W
Front of Building Faces	South
Zip	32405
Exposure Category	B
Primary upwind terrain	Smooth (parking lot etc.), Buildings -Smaller, Buildings - Similar Height
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	20 years old
Roof Age	16+
Source	Data - From Source
System	Modified Bitumen
Surface	Granular Surfaced
Number of Plies	3
Membrane Attachment	Mechanically attached and adhered
Membrane Attached to:	Perlite cover board
Insulation Type	Polyisocyanurate Foam
Insulation Thickness	3"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge Thickness	18 gauge
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	18"
Solar Equipment	None
Damage Assessment State Rank	5
Location of Damage	Entire Roof
Type of Damage	Metal edge, Cover Board Pull Through
Extent of Damage Detail Ranking	6
Damage Initiation	Cover board pull through the fastener plates and edge metal.

Describe damage in detail. discuss all references to "other"	Failure initiated with the perlite cover board pull through the fastener plates. The plates and fasteners remained anchored to the deck. No elongation of the deck at the punctures from fasteners was observed. The outer edge metal cleat was missing at the entire roof area perimeter. A limited number of interior cleat lengths were missing. No failure of the nailer was observed.
Parapet height	7'
Roof Width	130'
Roof Length	184'
Total Roof Area, Square feet	24,000 ft^2
Area damaged	More than 50%

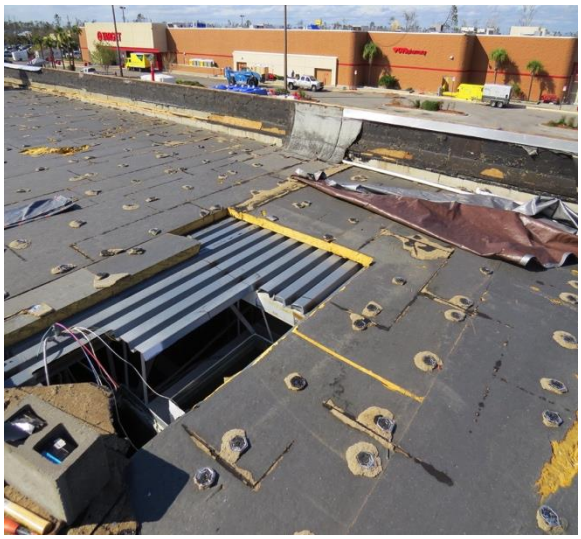
1.2.6 Overview

Perlite tore around fasteners

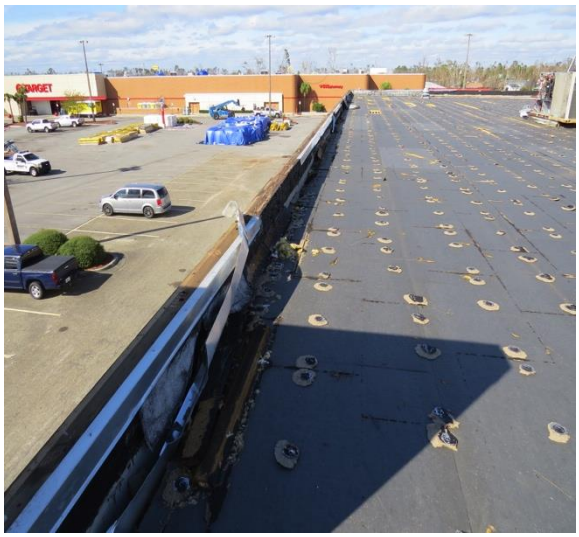
Membrane tore from wall



Insulation blown from deck



1.2.6 Deck Missing



Coping missing

Building Six – Retail Store – Building Height <30' - ~24,500 sq. ft. – 100% Damage

The metal deck was covered with three inches of Polyiso over which was installed twenty-four inch by forty-eight inch, one half inch depth perlite. Each perlite panel was anchored with three stress plates with #12 screws. The roof cover consisted of a three ply (11" felt exposure) with a granulated cap sheet.

A seven-foot high parapet wall was constructed on one perimeter. The remainder of the roof area was enclosed with low rise (<24") parapet walls. 18-gauge prefinished steel edge metal was anchored with a two-part cleat system. The cleat fasteners were paced eight-inches on centers.

Mode of failure was break down of perlite coverboard. The coverboard plates and fasteners remained anchored to deck. No elongation of the deck at punctures from coverboard fasteners was observed.

The outer edge metal cleat was missing at the entire roof area perimeter. A limited number of interior cleat lengths were missing.

Inspection #	2.1.5
Team #	2
Date	10/25
Primary Building Use	Hospital
Building Latitude "	30º.09'52.00" N
Building Longitude "	85º38'57.00” W
Front of Building Faces	North
Zip	
Exposure Category	B
Primary upwind terrain	Trees, Buildings -Smaller
Highest wind direction in storm	North East
Wind Speed ARA	140
Wind Primarily hit building on:	Corner
Building Age	50
Roof Age	16+
Source	GIS
System	BUR
Surface	Pea Gravel surfaced
Number of Plies	Not Determined
Membrane Attachment	Not determined
Membrane Attached to:	Not Determined
Insulation Type	Not Determined
Insulation Thickness	Not determined
Insulation Attachment	Asphalt
Deck Type	Not Determined
Metal Edge Thickness	Not Determined
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	Not determined
Solar Equipment	None
Damage Assessment State Rank	2
Location of Damage	Entire Roof
Type of Damage	Aggregate Scour
Extent of Damage Detail Ranking	2
Damage Initiation	Pea Gravel scoured from roof
Describe damage in detail. discuss all references to "other"	Peas gravel scoured from roof as there was no parapet
Parapet height	0
Roof Width	80
Roof Length	260
Total Roof Area, Square feet	20800
Area damaged	More than 10% but less than 25%

2.1.5 Overview of pea graveled BUR, far side appears to have had membrane issue

Scour patterns on BUR, Several different patterns

Glass broken by debris, sacrificial exterior layer shatters, interior layer may crack. Typical of all windows on the east side of this hospital tower.

Gravel & debris that accumulated on lower roof

BUILT UP ROOF MODIFIED BITUMEN INVESTIGATION SITES

Inspection #	4.1.1
Team #	4
Date	10/25/18
Primary Building Use	Fast food restaurant
Building Latitude "	21º19’57.1” N
Building Longitude "	72º80’84” W
Front of Building Faces	South
Zip	32407
Exposure Category	D
Primary upwind terrain	Open Water, Smooth (parking lot etc.), Buildings Taller
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	Remodeled 5 years ago
Roof Age	5
System	Modified Bitumen
Surface	Reflective Coated
Number of Plies	1
Membrane Attachment	Torch
Membrane Attached to:	Unknown
Insulation Type	Unknown
Insulation Thickness	?
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge Thickness	0.032
Type of Metal Edge	Aluminum
Metal Edge Fasteners distance between centers (typical)	
Solar Equipment	None
Damage Assessment State Rank	1
Location of Damage	Metal Edge
Type of Damage	Corner or edge peel
Extent of Damage Detail Ranking	3
Damage Initiation	coping
Describe damage in detail. discuss all references to "other"	Coping rolled back due to lack of substrate only had spaced gussets
Parapet height	24
Roof Width	30
Roof Length	60
Total Roof Area, Square feet	1200
Area damaged	Less than 10%

4.1.1 Overview with damaged coping

Opposite side

Coping tore over fastener

Coping tear

METAL ROOF INVESTIGATION SITES

Inspection #	2.1.1
Team #	2
Date	10/25/18
Building Name	School
Primary Building Use	School Library and Classrooms
Building Latitude "	30.09'57.08" W
Building Longitude "	85.36'54.80" N
Front of Building Faces	West
Zip	32404
Exposure Category	B
Primary upwind terrain	Trees, Buildings -Smaller
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	30+
Roof Age	8-12
Source	GIS
Building Width	82
Building Length	260
Building Height	40
Eave Height ft.	22
Slope	Low-slope >3 1/2 to 5 on 12
System Type	Architectural Standing Seam
Unfinished Metal	
Painted	Aluminum
Installation	Concealed Clips
Number of square feet per fastener	5
Corner or perimeter enhancement	None
Valleys	None
Underlayment	#30 felt
Underlayment Type	Asphaltic felt
Deck	Steel
Ventilation	Soffits, Ridge
Damage Assessment State Rank	6. Panels missing and structural damage
Location of Roof Damage	Corner, Eave, Rake Edge, Field, Soffit vents
Type of damage	Sheets Dislodged, Metal Edge, Punctures, Seam Failure, Fastener Pull out, Structural Deck Failure
Damage Initiation	Pressurized attic due to soffit ventilation that opened to large attic. Gutters pulled off and pried metal edge off roof. Progressive damage

Describe Damage	Architectural metal panels dislodged from most of the roof, metal deck welds failed and a large area of metal deck was dislodged as the welds at 24" center failed. There were several other metal standing seam metal panel roofs in this complex that were damaged, but not to the extent of this roof, as they were mostly protected by this building. This was an architectural metal roof system installed over a wood deck. The clip fasteners from the architectural metal deck were attached to metal plates that were attached with 4 screws that penetrated the wood deck, the isocyanuate insulation then penetrated the original metal deck at least 1.5". The wood deck was also screwed to the original metal deck. The metal deck was welded to trusses. It appears the main cause of the architectural metal roof coming off was due to the fasteners that totally missed the wood nailer at the windward perimeter. There are sets of 4 plate screws that penetrated the metal deck in the bottom right photo. In addition, the entire attic space below the roof was pressurized by soffit ventilation and later loss of soffit panels.
Nails or fasteners per linear foot of perimeter	1 per 4 feet
Deck attachment	Welded

2.1.1 Overview of area of dislodgement

Dislodgement down to deck

2.1.1 System profile showing clips

Ridge dislodgement and underlying insulation

2.1.1 Building overview

System: Standing seam, 2.75 Iso insulation, #30 felt, Metal deck, all dislodged in some locations

Fasteners that completely missed 2” x 4” nailer that was installed vertically.

Deck welds did not resist the uplift.

Inspection #	2.2.2
Team Number	2
Date	10/25/18
Primary Building Use	School
Building Latitude "	30º14'29.82" N
Building Longitude "	85º33'50.15" W
Front of Building Faces	South
Zip	32404
Exposure Category	B
Primary upwind terrain	Trees, Buildings -Smaller
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	10
Roof Age	10
Source	GIS
Building Width ft	160
Building Length ft	75
Building Height ft	20
Eave Height ft.	14
Slope	Low-slope >3 1/2 to 5 on 12
System Type	Structural Standing Seam
Unfinished Metal	
Painted	Galvanized
Installation	Concealed Clips
Fastener Spacing ft	4
Corner/perimeter enhancement	None
Valleys	None
Underlayment	Exposed No
Underlayment Type	
Deck	None (Structural Roof)
Ventilation	Soffits
Damage Assessment State Rank	1.Dents Punctures
Location of Roof Damage	Field
Type of damage	Seams distorted
Damage Initiation	Pressurization of roof likely distorted some of the panels and likely dislodged one or more seam clips
Describe Damage	This very large school complex had hardly any damage. A few edge metal securement issues on the south and east side of the building and some slightly distorted panels in one section of a south facing roof. Otherwise no damage.
Nails or fasteners per linear foot of sheathing perimeter	NA
Deck attachment	NA

2.2.2 Overview of large complex with Standing seam metal panels

Some wrinkles at seams

Edge damage; some due to trees and other to uplift

No observed damage on other sections

Inspection #	2.2.3
Team Number	2
Date	10/25/18
Primary Building Use	School
Building Latitude "	30º04'59.50" N
Building Longitude "	85º36'33.31" W
Front of Building Faces	West
Zip Code	32403
Exposure Category	B
Primary upwind terrain	Trees
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	35
Roof Age	16+
Source	GIS
Building Width, ft	84
Building Length, ft	200
Building Height, ft	26
Eave Height ft.	18
Slope	Low-slope >3 1/2 to 5 on 12
System Type	Structural Standing Seam
Unfinished Metal	Galvanized
Painted	
Installation	Concealed Clips
Fastener Spacing, ft	6
Corner or perimeter enhancement	None
Valleys	No Valleys
Underlayment Type	
Deck	None (Structural Roof)
Ventilation	Ridge
Damage Assessment State Rank	6. Panels missing and structural damage
Location of Roof Damage	Rake Edge, Ridge
Type of damage	Sheets Dislodged, Metal Edge, Seam Failure, Fastener Pull out, Structural Deck Failure
Damage Initiation	Exterior wall collapsed, pressurized building, progressive failure.
Describe Damage	Windward side wall was pushed in by the storm, metals panels on side walls were dislodged and standing seam structural roof was torn off for about 100 feet in from the wall collapse. Purlins and major roof beams were distorted. Several lower buildings on the campus did not have any damage.

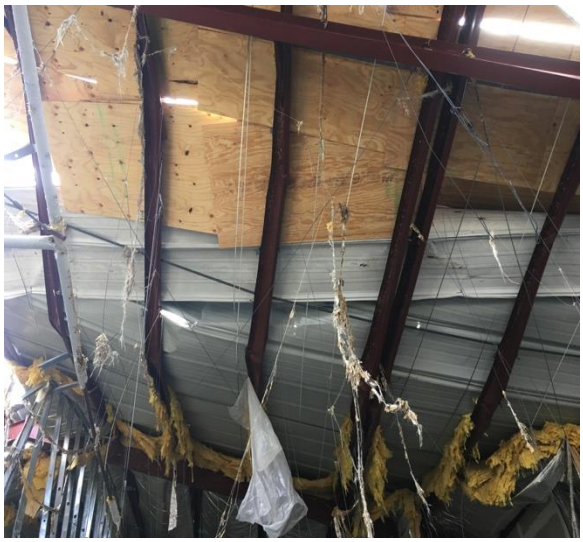
Nails or fasteners per linear foot of sheathing perimeter	
Deck attachment	Standard Clips

2.2.3 Overview: Missing & bent panels

Collapsed wall and missing panels

Collapsed Brick Wall

Twisted support beams



2.2.3Interior twisted beams

Wall side interior

Clip

26-gauge metal

Inspection #	3.2.4
Team #	3
Date	10/26/18
Primary Building Use	Bank
Building Latitude "	30º22’56.19” N
Building Longitude "	85º57’15.60” W
Front of Building Faces	South
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Trees
Highest wind direction in storm	North East
Estimated gust wind speed	
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	3
Building Code	
Roof Age	3
Source	GIS
Building Width, ft	47
Building Length, ft	66
Building Height, ft	40
Inspection #	3,2,4
Eave Height ft.	12
Slope	Moderate >5 1/2 to 9 on 12
System Type	Structural Standing Seam
Unfinished Metal	
Painted	24 ga. Polyvinilidene floride
Installation	Concealed Clips. This was a single lock, 1.5 inch to 1.75inch high likely 24 gauge.
Fastener Spacing	Cannot tell
Corner or perimeter enhancement	None
Valleys	All open
Underlayment	
Underlayment Type	
Deck	
Ventilation	Soffits, linear vents within soffit
Damage Assessment State Rank	0. No Damage
Location of Roof Damage	
Type of damage	
Damage Initiation	None
Describe Damage	

Nails or fasteners per linear foot of sheathing perimeter	
Deck attachment	

3.2.4 Overview

No roof damage

3.2.4 No roof damage

Downspout broken

Inspection #	3.2.5
Team #	3
Date	10/26/18
Primary Building Use	Police station
Building Latitude "	30º23’59.58” N
Building Longitude "	85º57’81.95” W
Altitude (At Ground)	41
Front of Building Faces	East
Zip Code	32404
Exposure Category	B
Primary upwind terrain	Open grassland, Trees
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	2002
Roof Age	16+
Source	Data - From Source
Building Width, ft	121
Building Length, ft	96
Building Height, ft	40
Eave Height ft.	12
Slope	Low-slope >31/2 to 5/12
System Type	Structural Standing Seam
Unfinished Metal	Not unfinished
Painted	Polyvinilidene floride coated 24 ga. zinc/aluminum coating
Installation	Concealed Clips
Fastener Spacing	16 in seam spacing height 1.5" double lock
Corner or perimeter enhancement	
Valleys	Open, typical
Underlayment	
Underlayment Type	Self-adhered
Deck	Can't tell, but self-drilling screw found, likely drilled through purlin or deck
Ventilation	Don’t recall, not at ridge
Damage Assessment State Rank	0.No Damage
Location of Roof Damage	One piece of hip flashing near leeward corner, not enough hip engagement
Type of damage	See above, also aluminum gutter on back
Damage Initiation	Just one piece of hip flashing
Describe Damage	No panels damaged, only one piece of hip flashing with improper engagement

Nails or fasteners per linear foot of sheathing perimeter	
Deck attachment	

3.2.5 Overview

Standing seam

Damaged Gutter

Missing ridge cap

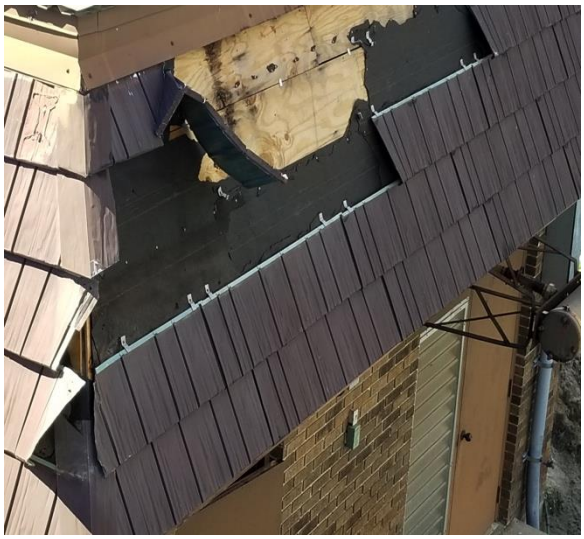
Inspection #	3.2.6
Team #	3
Date	10/26/18
Primary Building Use	Commercial
Building Latitude "	30º32’16.79” N
Building Longitude "	85º65’88.29” W
Front of Building Faces	South
Zip Code	NA
Exposure Category	B
Primary upwind terrain	Open grassland, Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	131
Wind Primarily hit building on:	Short Side
Building Age	Converted bank with more recent additions original 38 years old
Roof Age	16+
Source	GIS
Building Width	
Building Length	
Building Height	Don’t know, less than 40
Eave Height	9.5
Ridge Height	Don’t know, less than 40
Slope	Steep >9/12
Design	Mansard for shingles, but other types on low-slope
Metal	Aluminum
Surfacing	Painted Metal
Fastening	aluminum cleats only 1" wide
Underlayment	Exposed After event
Underlayment Type	Synthetic
Deck Type	Plywood
Deck attachment	
Number of perimeter fasteners per linear foot of deck section	
Ventilation Check all that apply	Soffits, the low-slope corrugated vented, but because foam closures missing, just stuffed in
Solar Equipment on Roof	No
Damage Assessment	5. More than 50% of Roof covering missing from one slope
Location of Damage Check all that apply	Field, vast majority of damage on al mansard, low-slope membrane and corrugated metal OK, except one piece hip flashing
What Failed First How do you know	Field of al mansard

Describe Damage	Aluminum mansard shingles, stamped, simply pulled off. Al cleats, disengaged, cleats 16 to 24" only one nail each, but the al clips simply disengaged

3.2.6 Overview

Attachment

More attachment



Underlying system

Inspection #	4.1.4
Team #	4
Date	10/25/18
Primary Building Use	Residence
Building Latitude "	30º04’7”
Building Longitude "	85º75’26”
Front of Building Faces	East
Zip Code	32408
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	30+
Roof Age	1
Source	Data - From Source
Building Width	20
Building Length	35
Building Height	18'
Eave Height ft.	8
Slope	Moderate >51/2 to 9/12
System Type	Architectural Standing Seam
Unfinished Metal	Steel (?)
Painted	Steel (I don’t remember seeing anyone check this, but I think there would have been a lot of punctures at the impact locations if the panels had been aluminum.
Installation	Concealed clips
Fastener Spacing	
Corner or perimeter enhancement	None
Valleys	None
Underlayment	Exposed No
Underlayment Type	Other
Deck	Unknown
Ventilation	Soffits
Damage Assessment State Rank	1.Dents Punctures
Location of Roof Damage	Eave, Rake Edge, Field
Type of damage	Metal Edge, impact
Damage Initiation	Metal edge and field
Describe Damage	Uplift tore off metal edging and debris damaged field

Nails or fasteners per linear foot of sheathing perimeter	Unknown
Deck attachment	Unknown

4.1.4 Overview

Undamaged roof area

Damage from debris

Damage from debris

Inspection #	4.2.1
Team #	4
Date	10/26/18
Primary Building Use	School
Building Latitude "	30º15’38” N
Building Longitude "	85º56’93”
Front of Building Faces	South
Zip	32404
Exposure Category	B
Primary upwind terrain	Open grassland
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	30 years
Roof Age	6
Source	GIS
Building Width	Over 400' varies
Building Length	Over 800' varies
Building Height	12' to 24' gym/auditorium
Inspection #	4,2,1
Eave Height ft.	12 & 24
Slope	Shallow <31/2/12
System Type	Architechtural Standing Seam
Unfinished Metal	Galvanized
Painted	Galvanized
Installation	Concealed Clips
Fastener Spacing	Unknown
Corner or perimeter enhancement	None
Valleys	None
Underlayment	Exposed No
Underlayment Type	Other
Deck	None (Structural Roof)
Ventilation	None
Damage Assessment State Rank	2.Less than 10% of panels missing
Location of Roof Damage	Entire Roof Edge and Rake Edge
Type of damage	Metal Edge
Damage Initiation	Wind uplift from the north and tree impact
Describe Damage	Custodian said wind lifted many wall panels (especially were there was no bottom j channel) and tree impact opened up roof
Nails or fasteners per linear foot of sheathing perimeter	
Deck attachment	Unknown

4.2.1Overview

Missing Siding and roof edge damage

Missing siding

Missing siding and roof edge damage

Inspection #	4.2.2
Team #	4
Date	10.26.2018
Primary Building Use	Church
Building Latitude "	30º15’2327” N
Building Longitude "	85º57’0601” W
Front of Building Faces	North
Zip	32404
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	North
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	40+
Roof Age	16+
Source	GIS
Building Width	30
Building Length	50
Building Height	32
Eave Height ft.	18
Slope	Moderate >51/2 to 9/12
System Type	Architectural Through Fastened
Unfinished Metal	
Painted	Galvalume
Installation	Screws
Fastener Spacing	
Corner or perimeter enhancement	None
Valleys	None
Underlayment	Exposed Yes
Underlayment Type	#15 Felt
Deck	Plywood
Ventilation	Soffits, Gable Ends
Damage Assessment State Rank	6
Location of Roof Damage	Entire Roof
Type of damage	Sheets dislodged, metal edge, punctures, seam failure, fastener pull out, structural deck failure, failure in attachment of wood “slats” to deck; yes the slats also failed
Damage Initiation	Rake end front overhang
Describe Damage	Deck came off and peeled the remaining primary roofing off

Nails or fasteners per linear foot of sheathing perimeter	4
Deck attachment	Limited nailing

4.2.2 Roof damage

Debris showing deck and metal

Building front

Building back

Base of the Roof system

Inspection #	4.2.6
Team #	4
Date	10/26/18
Building Name	Quality Plus Services
Primary Building Use	Manufacturing
Building Latitude "	30º20’33” N
Building Longitude "	85º52’49” W
Front of Building Faces	West
Zip	32404
Exposure Category	B
Primary upwind terrain	Open grassland, Buildings -Smaller
Highest wind direction in storm	North East
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	11
Roof Age	11
Source	GIS
Building Width	60'
Building Length	100'
Building Height	40'
Eave Height ft.	30
Slope	Shallow <3 1/2/12
System Type	Structural Through Fastened
Unfinished Metal	Galvanized
Painted	Galvanized
Installation	Screws
Fastener Spacing	2
Corner or perimeter enhancement	Corner metal
Valleys	None
Underlayment	
Underlayment Type	Other
Deck	None (Structural Roof)
Ventilation	Ridge
Damage Assessment State Rank	6.10% to 25% of panels missing
Location of Roof Damage	Corner
Type of damage	Structural Failure
Damage Initiation	Doors failed than roof/walls by debris
Describe Damage	Wind load blew out front doors, side door and pressure imploded the wall/roof
Nails or fasteners per linear foot of sheathing perimeter	6
Deck attachment	NA

4.2.6 Metal Collapse

Metal Collapse

Metal Collapse

Broken Weld

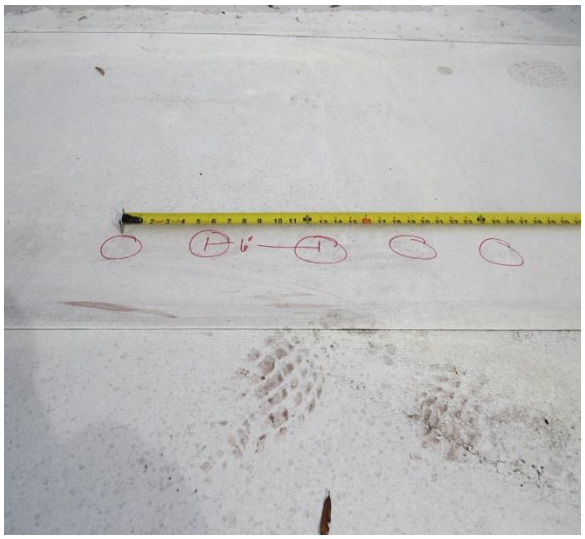
SINGLE PLY INVESTIGATION SITES

Inspection #	1.1.1
Team #	1
Date	October 25 2018
Primary Building Use	Department Store
Building Latitude "	30º19’0271” N
Building Longitude "	85º64’9814” W
Front of Building Faces	South
Zip	32405
Exposure Category	B
Primary upwind terrain	End of street, Trees, Buildings -Smaller
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	16+
Roof Age	4-7
Source	Data - From Source
Surface	White
Membrane Type	PVC Coated
# of Perimeter Membrane Attachment rows	4 sheets, 3 ft. wide each
Perimeter Row Spacing ft.	3 ft.
Perimeter Fasteners on Centers Spacing (inches)	6" o.c.
Field Row Spacing ft.	69" o.c.
Field fasteners on Centers Spacing (inches)	6" o.c.
Fastener Type	unknown
Plate Diameter	2.5" circular
Directly Below Membrane	Gypsum based roof board
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	2.5"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	Unknown
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	32" o.c., 6" long nails
Damage Assessment State Rank	3
Location of Damage	Metal Edge
Types of Damage	Corner or edge peel, Metal edge, Punctures
Extent of Damage Rating	3

Damage initiation	1) Roof edge on back side of building 2) rooftop equipment failure
Describe damage details, include all reference to "other"	
Roof Height	20 ft.
Parapet Height	Parapet only on 2 sides, variable height
Roof Width	335'
Roof Length	377'
Roof Area	118,000 Sf.
Damage Area	10% or more but less than 25%

1.1.1 Overview

Half sheets at the perimeter



Fastener spacing 6''

Puncture damage

1.1.1 Trail of puncture damage from dislodged

Edge metal missing, not typical

Gutter damaged

Gutter missing

Inspection #	1.1.4
Team #	1
Date	October 25 2018
Primary Building Use	Offices
Building Latitude "	30º15’9794” N
Building Longitude "	85º65’9362” W
Front of Building Faces	West
Zip	32401
Exposure Category	B
Primary upwind terrain	Smooth (parking lot etc.), Buildings -Smaller, Buildings - Similar Height, Buildings Taller
Highest wind direction in storm	West
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	
Roof Age	7
Source	GIS
Surface	White
Membrane Type	Thermoplastic olefin (TPO)
Membrane Adhered to:	Gypsum Board
Insulation Type	None
Insulation Thickness	not applicable
Insulation Attachment	Not Determined
Deck Type	Cementitious Wood Fiber
Metal Edge	Yes
Metal Edge Thickness	Not determined
Metal Edge metal	Steel
Fastener Spacing inches on center "typical"	Not determined
Damage Assessment State Rank	5
Location of Roof Damage	Entire Roof, Metal Edge, Corner, Field, Perimeter
Extent of Damage Details	5
Damage Initiation	Corner and edge.
Describe Damage	Gypsum delaminated from Cementitious wood fiber deck due to poor bonding of adhesive. Total failure, delamination of gypsum facer. Rooftop equipment failure (insufficient screws). Also noted. Wood fiber deck was sagging in the center of the panels and as a result, gypsum boards were not fully adhered. At rooftop equipment failures, you could see into the building.
Roof Height	12 ft.
Parapet Height	16"

Roof Width	50"
Roof Length	110 ft.
Roof Area	5500 ft.

1.1.4 Overview

Cementitious Wood Fiber Deck

Paper Facer Debonded from Gypsum Board

Foam Adhesive did not bond to gypsum board

Inspection #	1.1.5
Team #	1
Date	October 25 2018
Primary Building Use	Apartment Building
Building Latitude "	30º15’3171” N
Building Longitude "	85º66’2273” W
Front of Building Faces	North
Zip	32401
Exposure Category	D
Primary upwind terrain	Open Water, Smooth (parking lot etc.), Buildings - Smaller
Highest wind direction in storm	North
Wind Speed ARA	140
Wind Primarily hit building on:	Corner
Building Age	42 years old
Building Code	
Roof Age	9 to 12
Source	Data - From Source
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	2
Perimeter Row Spacing ft	2.5
Perimeter Fasteners on Centers Spacing (inches)	6
Field Row Spacing ft.	6
Field fasteners on Centers Spacing (inches)	12
Fastener Type	Not Determined
Plate Diameter	Not Determined
Directly Below Membrane	Foam Insulation
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	1
Insulation Attachment	Screws & Plates
Deck Type	Concrete
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	Not determined
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	24
Damage Assessment State Rank	3
Location of Damage	Corner, Metal Edge, Perimeter, Field
Types of Damage	Corner or edge peel, Metal edge, Punctures
Extent of Damage Rating	3
Damage initiation	Parapet wall cladding failure, caused edge metal failure

Describe damage details, include all reference to "other"	Rooftop equipment failure. Parapet cladding failure, caused parapet failure which led to membrane ballooning. Ballast from old roof below was blown on top of new membrane.
Roof Height	14 stories, approximately 100 ft.
Parapet Height	23”
Roof Width	80 ft.
Roof Length	211 ft.
Roof Area	11,550 ft^2
Damage Area	10% or more but less than 25%

1.1.5 Overview

Missing Coping, bulge in parapet cladding

1.1.5 Torn Membrane

Missing Cladding over parapet

1.1.5 Parapet Cladding

Membrane dislodged from parapet

Inspection #	1.2.2
Team #	1
Date	October 26 2018
Primary Building Use	Theatre
Building Latitude "	30º15’5423” N
Building Longitude "	85º66’0557” W
Front of Building Faces	East
Zip	32401
Exposure Category	B
Primary upwind terrain	Buildings -Smaller, Buildings - Similar Height, Buildings Taller
Highest wind direction in storm	West
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	
Roof Age	1
Source	GIS-Owner
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	2
Perimeter Row Spacing ft	5
Perimeter Fasteners on Centers Spacing (inches)	12
Field Row Spacing ft.	8
Field fasteners on Centers Spacing (inches)	18
Fastener Type	Unknown
Plate Diameter	Unknown
Directly Below Membrane	Foam Insulation
Insulation Type	Polystyrene Foam Board
Insulation Thickness	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	Not Determined
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	Not determined
Damage Assessment State Rank	3
Location of Damage	Corner, Metal Edge, Perimeter, Field
Types of Damage	Corner or edge peel, Metal edge
Extent of Damage Rating	4
Damage initiation	Edge pulled out of top of brick wall

Describe damage details, include all reference to "other"	Edge pulled loose and then pulled the membrane back.
Roof Height	41
Parapet Height	3’
Roof Width	66
Roof Length	126
Roof Area	
Damage Area	10% or more but less than 25%

1.2.2 Overview Red temporary roof

Membrane bonding

1.2.2 Fastener Some corrosion

Coping and termination bar

Additional Notes: See next page

Additional Notes: 1.2.2

Building Two – Theater - Building Height 30-60' – ~6,000 sq. ft. – 100% Damage

The was composed of a steel deck over which was installed five and three quarters inch Polyiso, 0.5" gypsum deck with w a white, single ply, thermoplastic PVC membrane. The coverboard was attached in three-inch plates and eight-inch #12 screws. The membrane was attached the coverboard with low rise urethane foam. The foam beads were commonly spaced eight inches.

The roof area was enclosed with varying height (24"-48") parapet walls. The coping cap was 22-gauge prefinished non-magnetic metal. The cap was anchored to a wood nailer on its interior flange using screws spaced twelve inches on centers. The cap exterior flange was secured with a cleat.

Single ply white, PVC membrane attached with low rise, urethane foam. The foam beading was 8" on center.

Mode of failure was at the membrane/coverboard interface.

Inspection #	1.2.3
Team #	1
Date	October 26 2018
Primary Building Use	Theatre and recreational spaces
Building Latitude "	30º15’2128” N
Building Longitude "	85º66’2952” W
Front of Building Faces	North
Zip	32401
Exposure Category	D
Primary upwind terrain	Open Water, Smooth (parking lot etc.), Buildings - Smaller
Highest wind direction in storm	North
Wind Speed ARA	140
Wind Primarily hit building on:	Long Side
Building Age	
Roof Age	16+
Source	GIS
Surface	White
Membrane Type	Thermoplastic Olefin
# of Perimeter Membrane Attachment rows	Thermally welded fasteners 9"x17"
Perimeter Row Spacing ft.	none
Perimeter Fasteners on Centers Spacing (inches)	Thermally welded fasteners 18"x30"
Field Row Spacing ft.	10'
Field fasteners on Centers Spacing (inches)	Thermally welded- fasteners 18"x30"
Fastener Type	8"
Plate Diameter	3", 1"x3" at seams.
Directly Below Membrane	Gypsum Board
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	5.5"
Insulation Attachment	Screws & Plates
Deck Type	Not Determined
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	22-gauge
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	horizontal - 6" on center, front face 12" on center
Damage Assessment State Rank	2
Location of Damage	Entire Roof, Corner, Metal Edge, Perimeter, Field, Punctures and tears to roof from windblown debris
Types of Damage	Corner or edge peel, Metal edge, Punctures
Extent of Damage Rating	4

Damage initiation	Metal cladding at perimeter failed with edge peel allowing wind under the membrane. Fastener pull out resulted. Bond between plates and membrane was not damaged.
Describe damage details, include all reference to "other"	Perimeter of roof damaged with edge peel, fasteners punctured membranes throughout or backed out. Punctures from wind-blown debris,
Roof Height	80'-90'
Parapet Height	0
Roof Width	48
Roof Length	102
Roof Area	4900
Damage Area	More than 50%

1.2.3 Outside overview showing missing coping

Missing Coping

Fastener Bond

Fastener Corrosion at top and near bottom

1.2.3 Fasteners that were pulled out due to membrane uplift

Impact damage

Additional Notes:

Building Three – Building Height 80-90' - ~4,900 sq. ft. – 100% Damage

The roof deck type was unknown. A white, single ply thermoplastic, TPO surface membrane was installed. The ten-foot wide sheets were installed using the plate welded system. The plates along the perimeter were in a rectangular fashion, 9" x 17". The field plates were also in a rectangular configuration, 18" x 30". The metal three-inch plates were secured with eight-inch long fasteners. One inch by three-inch plates were found at sheet seams. The plate spacing at seams is unknown.

The insulation bed consisted of five and one-half inches of Polyiso. A one-half inch gypsum coverboard was used.

22-gauge prefinished steel edge metal was secured with varying length gasketed screws. The screws were spaced six inches on centers on its interior flange and twelve inches on centers on its exterior flange. Some of the edge metal fasteners did not penetrate the wood nailer.

Failure was due to edge peel which caused stress at bond plates and fasteners. The bond between the plate and membrane was intact. Stress resulted in plate fastener pull out.

Tears, punctures and other surface damage was found due to debris impact were prevalent. Punctures from elevated fasteners were less common.

Inspection #	1.2.4
Team #	1
Date	October 26 2018
Primary Building Use	Offices
Building Latitude "	30º15’3175” N
Building Longitude "	85º66’4009” W
Front of Building Faces	East
Zip	32401
Exposure Category	D
Primary upwind terrain	Open Water, Smooth (parking lot etc.), Buildings - Similar Height
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Long Side
Building Age	
Roof Age	16+
Source	GIS
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	5 sheets
Perimeter Row Spacing ft.	2'
Perimeter Fasteners on Centers Spacing (inches)	6" on center
Field Row Spacing ft.	4'
Field fasteners on Centers Spacing (inches)	6" on center
Fastener Type	unknown
Plate Diameter	2.75"
Directly Below Membrane	Foam Insulation
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	2"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	unknown
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	unknown
Damage Assessment State Rank	3
Location of Damage	Field
Types of Damage	Punctures
Extent of Damage Rating	2
Damage initiation	Rooftop equipment and other wind-blown debris tore and punctured membrane throughout.

Describe damage details, include all reference to "other"	Roof membrane and insulation was torn and punctured throughout from wind-blown debris. Roof approximately 80' away and 10' lower was a total failure of membrane and half of metal deck.
Roof Height	30'
Parapet Height	0
Roof Width	120
Roof Length	130
Roof Area	15600
Damage Area	More than 50%

1.2.4 Overview with tares

Edge damage

Large tears

Membrane torn off

Additional Notes: Next page:

Additional Notes: 1.2.4

Building Four – Building Height <30' – ~15,600 sq. ft. - >50% Damage

The roof was composed of a metal deck, previous aggregate surface asphalt roof cover, two inches Polyiso and mechanically attached 45 mil PVC membrane. The perimeter was constructed with five, twenty-four inch perimeter sheets. The perimeter sheet fasteners were spaced six inches on center. The forty-eight wide field sheet fasteners were also spaced six inches on centers. Ten, plastic, two and three-quarter inch stress were used per four foot by eight foot insulation panel. Two stress plates were placed with the long end joint.

Extensive punctures/tears from wind born debris.

Inspection #	1.2.5
Team #	1
Date	October 26 2018
Primary Building Use	Department Store
Building Latitude "	30º16’1539” N
Building Longitude "	85º59’3254” W
Front of Building Faces	East
Zip	32404
Exposure Category	B
Primary upwind terrain	Smooth (parking lot etc.), Trees, Buildings - Smaller, Buildings - Similar Height
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Long Side
Building Age	
Roof Age	4-7
Source	Data - From Source
Surface	White
Membrane Type	TPO
# of Perimeter Membrane Attachment rows	4
Perimeter Row Spacing ft.	4'
Perimeter Fasteners on Centers Spacing (inches)	12"
Field Row Spacing ft.	7.5'
Field fasteners on Centers Spacing (inches)	12" on center
Fastener Type	Not determined
Plate Diameter	Not determined
Directly Below Membrane	Gypsum based roof board
Insulation Type	Not determined
Insulation Thickness	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	22-gauge
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	6" on center
Damage Assessment State Rank	1
Location of Damage	Perimeter, Field
Types of Damage	Metal edge, Punctures
Extent of Damage Rating	1
Damage initiation	Wind-blown debris and rooftop unit failure

Describe damage details, include all reference to "other"	Rooftop unit failure and wind-blown debris punctured membrane. Cladding at front caused localized area of displaced coping.
Roof Height	20'
Parapet Height	3.5'
Roof Width	536
Roof Length	325
Roof Area	208,600
Damage Area	Less than 10%

1.2.5 Overview

Missing unit

1.2.5 Trail of damage

Other punctures from debris

Additional Notes: Next Page:

Additional Notes: 1.2.5

Building Five – Building Height <30' - ~208,600 sq. ft. - <10%

The roof profile consisted of a metal deck, unknown insulation bed depth/type, a gypsum coverboard and a mechanically attached TPO membrane. The perimeter was constructed using four, forty-eight-inch wide sheets. The perimeter sheet fasteners were spaced twelve inches on centers. Additional perimeter sheet securement was present in the form of termination bars spaced forty-eight inches on centers. The termination bar extended into the field fifteen feet. The type of fasteners used to secure the termination bar is unknown. The seven feet six-inch wide field sheets were anchors were spaced twelve inches on centers.

The roof area was enclosed on three of its perimeters by three and one-half foot tall parapet walls. 22-gauge prefinished steel edge metal was used. The edge metal fasteners were spaced six inches on centers.

The membrane suffered from tears/punctures from debris impact. Isolated skylights were missing lenses. One RTU sustained damage.

Exterior wall cladding (EIFS) failure on front elevation resulted in deformation of the edge metal.

Inspection #	2.1.2
Team #	2
Date	10/25/18
Primary Building Use	Classroom
Building Latitude "	30.09'57.07" N
Building Longitude "	86.36'53.00” W
Front of Building Faces	East
Zip	32401-5157
Exposure Category	B
Primary upwind terrain	Trees, Buildings - Similar Height
Highest wind direction in storm	North East
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	40
Roof Age	10
Source	GIS
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	2
Perimeter Row Spacing ft	5
Perimeter Fasteners on Centers Spacing (inches)	12
Field Row Spacing ft.	8
Field fasteners on Centers Spacing (inches)	18
Fastener Type	Unknown
Plate Diameter	Unknown
Directly Below Membrane	Foam Insulation
Insulation Type	Polystyrene Foam Board
Insulation Thickness	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	Not Determined
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	Not determined
Damage Assessment State Rank	3
Location of Damage	Corner, Metal Edge, Perimeter, Field
Types of Damage	Corner or edge peel, Metal edge
Extent of Damage Rating	4
Damage initiation	Edge pulled out of top of brick wall
Describe damage details, include all reference to "other"	Edge pulled loose and then pulled the membrane back.

Roof Height	14
Parapet Height	3"
Roof Width	66
Roof Length	126
Roof Area	8316
Damage Area	10% or more but less than 25%

2.1.2 Overview entire edge dislodged

Membrane attached to nailer that was nailed to a vertical board

Metal edge dislodged from brick

Nailers not adequately fastened to building

Inspection #	2.1.3
Primary Building Use	Gymnasium
Building Latitude "	30.09'57.09” N
Building Longitude "	85.36'54.80" W
Front of Building Faces	West
Zip	
Exposure Category	B
Primary upwind terrain	Trees, Buildings -Smaller, Buildings - Similar Height
Highest wind direction in storm	North East
Estimated gust wind speed	120
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	10
Roof Age	12-15
Source	Best Guess
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	2
Perimeter Row Spacing ft.	5
Perimeter Fasteners on Centers Spacing (inches)	12
Field Row Spacing ft.	8
Field fasteners on Centers Spacing (inches)	18
Fastener Type	Unknown
Plate Diameter	Unknown
Directly Below Membrane	Foam Insulation
Insulation Type	Polystyrene Foam Board
Insulation Thickness	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	Not Determined
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	Not determined
Damage Assessment State Rank	3
Location of Damage	Corner, Metal Edge, Perimeter, Field
Types of Damage	Corner or edge peel, Metal edge
Extent of Damage Rating	4
Damage initiation	Edge pulled out of top of brick wall
Describe damage details, include all reference to "other"	Edge pulled loose and then pulled the membrane back.
Roof Height	14

Parapet Height	3"
Roof Width	66
Roof Length	126
Roof Area	8316
Damage Area	More than 50%

2.1.3 Undamaged lower roof

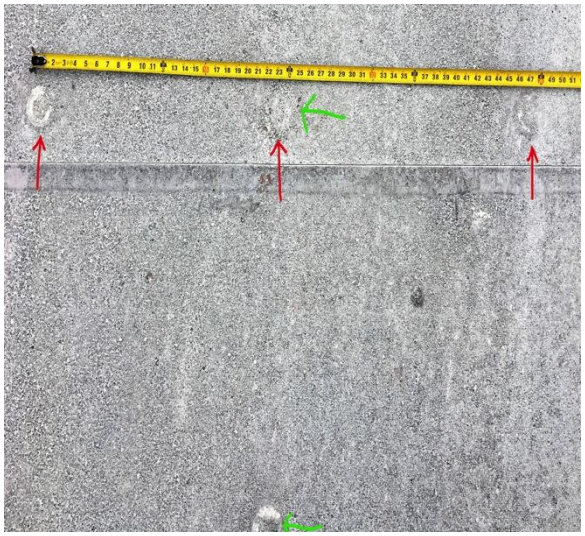
Temporary cover of upper roof

Dislodged coping on upper roof

Coping system

2.1.3 Coping fastening

Membrane edge fastening



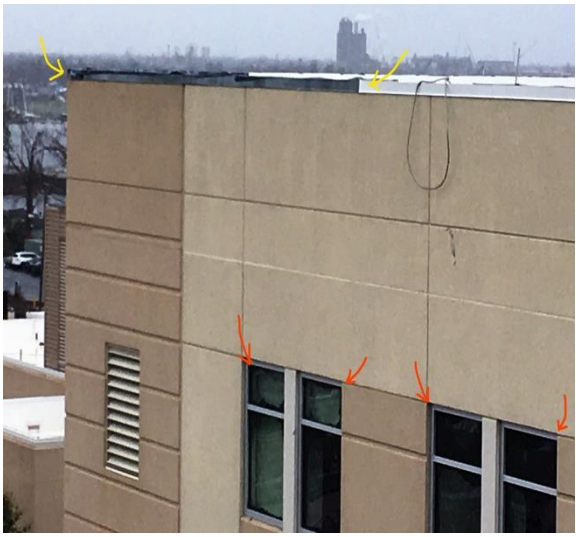
Membrane field fastening

Fastener and insulation

Inspection #	2.1.4
Team #	2
Date	10/26/18
Primary Building Use	Hospital
Building Latitude "	30º.09'33.51" N
Building Longitude "	85º38'57.50" W
Front of Building Faces	Southwest
Zip	
Exposure Category	B
Primary upwind terrain	Buildings -Smaller, Buildings - Similar Height
Highest wind direction in storm	North East
Estimated gust wind speed	130
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	16+
Roof Age	15
Source	GIS
Surface	White
Membrane Type	TPO
# of Perimeter Membrane Attachment rows	1
Perimeter Row Spacing ft	2
Perimeter Fasteners on Centers Spacing (inches)	Not determined
Field Row Spacing ft.	Not determined
Field fasteners on Centers Spacing (inches)	Not determined
Fastener Type	Not determined
Plate Diameter	Not determined
Directly Below Membrane	Foam Insulation
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Concrete
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	.040"
Metal Edge metal type	Aluminum
Metal edge fastener spacing inches on center "typical'	12
Damage Assessment State Rank	3
2.1.4 Location of Damage	Corner, Metal Edge, Perimeter, Field
Types of Damage	Corner or edge peel, Metal edge, Punctures
Extent of Damage Rating	5

Damage initiation	Cladding failure on upwind side of parapet wall, parapet was pressurized and the membrane separated from the wall surface. The coping also dislodged leading to progressive billowing and fastener pull out.
Describe damage details, include all reference to "other"	Coping dislodged from a large area, membrane dislodged and torn, insulation shuffled under the membrane.
Roof Height	80
Parapet Height	48"
Roof Area	
Damage Area	25% or more but less than 50%

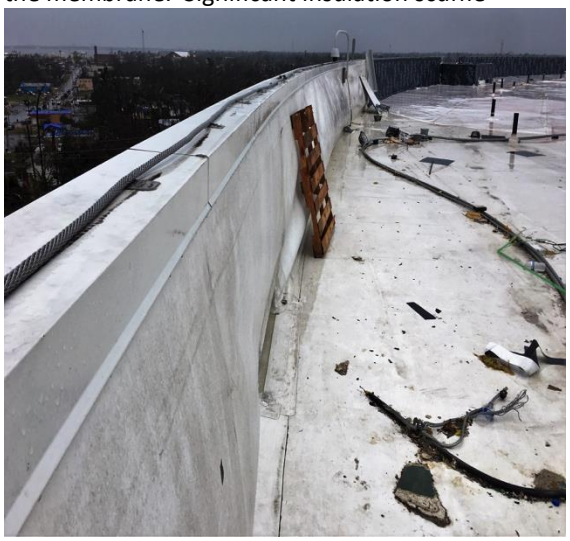
2.1.4 Exterior wall and parapet damaged and a large area of the roof already temporarily recovered. The lower roof was intact, but likely had many punctures from the bricks dislodged from the adjacent building



A large section of coping missing

2.1.4 Air is getting into the parapet wall and under the membrane. Significant insulation scuffle

Coping cleats intact, but coping missing



High parapet billowed

Large section of temporary parapet cover and roof membrane

Inspection #	2.2.1
Team #	2
Date	10/26/18
Primary Building Use	School
Building Latitude "	30º10'29" W
Building Longitude "	85º33'29" N
Front of Building Faces	South
Zip	32404
Exposure Category	B
Primary upwind terrain	Open grassland, Trees, Buildings -Smaller
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	30
Roof Age	16+
Source	Best Guess
Surface	White
Membrane Type	TPO
Membrane Adhered to:	Lightweight Insulating Concrete
Insulation Type	Lightweight Concrete
Insulation Thickness	3
Insulation Attachment	Not Determined
Deck Type	Metal
Metal Edge	Yes
Metal Edge Thickness	26
Metal Edge metal	Steel
Fastener Spacing inches on center "typical"	24
Damage Assessment State Rank	6
Location of Roof Damage	Metal Edge, Corner, Field, Perimeter
Extent of Damage Details	6
Damage Initiation	Difficult to determine as the edge metal, membrane & deck were all dislodged in the upwind corner at some other high points on the roof.
Describe Damage	The membrane was an aged early version TPO with little life left. It was delaminated from the deck at several places where the deck was intact. The deck was dislodged from a large section of the roof. This was a large campus where there were several roofs with similar membrane that were mostly intact. We did not determine if they had punctures or leaks
Roof Height	42
Parapet Height	0

Roof Width	75
Roof Length	162
Roof Area	12150

2.2.1 Overview of most damaged area. Membrane and deck dislodged.

Typical gutter, metal edge and gutter dislodged

Shredded membrane

Complete system including membrane lightweight concrete, underlayment board and metal deck dislodged

2.2.1 Coping and parapet wall flashing dislodged

Rusted metal deck showing complete system

Gutter and metal edge dislodged

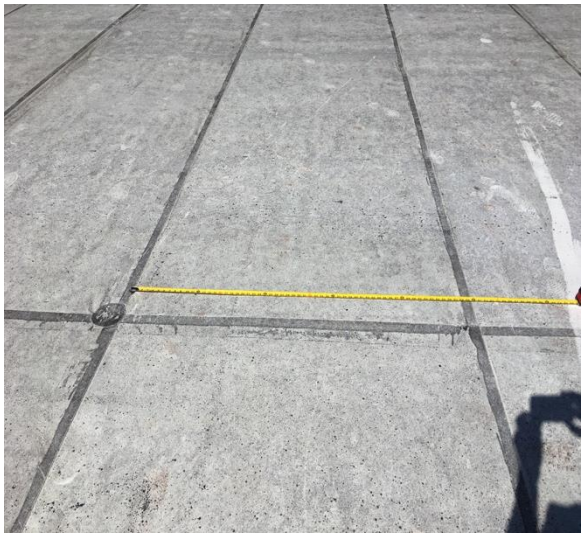
Typical of frequent punctures

Inspection #	2.2.4
Team #	2
Date	10/26/18
Primary Building Use	School
Building Latitude "	30º12'36.36" N
Building Longitude "	85º38'37.75” W
Front of Building Faces	North
Zip	32444
Exposure Category	B
Primary upwind terrain	Trees
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	30
Roof Age	14
Source	GIS
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	10
Perimeter Row Spacing ft	2
Perimeter Fasteners on Centers Spacing (inches)	6
Field Row Spacing ft.	5
Field fasteners on Centers Spacing (inches)	6
Fastener Type	Unknown
Plate Diameter	Unknown
Directly Below Membrane	Foam Insulation
Insulation Type	Polystyrene Foam Board
Insulation Thickness	4
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	24
Metal Edge metal type	Steel
Metal edge fastener spacing inches on center "typical'	24"
Damage Assessment State Rank	4
Location of Damage	Metal Edge, Perimeter
Types of Damage	Corner or edge peel, Metal edge, Punctures, Structural Deck Failure
Extent of Damage Rating	6
Damage initiation	Edge Metal pressurized and dislodged, Metal deck failed.

Describe damage details, include all reference to "other"	Edge meal on one side was pressurized and pulled off wetting insulation below. In another area the underlying metal deck was dislodged as well as a standing seam metal deck attached to it by clips and the membrane that was attached to the standing seam roof.
Roof Height	22
Parapet Height	0
Roof Width	400
Roof Length	480
Roof Area	192,000
Damage Area	10% or more but less than 25%

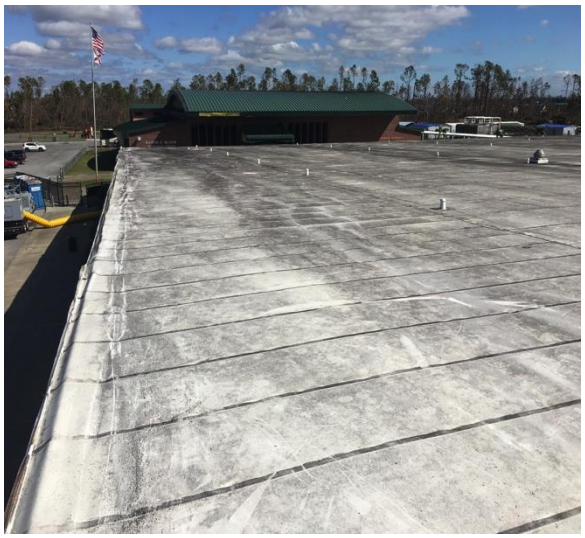
2.2.4 Overview of large roof

Perimeter row spacing 29”



2.2.4 Field row spacing 68”

Dislodged divider coping



2.2.4 Entire Perimeter edge open up.

Metal edge detail that was opened

2.2.4 System detail: Original Graveled BUR, covered by framed standing seam metal roof, covered by 4" polystyrene insulation flute inserts and PVC membrane

A large section of the standing seam metal roof and the single ply cover was dislodged in this steeper roof area.

Inspection #	4.1.1
Team #	4
Date	10/25/18
Primary Building Use	Fast food restaurant
Building Latitude "	21º19’571” N
Building Longitude "	72º80’84” W
Front of Building Faces	South
Zip	32407
Exposure Category	D
Primary upwind terrain	Open Water, Smooth (parking lot etc.), Buildings Taller
Highest wind direction in storm	North
Wind Speed ARA	135
Wind Primarily hit building on:	Long Side
Building Age	Remodeled 5 years ago
Roof Age	5
System	Modified Bitumen
Surface	Reflective Coated
Number of Plies	1
Membrane Attachment	Torch
Membrane Attached to:	Unknown
Insulation Type	Unknown
Insulation Thickness	?
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge Thickness	0.032
Type of Metal Edge	Aluminum
Metal Edge Fasteners distance between centers (typical)	
Solar Equipment	None
Damage Assessment State Rank	1
Location of Damage	Metal Edge
Type of Damage	Corner or edge peel
Extent of Damage Detail Ranking	3
Damage Initiation	coping
Describe damage in detail. discuss all references to "other"	Coping rolled back due to lack of substrate only had spaced gussets
Parapet height	24
Roof Width	30
Roof Length	60
Total Roof Area, Square feet	1200
Area damaged	Less than 10%

4.1.1 Overview with damaged coping

Opposite side

Coping tore over fastener

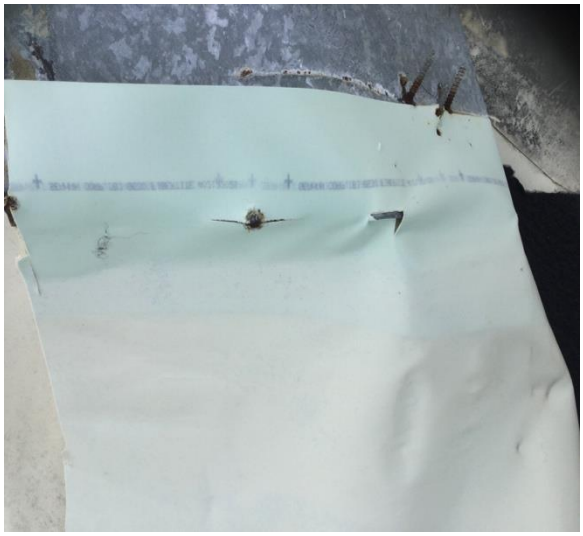
Coping tear

Inspection #	4.2.3
Team #	4
Date	10/26/18
Primary Building Use	Municipal
Building Latitude "	30º15’27”
Building Longitude "	85º66’34”
Altitude (At Ground)	8
Front of Building Faces	North
Zip	32401
Exposure Category	D
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	West
Wind Speed ARA	140
Wind Primarily hit building on:	Corner
Building Age	40+
Roof Age	16
Source	Best Guess
Surface	White
Membrane Type	TPO
Membrane Adhered to:	Polyisocyanurate Insulation
Insulation Type	Polyisocyanurate Foam
Insulation Thickness	2
Insulation Attachment	Screws & Plates
Deck Type	Concrete
Metal Edge	Yes
Metal Edge Thickness	0.4
Metal Edge metal	Aluminum
Fastener Spacing inches on center "typical"	6 to 8"
Damage Assessment State Rank	2
Location of Roof Damage	Perimeter, Around Penetrations 4' or larger
Extent of Damage Details	2
Damage Initiation	Field
Describe Damage	Debris from roof top HVAC, vents and other debris impacted roof membrane and ISO board. Next, wind tore apart the impacted areas
Roof Height	32
Parapet Height	32
Roof Width	80
Roof Length	80
Roof Area	16000

4.2.3 Overview

Membrane dislodged from tower

4.2.3 Perimeter securement



Edge metal

Inspection #	4.2.4
Team #	4
Date	10/26/18
Primary Building Use	Municipal
Building Latitude "	30º15’54” N
Building Longitude "	85º66’21” W
Front of Building Faces	South
Zip	32401
Exposure Category	B
Primary upwind terrain	Buildings - Similar Height
Highest wind direction in storm	West
Wind Speed ARA	140
Wind Primarily hit building on:	Short Side
Building Age	30
Roof Age	8-12
Source	Best Guess
Surface	White
Membrane Type	PVC
Membrane Adhered to:	Unknown
Insulation Type	Unknown
Insulation Thickness	Unknown
Insulation Attachment	Not Determined
Deck Type	Concrete
Metal Edge	No metal edge
Metal Edge Thickness	0
Metal Edge metal	Coping metal and clay tile
Fastener Spacing inches on center "typical"	Unknown
Damage Assessment State Rank	1
Location of Roof Damage	Perimeter, Near Soil Pipes, Around Penetrations 4' or larger
Extent of Damage Details	1
Damage Initiation	Wind blew oft edge coping and HVAC units
Describe Damage	Clay coping and mechanical units were blown over causing impact damages and tears on membrane
Roof Height	28
Parapet Height	32
Roof Width	42
Roof Length	50
Roof Area	2100

4.2.4 Overview of Barrel Roof

Same

4.2.4 Lower Roof

Missing composite Tile

4.2.4 No Bond

Membrane pulled paver from parapet

4.2.4 Membrane pulled off parapet and tiles

Corner dislodged

Inspection #	4.2.5
Team #	4
Date	10/26/18
Primary Building Use	Municipal
Building Latitude "	30º15’36” N
Building Longitude "	85º66’49” W
Front of Building Faces	North
Zip	32401
Exposure Category	D
Primary upwind terrain	Open Water
Highest wind direction in storm	North West
Wind Speed ARA	140
Wind Primarily hit building on:	Long Side
Building Age	Unknown
Roof Age	8-12
Source	Best Guess
Surface	White
Membrane Type	TPO
Membrane Adhered to:	Polyisocyanurate Insulation
Insulation Type	Polyisocyanurate Foam
Insulation Thickness	2
Insulation Attachment	Screws & Plates
Deck Type	Cementitious Wood fiber
Metal Edge	Yes
Metal Edge Thickness	.040 and .032
Metal Edge metal	Aluminum
Fastener Spacing inches on center "typical"	6 to 12"
Damage Assessment State Rank	6
Location of Roof Damage	Entire Roof
Extent of Damage Details	6
Damage Initiation	Edge metal was the first to go location on ground
Describe Damage	Edge metals failed and the membrane peeled off. This re roof was not properly secured at the ISO board and the membrane adhesive failed and the deck
Roof Height	32'
Parapet Height	0
Roof Width	90
Roof Length	180
Roof Area	16200

4.2.5 Overview

Cementitious Wood fiber deck material

4.2.5 Fastener: it appears it was never attached to the roof deck or a nailer.

Nailer

TILE ROOF INVESTIGATION SITES

Inspection #	4.1.2
Team #	4
Date	10.25.18
Primary Building Use	Single Family Residential
Building Latitude "	21º19’571” N
Building Longitude "	72º80’84” W
Front of Building Faces	South
Zip	32407
Exposure Category	D
Primary upwind terrain	Open Water
Highest wind direction in storm	North West
Wind Speed ARA	135
Wind Primarily hit building on:	Corner
Building Age	3.5- built in May 2015
Roof Age	3
Source	Data - From Source
Building Width	60
Building Length	80
Building Height	28-30'
Eave Height ft.	20'
Ridge Height	30'
Slope	Low-slope 3/12 to 5/12
Tile Type	Barrel
Tile Material	Concrete
Attachment	Screws
Underlayment Type	Self-adhered
Deck	
Ventilation, check all that apply	None
Solar Equipment on Roof	NO
Damage Assessment	Less than 25% of tiles damaged
Location of Damage-Check all that apply	Corner, Eave, Rake Edge, Field, Near Chimney, Ridge, Valley
What Failed First - How do you know	Hip caps
Describe Damage	Hip & Ridge failed and caused impact to field
Describe Damage	Gypsum delaminated from Cementitious wood fiber deck due to poor bonding of adhesive. Total failure, delamination of gypsum facer. Rooftop equipment failure (insufficient screws). Also noted. Wood fiber deck was sagging in the center of the panels and as a result, gypsum boards were not fully adhered. At rooftop equipment failures, you could see into the building.

4.1.2 Street side overview

Water Side overview

Ridge Tile – It is not clear how the tile were attached. Note: Nail holes and possible foam adhesive.

Field Tile screw attachment.

Acknowledgements

RICOWI wishes to thank the following organizations, corporations, and individuals for supporting this research investigation program through their generous contribution of time, knowledge and funding to this sixth hurricane investigation.

We gratefully acknowledge the following supporters:

- Asphalt Roofing Manufacturers Association (ARMA)
- Cedar Shake and Shingle Bureau (CSSB)
- Copper Development Association, Inc. (CDA)
- EPDM Roofing Association (ERA)
- Insurance Institute for Business and Home Safety (IBHS)
- International Institute of Building Enclosure Consultants (IIBEC)
- International Staple, Nail and Tool Association (ISANTA)
- Metal Building Manufacturers Association (MBMA)
- Metal Construction Association (MCA)
- National Research Council Canada (NRCC)
- National Roof Deck Contractors Association (NRDCA)
- Spray Polyurethane Foam Alliance (SPFA)
- Single Ply Roofing Institute (SPRI)
- Synthetic Roof Underlayment Institute (SRUI)
- Tile Roofing Industry Alliance (TRI)

Thank you to the Wind Investigation Program (WIP) Committee Members, and especially the Wind Investigation Team (Appendix C) for this event. Many of the team members gave up their vacation days, and all funded their travel and expenses. Thank you to WIP Committee Chair John Kouba, Vice Chair Phil Mayfield, Program Coordinator David Roodvoets, and Executive Director Joan Cook for your strong leadership and dedication to this program.

The teams were very self-motivated to get as much data as possible in the time available. Rain was forecasted for entire day on Oct. 25, fortunately the rain did not arrive until early afternoon. Teams continued their inspections in the rain and then completed some street surveys. The management at Panama City were very helpful in giving access and support to inspections of several municipal buildings. Thank you Sharon Churchwell for making it happen. The Police were very helpful with directions and permissions to inspect roofs. The residents, contractors and building owners in Panama City were most cooperative granting access when asked.

Special thanks to Lois Riesebieter for her excellent work providing the name badges to the team. We also thank Wade Sticht and Douglas Dewey for their hard work in providing independent data information for the report.

RICOWI appreciates the State of Florida and the communities that welcomed the researchers and assisted with directions and suggestions.

Appendices

Appendix A

RICOWI WIND INVESTIGATION TEAM

HURRICANE MICHAEL

Team Members (Left to right)

Front row:
Larry Peters, Dr. Bas Baskaran, David Roodvoets, and Phil Mayfield
Back Row:
Tim McQuillen, Brett Cholewa, Brent DeRose, Doug Dewey, Dominique LeFebvre, and Michael Schwent

Team Members not pictured:
Scott Holloway, Joel May, Bill Neaves, Parthiv Dangodara, Nancy Samatas, Mike Silvers, and Jeff Walsh

TEAM MEMBERS

Team 1:
Bas Baskaran, National Research Council Canada (NRCC)
Brett Cholewa, Building Envelope Consultants, Ltd.
Brent De Rose. Nederveld Inc.
Dominique Lefebvre, NRCC

Team 2:
Phil Mayfield, PSM
David Roodvoets, DLR Consultants
Parthiv Dangodora, AIG
Bill Neaves, AIG
Nancy Samatas, AIG

Team 3:
Doug Dewey, State Farm Insurance
Tim McQuillen, Asphalt Roofing Manufacturers Association (ARMA)
Michael Schwent, GAF
Larry Peters, Copper Development Association (CDA)

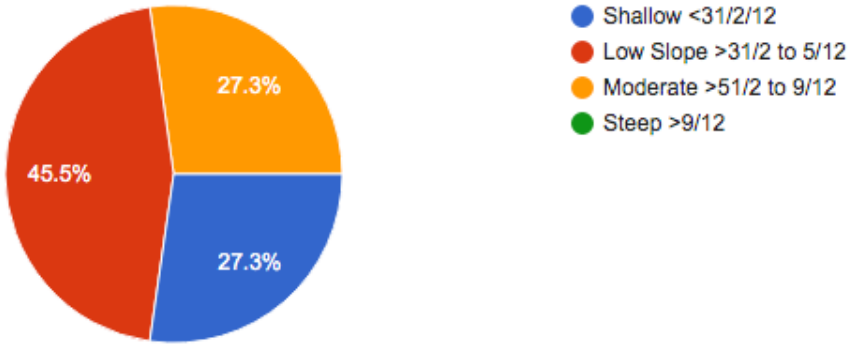
Team 4:
Joel May, BASF
Scott Holloway, Eagle Roofing Products, Inc.
Mike Silvers, Florida Roofing and Sheet Metal Contractors Association (FRSA)
Jeff Walsh, American Buildings Company

Appendix B

METAL PANEL INSPECTION SUMMARIES

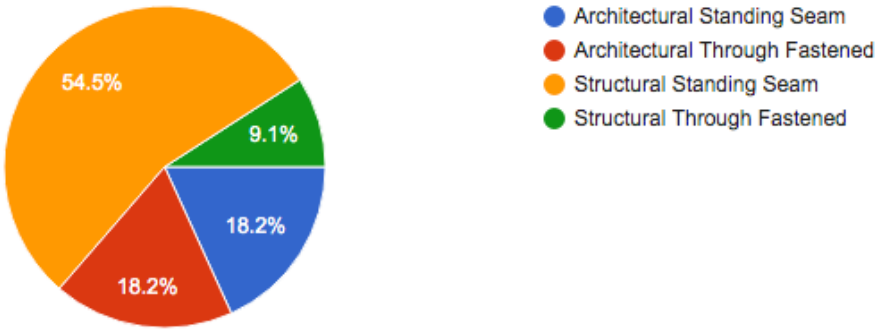
Slope

11 responses



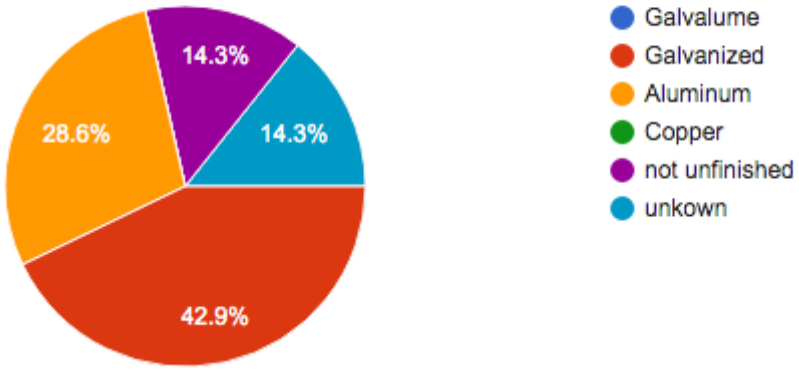
System Type

11 responses



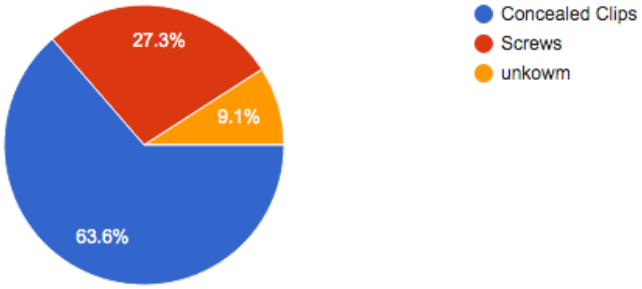
Unfinished Metal

7 responses



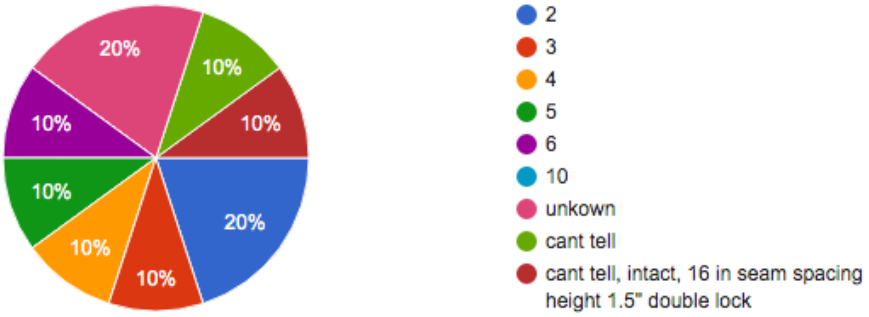
Installation

11 responses



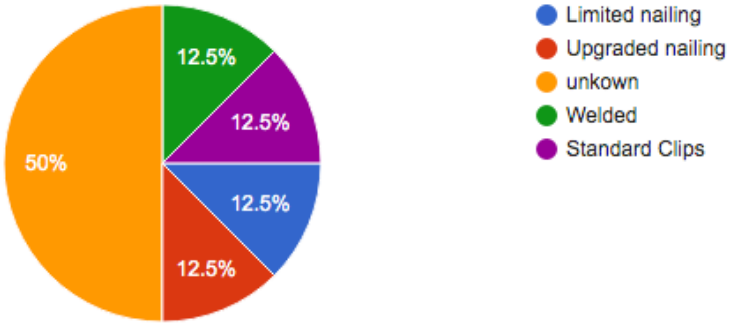
Fastener Spacing

10 responses



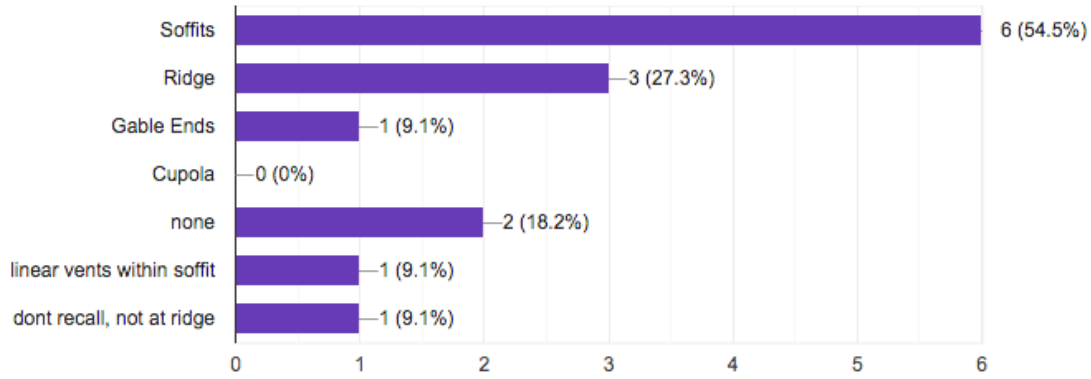
Deck attachment

8 responses



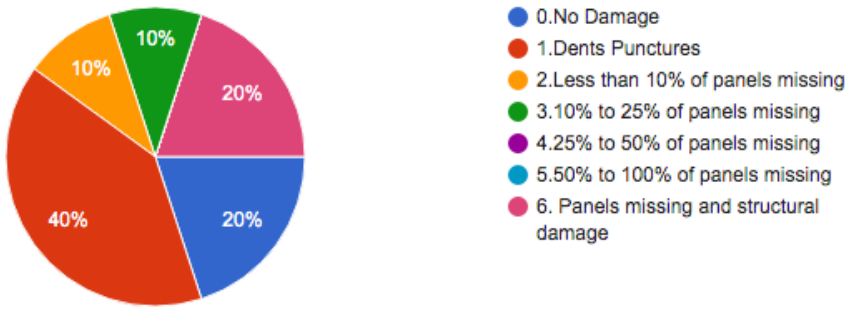
Ventilation

11 responses



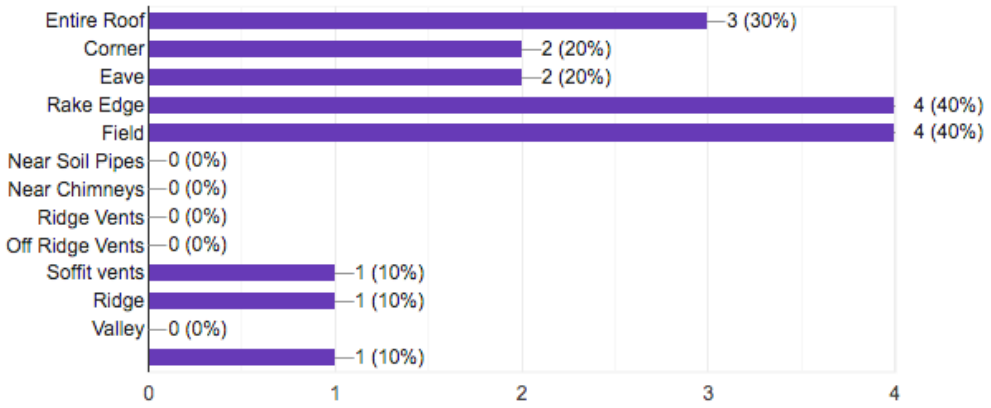
Damage Assessment State Rank

10 responses



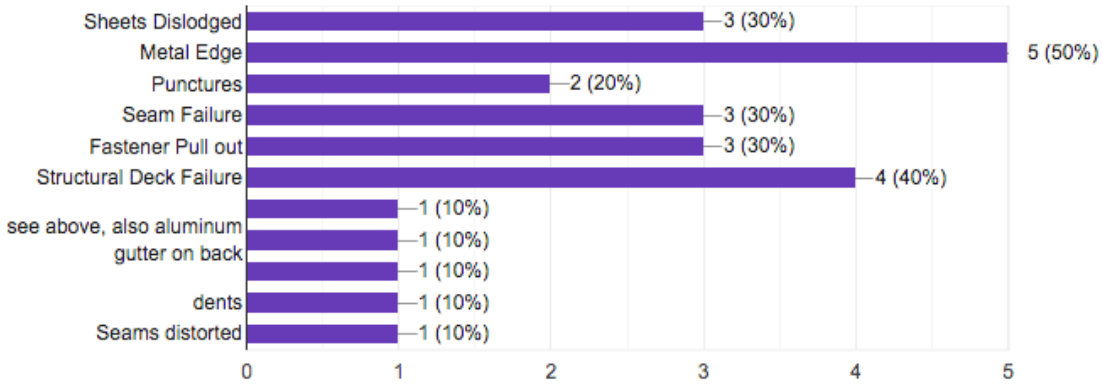
Location of Roof Damage

10 responses



Type of damage

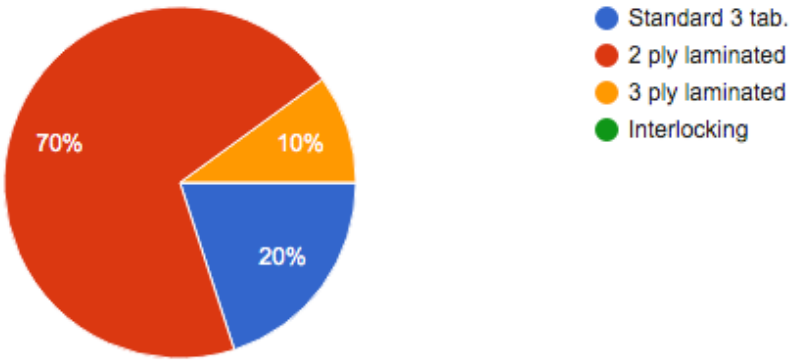
10 responses



APPENDIX C
ASPHALT SHINGLES INSPECTION SUMMARIES

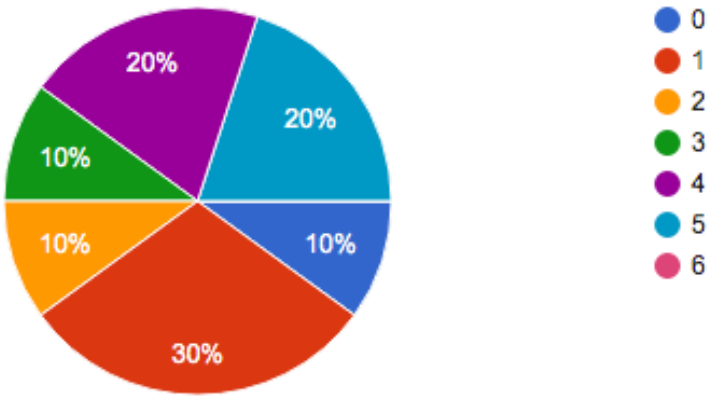
Shingle Type

10 responses



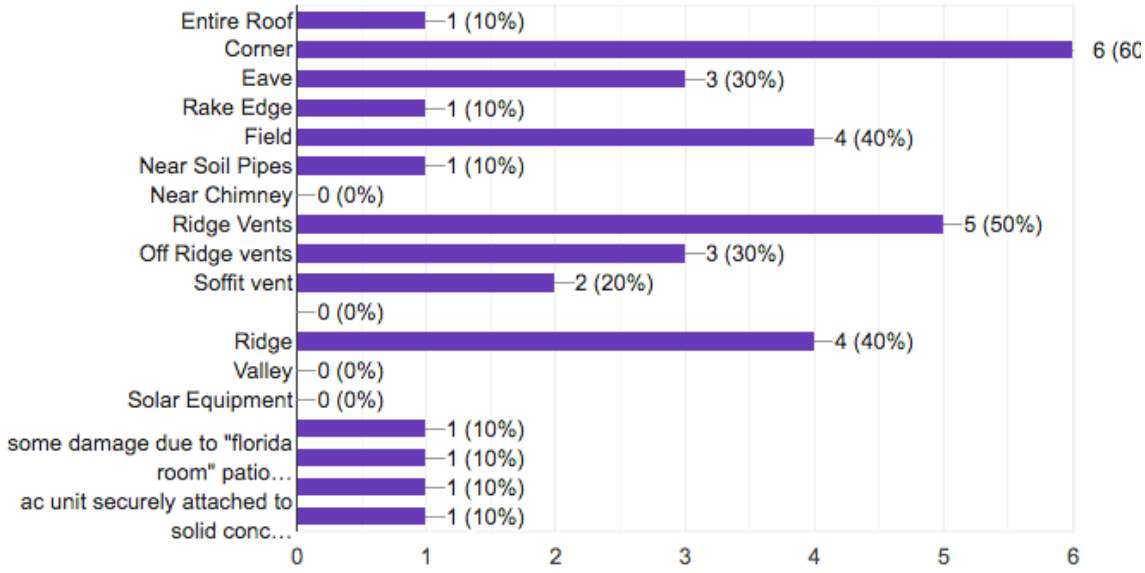
Damage Assessment

10 responses



Location of Roof Damage

10 responses

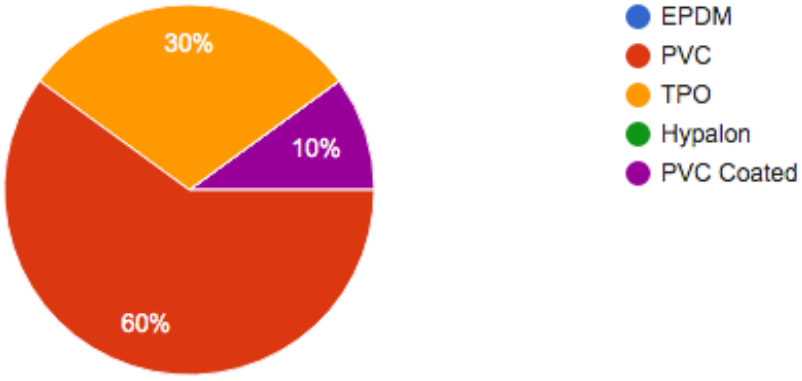


APPENDIX D

MECHANICALLY ATTACHED SINGLE-PLY INSPECTION SUMMARIES

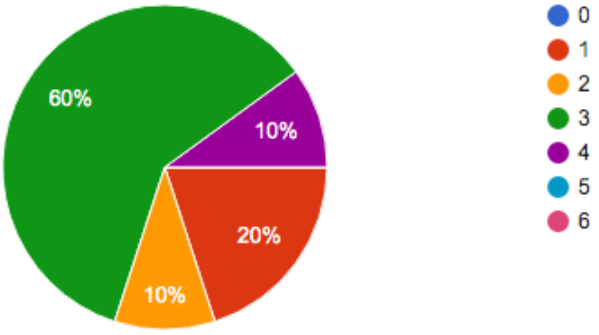
Membrane Type

10 responses



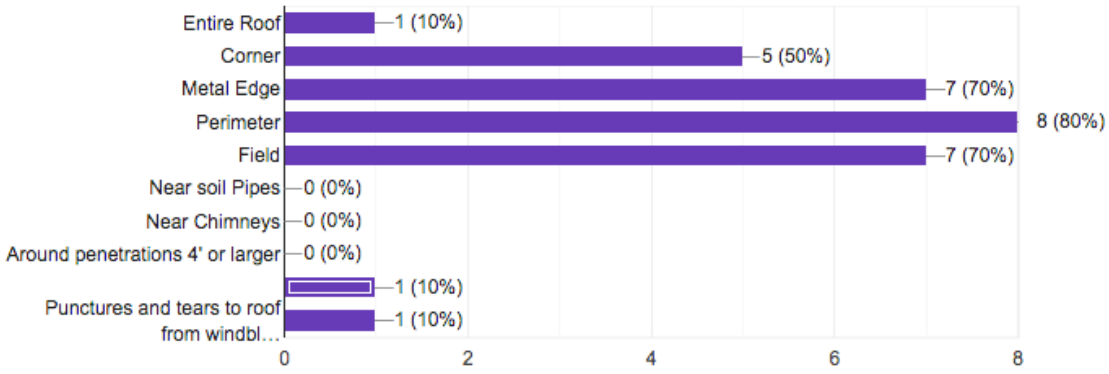
Damage Assessment State Rank

10 responses



Location of Damage

10 responses



Appendix E

Steep-slope:
Team 3 Street Surveys

Steep-slope TEAM #3 –
Street Survey @ Callaway Point [Day 1]

This is an older neighborhood with most houses 12 to 20 years old.
Some have been reroofed recently. Most, over 70% of the older roofs had damage. Most newer roofs had no or limited damage.

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Ridge line damage tarped
Ranch [single story]	24 yrs (Blt 1994)	[Gable / Hip Combination]	Asphalt Comp [Lam]	No	Newer roof, garage door - lower right corner distressed, downspout elbow missing @ garage
Ranch [single story]	<1 yr (RERF permit 2.15.2018)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Newer roof, likely damage @ locations where trees are laying on roof, 16' garage door
Ranch [single story]		Gable	Asphalt Comp [Lam]	No	Newer roof, excellent condition again subjective if a formal scale isn't referenced. I would say *no visual damage* as opposed to *excellent condition*

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]	20 yrs (Blt 1998)	[Gable / Hip Combination]	Asphalt Comp [3-Tab]	Yes	Missing shingles, racked installation method
Ranch [single story]	23 yrs (Blt 1995)	Gable	Asphalt Comp [3-Tab]	Yes	Older roof, racked installation method, garage door blown in
Ranch [single story]	24 yrs (Blt 1994)	Gable	N/A	Yes	Roof tarped, siding damage
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Missing shingles, portions tarped, missing siding, and fascia wrap
Ranch [single story]		Gable	Asphalt Comp [Lam]	Yes	Missing shingles @ garage ridge and edge, missing soffit @ garage roof edge
Ranch [single story]	23 yrs (Blt 1995): Add'n 2002	[Hip / Gable Combination]	Asphalt Comp [3-Tab]	Yes	Older roof, racked installation method, missing ridge cap with tarp

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		Gable	Asphalt Comp [Lam]	No	Newer roof, No damage visible from front elevation
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Shingles installed racked method, two windows broken out of garage door, roof @ rear elevation
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Missing shingles, large portions tarped, racked installation method
Ranch [single story]		Gable	Asphalt Comp [Lam]	Yes	New roof, small portion damaged by tree fall on main house section @ gable rake
Ranch [single story]	13 yrs (RERF permit 9.22.2005)	[Gable / Dutch Hip / Hip Combination]	Asphalt Comp [Lam]	Yes	Large sections of missing shingles
Ranch [single story]	13 yrs (RERF permit 7.5.2005)	Hip	Asphalt Comp [3-Tab]	No	No damage visible @ front elevation

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		[Dutch Hip / Hip Combination]	Asphalt Comp [Lam]	No	No visible roof damage, estimated roof age two years, note home in photo background with siding blown off
Ranch [single story]		[Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	Yes	Newer roof, did well, only small section missing @ ridge and rake of main roof. Maybe damage to rear roof elevation due to tree fall
Ranch [single story]	20 yrs (Built 1998)	Hip Main / Gable Entrance	Asphalt Comp [Lam]	Yes	Missing shingles, soffit, and fascia wrap
Ranch [single story]	7 yrs (RERF permit 1.6.2011)	Gable	Asphalt Comp [3-Tab]	No	Racked installation method, broken windows, interior water damage, newer garage door
Ranch [single story]		Hip	Asphalt Comp [Lam]	No	Newer roof
Ranch [single story]		Gable	Asphalt Comp [Lam]	No	Newer roof
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Missing shingles & fascia wrap, older roof, large tree down in front yard
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Missing window & tarped, no photo available

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]	27 yrs (Blt 1991):Add'n 2003	Gable	Asphalt Comp [Lam]	Yes	Large sections tarped, broken windows
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Large sections tarped, broken windows
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Large sections of missing shingles, felt, and exposed sheathing with broken windows
Ranch [single story]		Hip	Concrete Tile	Yes	Missing tile @ ridge
Ranch [single story]		Gable	Asphalt Comp [Lam]	No	Tree damage in front yard, the address needs to be verified
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Large section of main roof tarped, missing shingles

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Two Story		Hip Main / Gable Entrance	Asphalt Comp [Lam]	Yes	Missing shingles with exposed sheathing, home is in a unique location for this neighborhood, lower level is concrete
Ranch [single story]		Dutch Hip	Asphalt Comp [Lam]	No	Minimal visible damage @ front fascia likely due to tree fall, windows boarded up
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Roof intact and performed well but tree fell through ridge
Two Story		Gable	Asphalt Comp [Lam]	Yes	Missing shingles at ridge and rake areas, heavy tree fall in this area, broken window at dormer location

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]	24 yrs (Blt 1994)	Gable	Metal [Standing Seam]	No	Strange anomaly: Three trees blown in three different directions
Ranch [single story]		Gable	Asphalt Comp [3-Tab]	Yes	Synthetic underlayment, **no photo available**
Three Story	8 yrs (Blt 2010)	Hip / Turret	Tile	Yes	Broken tiles

Steep-slope TEAM #3 – Street Surveys @ Cove Pointe Drive, Cove Garden Circle, & Watson Bayou Circle (Near Watson Bayou) [Day 1]

These are mostly older neighborhoods with houses 20 to 30 years old. More than 55% of the roofs were damaged. However only 2 of the newer roofs had damage.

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		[Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	Yes	Minimal damage to main roof, missing shingles near ridge, fascia wrap gone in gable areas, PVC fence gone, posts remaining, home built after April 2011, all brick,
Two Story		Gable	Asphalt Comp [Lam] / Metal Standing Seam	Yes	Tarped at ridge, rake and fascia wrap missing, standing seam metal roof over front porch and garage over hang intact, home newer than April 2011
Two Story	10 yrs (Bld Date 2008)	[Gable / Dutch Hip / Hip Combination]	Asphalt Comp [Lam]	Yes	Corner lot, NW winds, high nailed shingles found on ground, fascia wrap at rakes missing, large areas of the roof are tarped
Two Story		[Gable / Hip Combination]	Asphalt Comp [Lam]	Yes	Missing shingles at hip ridge, fascia wrap gone at rake

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Two Story		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Moderate area tarped, windows intact, carport okay,
Two Story		Hip	Metal Standing Seam	No	Broken windows, home built after April 2011
Ranch [single story]	11 years (Bld date 2007)	Hip	Clay Tile	Yes	Corner lot, NW winds, broken tiles, turret tarped
Two Story		[Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	Yes	Some areas tarped, all of ridge tarped, fascia wrap at gable rakes over garage Dutch hip missing, home built after April 2011
Two Story	2 yrs (Bld date 2016)	[Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	No	Fascia wrap at rake near garage missing, structural issues observed with SW side of home @ garage brick veneer collapse, home built after April 2011
Two Story		[Gable /Shed / Hip Combination]	Asphalt Comp [Lam]	Yes	Very minor damage at ridge cap, roof field looks good, shutter blown off west elevation, garage not attached, home built prior to April 2011
Ranch [single story]	10 yrs (Bld Date 2008)	[Hip /Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	Yes	Roof is tarped, missing fascia wrap, missing siding in garage gable end

Steep-slope TEAM #3 – Street Survey @ Kirkland Manor at Nautical Point (Newer Homes) [Day 2]

Most of these homes were built since 2003, and very few had been reroofed. More than 90% of the homes in this neighborhood had some roof damage.

Residence Description	Approximate Roof Age	Roof Configuration	Roof Material Type	Roof Damage (Yes/No)	Roof Damage Description & Additional Observations
Two Story	13 years (Blt 2004)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Tarped areas on north slope, missing fascia wrap, hinged storm shutters on home
Ranch [single story]	5 yrs (Blt 2013)	[Hip / Dutch Gable Combination]	Asphalt Comp [Lam] / Metal Panel	Yes	Tarped areas over garage gable and edge at single door, missing ridge shingles, fascia wrap, siding in gable ends, metal panels in Dutch gables intact, turned over boat in front yard
Ranch [single story]	10 yrs (Blt 2008)	[Hip / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	Small piece of fascia wrap missing at garage gable end
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Tarped areas over roof front (west) field and (north), fascia wrap at garage rake missing, shutter missing on side entry garage,
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Tarped area is extensive
[Hip / Gable Combination]		Hip	Asphalt Comp [Lam]	Yes	NE areas tarped w/ tarped ridges, missing shingles at garage roof edge

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Two Story	9 yrs (blt 2009)	Hip / Turret	Asphalt Comp [Lam]	Yes	Minimal tarped damage at turret, tarped front elevation (north NE) facing hip slope, missing fascia wrap also at that area, large home and extensive roof area
Two Story	10 yrs (Roof permit 6.20.2008)	Gable	Asphalt Comp [Lam]	Yes	Missing shingles at ridge, dormer ridges, non-attached garage also on sight
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Missing shingles front (south) field, tarped field and ridge areas, missing shutter, side load east facing garage
Two Story	14 yrs (Blt 2004)	Gable	Asphalt Comp [Lam]	Yes	Missing shingles at ridge, minimal in front (north) field, east elevation exposed sheathing at both gable ends, missing siding, soffits, fascia wrap
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Mix of tarped field, ridges, and edges
Ranch [single story]		Hip	Asphalt Comp [Lam] / Metal Standing Seam	Yes	Tarped at ridge, missing some shingles on hip ridge at garage, rake and fascia wrap missing at gable over garage, standing seam metal roof overhang at 16ft garage door and living area gable bump out intact, siding missing over living area gable and at fireplace chimney, destroyed camper in front yard

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Tarped at northwest rear corner, west edge, minimal damage from (south) elevation, missing only ridge cap shingles, home newer than 2011
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Small tarped field area just below main ridge and at some hip ridge lines
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Large tarped areas at main ridge, missing ridge shingles
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Tarped areas where ridge cap shingles are missing, tarp at front (NE) hip bump out ridge and field area
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Large tarped areas at main ridge, missing ridge shingles
Ranch [w/Attic Space]		[Hip /Gable / Dutch Hip Combination]	Asphalt Comp [Lam] / Metal Standing Seam	Yes	Metal roofing at porch intact, large areas in main roofing field with missing shingles, exposed synthetic underlayment, missing fascia wrap, missing shutter
Ranch [single story]	13 (Blt 2005)	[Hip / Gable Combination]	Asphalt Comp [Lam]	No	Possibly some unsealed shingles, faired very well, note garage lights tilted from N / NW wind direction

Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		[Hip /Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	90% tarped
Ranch [single story]		Hip	Asphalt Comp [Lam]	No	No visible damage
Ranch [single story]	14 yrs (Blt 2005)	[Hip /Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip field almost completely tarped, no damage at Dutch gable roof areas check throughout – this really should be capitalized
Ranch [single story]		[Hip / Gable / Turret Combination]	Asphalt Comp [Lam]	Yes	99% tarped, missing fascia wrap at garage gable rake
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	South facing roof area over the garage is missing shingles and fascia wrap missing at garage gable rake
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip and ridge area tarped as well as south facing roof area over gable
Ranch [single story]	11 (Blt 2007)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip missing shingles, fascia wrap missing at garage gable rake
Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Missing hip and ridge shingles, tarped areas at hip ridge locations and south facing garage hip roof field

Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip area ridge tarped as well of some smaller field areas
Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Two Story	15 years (Blt 2003)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip area tarped in center field over ridge, missing wood fence with brick posts and arch remains
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip tarped near ridge, fascia wrap missing at all front gable rake locations
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Minimal tarped areas in main field and south facing field over garage, fascia wrap missing at all front gable rake locations
Ranch [single story]		[Hip /Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	75% of main hip areas tarped, Dutch gable locations not damaged, siding damage above garage
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	South facing main hip tarped, hip ridges also tarped, replacement shingle bundles laying on roof
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Main hip area missing a few shingles, garage missing a shutter
Ranch [single story]		[Hip / Dutch Gable Combination]	Asphalt Comp [Lam] / Metal Standing Seam	Yes	85% tarped, metal standing seam at Dutch gables over entry intact, siding damage at chimney

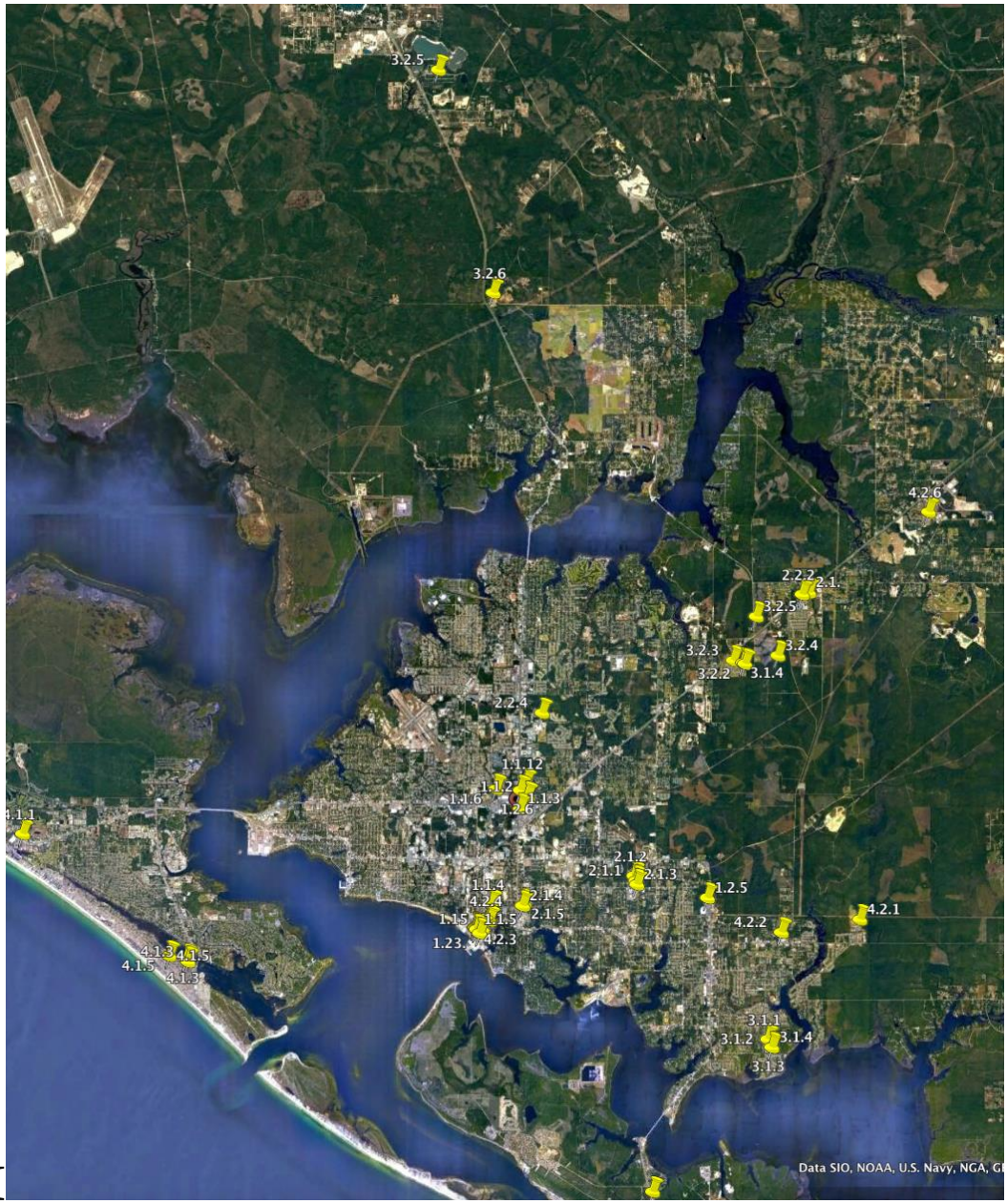
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Minor damage at hip ridge
Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]	11 yrs (Blt 2007)	[Hip / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	40% tarped, metal standing seam at Dutch gables over entry and garage area in tact
1.5 Story		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Fascia wrap missing at garage gable rakes three missing shutters, tarped areas at main hip and ridge areas
Ranch [single story]		[Hip /Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	No	**New construction not occupied, no visible damage observed**
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Hip and ridge shingle missing on main ridge, fascia wrap missing at garage gable rake and main living area rake
Ranch [single story]	14 (Blt 2004)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Missing shingles on south exposure, fascia wrap missing at south rear hip and garage gable rake
Two Story		[Hip / Turret Combination	Asphalt Comp [Lam]	Yes	Main hip tarped, fascia wrap missing in most visible areas, broken second story window, detached garage

1.5 Story		[Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	Large tarped areas, fascia wrap missing at garage gable rake, missing two shutters, photo did not show existing detached garage w/ 16x7 door
Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Two Story		Gable	Asphalt Comp [Lam]	Yes	90% tarped, all siding at north elevation gone with exposed sheathing including upper dormer, fascia wrap missing over front entrance, balcony over front entrance damaged
1.5 Story		Gable	Asphalt Comp [Lam]	Yes	Missing shingles main field, exposed synthetic underlayment, main ridge tarped, north slope tarped and exposed sheathing at north slope living area gable jet out (per 7517 NC image), built before May 2011
1.5 Story		[Hip / Dutch Gable / Gable Combination]	Asphalt Comp [Lam]	No	No visible roof damage but missing fascia wrap at dormer over garage
Ranch [single story]		[Gable / Dutch Gable Combination]	Asphalt Comp [Lam]	Yes	Missing and broken shingles, some still laying on roof, large tarped areas

Ranch [single story]		[Hip / Dutch Gable / Gable Combination]	Asphalt Comp [Lam]	Yes	Ridges on main hip roof tarped, sign indicates wind direction from north, newer construction
Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
1.5 Story		Gable	Asphalt Comp [Lam]	Yes	Tarped areas over ridge on main gable roof field, missing soffit and fascia wrap at north gable rake, dormer roofs tarped and some fascia wrap also missing
Ranch [single story]		[Hip / Dutch Gable / Gable Combination]	Asphalt Comp [Lam]	Yes	Two tarped hip ridges that are N / NE facing, newer construction (after May 2011)
Ranch [single story]		[Gable / Dutch Hip Combination]	Asphalt Comp [Lam]	Yes	Main gable ridge tarped, missing fascia wrap
Ranch [single story]	2 yrs (RERF Permit 9.26.16)	[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Missing shingles at north facing garage edge and at hip ridges, damaged gutter and downspout at garage, note light pole (wind out of NE)
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	90% tarped, fascia wrap missing at one front (west) gable end rake

Ranch [single story]		Hip	Asphalt Comp [Lam]	Yes	Minor damage at hip ridge locations, main field has no visible damage
Residence Description	**Approximate Roof Age**	**Roof Configuration**	**Roof Material Type**	**Roof Damage** (Yes/No)	**Roof Damage Description & Additional Observations**
Ranch [single story]		[Hip / Gable Combination]	Asphalt Comp [Lam]	Yes	Tarped damage at hip ridge locations, south facing main hip field may also tarped, main field front (west) elevation has no visible damage, fascia wrap missing at front gable rakes
Ranch [single story]		[Hip / Dutch Hip Combination]	Asphalt Comp [Lam] / Metal Standing Seam	Yes	Northeast facing roof areas nearly all tarped, broken shingle at eave edge left of porch, metal roofing in Dutch hip intact, missing two shutters, south west facing slope nearly completely tarped note tree direction (wind out of NW)

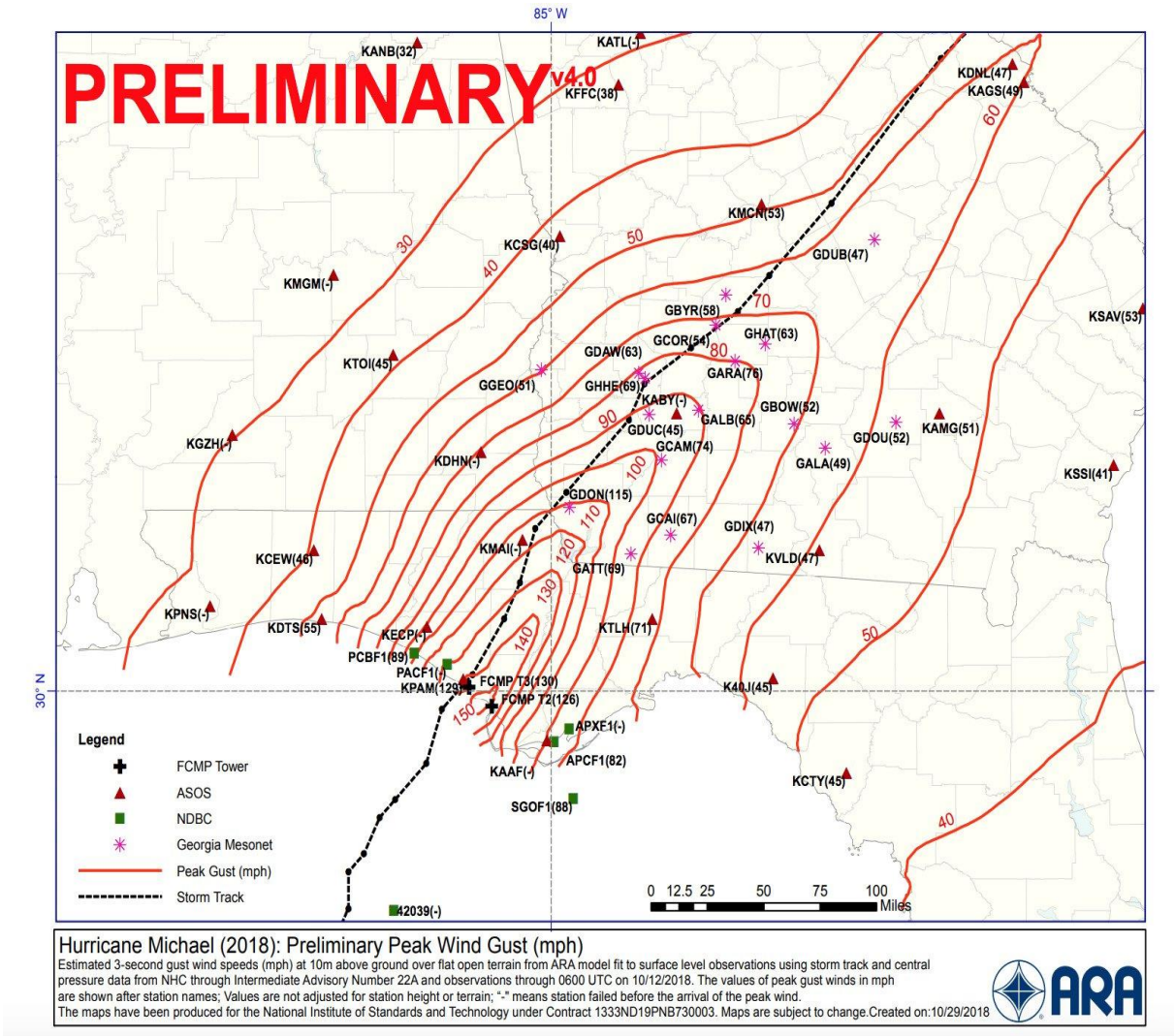
Appendix F
RICOWI INSPECTION SITES



Appendix G
DOWNTOWN PANAMA CITY INVESTIGATION SITES

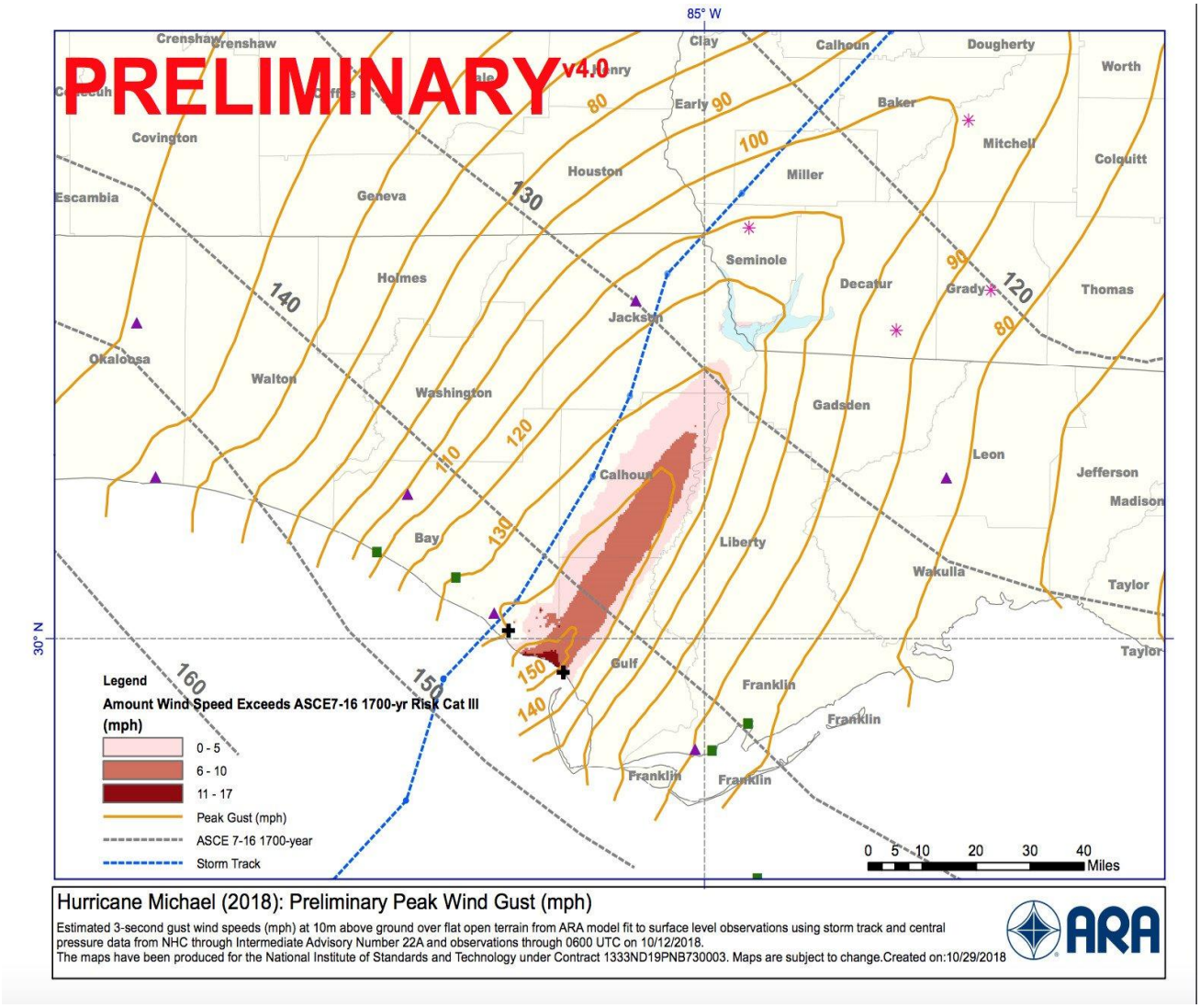
APPENDIX H

HURRICANE MICHAEL WIND MAPS



Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018. The values of peak gust winds in mph are shown after station names; Values are not adjusted for station height or terrain; "-" means station failed before the arrival of the peak wind.
The maps have been produced for the National Institute of Standards and Technology under Contract 1333ND19PNB730003. Maps are subject to change.Created on:10/29/2018


PRELIMINARY
v4.0
85° W
30° N
Crenshaw
Clay
Calhoun
Dougherty
Worth
Early
Baker
Mitchell
Colquitt
Covington
Houston
Miller
Escambia
Geneva
Seminole
Decatur
Grady
Thomas
Holmes
Jackson
Okaloosa
Walton
Washington
Gadsden
Leon
Jefferson
Madison
Bay
Calhoun
Liberty
Wakulla
Taylor
Gulf
Franklin
80
90
100
110
120
130
140
150
160
Legend
Amount Wind Speed Exceeds ASCE7-16 1700-yr Risk Cat III (mph)
0 - 5
6 - 10
11 - 17
Peak Gust (mph)
ASCE 7-16 1700-year
Storm Track
0 5 10 20 30 40
Miles
Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)
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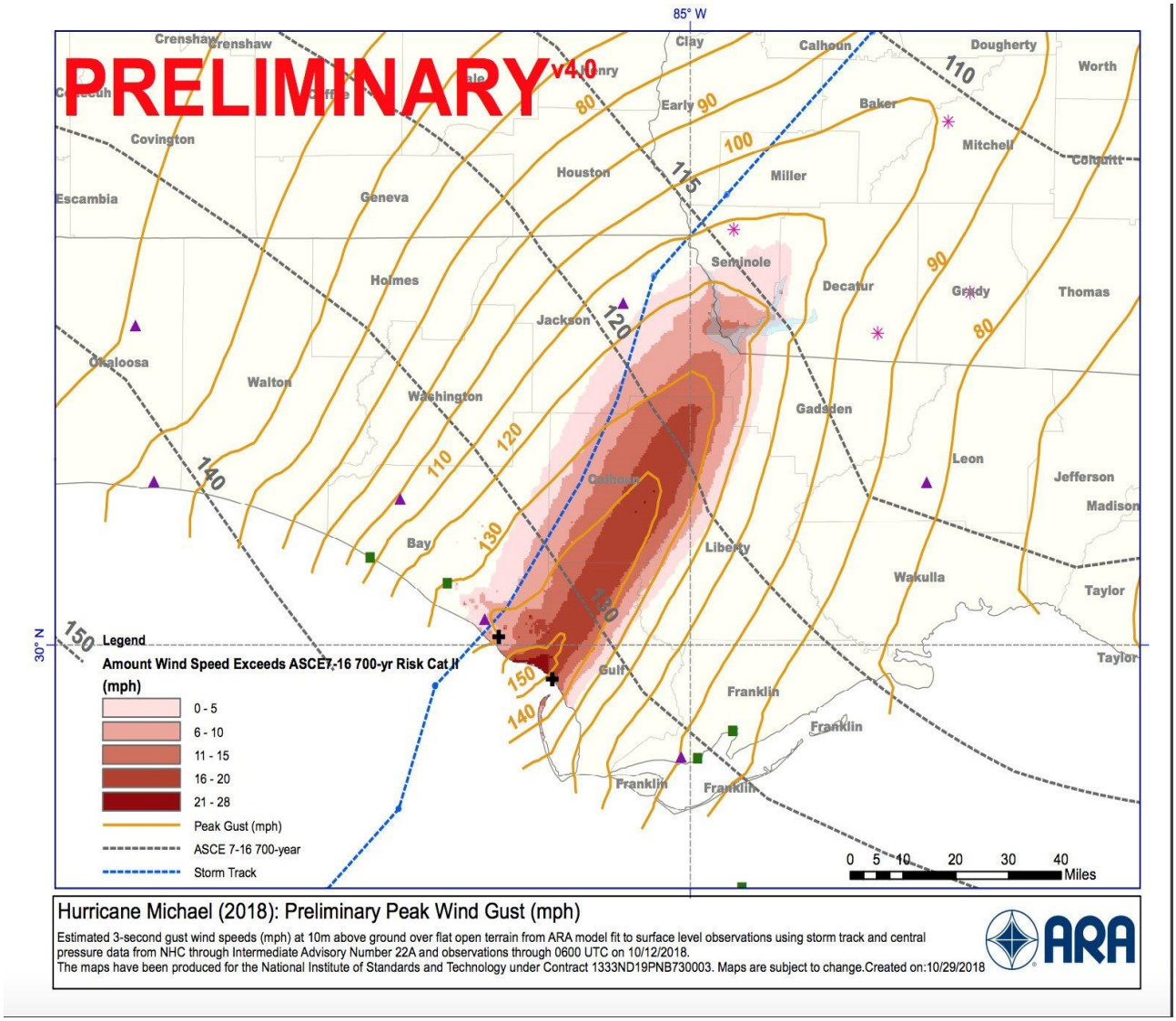
ARA


PRELIMINARY v4.0
85° W
30° N
Crenshaw
Clay
Calhoun
Dougherty
Worth
Early
Baker
Mitchell
Colquitt
Covington
Houston
Miller
Escambia
Geneva
Seminole
Decatur
Grady
Thomas
Holmes
Jackson
Okaloosa
Walton
Washington
Gadsden
Leon
Jefferson
Madison
Bay
Liberty
Wakulla
Taylor
Gulf
Franklin
80
90
100
110
115
120
130
140
150
Legend
Amount Wind Speed Exceeds ASCE7-16 700-yr Risk Cat II (mph)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 28
Peak Gust (mph)
ASCE 7-16 700-year
Storm Track
0 5 10 20 30 40
Miles
Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)
Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018.
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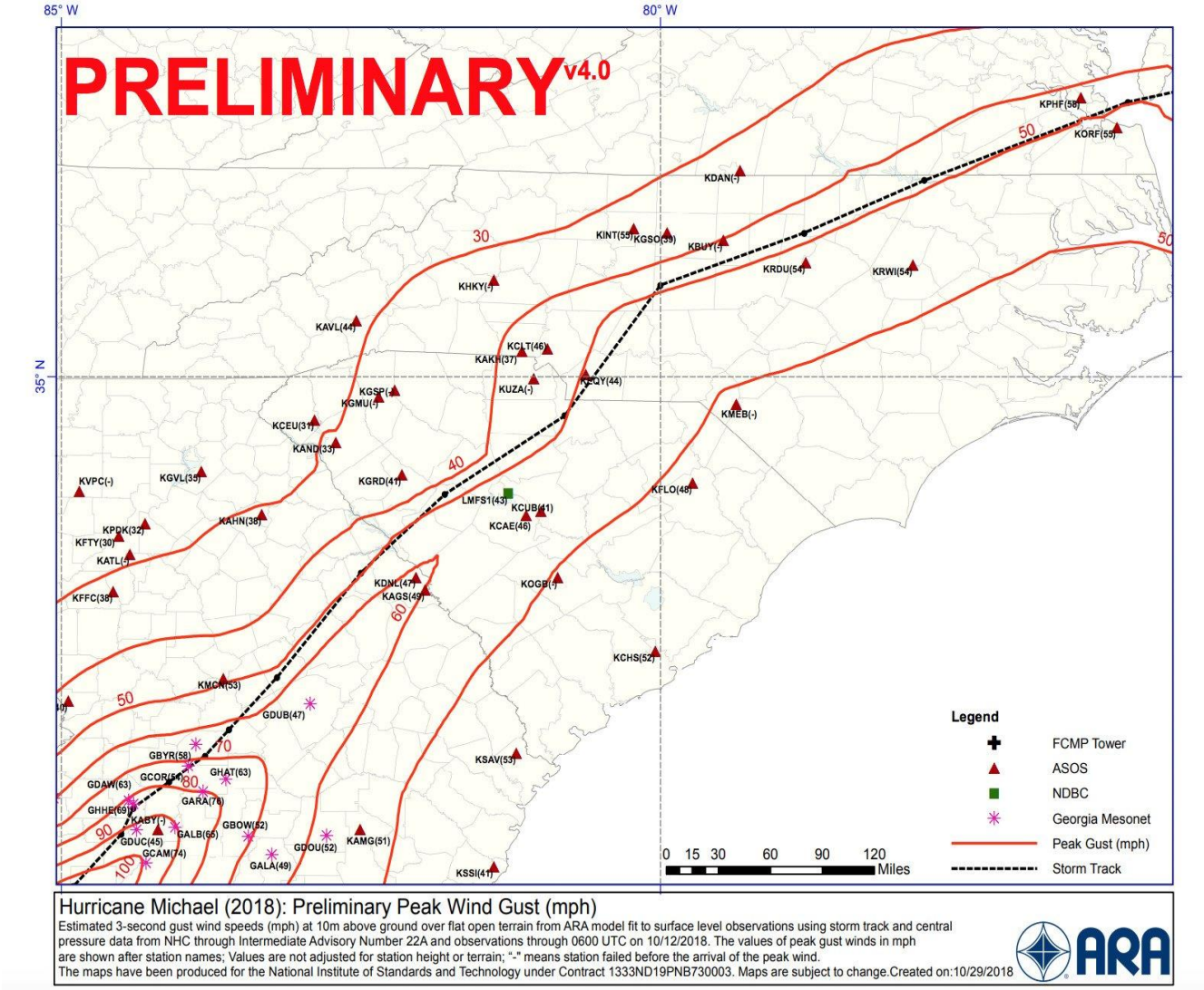
ARA



Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018. The values of peak gust winds in mph are shown after station names; Values are not adjusted for station height or terrain; "-" means station failed before the arrival of the peak wind.
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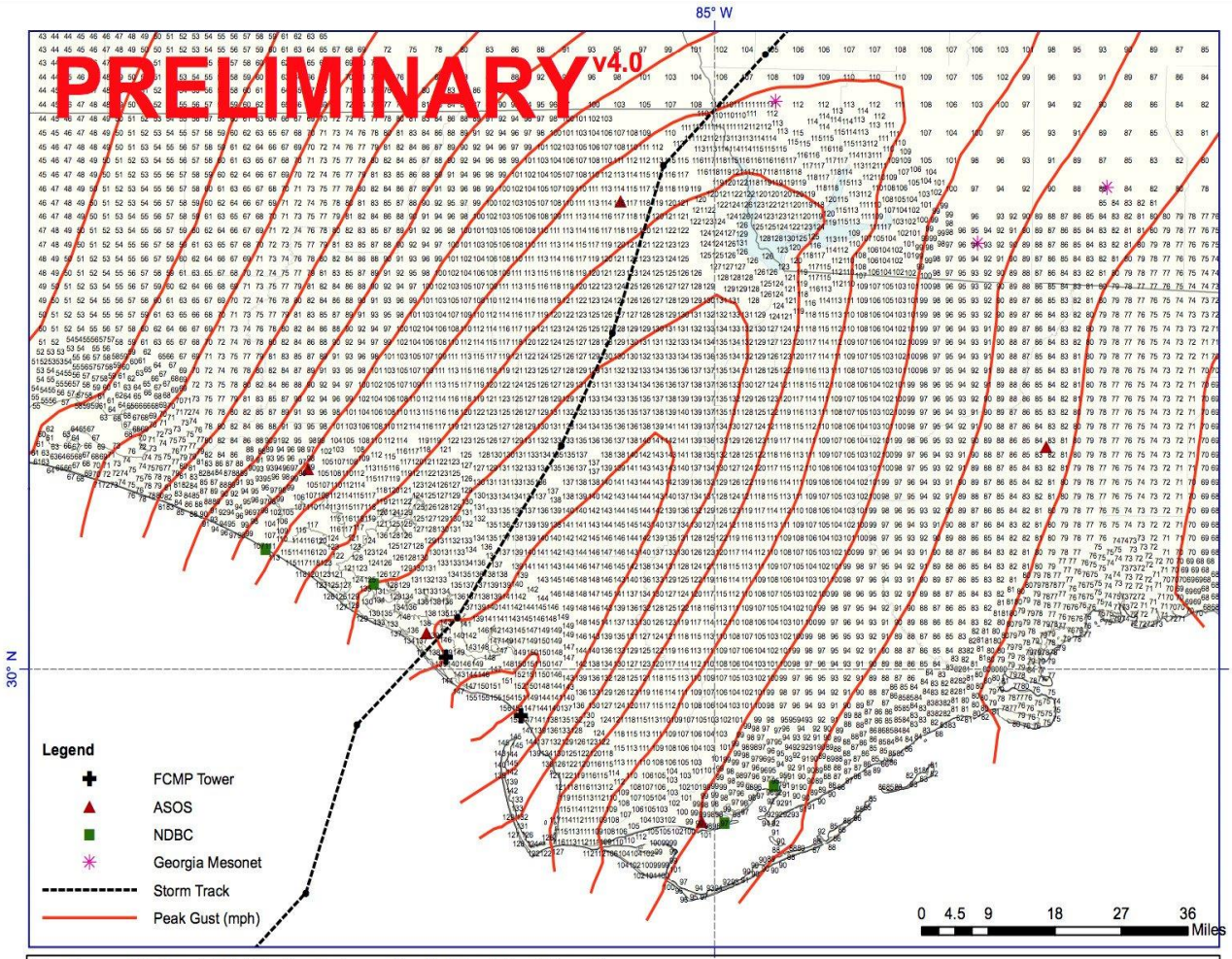

Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018.
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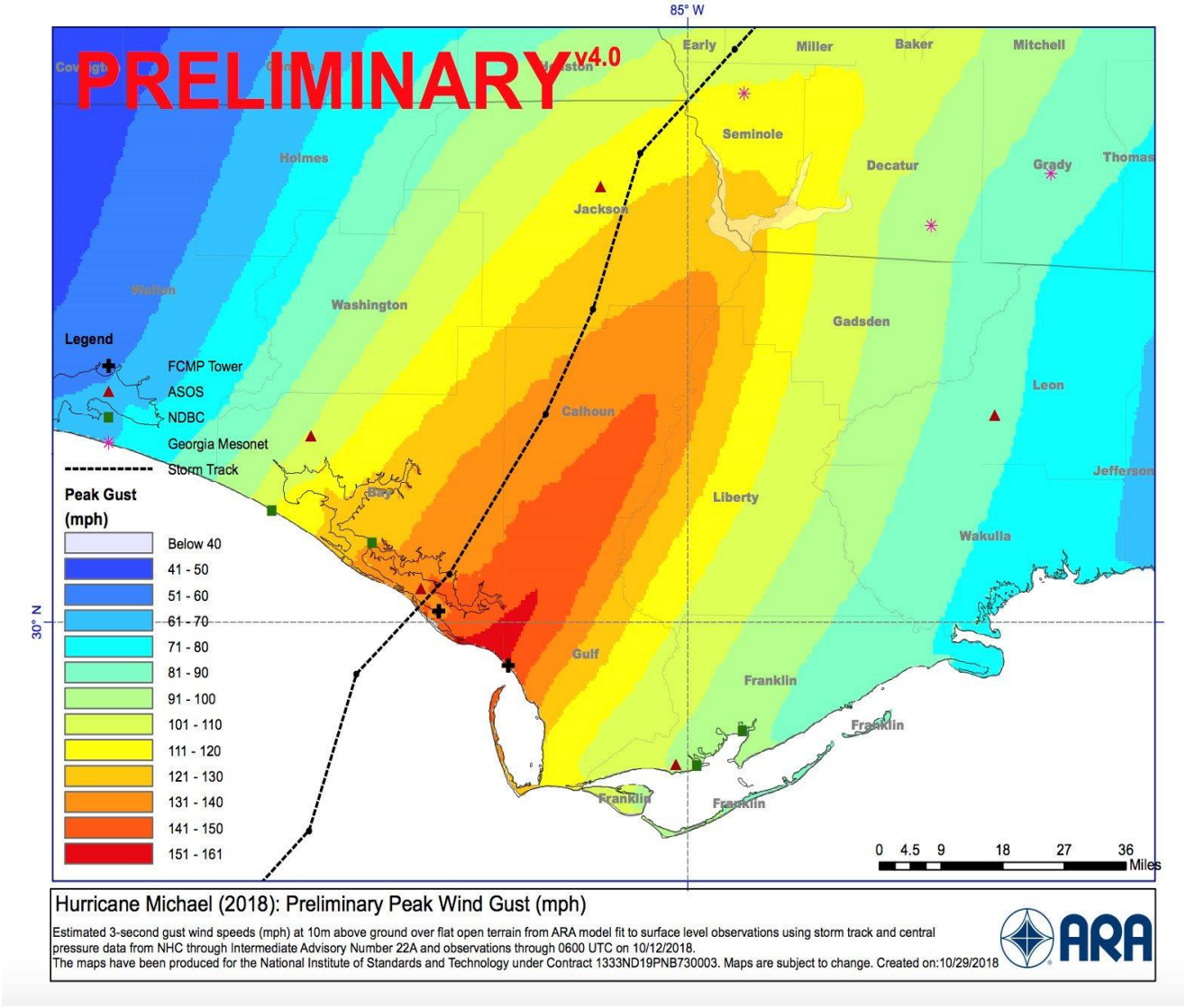

Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018.
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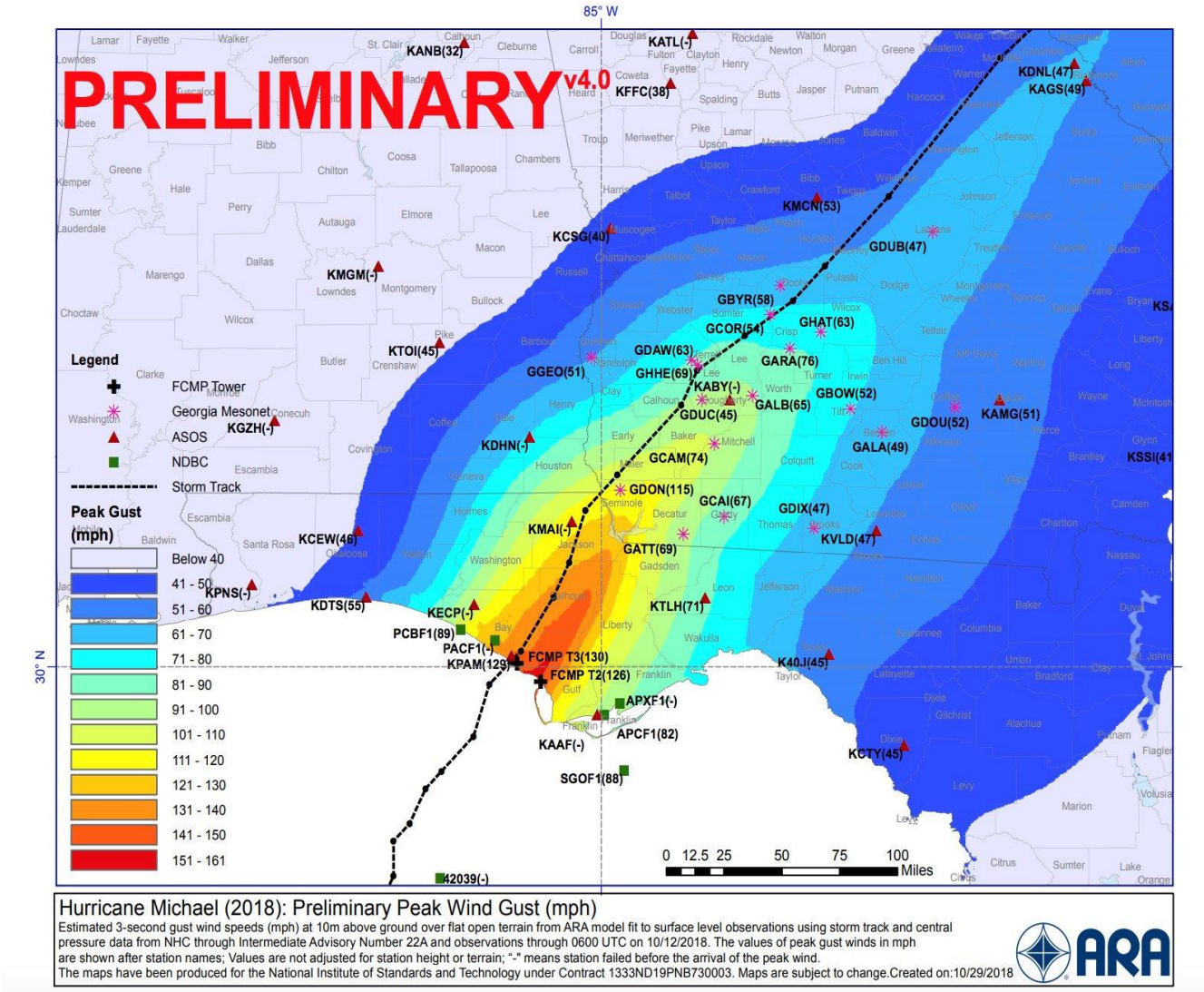

Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018. The values of peak gust winds in mph are shown after station names; Values are not adjusted for station height or terrain; "-" means station failed before the arrival of the peak wind.
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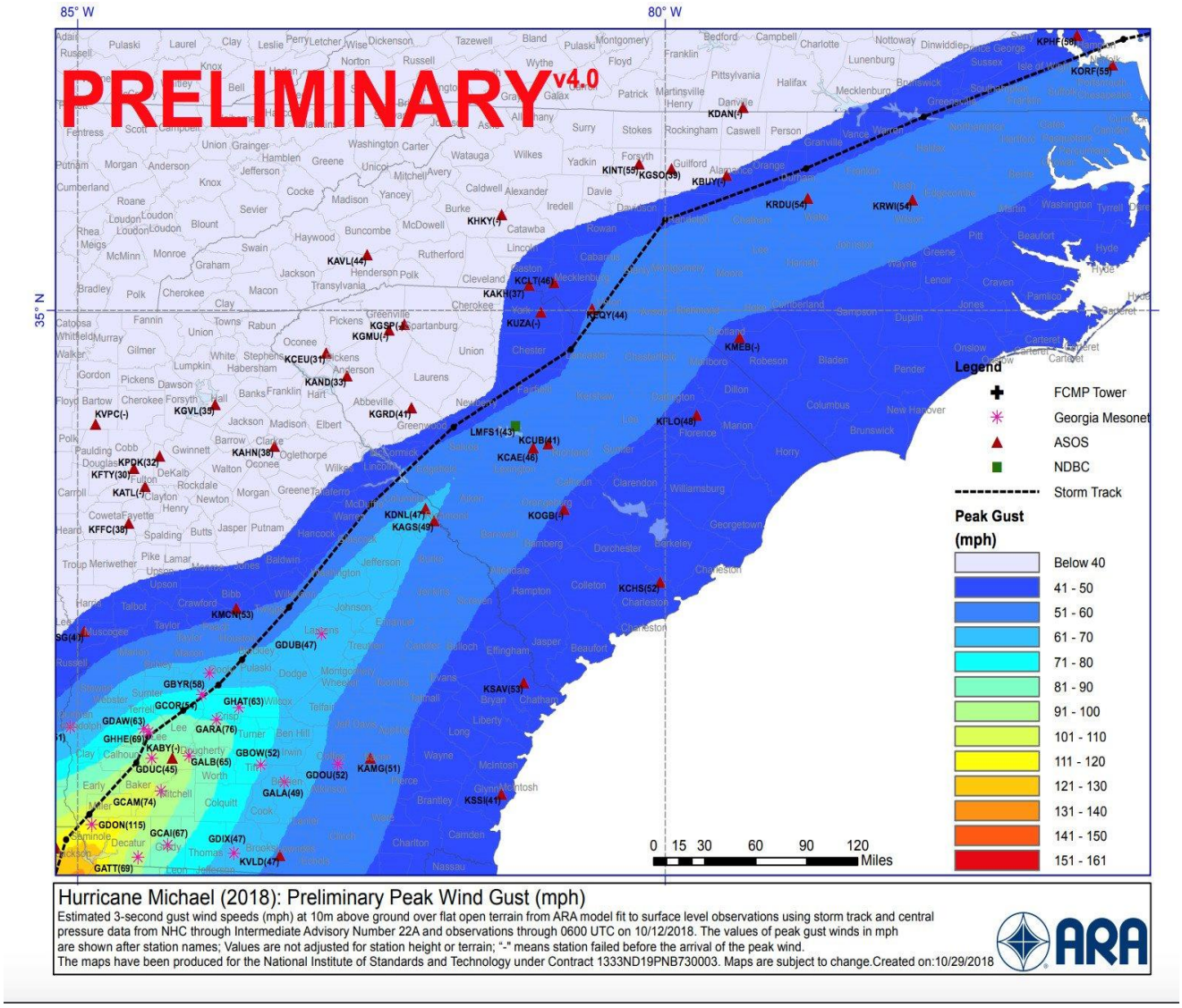

Hurricane Michael (2018): Preliminary Peak Wind Gust (mph)

Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Intermediate Advisory Number 22A and observations through 0600 UTC on 10/12/2018. The values of peak gust winds in mph are shown after station names; Values are not adjusted for station height or terrain; "-" means station failed before the arrival of the peak wind.
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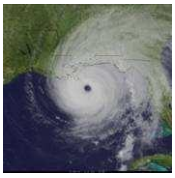
APPENDIX I

RICOWI Wind Investigation Program



In 1989, Oak Ridge National Laboratory held two workshops devoted to identifying and discussing roof wind uplift issues and alternatives. Discussions of important technical issues included causes of roof wind damage, dynamic testing of roof systems, the importance of sample size for tests, the role of wind tunnels, air retarders, and the need for acceptable procedures for ballasted systems. There was also concern for the general lack of communication within the roofing industry as to what the problems are, what is being done to alleviate them, and how effectively technology transfer is accomplished within the roofing industry and the building community. At the conclusion of the workshops, a consensus recommendation was to form a committee to address these matters. The Roofing Industry Committee on Wind Issues (RICOWI) was established and the Charter approved October 11, 1990.

Subsequent to RICOWI's formation, other concerns were raised. The insurance industry conveyed its concern regarding excessive property loss from windstorms. Industry experts estimated that from 1984 to 2003 hurricanes and high winds have accounted for nearly 64% of catastrophic losses. Insured losses from hurricanes reach billions of dollars each year. In August 1992, Hurricane Andrew caused $16 billion in insured losses. A one-month period of hurricanes in 2004 resulted in more than $20 billion in insured losses. Of the top ten most costly catastrophes to ever hit the United States, 8 are hurricanes or a tropical storm. Hurricane Katrina set new loss record of $125 billion in losses. Hurricane Michael losses are projected to approach $25 billion.

There is an essential link between product research, performance and the model building codes. The model code groups are moving more toward "objective based codes" versus "prescriptive codes." Performance requirements are generally perceived to be requirements stated in a way that allows flexibility in the choice of solutions to satisfy the requirements and are based upon explicitly stated objectives. In addition, there is a general feeling that the right type of data, following a wind storm event, has not been gathered. There is no question that all roofing products and systems of all roofing manufacturers are going to have to meet more rigorous specifications and will be subject to tougher scrutiny of building departments such as seen in Dade and Broward counties (FL). Industry involvement in follow-up of wind events is imperative.

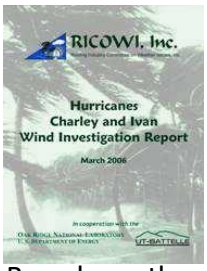
RICOWI and the Department of Energy / Oak Ridge National Laboratory responded to industry involvement by entering into a Cooperative Research Development Agreement (CRADA) to facilitate the Wind Investigation Program (WIP). The Program includes all of the major roofing trade associations in North America. In 1996, a pool of eighty investigators were trained in wind issues by the country's leading scientists and others qualified in examining wind damage to roofing systems.

RICOWI Wind Investigation
Hurricane Michael, Florida

WIP identifies an event as a major hurricane making landfall in a heavily populated area, or in an area previously investigated by RICOWI, with wind speeds at or above ASCE 7- 2005 design levels based on early projections by NOAA/NHC and/or other credible sources. Alternatively, a hurricane similarly projected by NOAA/NHC to include one-minute sustained wind speeds equal or greater than 95 mph (Category II) making landfall along the northeast corridor.

The WIP mission is to investigate the field performance of roof assemblies after major wind storm events, factually describe roof assembly performance and modes of damage, and formally report results of investigations and damage modes for substantiated wind speeds.

WIP puts credible people in the field that have the required product knowledge and program training to ensure that sound, scientific and unbiased reporting occurs. Buildings will be safer, property losses will be reduced and industry will meet the challenge with clear insight as to needed direction. The reports generated by investigation teams and findings will be utilized to help educate, improve products, installation techniques, safety and reduce overall roofing and insurance costs for industry. The results will also provide a valuable resource to FEMA and state emergency management agencies.



RICOWI has now conducted six of the most comprehensive roofing investigations of hurricane stricken areas immediately following Hurricanes Charley (Aug. 13/04), Ivan (Sept. 16/04), Katrina (Aug. 29/05) Ike (Sept. 13/08). Irma (10/17) and Michael (10/18). The reports can be downloaded from www.ricowi.com and are also available on CD. The research is available online.

Based on the success of the past investigations, RICOWI's Board of Directors is reviewing investigation processes for future events. When an event occurs, up to eight four-members teams will be assembled, along with several observers. A logistics team will be deployed immediately following the storm to target damaged areas, select specific buildings and make the preliminary contacts.

Interested members are encouraged to volunteer by signing up as a Team Member online at www.ricowi.com

RICOWI has a similar program for hail investigations. Check the website (www.ricowi.com) for more detail. For additional information, contact RICOWI's Executive Director, Jordan Loudon by phone: 808-421-8392 or by email: jlemke@ricowi.com.