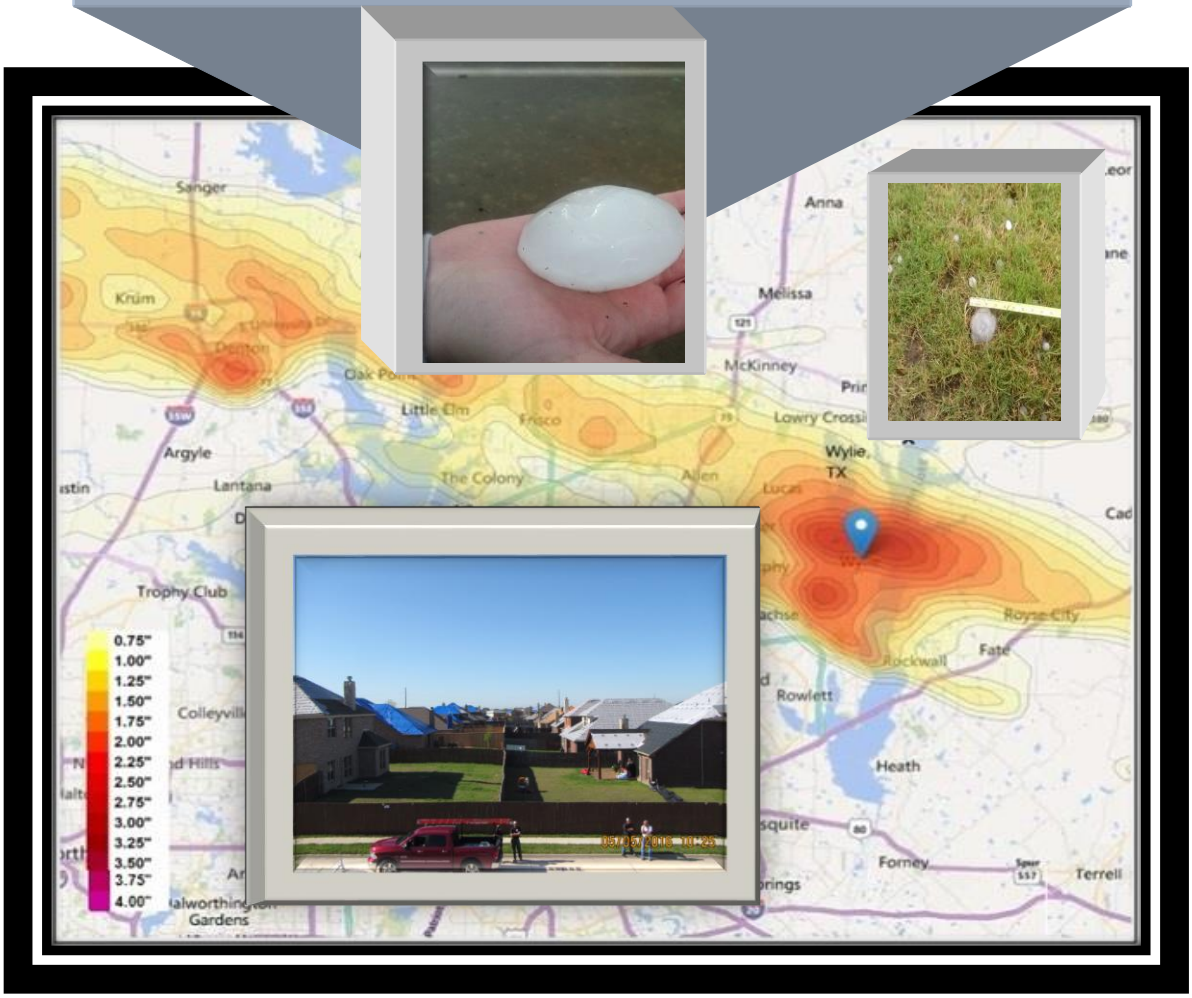
Hailstorm Investigation North Texas

RICOWI, Inc.
Roofing Industry Committee on Weather Issues, Inc.



Hail size analysis of April 11, 2016, storm courtesy of CoreLogic
Hail photos courtesy of Sherry & Don Takak

HAILSTORM INVESTIGATION REPORT
NORTH TEXAS – APRIL 11, 2016

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Preface

This document was prepared and published by the Roofing Industry Committee on Weather Issues, Inc. (RICOWI). The following organizations are Sponsor Members of RICOWI:

This document will be posted on RICOWI's website (www.ricowi.com) and available for free download. Copies on CD can be ordered by email: jcook@ricowi.com. A shipping and handling fee will be charged.

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Leading the Roofing Industry through Innovative Collaboration

The Roofing Industry Committee on Weather Issues, Inc.

Mission
RICOWI is committed to:

- Encourage and coordinate research to provide a more knowledgeable information base of roof issues including wind, hail, energy efficiency and durability effects;
- Accelerate the establishment of new or improved industry consensus standard practices for weather design and testing where they are recognized as needed;
- Improve the understanding of roof weather concepts and issues within the building community in general.

Background
The Roofing Industry Committee on Weather Issues, Inc. (RICOWI) was established in 1990 as a non-profit organization to identify and address important technical issues related to the cause of wind damage which include:

- Dynamic testing of roof systems;
- Importance of sample size for tests;
- Role of wind tunnels and air retarders;
- Need for acceptable procedures for ballasted systems;
- Field data and response team reports;
- General lack of communication within the roofing industry as to what the problems are, what is being done and should be done to alleviate them, and how effectively information is transferred within the roofing industry and to others in the building community.

In 1996, RICOWI was incorporated as a non-profit corporation devoted to research and education on wind issues. After a review of the need for similar education and research in the areas of hail, energy efficiency and durability effects, the organization's objectives were broadened in 1999 to include other weather topics, and "Wind" in RICOWI's name was changed to "Weather" to reflect the expanded scope.

Meetings
RICOWI meetings are held twice a year, in the spring and fall. The spring meeting is usually held in conjunction with the RCI, Inc.'s annual convention.

The meetings include a technical forum and a business session where the direction and business of RICOWI is discussed. During the technical segment, the Sponsor and Affiliate Members have an opportunity to report on the latest developments in their organizations and technical subjects of common interest. Any concerned or interested individual can bring their knowledge or concern to another group of experts that can peer review their ideas, suggest tests or procedures, or confirm that they are headed in the right direction.

Seminars
RICOWI Seminars on the proper design, installation and testing procedures for specific roofing materials are held once or twice a year. Fall seminars are usually held at research testing or educational facilities and include a tour. They are of interest to roofing professionals, architects, contractors, engineers, facility managers and those in the insurance industry.

Wind and Hail Investigation Programs

RICOWI implemented two strategic investigation programs:

- Wind Investigation Program (WIP)
- Hail Investigation Program (HIP)

The purpose of these programs is to investigate the field performance of roofing assemblies after major hurricane and hailstorm events and:

- To factually describe roof assembly performance and modes of damage;
- To formally report the results for substantiated hurricane/hail events.

The data collected provides unbiased detailed information on the wind and hail resistance of low-slope and steep-slope roofing systems from credible investigative teams. We can expect a greater industry understanding of what causes roofs to perform or fail in severe wind and hail events, leading to overall improvements in roof system durability, the reduction of waste generation from re-roofing activities, and a reduction in insurance losses that will lead to lower overall costs for the public. The reports document roofing systems that fail or survive major weather events and provides educational materials for roofing professionals to design wind and hail resistant roofing systems. The data can be used to improve building codes, roof systems design, and educate the industry and the public.

HAILSTORM INVESTIGATION REPORT

North Texas – April 11, 2016

1. INTRODUCTION

A field investigation program has been completed by RICOWI (Roofing Industry Committee on Weather Issues, Inc.) regarding hail effects to roofing from a storm that occurred in the northern portion of the Dallas-Fort Worth metropolitan area on April 11, 2016.

The mission of the Hail Investigation Program (HIP) is:

- To investigate the field performance of roof assemblies after major hailstorm events;
- To factually describe roof assembly performance and modes of damage after major hailstorm events;
- To formally report results of the investigation.

This RICOWI HIP project was the third industry-wide research program conducted to assess field damage from a major hailstorm in the United States. RICOWI is a non-profit corporation devoted to research and education on roof issues, and the membership is comprised of industry, consulting, and research organizations. Earlier RICOWI HIP[1,2] reports were published following an April 21, 2004, hailstorm in the Oklahoma City area, and a May 24, 2011, hailstorm in the Dallas/Ft. Worth area. The goal of the RICOWI HIP project and report is to create a greater industry understanding of how roofs perform in severe hail events. This will lead to overall improvements in roof system durability; reduction of waste from reroofing activities; and a reduction in insurance losses, which can lead to lower overall costs for the public. The RICOWI report provides unbiased detailed information from balanced teams of investigators representing all sectors of the roofing industry. The data can be used to improve building codes, roof system design, and educate the industry and public.

The storm on April 11, 2016, was selected for deployment by the RICOWI criteria of having been declared an insurance catastrophe by Property Claim Service (an insurance services company) and having hailstones larger than 1.5 inches in diameter in a region of five square miles or greater in a previously defined area. Core-Logic® reported that the April 11, 2016 storm left a path of destruction nearly 200 miles in length and had hail reported up to 4” diameter. The RICOWI teams confirmed large hail up to 4-inch diameter in the Wylie TX area.

In the 2011 HIP investigation, asphalt shingles were targeted to attempt to determine if Class 4 products (per the UL 2218 or FM 4473 impact resistance tests) performed better than standard or Class 1 products. Unfortunately during this investigation only a few roofs were clearly defined as Class 4.

Although hail up to 4.0 inches in diameter occurred in the Wylie area, many surrounding areas had much smaller hail. Roofs are not expected to survive 4.0 inch hail and most subjected to this size hail were seriously damaged. In some areas parts of the storm path, there was a large quantity of hard, wind-driven, moderately-sized hail that also caused considerable damage to roofs. The relative description of the hail as "hard" was provided by eyewitnesses, and our inspectors observed the large quantity of dents in metal items to attest to this.

2. METEOROLOGICAL INFORMATION

In the afternoon of April 11, 2016, a supercell thunderstorm erupted near Wichita Falls and moved towards the east-southeast, affecting several counties in Texas. This long-lived storm began to produce copious amounts of dangerously large hail and left a path of destruction nearly 200 miles in length. In the northern portion of the Dallas-Fort Worth Metroplex, the three counties primarily affected by the storm were Denton, Collin, and Rockwall. The population density in the storm path was highest in portions of Collin County, and the property damage estimate was largest as well. According to the *Storm Events Database* of the National Climatic Data Center (NCDC), there were 39 individual hail reports listed in these three counties. Twenty one of the reports were for hail of 2.0-inch diameter or larger, and six were for hail of 3.0-inch diameter or larger as shown in Table 1. The damage was most extreme in and near the town of Wylie, where an estimated 80% of roofs were damaged by the hail according the NCDC report, and hail reports of 3.5-, 4.25-, and 5.25-inch were listed. The large, wind-driven hail also caused interior damage to hundreds of homes in Wylie due to broken windows, broken skylights, and punctures through the roof decking. (Refer to Appendix D-NCDC information.)

Table 1: NCDC *Storm Events* Hail Reports

County	0.75-1.75 inch	2.0-2.75 inch	3.0-inch +
Denton	7	5	1
Collin	9	9	3
Rockwall	2	1	2
Total	**18**	**15**	**6**

Hail maps of the projected maximum hail size were provided by CoreLogic® and were used to select the areas where teams were sent to investigate. The largest hail was projected to be in the Wylie area, and it was the largest hail many of our experienced investigators had ever encountered. The radar-based analyses do not provide data on quantity of hail or speed/direction of the wind; information about the amount and direction of hail was confirmed by building owners and observations of hail impacts on many objects.

The quantity of hail was found to be large in many areas of the storm path, both where the hail was very large in the Wylie area and in other areas where the hail was in the range of 1.0- to 2.0-inches in diameter. In certain areas where the hail maps identified large hail, investigators did not find evidence of large hail nor significant hail-caused damage.

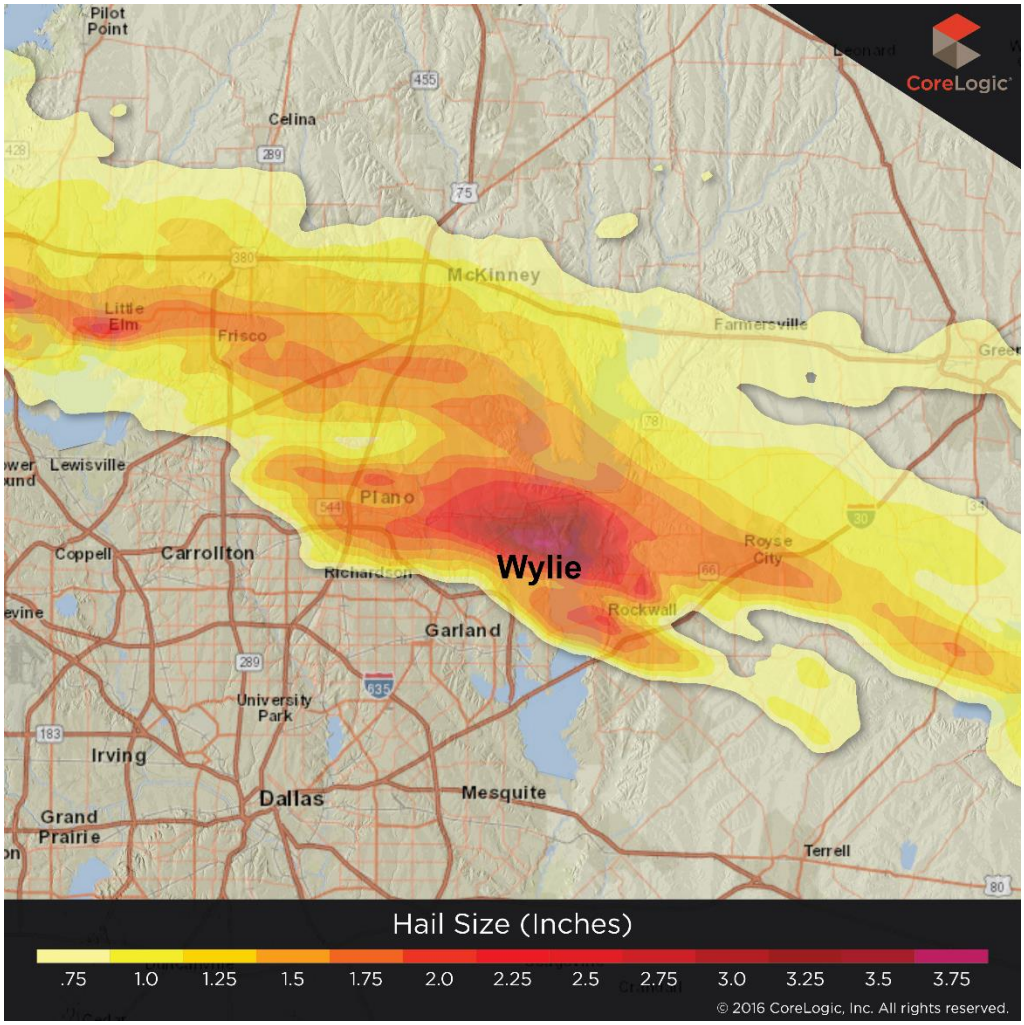


Figure 1. Zoomed view of eastern Collin County where hail size was largest (courtesy of CoreLogic®).

3. PROPERTY DAMAGE ESTIMATE

CoreLogic®[3] made an analysis of the number of homes that were affected by the April 11, 2016 event in Texas. A total of 310,088 residential properties were located in the storm's footprint where the hail was analyzed to be 0.75-inches in diameter or larger (according the above-described radar analysis), and approximately 15% of the homes were located in areas where the hail size was estimated to be 2.0-inch diameter or larger. The property damage modeling was done using data obtained from prior hailstorm analyses that correlated average residential roof damage to hail size ranges. In total, the residential property damage was estimated to be near $250 million, and this amount did not include vehicles or commercial property that likely would more than double this damage amount for the overall storm. (Table 2.)

Table 2: Residential Property Damage Estimates (source: CoreLogic®)

Hail Size (Inches)	Loss $ (Millions)	Residential Properties
0.75	9	47,116
1	12.6	74,775
1.25	15.2	45,368
1.5	18.5	53,679
1.75	33.7	42,125
2	21.4	25,946
2.25	11.8	5,100
2.5	22.7	3,242
2.75	44.4	5,549
3	34.1	4,259
3.25	19.2	2,405
3.5	4.2	524
Total	**$246.8**	**310,088**

4. INVESTIGATION PROTOCOL

A review of the HIP procedures took place on the first day with a focus on safety and hail size identification. Personnel were assigned to 10 teams of 3 members on each team based on experience and interest of the participants. Teams had a balance of manufacturer representatives, trade group representatives, insurance adjusters, engineers, roof consultants, and roofing contractors. Each day the teams were assigned investigation sites. Teams were also encouraged to take advantage of opportunities to investigate properties near their assigned sites.

The teams began inspections 22 days after the hail storm and found that many of the leaking roofs were either tarped, had been replaced, or temporarily repaired. Active contractors were abundant. It is unlikely that a hail investigation could occur before temporary repairs were made, and we do not believe this resulted in significant data loss. RICOWI staff was based in a hotel in the local area to

make media contacts and reach out to government agencies and building owners to arrange for inspections.

Hail information was gathered on the sites by examining a variety of materials and surfaces that would contain impact marks or dents from hail impact, in addition to any damage found to the roof materials. Property owners also offered some eyewitness accounts of hailstone size and quantity, photographs, videotapes, and/or presented stored frozen hailstones for documentation. The photographs and videos reviewed indicated a variety of hail sizes at each site up to the determined "maximum" hailstone size as would be normal in a hailstorm event. It should be understood the hailstone sizes listed are best estimates from the information gathered on-site and data offered in referenced articles by Crenshaw[4] and Morrison[5]. The maximum hail sizes determined on-site sometimes differed (larger or smaller) than those estimated by the Core Logic map. In these cases, the inspection-based data would be considered more accurate.
An online accessible data form was developed to record pertinent information from each site. Having a cloud based database eased data entry and provided immediate results and data comparison. Data included location, roof construction details, generic roof material descriptions, roof slope, estimated maximum hailstone size at the site, range of hail sizes, quantity of hail strikes per unit area, and the type(s)/severity of hailstone impact damage to the roofing product. Impact effects were listed on a scale of 0-5:

0. No apparent damage.
1. Surface impact marks without fractures or punctures.
2. Minimal damage (low severity and low quantity).
3. Moderate amount of fractures, punctures, or spalling.
4. Moderate/severe denting of metal roofing.
5. Severe damage resulting in potential leakage.

The selection of inspection sites was targeted towards areas with moderate to large hail sizes and to include a variety of roof system types. Sites primarily were obtained through contacts by RICOWI member organizations, owners or managers of large facilities, governmental organizations, and local roofing contractors. The people offering their property for inspection were told in advance that RICOWI would not be assisting with roof replacement bids, nor would assistance be given regarding their insurance claims. Overall, close to 180 buildings were inspected, with about 65% steep-slope and 35% low- slope.

Typical inspections consisted of a complete visual survey of the roof surface. This was followed by randomly selecting test areas where the hail hits were counted and the hail size was estimated. On steep roofs, hail hit counts were conducted on both the windward and leeward slopes where possible[6]. On low-slope roofs several random test areas were selected for counting the locations that exhibited hailstone impact effects**.** Other building or surrounding elements were also used to establish the size of the hail at the specific site being investigated.

The inspections were non-destructive, with no test cuts performed or samples removed unless contractors were present and working on the roof at the time of inspection. Following the field investigation, the information from the inspection form was input into a central database, and digital photographs from each site were consolidated.

5. FIELD RESULTS

A. Low-Slope Systems

Five teams were assigned to low-slope sites; sites were offered for inspection by one large retailer and some governmental agencies in the area. As observed in the previous HIP investigations, roof membranes that were solidly supported (installed over a substrate with relatively high compressive strength such as gypsum board products or wood-fiber board) and or protected with gravel or aggregate ballast performed well. Approximately 2.5 million square feet of low-slope roofing was inspected, and at least 1 million square feet of the roofing was scheduled for replacement. Appendix C provides photographs from a sampling of the low-slope inspections.

A.1. Built-Up Roofing (BUR)

BUR roofs appeared to perform well. Nine (10) BUR roofs were inspected; all were aggregate-surfaced. They were impacted by hail from 0.75 to 3.5 inches. Three roofs were rated a 3 that were struck with 1.5 inch or greater hail, and the rest had less damage. Two roofs hit by large hail had only perimeter flashing damage.

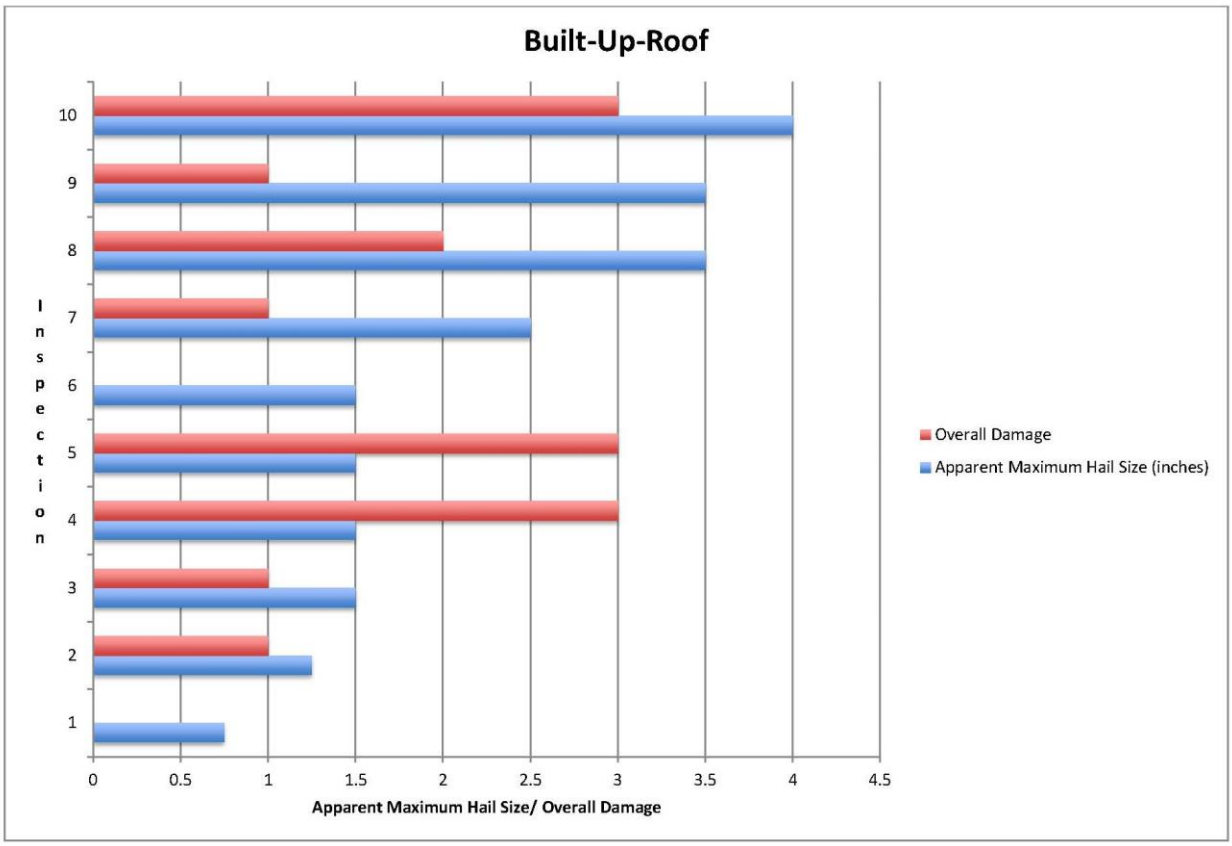


Figure 2. Maximum hail size versus damage rating for built-up roofing inspections.

A.2. Modified Bitumen

A total of fifteen modified bitumen membrane roofs were inspected in the study. They were impacted by hail from 0.25- to 4.0-inches in diameter with six of the fifteen being rated at damage level 5 indicating they were severely damaged. The vast majority of membranes were SBS variety with granule surfacing. The roofs with severe damage were not supported by a high compressive strength substrate. One poorly supported modified bitumen roof was damaged by hail as small as 1.25 inches in diameter, but generally the significant damage to modified bitumen membrane over low compressive strength substrates (standard foam insulation boards directly below the membrane) was with hail 1.5 inches in diameter or larger.

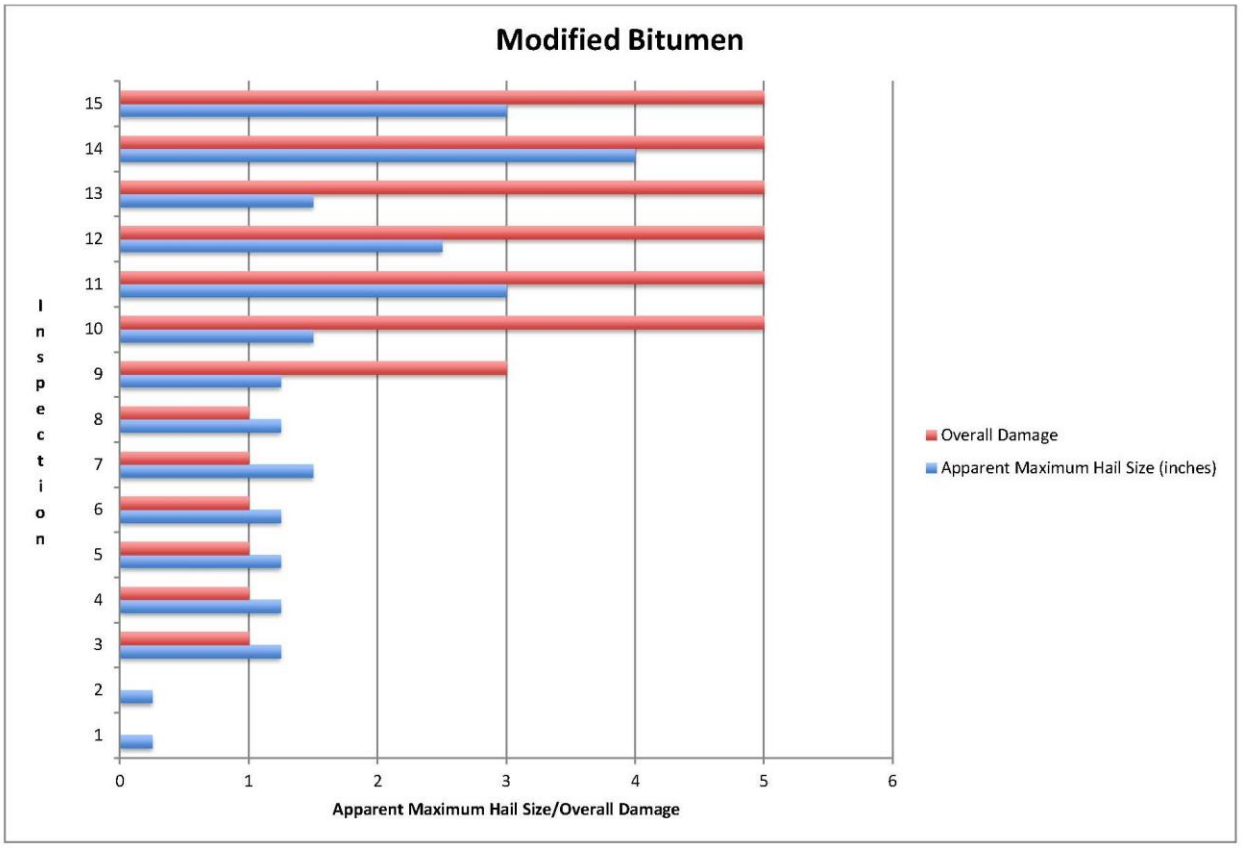


Figure 3. Maximum hail size versus damage rating for modified bitumen membrane inspections

A.3. Sprayed Polyurethane Foam (SPF)

There was one sprayed polyurethane foam roof inspected; it had significant damage from 1.5-inch hail. The SPF was surfaced with an elastomeric coating; and frequent coating fractures with foam indentations were found. Leakage was reported by the site contact, but the severity of leakage and the specific cause was not investigated.

A.4. Metal

There were seven low-slope metal roofs inspected. Three roofs that were exposed to 2.5 inch or larger hail were severely damaged, with large dents, some distortion of seams, but no noticeable fractures or panel punctures. Metal roofs impacted by hail 2.0 inches or smaller were not found to have effects other than denting.

A.5. Single-Ply Membranes

A total of 27 single-ply roofs were inspected; seven were severely damaged. Four of the severely damaged roofs were exposed to hail 2.5 inches and greater. Two thermoplastic membranes (without ballast) sustained significant damage from hail less than two inches in diameter (in the range of 1.25-1.5 inches in diameter). Although the membranes damaged by smaller hail were supported by a high compressive strength substrate, they had fractures at the edges of fastener plates. Age also may have been a factor as one roof was between 12 and 15 years old and the other was greater than 15 years old. Three inspections were made on EPDM membranes with hail sizes between 1.0 and 3.0 inches in diameter, and no punctures or fractures were documented.

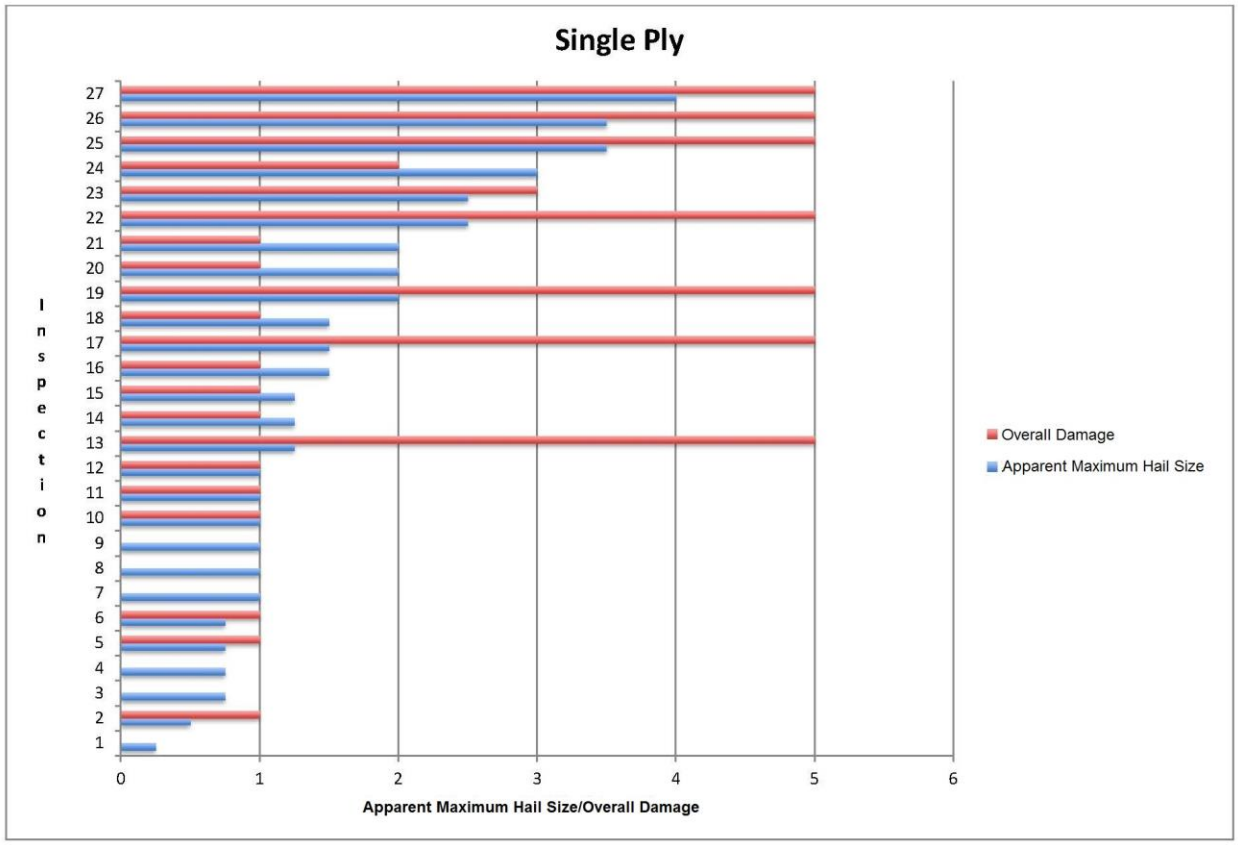


Figure 4. Maximum hail size versus damage rating for single-ply membrane inspections

B. Steep-Slope Systems

More than 600,000 square feet of steep roofing was inspected, and at least 300,000 square feet is scheduled for replacement. Appendix B provides photographs and reports from a sampling of the steep-slope inspections

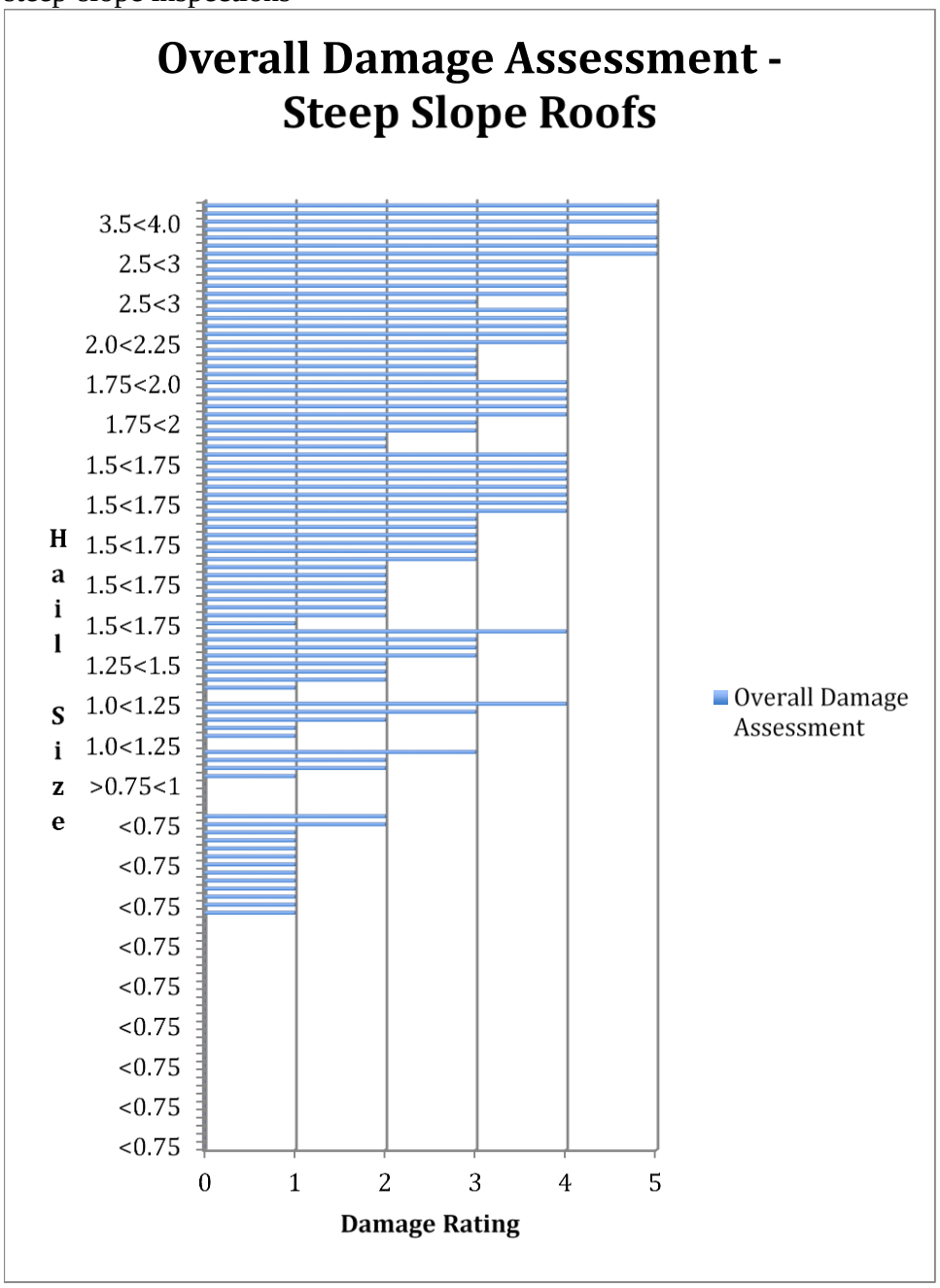


Figure 7. Maximum hail size versus damage rating for steep-slope inspections (nearly all asphalt shingles)

B.1. Asphalt Shingles

A total of 99 asphalt or modified bitumen shingle roofs were inspected during the survey; most were standard asphalt laminated shingles with fiberglass reinforcement. Of the inspected roofs, 29 did not have any confirmed damage when exposed to hail up to 0.75-inch diameter. An additional eleven had a small amount of granule loss. Hail of 1- to 1.5-inch in diameter resulted in a variance of damage (damage ratings from 1 to 3), which would indicate an average threshold size for damage of approximately 1.25 inches in diameter. Some roofs performed well with only limited visible effects from hail impacts. On other roofs, there was granule loss and fracturing of the shingle reinforcements, with the damage concentrations quite high on the windward slopes of some roofs and less-supported ridge and hip shingles. Hail of 1.5 inches and larger generally resulted in significant damage (mostly damage ratings of 3 or higher). Due to the quantity of the hard and wind-driven hail, some roofs had multiple visible impact marks on each shingle on the windward side (typically the west slopes had the most damage). On several roofs, from 100 to 300 damage locations were identified per 100 square foot area on the most severely affected roof areas, resulting in considerable granule loss. Many roofs in the Wylie area hit by large quantities of 2.5 inch or larger hail had multiple punctures through the shingles and occasional fractures in the underlying plywood or OSB sheathing.

Damage modes were primarily fracturing or rupturing of the shingle mats or broken shingle edges common for shingles hit by hail greater than 1.5 inches. Areas with fractured mats generally displayed loss of granules sufficient to expose asphalt, and the recently exposed asphalt was dark in color with limited oxidation. Hail impact damage was most concentrated on the windward roof slopes having the most direct hail impacts. Less-supported ridge, hip, and valley shingles were noted as being damaged more severely than field shingles in areas where the hail size was close to the threshold size for damage (approximately 1.25 inches in diameter).

Figure 8. The quantity and wind-driven nature of the hail is visible on the asphalt shingles at a hip.

Known or estimated ages of the roofs ranged from less than three years to older than 15 years. Damage was not strongly correlated with age; the spread of damage was similar for all ages of the shingles. This is different from the findings of the previous HIP reports where older shingles were found to be more brittle and subject to damage.

Unfortunately, the investigation teams found only 3 roofs that were clearly identifiable Class 4 (Impact Resistant) roofs. A Class 4 roof that was exposed to 3.5 to 4 inch hail had scattered large fractures and punctures that were mostly 1.75- to 3.5-inches across. This roof did not have the great quantity of smaller damage area (from 1.0- to 1.75-inches across) that other nearby standard asphalt shingle roofs exhibited, indicating greater resistance to the moderate hail size. The other two class 4 roofs were struck with relatively small hail (1.5 inch diameter and smaller) and did not have damage.

B.2. Tile

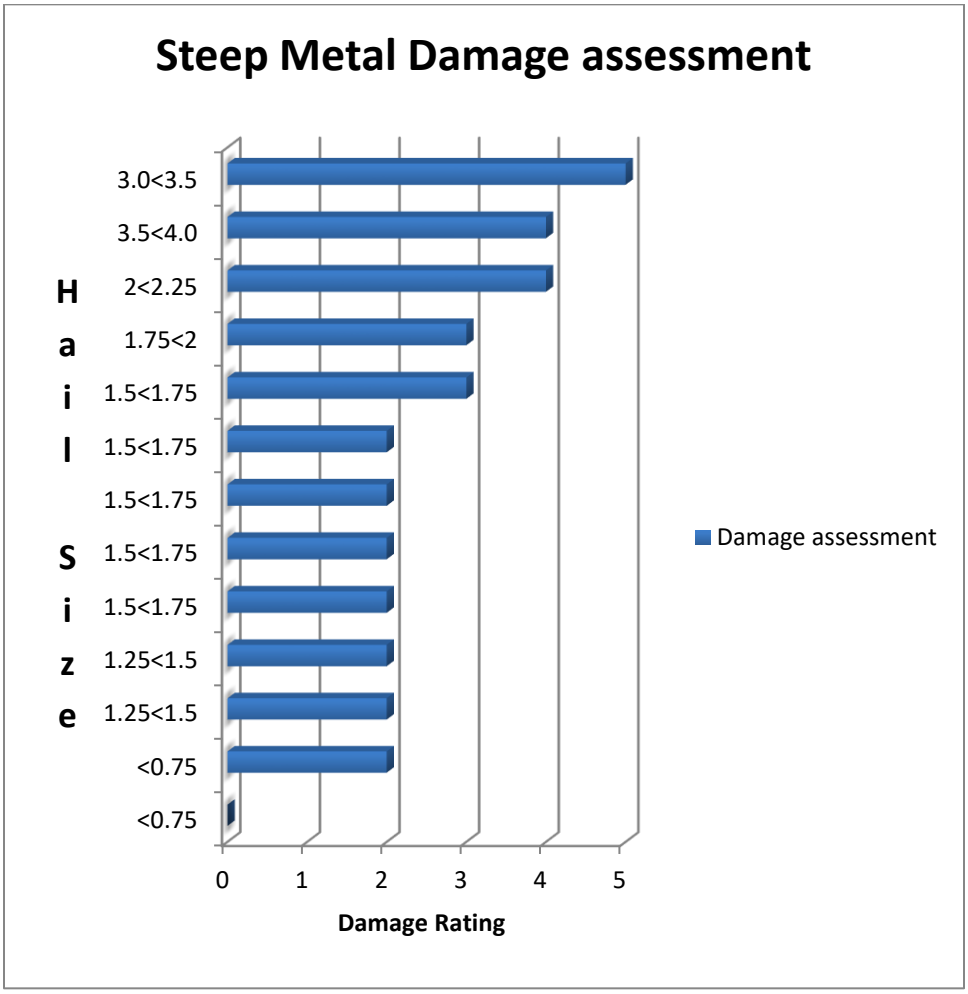
There was one concrete tile roof inspected in the survey. This roof was hit with hail smaller than 1 inch and was not damaged.

B.3. Cedar Shake & Shingles

There was one cedar shingle roof found in the surveyed area. This roof was in Wylie where 3.5- to 4.0-inch diameter hail damaged this roof. There were multiple fresh splits in the cedar shingles coincident with large impact marks, and several large pieces of shingles had been broken off. There was also evidence of the hail being driven by high winds resulting in broken windows and punctured siding to the building.

B.4. Metal Shingles & Panels

Metal roofing on steep-slopes performed well. Thirteen roofs were inspected; one roof was exposed to hail less than 0.75-inch and was not dented nor otherwise damaged. One roof was exposed to 3.0-3.5 inch hail and was significantly damaged with distortion of the overlap seams. The other 11 roofs had noticeable dents, but no fractures were found in the metal and no seams had been opened. The denting of the metal would be considered a cosmetic condition only.



6. RESULTS

Hail size was the primary determinate of performance for the roofs. While this conclusion has been drawn in the other HIP investigations, the truly catastrophic damage found in and near Wylie was rare even for Texas. The inspection sites covered the full range of hail sizes in the storm to provide identification of the threshold hail size for physical hail damage for various roof covering types and conditions. Overall, 175 roofs were documented in the research project and the maximum hailstone size was listed by location as follows: less than 1.0-inch, 65 roofs (37%); 1.0-2.0 inch, 67 roofs (38%); 2.0-3.0 inch, 24 roofs (14%); and greater than 3.0 inch, 19 roofs (11%); please refer to Figure 9. The greatest change in damage level for most roof coverings occurred between 1.25- and 2.0-inches in diameter. Currently, that is the range of focus for the most common laboratory tests for impact resistance, UL 2218, FM 4471, and FM 4473. The RICOWI research confirms that this is an appropriate range in which to grade and rank products for hail-prone areas. FM Approvals[7], a division of FM Global, is developing requirements for low-slope roofing products that would provide a "very severe" hail rating (something greater than the equivalent of a 2.0-inch hailstone). The damage observed in the worst areas of the April 11, 2016 storm path; show that there would be value to this for critical facilities in areas where very large hail is prone to fall. Our investigation indicates that certain low-slope systems can survive hail larger than 2.0 inch diameter. Although not intended to be the only options, data from the three RICOWI HIP investigations have shown that built-up roofs with a combination of loose and embedded aggregate ballast and unreinforced EPDM membrane (especially with No. 4 aggregate ballast) have performed successfully against hail larger than 2.0 inches in diameter. The use of substrates with relatively high compressive strength also improves performance of low-slope roof membranes against hail impacts.

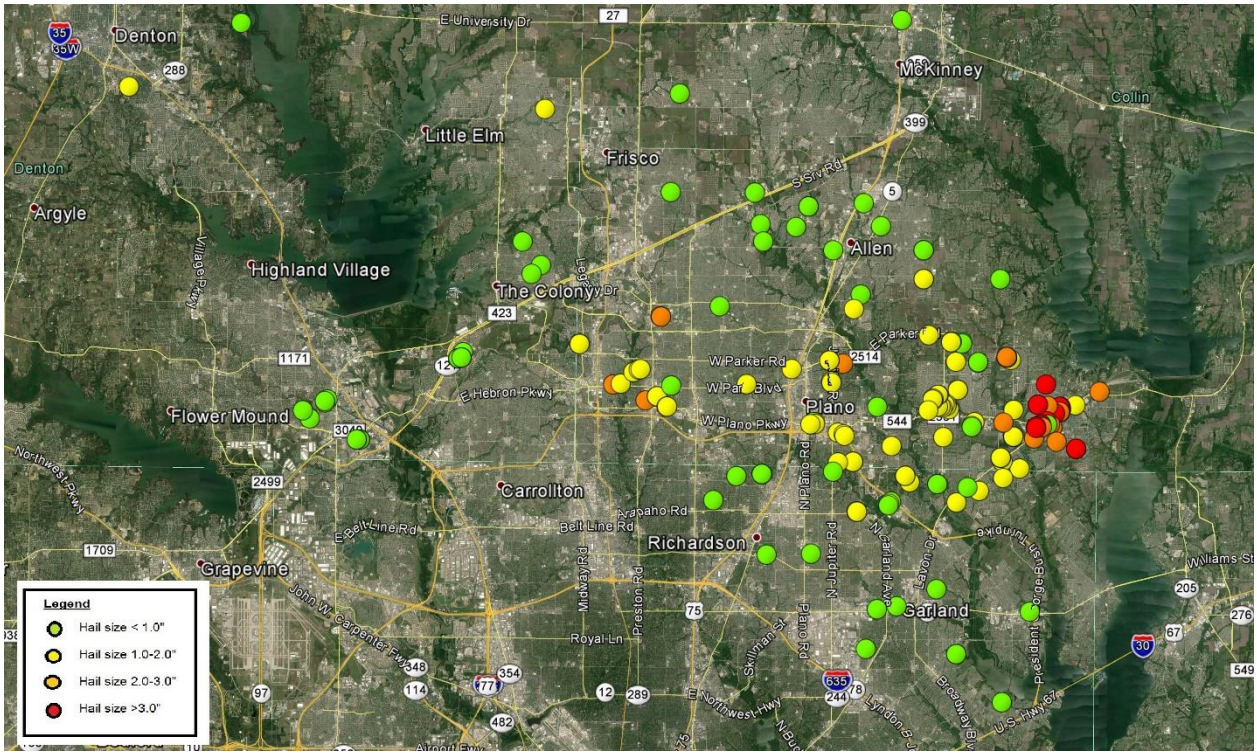


Figure 9. Plot of inspection sites with estimated maximum hailstone sizes.

There were too few identified Class 4 roofs to draw conclusions on their performance relative to standard shingles. Also, no conclusion can be drawn for wood or tile roofs due to the limited number of inspected properties. Where hail size was not extreme, the quantity of hail played a significant role. Governmental and third-party meteorological sources provide information about the maximum size of the hail; however, they are silent about the quantity. In portions of the storm path, large quantities of hail in the range of 1.25-1.75 inches was found to cause damage to virtually every asphalt shingle on the windward sides of some roofs.

Some progress appears to have been made in shingle application. There were no reports of more than one layer of shingles. Shingles installed over existing shingles are allowed by building codes and can be cost effective in areas not prone to hail, but double layers of shingles can become partially unsupported and then are more easily punctured by hail. (The IRC from 2000-2009 had prohibited re-covers in hail-prone areas, but this was removed in 2012.)

Although age was a factor in low-slope roofing performance, roof age was not significant when the hail was greater than 3.0 inches in diameter. About one third of the inspected low-slope roof covers were supported by a relatively high compressive strength substrate. Over 43% percent of the

membranes installed over low compressive substrates had significant damage and only 25% percent of the roof covers installed over high compressive strength substrates had damage. Modified bitumen roof covers installed directly over low compressive strength substrates have been found to be the system most prone to damage causing leaks in all three RICOWI hail investigations. Single-ply membranes generally had good performance with only a small number of roofs sustaining damage with less than 1.5 inch hail, and several performing adequately with 2.0 inch or larger hail.

7. FUTURE RESEARCH

Cooperation from building owners, industry organizations, and from insurers is critical to the success of this type of field investigation, and this has proved to be a challenge during our HIP investigations. More data about the roof types (particularly Impact-Resistant) and ages must be secured if new meaningful data can be obtained. Consideration could be given to developing a database in certain hail-prone metropolitan areas of Impact-Resistant roofs or roof permits from building departments so that the statistically critical roofs can be selected for inspection and analysis.

With three investigations complete the basics of hail damage and damage prevention are well known. The largest missing data is the difference in performance between Impact-Resistant and standard roofing products. This data may also be better obtained in a controlled environment setting, where the products can age naturally over many years.

8. REFERENCES

1. RICOWI, Inc., *Hailstorm Investigation Report, Oklahoma City, OK, April 21, 2004*, from http://www.ricowi.com

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3. CoreLogic, *Everything is Bigger in Texas-Hail Events 2016.* Retrieved August 16, 2016, from http://www.corelogic.com/about-us/researchtrends/everything-is-bigger-in-texas-hail-events-2016.aspx#

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6. Herzog, R. F., Marshall, T. P., *Protocol For Assessment of Hail-Damaged Roofing*, Proceedings of the North American Conference on Roofing Technology, 1999, Toronto, Canada.

7. FM Global, *Property Loss Prevention Data Sheets, 1-34; Hail Damage*, October 2014.

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B. Steep Slope Team Summary and Inspection Reports

C. Low Slope Team Summary and Inspection Reports

D. CoreLogic Reports

- **Map – *Courtesy of CoreLogic.***

E. Storm Event Data Reports *Courtesy of the National Climatic Data Center*

- ***Denton County***
- ***Collin County***
- ***Rockwall County***

F. RICOWI Hail Investigation Team

G. Acknowledgements

APPENDIX A: Inspection Summary Tables

And Charts

Summary of Steep Slope Inspections by Report Number

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
L2-2-1	2.5<3	4	Asphalt Shingles	Wylie
L3-3-D	>0.75<1	1	Asphalt Shingles	Denton
L3-3-A	1.25<1.5	2	Asphalt Shingles	Allen
L3-3-B	<0.75	2	Metal Roofing	Allen
L3-3-C	1.25<1.5	2	Metal Roofing	Allen
S-4-1-G	<0.75	0	Metal Roofing	Garland
S1-1-A	1.75<2	4	Asphalt Shingles	Sachse
S1-1-B	1.75<2	2	Metal Roofing	Sachse
S1-1-C	1.75<2	4	Asphalt Shingles	Sachse
S1-1-D	1<1.25	2	Asphalt Shingles	Sachse
S1-1-E	1.75<2	2	Asphalt Shingles	Wylie
S1-1-F	>0.75<1	0	Asphalt Shingles	Wylie
S1-2-F	<0.75	0	Asphalt Shingles	The Colony
S1-2-H	<0.75	0	Asphalt Shingles	The Colony
S1-2-J	<0.75	0	Asphalt Shingles	The Colony
S1-2-K	1<1.25	1	Asphalt Shingles	Sachse
S1-3-L	<0.75	0	Asphalt Shingles	Richardson
S1-3-L1	<0.75	0	Asphalt Shingles	Richardson
S1-3-M	>0.75<1	0	Asphalt Shingles	Richardson
S1-3-N	<0.75	0	Asphalt Shingles	Richardson
S1-3-O	<0.75	0	Asphalt Shingles	Richardson
S1-3-P	1.75<2	4	Asphalt Shingles	Richardson
S1-3-Q	1.25<1.5	4	Asphalt Shingles	Richardson
S1-3-R	1.25<1.5	0	Asphalt Shingles	Richardson
S1-3-S	1<1.25	4	Asphalt Shingles	Richardson
S2-1-A	1<1.25	1	Asphalt Shingles	Frisco
S2-1-B	<0.75	1	Asphalt Shingles	Frisco

Summary of Steep Slope Inspections by Report Number

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S2-1-D	2.5<3	4	Asphalt Shingles	Plano
S2-1-E	2.5<3	4	Asphalt Shingles	Plano
S2-1-F	<0.75	0	Asphalt Shingles	Plano
S2-2-G	1.5<1.75	1	Asphalt Shingles	Plano
S2-2-H	>1.25<1.5	1	Asphalt Shingles	Plano
S2-2-I	2.5<3	3	Asphalt Shingles	Plano
S2-2-J	2<2.25	3	Asphalt Shingles	Plano
S2-2-K	2<2.25	3	Asphalt Shingles	Plano
S2-2-L	1.5<1.75	3	Asphalt Shingles	Plano
S2-2-M	2<2.25	3	Asphalt Shingles	Plano
S2-2-N	2<2.25	3	Asphalt Shingles	Plano
S2-3-O	1.5<1.75	2	Asphalt Shingles	Plano
S2-3-P	>4	5	Asphalt Shingles	Wiley
S2-3-Q	1.5<1.75	3	Asphalt Shingles	Plano
S3-1-A	3<3.5	5	Asphalt Shingles	Wylie
S3-1-B	3<3.5	5	Asphalt Shingles	Wylie
S3-1-C	3<3.5	5	Metal Roofing	Wylie
S3-1-D	3.5<4.0	5	Cedar Shingles	Wylie
S3-1-E	3.5<4.0	5	Asphalt Shingles	Wylie
S3-1-F	3.5<4.0	4	Metal Roofing	Wylie
S3-1-G	1.75<2.0	4	Asphalt Shingles	Murphy
S3-2-L	1.25<1.5	3	Asphalt Shingles	Murphy
S3-2-M	1.25<1.5	3	Asphalt Shingles	Murphy
S3-2-O	1.5<1.75	3	Asphalt Shingles	Sachse
S3-2-P	1.5<1.75	4	Asphalt Shingles	Plano
S3-3-O	1.5<1.75	3	Metal Roofing	Denton
S4-1-A	>0.75<1	2	Concrete Tile	Garland
S4-1-B	<0.75	1	Asphalt Shingles	Garland
S4-1-C	1<1.25	3	Asphalt Shingles	Garland
S4-1-D	1.5<1.75	4	Asphalt Shingles	Garland

Summary of Steep Slope Inspections by Report Number

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S4-1-D	1.5<1.75	4	Asphalt Shingles	Garland
S4-1-E	<0.75	0	Asphalt Shingles	Garland
S4-1-F	<0.75	0	Metal Roofing	Garland
S4-1-G	<0.75	0	Asphalt Shingles	Garland
S4-1-H	1.5<1.75	4	Asphalt Shingles	Garland
S4-2-A	1.5<1.75	4	Asphalt Shingles	Murphy
S4-2-B	1.5<1.75	3	Asphalt Shingles	Murphy
S4-2-C	1.5<1.75	2	Asphalt Shingles	Murphy
S4-2-D	1.5<1.75	3	Asphalt Shingles	Murphy
S4-2-E	1.25<1.5	2	Asphalt Shingles	Murphy
S4-2-F	1.5<1.75	2	Asphalt Shingles	Murphy
S4-2-G	1.5<1.75	4	Asphalt Shingles	Murphy
S4-2-H	1.75<2	4	Asphalt Shingles	Murphy
S4-2-I	1.75<2	3	Asphalt Shingles	Murphy
S4-2-I	1.75<2	3	Asphalt Shingles	Murphy
S4-3-A	2<2.25	4	Asphalt Shingles	Wylie
S4-3-B	2<2.25	4	Asphalt Shingles	Wylie
S4-3-B	2<2.25	4	Asphalt Shingles	Wylie
S4-3-C	2<2.25	4	Asphalt Shingles	Wylie
S4-3-C1	2<2.25	4	Metal Roofing	Wylie
S4-3-D	1.5<1.75	2	Metal Roofing	Plano
S4-3-E	1.5<1.75	2	Metal Shingles	Plano
S4-3-F	1.5<1.75	2	Metal Roofing	Plano
S4-3-G	1.5<1.75	2	Metal Shingles	Plano
S5-1-A	>0.75<1	0	Asphalt Shingles	Allen
S5-1-A	<0.75	1	Asphalt Shingles	Allen
S5-1-B	>0.75<1	0	Asphalt Shingles	Allen
S5-1-C	<0.75	0	Asphalt Shingles	Allen
S5-1-D	<0.75	1	Asphalt Shingles	Allen

Summary of Steep Slope Inspections by Report Number

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S5-1-E	<0.75	0	Asphalt Shingles	Allen
S5-1-F	>0.75<1.0	2	Asphalt Shingles	Allen
S5-1-G	<0.75	0	Asphalt Shingles	Allen
S5-1-H	1.25<1.5	2	Asphalt Shingles	Allen
S5-1-I	<0.75	0	Asphalt Shingles	Allen
S5-1-J	<0.75	0	Asphalt Shingles	Allen
S5-1-K	<0.75	0	Asphalt Shingles	Allen
S5-1-L	<0.75	0	Asphalt Shingles	Allen
S5-2-A	1.25<1.5	3	Asphalt Shingles	Plano
S5-2-B	1.25<1.5	3	Asphalt Shingles	Sachse
S5-2-C	2.5<3	4	Asphalt Shingles	Wylie
S5-2-D	2.5<3	4	Asphalt Shingles	Wylie
S5-2-E	1<1.25	0	Asphalt Shingles	Wylie
S5-2-F	1.5<1.75	4	Asphalt Shingles	Wylie
S5-2-G	<0.75	1	Asphalt Shingles	Wylie
S5-3-0	<0.75	0	Asphalt Shingle	Lewisville
S5-3-A	<0.75	0	Asphalt Shingles	Lewisville
S5-3-B	<0.75	0	Asphalt Shingles	Lewisville
S5-3-C	<0.75	0	Asphalt Shingles	Lewisville
S5-3-D	<0.75	0	Asphalt Shingles	Lewisville
S5-3-E	<0.75	1	Asphalt Shingles	Lewisville
S5-3-G	<0.75	1	Asphalt Shingles	Lewisville
S5-3-H	<0.75	0	Asphalt Shingles	Lewisville
S5-3-I	<0.75	0	Asphalt Shingles	Lewisville
S5-3-J	<0.75	0	Asphalt Shingles	Lewisville
S5-3-K	<0.75	1	Asphalt Shingles	Lewisville
S5-3-L	<0.75	1	Asphalt Shingles	Lewisville
S5-3-M	<0.75	1	Asphalt Shingles	Lewisville
S5-3-N	<0.75	0	Asphalt Shingles	Lewisville

Summary of Low Slope Inspections by Report Number

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
L1-1-A	3.5	2	Built Up Roof	Wylie
L1-1-B	3.5	1	Built Up Roof	Wylie
L1-1-C	2	5	Single Ply	Wylie
L1-2-D	1	0	Single Ply	Allen
L1-2-E	0.75	0	Single Ply	Allen
L1-2-E (b)	3.5	5	Metal	Wylie
L1-2-F	3.5	5	Single Ply	Wylie
L1-2-G	2.5	5	Metal	Wylie
L2-1-A	3	5	Modified Bitumen	Wylie
L2-1-B	2.5	5	Wood Shingles	Wylie
L2-1-C	2.5	5	Modified Bitumen	Wylie
L2-1-D	2.5	5	Single Ply	Wylie
L2-1-E	2	1	Single Ply	Wylie
L2-1-F	2.5	1	Built-Up	Wylie
L2-1-G	2	3	Metal	Wylie
L2-2-B	2	1	Single Ply	Wylie
L2-2-C	0.75	1	Single Ply	Wylie
L2-2-D	0.5	0	Single Ply	McKinney
L2-3-1	1.5	5	Modified Bitumen	Wylie
L3-1-A	1.25	1	Modified Bitumen	Garland
L3-1-B	1.25	2	Metal	Garland
L3-1-C	1.25	1	Built Up Roof	Garland
L3-1-D	0.25	0	Modified Bitumen	Garland
L3-2-A	1.5	1	Built Up Roof	Plano
L3-2-B	1.5	3	Built Up Roof	Plano
L3-4-I	1.25	0	Metal	Parker
L4-1-A	1.5	5	Sprayed Polyurethane Foam	Plano
L4-1-B	1.5	1	Single Ply	Plano
L4-1-C	1.5	3	Built Up Roof	Plano

Summary of Low Slope Inspections by Report Number Sites

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
L4-1-D	1.5	0	Built Up Roof	Plano
L4-1-E	1.5	5	Modified Bitumen	Plano
L4-1-F	1.25	5	Single Ply	Garland
L4-1-G	3	2	Single Ply	Wylie
L4-1-H	1	0	Single Ply	Garland
L4-1-I	0.25	0	Single Ply	Rowlett
L4-2-A	0.75	0	Single Ply	Richardson
L4-2-B	0.75	0	Built Up Roof	Garland
L4-2-D	0.75	1	Metal	Sachse
L4-2-E	4	5	Modified Bitumen	Wylie
L4-2-F	4	3	Built Up Roof	Wylie
L4-2-H	3	5	Modified Bitumen	Wylie
L4-2-I	3.5	5	Single Ply	Wylie
L4-2-J	4	5	Single Ply	Wylie
L4-3-A	1	1	Single Ply	Plano
L4-3-B	1.25	1	Modified Bitumen	Plano
L4-3-C	1.25	3	Modified Bitumen	Plano
L4-3-D	1.25	1	Single Ply	Plano
L4-3-E	1	1	Single Ply	Plano
L4-3-F	2.5	3	Single Ply	Wylie
L4-3-G	1	1	Single Ply	Wylie
L4-3-H	0.75	1	Single Ply	Wylie
L4-3-J	3.5	5	Metal	Wylie
L4-3-K	1.5	1	Single Ply	Sachse
L5-1-A	1.5	5	Single Ply	Plano
S3-1-H	1.25	1	Modified Bitumen	Murphy
S3-1-I	1.25	1	Modified Bitumen	Murphy
S3-1-J	1.25	1	Modified Bitumen	Murphy
S3-1-K	1.5	1	Modified Bitumen	Murphy
S3-2-N	1.25	1	Single Ply	Murphy

Summary of Steep Slope by Roof Types and Hail Size

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S5-3-0	<0.75	0	Asphalt Shingles	Lewisville
S1-2-F	<0.75	0	Asphalt Shingles	The Colony
S1-2-H	<0.75	0	Asphalt Shingles	The Colony
S1-2-J	<0.75	0	Asphalt Shingles	The Colony
S1-3-L	<0.75	0	Asphalt Shingles	Richardson
S1-3-L1	<0.75	0	Asphalt Shingles	Richardson
S1-3-N	<0.75	0	Asphalt Shingles	Richardson
S1-3-O	<0.75	0	Asphalt Shingles	Richardson
S2-1-B	<0.75	1	Asphalt Shingles	Frisco
S2-1-C	<0.75	1	Asphalt Shingles	Frisco
S2-1-F	<0.75	0	Asphalt Shingles	Plano
S4-1-B	<0.75	1	Asphalt Shingles	Garland
S4-1-E	<0.75	0	Asphalt Shingles	Garland
S4-1-G	<0.75	0	Asphalt Shingles	Garland
S5-1-A	<0.75	1	Asphalt Shingles	Allen
S5-1-C	<0.75	0	Asphalt Shingles	Allen
S5-1-D	<0.75	1	Asphalt Shingles	Allen
S5-1-E	<0.75	0	Asphalt Shingles	Allen
S5-1-F	<0.75	2	Asphalt Shingles	Allen
S5-1-G	<0.75	0	Asphalt Shingles	Allen
S5-1-I	<0.75	0	Asphalt Shingles	Allen
S5-1-J	<0.75	0	Asphalt Shingles	Allen
S5-1-K	<0.75	0	Asphalt Shingles	Allen
S5-1-L	<0.75	0	Asphalt Shingles	Allen
S5-2-G	<0.75	1	Asphalt Shingles	Wylie
S5-3-A	<0.75	0	Asphalt Shingles	Lewisville
S5-3-B	<0.75	0	Asphalt Shingles	Lewisville
S5-3-C	<0.75	0	Asphalt Shingles	Lewisville

Summary of Steep Slope by Roof Types and Hail Size

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S5-3-D	<0.75	0	Asphalt Shingles	Lewisville
S5-3-E	<0.75	1	Asphalt Shingles	Lewisville
S5-3-G	<0.75	1	Asphalt Shingles	Lewisville
S5-3-H	<0.75	0	Asphalt Shingles	Lewisville
S5-3-I	<0.75	0	Asphalt Shingles	Lewisville
S5-3-J	<0.75	0	Asphalt Shingles	Lewisville
S5-3-K	<0.75	1	Asphalt Shingles	Lewisville
S5-3-L	<0.75	1	Asphalt Shingles	Lewisville
S5-3-M	<0.75	1	Asphalt Shingles	Lewisville
S5-3-N	<0.75	0	Asphalt Shingles	Lewisville
L3-3-	>0.75<1	1	Asphalt Shingles	Denton
S1-1-F	>0.75<1	0	Asphalt Shingles	Wylie
S1-3-M	>0.75<1	0	Asphalt Shingles	Richardson
S5-1-A	>0.75<1	0	Asphalt Shingles	Allen
S5-1-B	>0.75<1	0	Asphalt Shingles	Allen
S5-1-H	>0.75<1	2	Asphalt Shingles	Allen
S5-2-B	>0.75<1	3	Asphalt Shingles	Sachse
S1-1-D	1.0<1.25	2	Asphalt Shingles	Sachse
S1-2-K	1.0<1.25	1	Asphalt Shingles	Sachse
S1-3-S	1.0<1.25	4	Asphalt Shingles	Richardson
S2-1-A	1.0<1.25	1	Asphalt Shingles	Frisco
S4-1-C	1.0<1.25	3	Asphalt Shingles	Garland
S5-2-E	1.0<1.25	0	Asphalt Shingles	Wylie
L3-3-A	1.25<1.5	2	Asphalt Shingles	Allen
S1-3-Q	1.25<1.5	4	Asphalt Shingles	Richardson
S1-3-R	1.25<1.5	0	Asphalt Shingles	Richardson
S3-2-L	1.25<1.5	3	Asphalt Shingles	Murphy
S3-2-M	1.25<1.5	3	Asphalt Shingles	Murphy
S4-2-E	1.25<1.5	2	Asphalt Shingles	Murphy
S5-2-A	1.25<1.5	3	Asphalt Shingles	Plano
S2-2-H	1.5<1.75	1	Asphalt Shingles	Plano
S2-2-G	1.5<1.75	1	Asphalt Shingles	Plano

Summary of Steep Slope by Roof Types and Hail Size

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
S2-2-L	1.5<1.75	3	Asphalt Shingles	Plano
S2-3-O	1.5<1.75	2	Asphalt Shingles	Plano
S2-3-Q	1.5<1.75	3	Asphalt Shingles	Plano
S3-2-O	1.5<1.75	3	Asphalt Shingles	Sachse
S3-2-P	1.5<1.75	4	Asphalt Shingles	Plano
S4-1-D	1.5<1.75	4	Asphalt Shingles	Garland
S4-1-H	1.5<1.75	4	Asphalt Shingles	Garland
S4-2-A	1.5<1.75	4	Asphalt Shingles	Murphy
S4-2-B	1.5<1.75	3	Asphalt Shingles	Murphy
S4-2-C	1.5<1.75	2	Asphalt Shingles	Murphy
S4-2-D	1.5<1.75	3	Asphalt Shingles	Murphy
S4-2-F	1.5<1.75	2	Asphalt Shingles	Murphy
S4-2-G	1.5<1.75	4	Asphalt Shingles	Murphy
S5-2-F	1.5<1.75	4	Asphalt Shingles	Wylie
S1-1-A	1.75<2	4	Asphalt Shingles	Sachse
S1-1-B	1.75<2	2	Asphalt Shingles	Sachse
S1-1-E	1.75<2	2	Asphalt Shingles	Wylie
S1-3-P	1.75<2	4	Asphalt Shingles	Richardson
S4-2-H	1.75<2	4	Asphalt Shingles	Murphy
S4-2-I	1.75<2	3	Asphalt Shingles	Murphy
S4-2-I	1.75<2	3	Asphalt Shingles	Murphy
S3-1-G	1.75<2.0	4	Asphalt Shingles	Murphy
S2-2-J	2.0<2.25	3	Asphalt Shingles	Plano
S2-2-K	2.0<2.25	3	Asphalt Shingles	Plano
S2-2-M	2.0<2.25	3	Asphalt Shingles	Plano
S2-2-N	2.0<2.25	3	Asphalt Shingles	Plano
S4-3-A	2.0<2.25	4	Asphalt Shingles	Wylie
S4-3-B	2.0<2.25	4	Asphalt Shingles	Wylie
S4-3-C	2.0<2.25	4	Asphalt Shingles	Wylie

Summary of Steep Slope by Roof Types and Hail Size

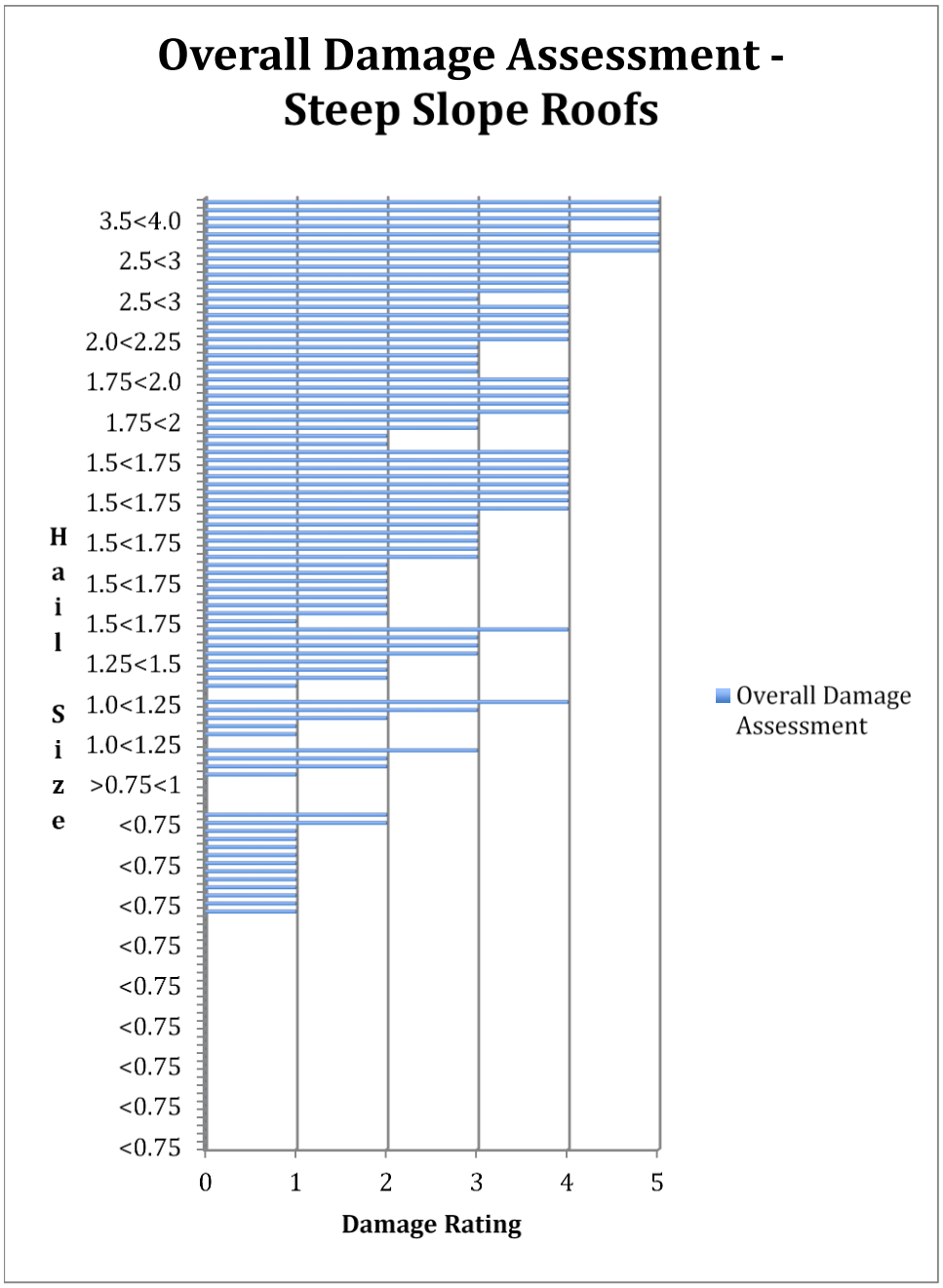
Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage Assessment [Rating]	Roof Cover Category	City
L2-2-1	2.5<3	4	Asphalt Shingles	Wylie
S2-1-D	2.5<3	4	Asphalt Shingles	Plano
S2-1-E	2.5<3	4	Asphalt Shingles	Plano
S2-2-I	2.5<3	3	Asphalt Shingles	Plano
S5-2-C	2.5<3	4	Asphalt Shingles	Wylie
S5-2-D	2.5<3	4	Asphalt Shingles	Wylie
S3-1-A	3<3.5	5	Asphalt Shingles	Wylie
S3-1-B	3<3.5	5	Asphalt Shingles	Wylie
S3-1-E	3<4.0	5	Asphalt Shingles	Wylie
S2-3-P	4.0<5	5	Asphalt Shingles	Wylie
S3-1-D	3.5<4.0	5	Cedar Shingles	Wylie
S4-1-A	>0.75<1	2	Concrete Tile	Garland
L3-3-B	<0.75	2	Metal Roofing	Allen
S-4-1-G	<0.75	0	Metal Roofing	Garland
S4-1-F	<0.75	0	Metal Roofing	Garland
L3-3-C	1.25<1.5	2	Metal Roofing	Allen
S3-3-O	1.5<1.75	3	Metal Roofing	Denton
S4-3-D	1.5<1.75	2	Metal Roofing	Plano
S4-3-E	1.5<1.75	2	Metal Roofing	Plano
S4-3-F	1.5<1.75	2	Metal Roofing	Plano
S4-3-G	1.5<1.75	2	Metal Roofing	Plano
S1-1-C	1.75<2	4	Metal Roofing	Sachse
S4-3-C1	2<2.25	4	Metal Roofing	Wylie
S3-1-C	3.0<3.5	5	Metal Roofing	Wylie
S3-1-F	3.5<4.0	4	Metal Roofing	Wylie

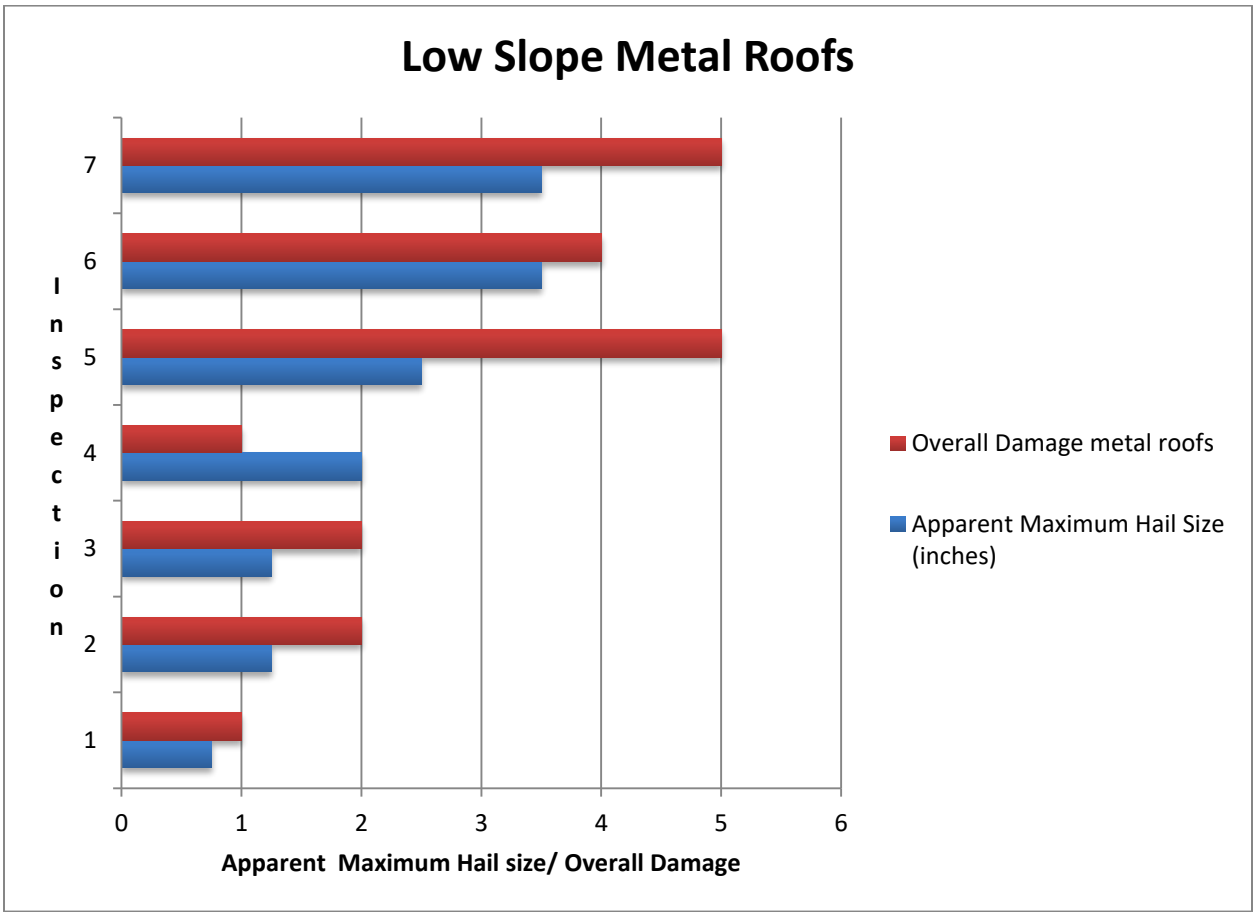
Summary of Low Slope by Roof Types and Hail Size

Inspection Number	Apparent Maximum Hail Size (inches)	Overall Damage-	Roof Cover Type	City
L3-1-C	1.25	1	Built Up Roof	Garland
L4-2-B	0.75	0	Built Up Roof	Garland
L3-2-A	1.5	1	Built Up Roof	Plano
L3-2-B	1.5	3	Built Up Roof	Plano
L4-1-C	1.5	3	Built Up Roof	Plano
L4-1-D	1.5	0	Built Up Roof	Plano
L1-1-A	3.5	2	Built Up Roof	Wylie
L1-1-B	3.5	1	Built Up Roof	Wylie
L4-2-F	4	3	Built Up Roof	Wylie
L2-1-F	2.5	1	Built-Up Roof	Wylie
L3-1-B	1.25	2	Metal	Garland
L3-4-I	1.25	2	Metal	Parker
L4-2-D	0.75	1	Metal	Sachse
L1-2-G	2.5	5	Metal	Wiley
L1-2-E	3.5	4	Metal	Wylie
L2-1-G	2	1	Metal	Wylie
L4-3-J	3.5	5	Metal	Wylie
L3--1-D	<0.25	0	Modified Bitumen	Garland
L3-1-A	1.25	1	Modified Bitumen	Garland
L3-1-C	<0.25	0	Modified Bitumen	Garland
S3-1-H	1.25	1	Modified Bitumen	Murphy
S3-1-I	1.25	1	Modified Bitumen	Murphy
S3-1-J	1.25	1	Modified Bitumen	Murphy
S3-1-K	1.5	1	Modified Bitumen	Murphy
L4-1-E	1.5	5	Modified Bitumen	Plano
L4-3-B	1.25	1	Modified Bitumen	Plano
L4-3-C	1.25	3	Modified Bitumen	Plano
L2-1-A	3	5	Modified Bitumen	Wylie
L2-1-C	2.5	5	Modified Bitumen	Wylie
L2-3-1	1.5	5	Modified Bitumen	Wylie

Summary of Low Slope by Roof Types and Hail Size

Team Number, Day & Inspection Number	Apparent Maximum Hail Size (inches)]	Overall Damage	Roof Cover Category	City
L4-2-E	4	5	Modified Bitumen	Wylie
L4-2-H	3	5	Modified Bitumen	Wylie
L1-2-D	1	0	Single Ply	Allan
L1-2-E	0.75	0	Single Ply	Allan
L4-1-F	1.25	5	Single Ply	Garland
L4-1-H	1	0	Single Ply	Garland
L4-1-I	1	0	Single Ply	Garland
L2-2-D	0.5	0	Single Ply	McKinney
S3-2-N	1.25	1	Single Ply	Murphy
L4-1-B	1.5	1	Single Ply	Plano
L4-3-A	1	1	Single Ply	Plano
L4-3-D	1.25	1	Single Ply	Plano
L4-3-E	1	1	Single Ply	Plano
L5-1-A	1.5	5	Single Ply	Plano
L4-2-A	0.75	0	Single Ply	Richardson
L4-1-I	<0.25	0	Single Ply	Rowlett
L4-3-K	1.5	1	Single Ply	Sachse
L1-1-C	2	5	Single Ply	Wylie
L1-2-F	3.5	5	Single Ply	Wylie
L2-1-D	2.5	5	Single ply	Wylie
L2-1-E	2	1	Single ply	Wylie
L2-2-B	2	1	Single Ply	Wylie
L2-2-C	0.75	1	Single Ply	Wylie
L4-1-G	3	2	Single Ply	Wylie
L4-2-I	3.5	5	Single Ply	Wylie
L4-2-J	4	5	Single Ply	Wylie
L4-3-F	2.5	3	Single Ply	Wylie
L4-3-G	1	1	Single Ply	Wylie
L4-3-H	0.75	1	Single Ply	Wylie
L4-1-A	1.5	5	Spray Polyurethane Foam	Plano
L2-1-B	2.5	5	Wood Shingles	Wylie


Overall Damage Assessment - Steep Slope Roofs
Hail Size
3.5<4.0
2.5<3
2.5<3
2.0<2.25
1.75<2.0
1.75<2
1.5<1.75
1.5<1.75
1.5<1.75
1.5<1.75
1.5<1.75
1.25<1.5
1.0<1.25
1.0<1.25
>0.75<1
<0.75
<0.75
<0.75
<0.75
<0.75
<0.75
<0.75
<0.75
<0.75
0
1
2
3
4
5
Damage Rating
Overall Damage Assessment


Low Slope Metal Roofs
Inspection
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Apparent Maximum Hail size/ Overall Damage
Overall Damage metal roofs
Apparent Maximum Hail Size (inches)

RICOWI Hailstorm Investigation
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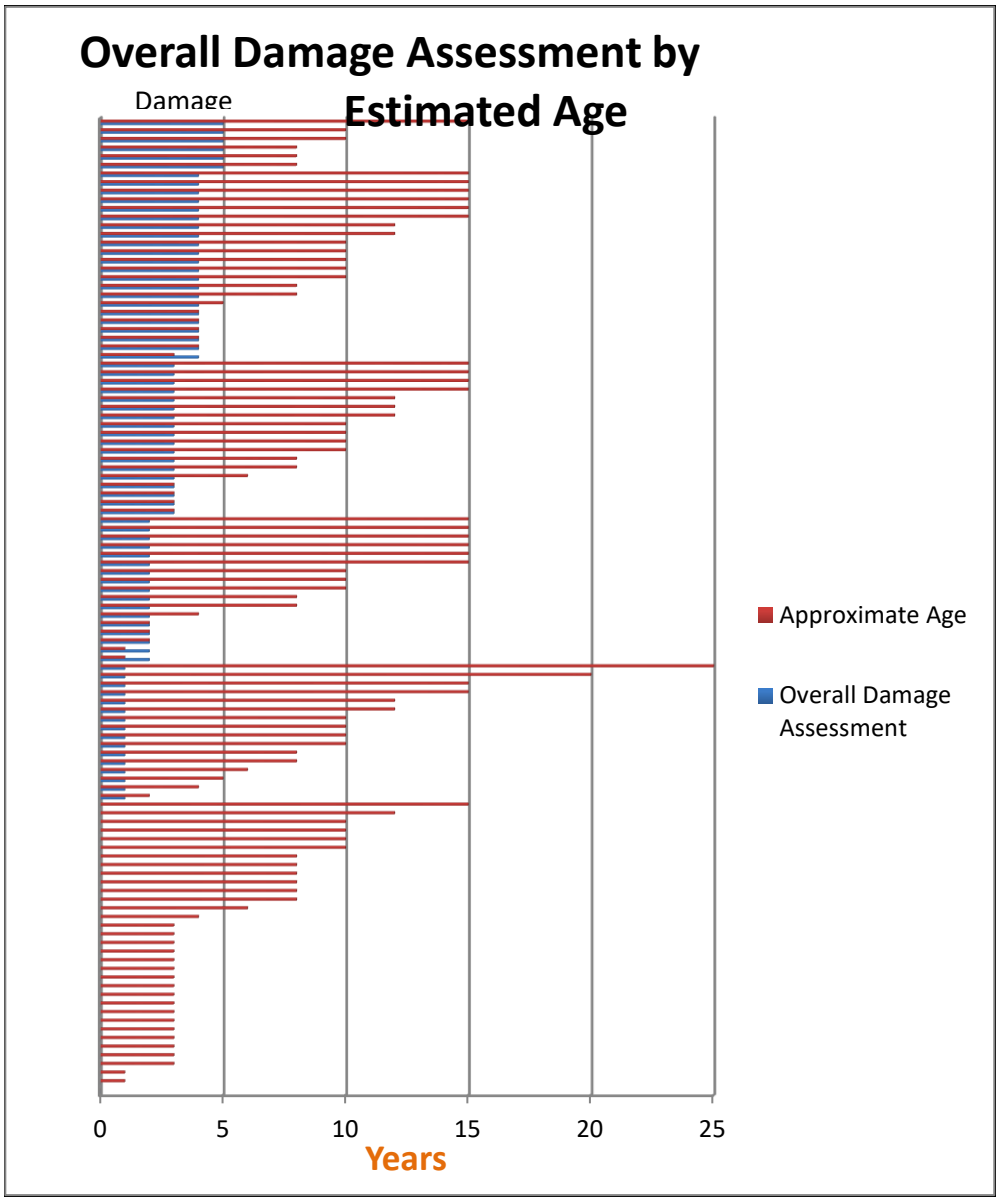

Substrate vs Damage Report

Inspection Number	Substrate Directly under membrane	Apparent Maximum Hail Size (inches)	Overall Damage
L2-1-F	Unknown	2.5	1
L3-1-D	High Compressive	0.25	0
L3-1-C	High Compressive	0.25	0
L4-1-I	High Compressive	0.25	0
L2-2-D	High Compressive	0.5	0
L1-2-E	High Compressive	0.75	0
L2-2-C	High Compressive	0.75	1
L4-2-A	High Compressive	0.75	0
L1-2-D	High Compressive	1	0
L4-3-E	High Compressive	1	1
L3-1-A	High Compressive	1.25	1
L4-1-F	High Compressive	1.25	5
S3-1-I	High Compressive	1.25	1
S3-1-J	High Compressive	1.25	1
L3-2-A	High Compressive	1.5	1
L3-2-B	High Compressive	1.5	3
L4-1-B	High Compressive	1.5	1
L5-1-A	High Compressive	1.5	5
S3-1-K	High Compressive	1.5	1
L1-1-C	High Compressive	2	5
L2-1-E	High Compressive	2	1
L2-2-B	High Compressive	2	1
L4-3-F	High Compressive	2.5	3
L4-2-B	Low Compressive	0.75	0
L4-2-D	Low Compressive	0.75	0
L4-3-H	Low Compressive	0.75	1

Substrate vs Damage Report

Inspection Number	Substrate Directly under membrane	Apparent Maximum Hail Size (inches)	Overall Damage
L4-1-H	Low Compressive	1	0
L4-1-I	Low Compressive	1	0
L4-3-A	Low Compressive	1	1
L4-3-G	Low Compressive	1	1
L3-1-3	Low Compressive	1.25	1
L3-1-B	Low Compressive	1.25	2
L3-4-I	Low Compressive	1.25	0
L4-3-B	Low Compressive	1.25	1
L4-3-C	Low Compressive	1.25	3
L4-3-D	Low Compressive	1.25	1
S3-1-H	Low Compressive	1.25	1
S3-2-N	Low Compressive	1.25	1
L2-3-1	Low Compressive	1.5	5
L4-1-A	Low Compressive	1.5	5
L4-1-C	Low Compressive	1.5	3
L4-1-D	Low Compressive	1.5	0
L4-1-E	Low Compressive	1.5	5
L4-3-K	Low Compressive	1.5	1
L1-2-G	Low Compressive	2.5	0
L2-1-D	Low compressive	2.5	5
L2-1-A	Low Compressive	3	5
L4-1-G	Low Compressive	3	2
L4-2-H	Low Compressive	3	5
L1-1-A	Low Compressive	3.5	2
L1-1-B	Low Compressive	3.5	1

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	Substrate Directly under membrane	Apparent Maximum Hail Size (inches)	Damage	Overall
L1-2-E(b)	Low Compressive	3.5		4
L1-2-F	Low Compressive	3.5		5
L4-2-I	Low Compressive	3.5		5
L4-3-J	Low Compressive	3.5		5
L4-2-E	Low Compressive	4		5
L4-2-F	Low Compressive	4		3
L4-2-J	Low Compressive	4		5
L2-1-C	Unknown	2.5		5
L2-1-G	Unknown	2		1
L2-1-B	Unknown	2.5		5

- **Two older roofs had high damage over compressive substrate**
- **One roof older than 15years had substantial damage over high compressive substrate**
- **Twelve roofs had high damage over low compressive substrate**
- **Three roofs had substantial damage over low compressive substrate**

RICOWI Hailstorm Investigation
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Appendix B:

Team Summary Reports and Steep Slope Inspection Reports

The individual site selections in both the steep and low slope section of this document do not include all of the investigations conducted by the RICOWI Hail Investigation Teams during this period. The included sites were selected for inclusion based on the following characteristics: relatively large hail; significant damage; or interesting information.

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 1 Steep Slope Summary Report

Overview

Team S1 observed and evaluated 18 roofs in total. There were a number of addresses where we were denied access. We also reviewed representative roofs in sections of towns.

The roof types were as follows:

- 13 Laminate composite asphalt, (one was a Class 4 hail resistant)
- 4 - 3-tab asphalt
- 1 corrugated panel

Day 1 included observations at two large apartment complexes in Sachse and Wylie. The Wylie was under construction and there were about 20 buildings on the site. At Sachse there was 35 Buildings on site and we evaluated 3 buildings with laminate asphalt shingles and one carport with corrugated metal panels.

Damage was extensive in Sachse location. We checked three different types of buildings widely dispersed in the complex. Extensive damage was found on all with most found on the west and north slopes. Damage consisted of fractures and bruising. None of the underlying courses were damaged by the hail impacts, only the upper covering shingles.
Wylie buildings were only a half to ¾ mile from the Sachse buildings and the findings were minimal damage to no damage.

Day 2 started in The Colony, Texas. We checked three buildings with 3-tab asphalt composite shingles. No damage found but we found up to 0.5” spatter marks on metal. Scouting the area for damage found no other hail indicators that appeared to indicate hail damage. We then scouted Little Elm in the afternoon with using the Hail Map that showed a potential 1.5-1.75” hail. Scouting south to north and east to west found no indicators. Residents indicated there was nothing more than “pea size”. Spatter marks were typically 0.25-0.5”, no damage found and we were located in the center of the largest ring of hail sizes on the Hail Map.

Day 3 the team was in Richardson, Texas. We started out near the west side near the University of Texas. None of the 4 we found on the west side in a cluster of 7 addresses had any hail damage. Although there were a number of roofers that had apparently sold roof replacements in the area. Spatter marks were all 0.25-0.5”.

There was a cluster of roofs on the east side of Richardson that were checked and we found damage to roof coverings on all but one. The roofs that were damaged were laminated asphalt roofs. The hail sizes were from 1.0”-1.75”. Damage was typically found on all slopes except the east slope. A high number of damage hits were found. Damages consisted of fractures, bruising and granular loss.

Some buildings consisted of ancillary areas with low slope roof membranes. No damage to those membranes were found in our investigations.

Collateral damages
Roofs that were damaged that had acrylic skylights were typically damaged. Metal vent covers were heavily damaged in Sachse and Richardson. Plastic vent covers were largely undamaged from hail impacts. Prefinished aluminum downspouts were dented in Sachse and Wylie and Richardson.

Experiences

By the last day we learned how to be more efficient and produce more results. Many of the places had issues with us ascending their roof. When this happened we’d cold call a nearby location and had moderate success until the afternoon of the last day. I think my teammates were looking too grubby.

We approached Richardson by entering the addresses with a label in Google Maps. We arranged a schedule to visit based on proximity and dispersion. We didn’t find much on the west side of Richardson. While we had 7 places in this area, we started at the upper end on the west side; found nothing. The next one we visited was the west end of the same cluster. Still nothing. We went south from there and checked another near the middle and found nothing. Finally we went on the lower east side of the western cluster and found nothing. We decided there wasn’t much value in checking the other three since we had those surrounded.

The next set of efforts were on the eastern side of Richardson and found more damage. We approached it similarly, except we were looking for the edges of the damage and different roof types. We didn’t have as much luck finding people to let us on their roof.

We spent some time scouting for damage areas on the second day after finding nothing. We used the Hail map to target the Little Elm area and found the maps were not consistent with found hail indicators and people’s experiences were. We also checked an area of Sachse where hail maps indicated there was heavy hail and only found small hail indicators on electric boxes and fences. There was also few, if any, tarped roofs and Roofing Contractors signs in these areas.

We were able to assess several roofs where there was a number of roofs under contract to be removed but our findings didn't support the level of damage or in several cases; any damage to the roofs in the immediate vicinity.

SUGGESTIONS

I would think that a team of 2 could scout for damage indicators using the Hail Map as guidance. The goal would be to find the actual areas where there is activity and damage and then radiate outward. Indicators on fences and electric boxes can be used. Local fire and police may also be able to tell us the areas where the larger hails hit and then evaluate the map for directions to check and then scout out those areas.

It was interesting to find that there was substantial impact damage to areas that were South of the main areas shown on the hail map (Plano and Richardson) whereas Sachse had less intense damage than expected based on the Hail Mapping.

Teams of 2 may be enough on inspections for steep slope. Having a hail map is helpful.

Team Members

Jeffery A. Cissell PE – Data recorder, inspections
Brett Cholewa, RRO – Photo, inspections
Robert White, RRO – Shingle technical advisor

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 1 Data Reports and Photographs
Steep Slope Inspection Site

Inspection Number	**S1-1-A**
Site Latitude	**33.0927**
Site Longitude	**-96.6796**
Area Size (Square feet)	**9500**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.75<2**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, puncture**
Comments Regarding Inspection	**Probably hard hail, good dents in copper with nice imprints** **Slopes facing wind direction over 200/square/ opposing side had 32/square**

RICOWI Hailstorm Investigation
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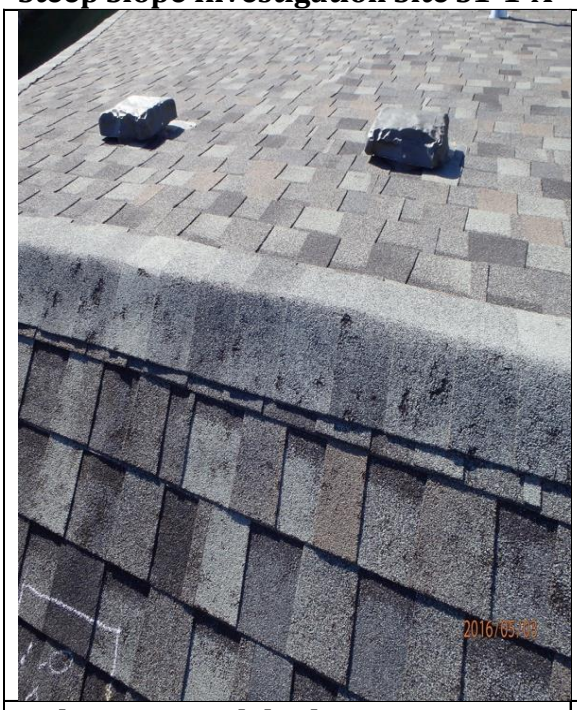
Steep Slope Investigation Site S1-1-A



Ridge units with hailstone impact damage. Note: Damaged vent covers.

Field units within west slope contain hailstone impact damage.

Fracture in mat due to hailstone impact. Note: ~2.00”

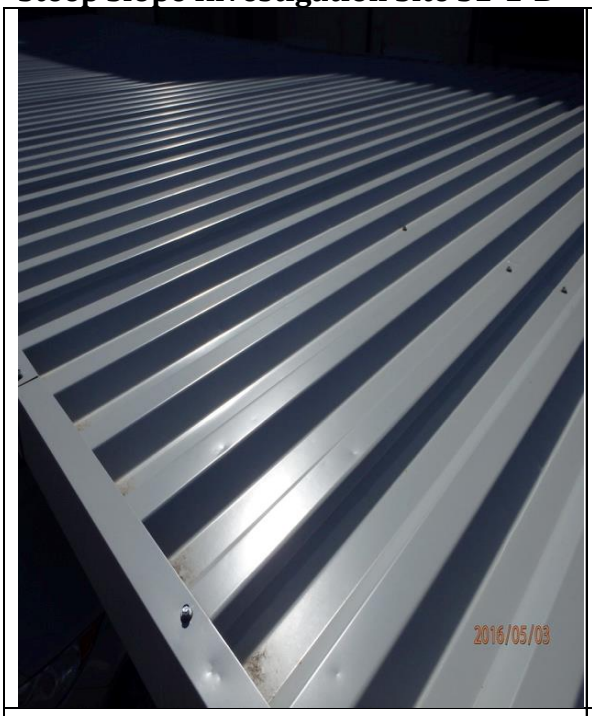
View of backside of mat at abrasion in previous photo.

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

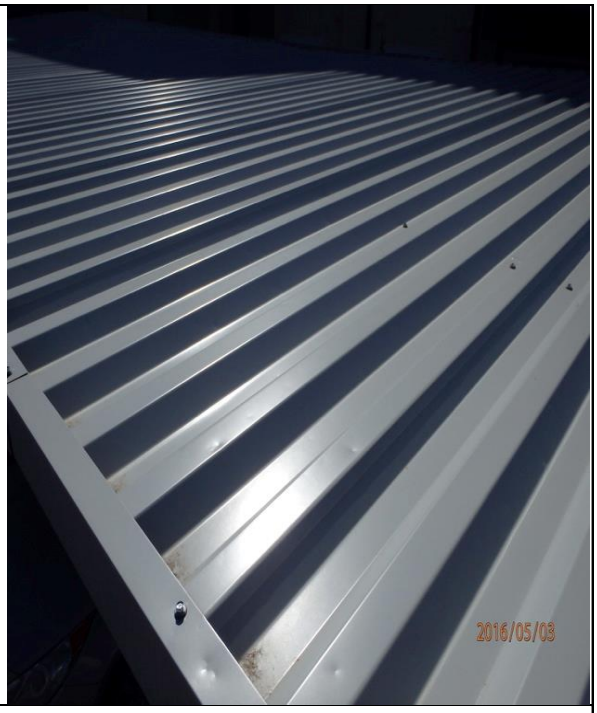
Steep Slope Inspection Site

Inspection Number	**S1-1-B**
Site Latitude	**33.0927**
Site Longitude	**-96.6796**
Area Size (Square feet)	**1000**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**3<4**
Roof Type	
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.75<2**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**No**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Dent (metal roofing)**
Comments Regarding Inspection	**Some vertical metal dented**

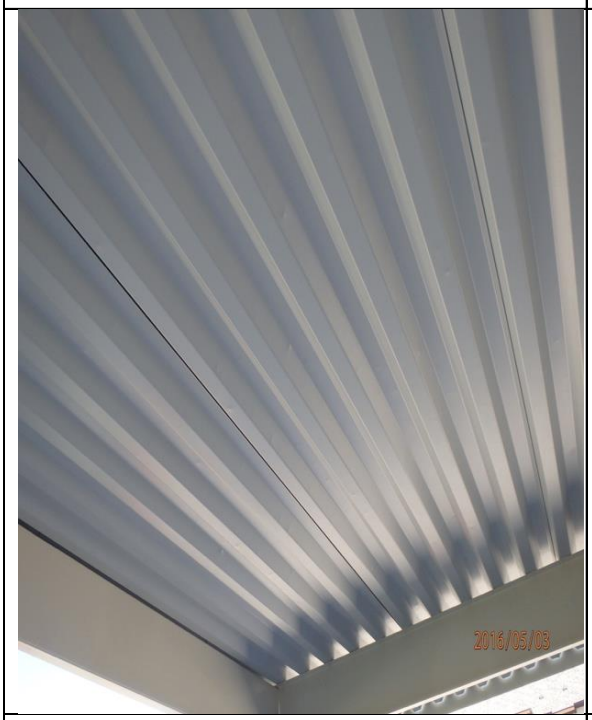
Steep Slope Investigation Site S1-1-B



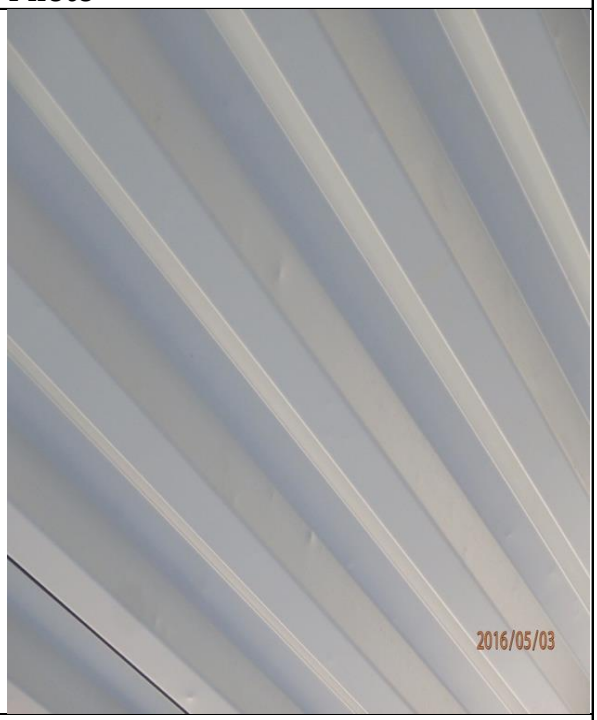
Close-Up of Dimples on Panel Surface



Close Up of Dimples from Previous Photo



Dimples on Underside of Panels



Close Up of Dimples

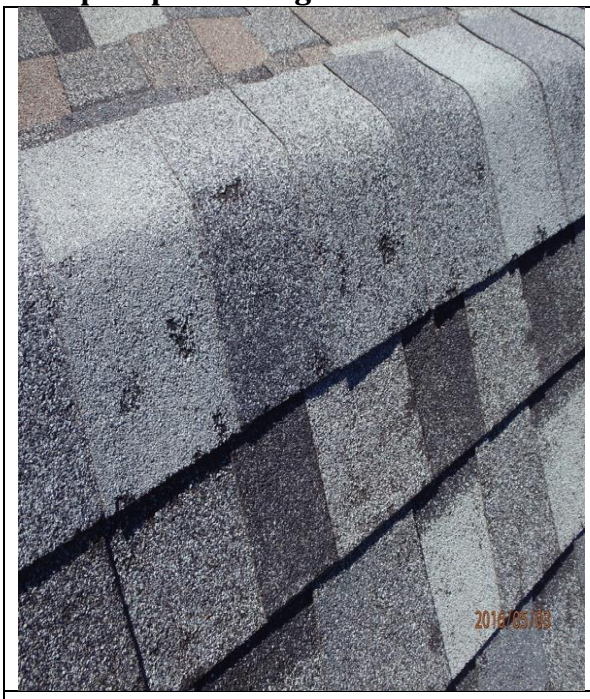
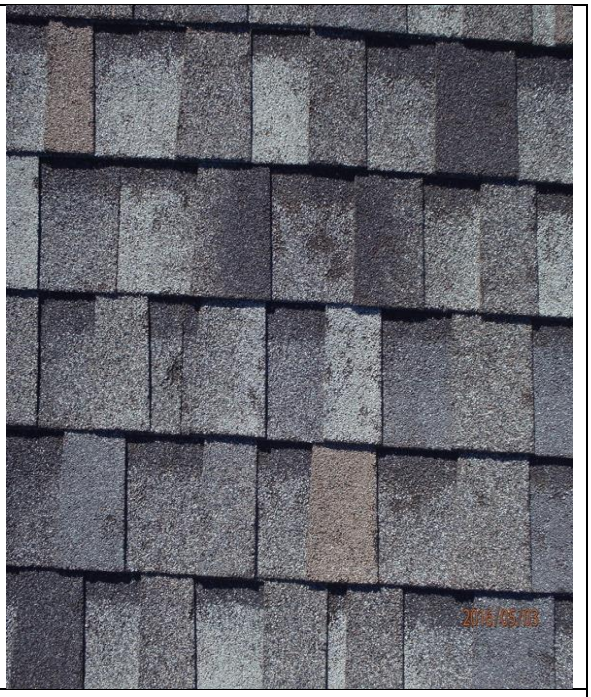
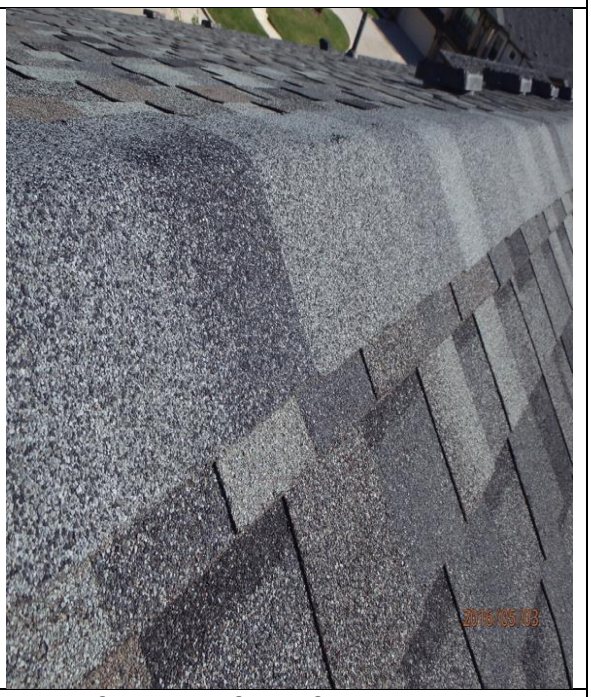
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S1-1-C**
Site Latitude	**32.5927**
Site Longitude	**-96.3434**
Area Size (Square feet)	**6000**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.75<2**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture, Bruised and fractured**
Comments Regarding Inspection	**North and west slopes severely damaged**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Investigation Site S1-1-C

	
Hailstone impact damage to ridge units. Note: North facing surface	**Damaged field units on north slope**
	
Damage with scale	**South facing surface of ridge units contain no damage**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S1-1-D**
Site Latitude	**32.5902**
Site Longitude	**-96.3353**
Area Size (Square feet)	**2800**
Approximate Age (Years)	**>15**
General Condition	**Fair**
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1<1.25**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Bruised and fractured ridge**
Comments Regarding Inspection	**Aged, more than 50% granule loss** **3 yrs remaining service life** **Only moderately affected west slope affected**

RICOWI Hailstorm Investigation
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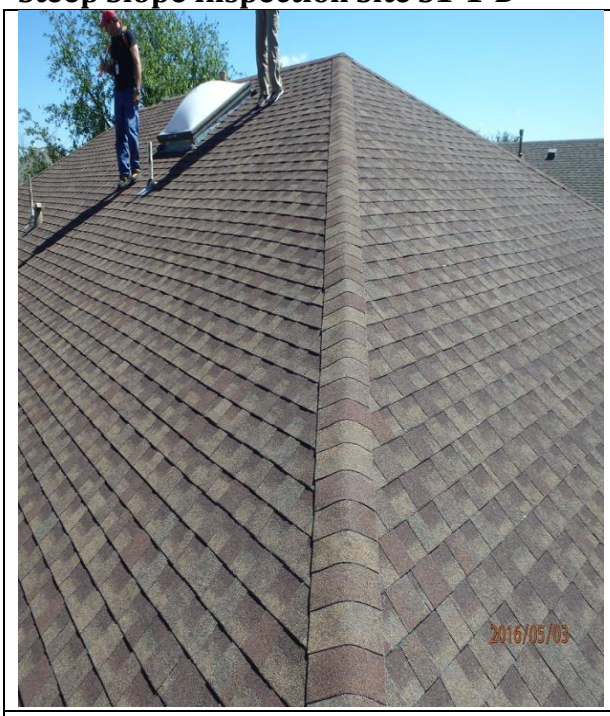
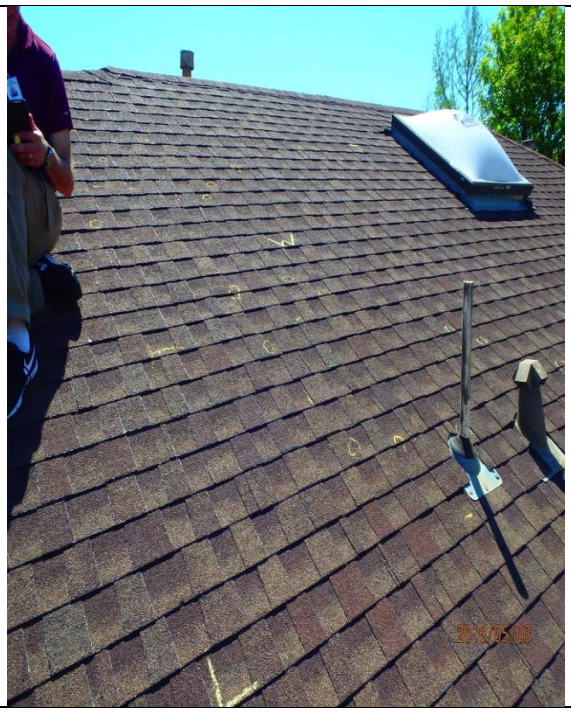
Steep Slope Inspection Site S1-1-D



Hip units with no damage



Damaged to units on west facing slope

Abrasion with scale. Note: ~1.00”

Granule loss due to natural weathering (typical).

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S1-3-P**
Site Latitude	**32.5912**
Site Longitude	**-96.4042**
Area Size (Square feet)	**4300**
Approximate Age (Years)	**12<15**
General Condition	
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.75<2**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**All slopes major damage except east (leeward side)**

RICOWI Hailstorm Investigation
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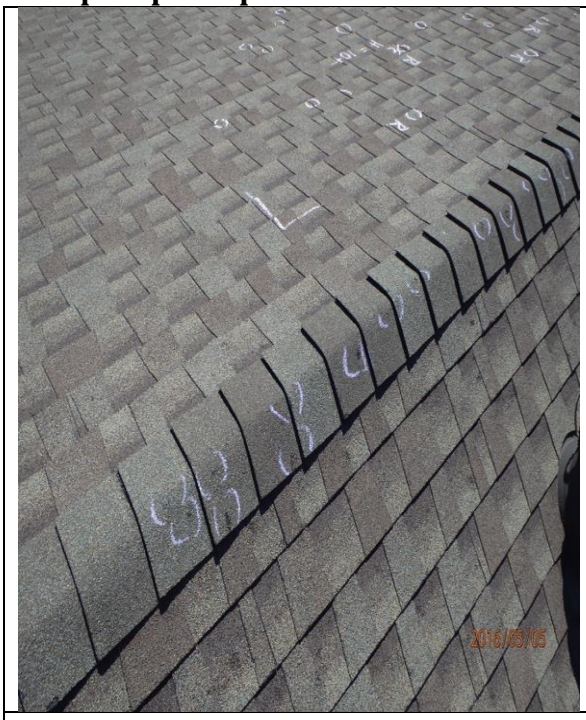
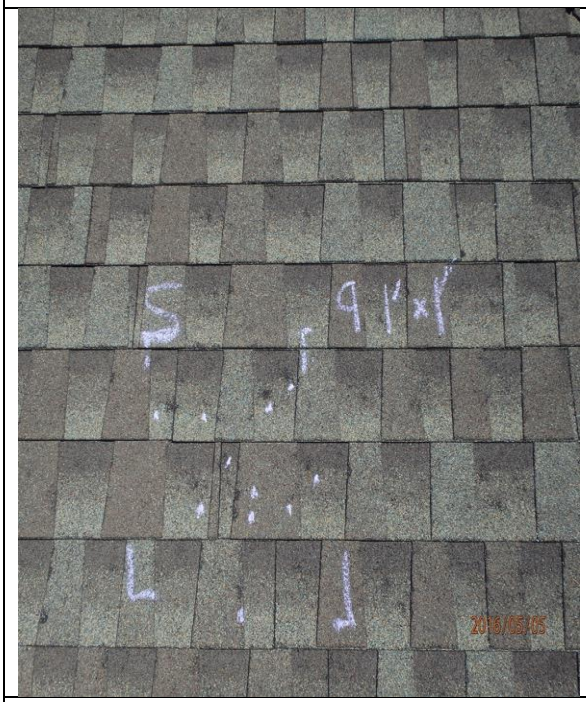
Steep Slope Inspection Site S1-3-P



Damaged ridge units.

Hailstone impact abrasion on ridge unit. Note: ~1.50”



Hailstone impact abrasions on field units.

Abrasion with scale.
Note: ~0.75”

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 02 Steep Slope Summary Report

Overview

Day One

Team S-2 issued 16 residential sites in Frisco, 12 of 16 were inspected. Very little if any damage to include impact distress to the asphalt shingles was observed. Some dents, dings to sheet metal components was observed. Returned to hotel to get more site listings.

During afternoon of day one began to attempt assessments from list of 45 residential sites in Plano. Notable conditions included extensive impact distress to two 20+ year old three-tab roofs. Despite extent of shingle depletion, shingles evidenced impact distress consistent with 1-1/2 to 1-3/4 inch hail stone impacts. Balance of roofs with varied age ranges evidenced impact distress which included punctures consistent with impacts caused by hail in the 2 to 2-1/2 inch range.

During day two and three accessed 16 of the 45 possible residential shingle roofs. Of these, several were gained through speaking to neighbors or individuals outside their homes. As expected shingles believed to be that of impact resistance type fared much better, and shingles not fully supported such as hip/ridge caps were damaged by impacts when field shingles were not. Lighter gage metals, particularly that of gas flues and box vents, sustained the most damage, even if the shingles only evidenced limited hits or impact distress.

Day three was started with a side trip to Wylie without specific sites to investigate. Found a homeowner with contractor on Longhorn lane where house was in the process of being re-roofed. Homeowner was receptive to allowing a roof inspection as well as walking the property. The OSB roof deck evidenced several punctures, some of which measured 4 inches in diameter. The yard evidenced numerous impact craters measuring approximately 4 inches in diameter. Wood fence evidenced multiple broken pickets due to impacts. Numerous photos were taken to surrounding area where severe impact damage to vinyl siding, auto windshields, signage, standing-seam roofs, etc. were observed.

Team Members

Scott Curry, Data Collector
Doug Thagard, Photographer
Stephen Towne, Report Writer

Team 02 Data Reports and Photographs

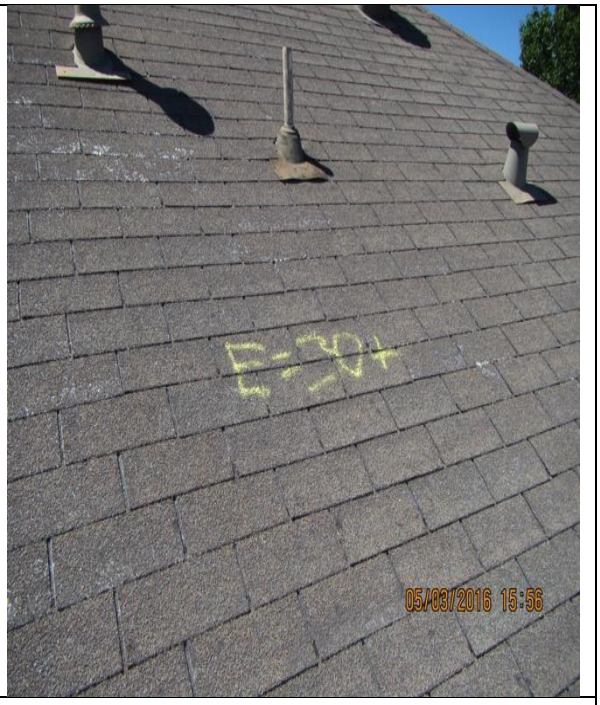
Steep Slope Inspection Site

Inspection Number	**S2-1-E**
Site Latitude	**33.1155**
Site Longitude	**96.7999**
Area Size (Square feet)	**30**
Approximate Age (Years)	**>15**
General Condition	**Poor**
Slope	**8<9**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2.5<3**
Typical or Mean Hail Size (Inches)	**1.5<1.75**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Very old 3-tab**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S2-1-E

Overview Severe Granule loss



Primary direction from east.

Approximately 1 inch hail, but severe granule loss

Damaged shingle and granule loss

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-2-H**
Site Latitude	**33.0500**
Site Longitude	**96.8407**
Area Size (Square feet)	**46**
Approximate Age (Years)	
General Condition	**Good**
Slope	**8<9**
Roof Type	**Laminated/Architectural**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.25<1.5**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**1**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Hail damage occurred on March 23**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S2-2-H

Overview

Impact distress

Hits to West

Impact with granule loss only

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-2-I**
Site Latitude	**33.0288**
Site Longitude	**96.6195**
Area Size (Square feet)	**40**
Approximate Age (Years)	**12<15**
General Condition	**Good**
Slope	**8<9**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**4**
Apparent Maximum Hail Size – (Diameter inches)	**2.5<3**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Puncture**
Comments Regarding Inspection	**impact resistant shingles however large hail caused puncture**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S2-2-I

Hits to western slope, 10

Impact Distress

Impact distress to hip cap

Hits to south slope, 7

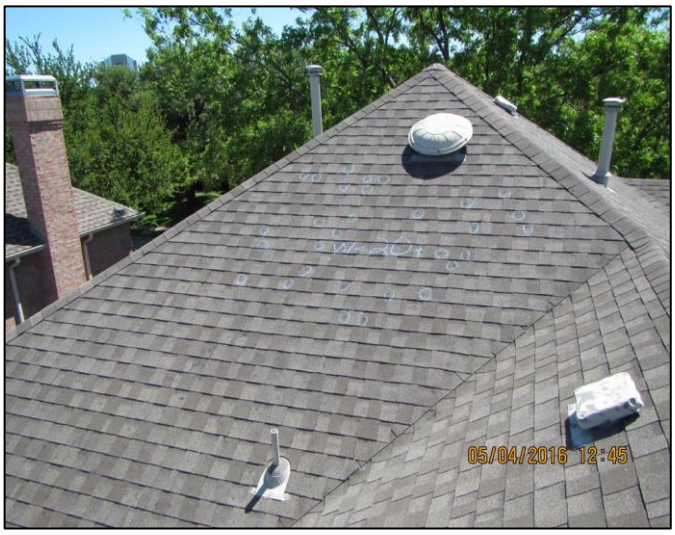
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

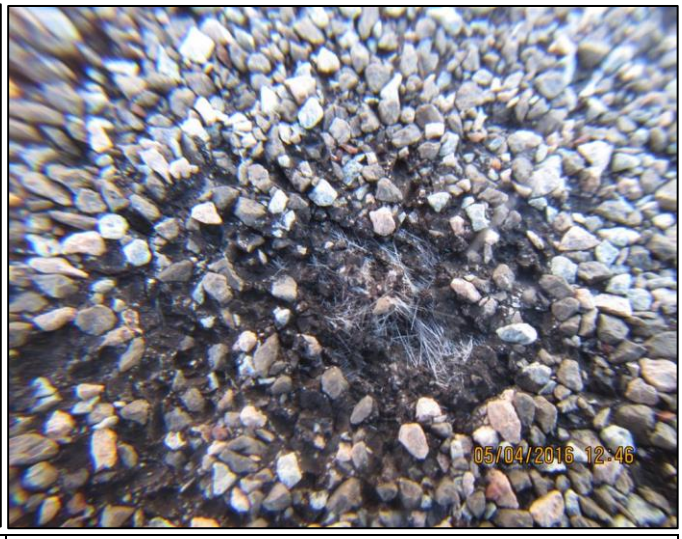
Inspection Number	**S2-2-J**
Site Latitude	**33.0288**
Site Longitude	**96.6195**
Area Size (Square feet)	**0**
Approximate Age (Years)	**10<12**
General Condition	**Good**
Slope	**8<9**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**75>90**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**High volume impacts on north and south slopes**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S2-2-J



Hits to south slope, 20+



Magnified view showing fractured mat

Hits to north slope, 20+

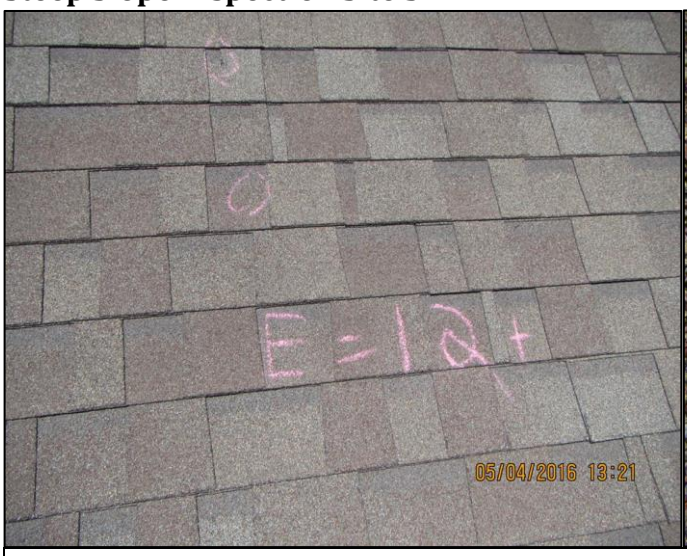
Perforated shingle

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-2-K**
Site Latitude	**33.0170**
Site Longitude	**96.7862**
Area Size (Square feet)	**35**
Approximate Age (Years)	**>15**
General Condition	**Poor**
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1<1.25**
Apparent Angle of Impact (Degrees)	**75>90**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Puncture**
Comments Regarding Inspection	**Old roof with previous buckling**

Steep Slope Inspection Site S2-2-K



Hits to east slope, 12+

Hits to east slope 12+

Another view of previous location showing perforated shingle

Impact Distress

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-2-L**
Site Latitude	**33.0171**
Site Longitude	**96.7859**
Area Size (Square feet)	**35**
Approximate Age (Years)	**12<15**
General Condition	**Fair**
Slope	**5<6**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**1<1.25**
Apparent Angle of Impact (Degrees)	**75>90**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Yes**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Puncture**
Comments Regarding Inspection	**Occured on March 23**

Steep Slope Inspection Site S2-2-L

Hits to north slope, 10

Impact Distress to hip cap

Hits to south slope, 15+

Hit: Showing relative depth

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-2-M**
Site Latitude	**33.0395**
Site Longitude	**96.6756**
Area Size (Square feet)	**30**
Approximate Age (Years)	**12<15**
General Condition	**Fair**
Slope	**5<6**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1.5<1.75**
Apparent Angle of Impact (Degrees)	**60<75**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Puncture**
Comments Regarding Inspection	

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S2-2-M

Hits to west slope, 30+

Impact Distress

Hits to east slope, 20+

Perforated Shingle

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S2-3-O**
Site Latitude	**33.0412**
Site Longitude	**96.6842**
Area Size (Square feet)	**45**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**10<12**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**45<60**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Hail hit on March 23rd & March 1st. New roof prior to hail**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 03 Steep Slope Summary Report

Overview

Our team conducted surveys on 16 roofs; 12 roofs were steep sloped and 4 were low-sloped with three buildings having a combination of low-sloped modified bitumen (MB) and standing-seam metal panels. The team observed evidence of maximum hail sizes ranging from 1.25- to 4- inches in diameter. The buildings were located in the cities of Wylie, Murphy, Sachse, Plano, and Denton.

The steep sloped roofs were a combination of asphalt shingles (8), metal (6), and cedar shingles. Collateral evidence at the sites indicated that the hail was numerous at all sites (over 15 impacts per square foot), frozen hard, and mostly wind-driven. Windows had been broken on the north and west sides of buildings in Wylie, with vinyl siding damage on the roof in Sachse, and broken skylights on the roof in Plano. One asphalt shingle was confirmed to Class 4 Impact Resistant by labeling on the back of the shingle. This roof was in the area of largest hail in Wylie (some hail-caused fractures approached 4-inches across). The Class 4 shingles appeared to withstand the smaller hail, with most bruised (fractured) areas 1.75-inches across or larger, while other nearby roofs had a greater number of bruised areas that started at about 1-inch across. The hail impact effects on the asphalt shingles was primarily bruises (fractures or ruptures of the fiberglass reinforcement) and punctures, and the asphalt exposed by the recent granule loss in these areas was black-colored (not oxidized). The plywood roof decking had not been broken in the area were two inspections were made of the maximum hail size was slightly larger than 3.0-inches in diameter (documented by photographs). Punctures were primarily in ridge, hip, and valley shingles that were not solidly supported. Age of shingles was not a significant factor, as two of the damaged roofs were less than five years.

The performance of metal roofs varied by thickness and profile. The most severe damage was found to a through-fastened R-panel with light-gauge steel in an area where the largest hail was at least 3.5-inches in diameter. Several panels had distorted enough at large hail impacts that the lap seams had opened. The paint coating had cracked at one large dent in rib, and several of the largest dents exhibited Lüders strains (irregular radial creases) without visible cracking of the metal or coating. A thicker galvanized steel panel (believed to be 24 gauge) on a nearby building had shallow rounded dents, with no distorted seams and no visible cracking or spalling of the galvanized coating. Standing-seam metal roofs in an area with maximum hail size of approximately 1.25-inches in diameter had shallow rounded dents, with no distorted seams and no visible cracking or spalling of the zinc-aluminum alloy coating. A roof with metal shingle panels had shallow rounded dents with no seams opened by impact.

One inspected building in the area of very large hail (at least 3.5-inch diameter) had cedar shingle roofing. Many broken pieces of cedar shingle roofing (and shingle siding) were found on the ground on the windward sides of the building. The wood had been crushed and split at the areas of large impacts, displaying bright orange-colored wood at the fresh fractures. Portions of the roof had been covered with tarps as the shingles were on spaced wood lath boards and some punctures into the attic space had occurred.

The team inspected a group of low-slope roofs with granule-surfaced SBS modified bituminous (MB) membrane in an area where the maximum hail size was from about 1.25- to 1.5-inches in diameter. No punctures were found in the field membrane or parapet flashings, and no bruises (impact-caused fractures or ruptures) were detected in the membranes even in areas of blistering. There was some quality variation in the granule adhesion of MB sheets, and there was minor granule displacement from the surface of some rolls. One roof with an adhered EPDM membrane in the same area had no visible fractures or tears from impact in the field areas or parapet flashings.

Collateral indications of hail impact were extensive in the city of Wylie: dents in stop signs, dents in roof-mounted satellite dishes, fractures in heavy-gauge metal louvers on mechanical units, broken skylights, shattered windshields, and shattered fiberglass basketball backboards. In other areas where the maximum hail size was less than the 2.0 inches in diameter, the collateral effects of hail impact were more typical and consisted primarily of dents in light-gauge metal components such as vents, HVAC cooling fins, gutters, and downspouts.

Team Members

Richard Herzog, Data Input, Report Writer
John Kouba, Photographer
John Erwin, Data Collector

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

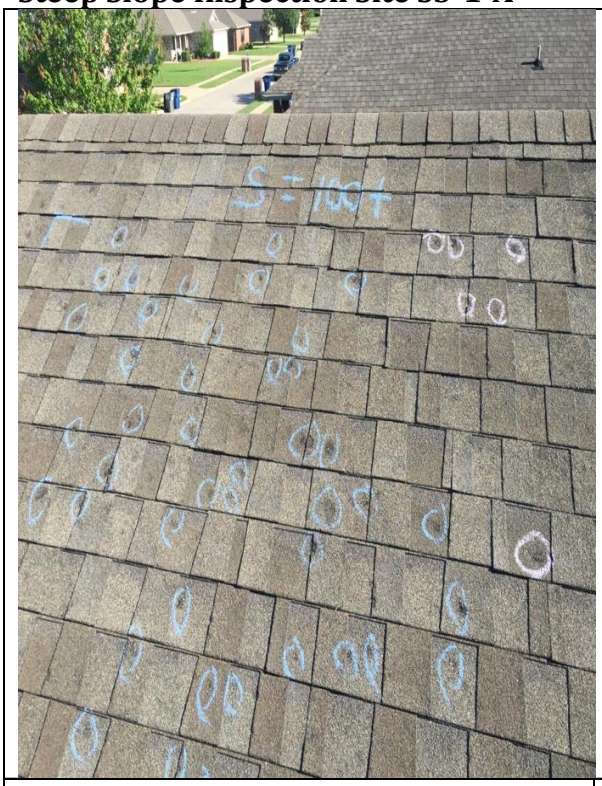
Team 3 Data Reports and Photographs

Steep Slope Inspection Site

Inspection Number	**S3-1-A**
Site Latitude	**33.9947**
Site Longitude	**-96.5297**
Area Size (Square feet)	**2500**
Approximate Age (Years)	**10<12**
General Condition	**Fair**
Slope	**5:12**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**3<3.5**
Typical or Mean Hail Size (Inches)	**1.75<2.0**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Yes**
Overall Damage Rating	**5**
Types of Hail Damage Observed	**Granule/Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Temporary repairs with metal shims and roofing cement. Broken windows on N and W sides. Photograph of owner showing 3" diameter hailstone.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-A



South side – 100 plus hits

North Side 100 plus hits

East side 100 plus hits

West side 100 plus hits

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

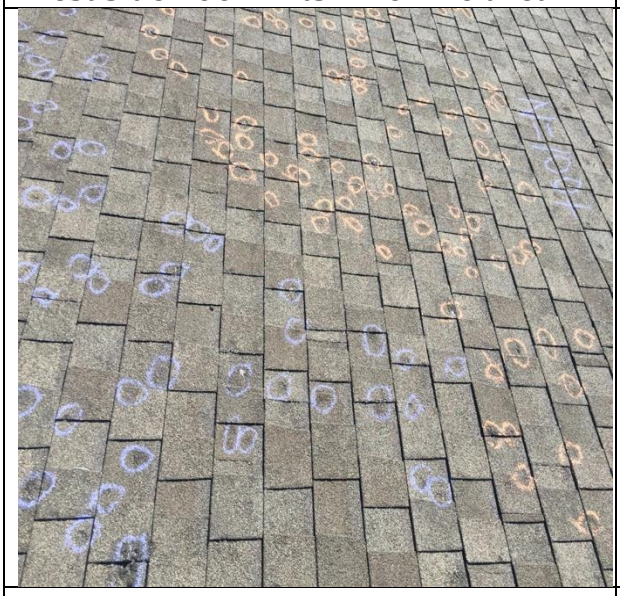
Inspection Number	**S3-1-B**
Site Latitude	**33.9947**
Site Longitude	**-96.5297**
Area Size (Square feet)	**2700**
Approximate Age (Years)	**10<12**
General Condition	**Fair**
Slope	**5:12**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**3<3.5**
Typical or Mean Hail Size (Inches)	**1.75<2.0**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Yes**
Overall Damage Rating	**5**
Types of Hail Damage Observed	**Granule/Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Temporary repairs with metal shims and roofing cement. Broken windows on N and W sides. Dents in steel garage door, and metal "hail guard" broken on ac unit.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-B

West side 100 + hits in10 x 10 area

East side 100 + hits in 10 x 10 area



North side 100 + hits in 10 x 10 area

South side 100 + hits in 10 x 10 area

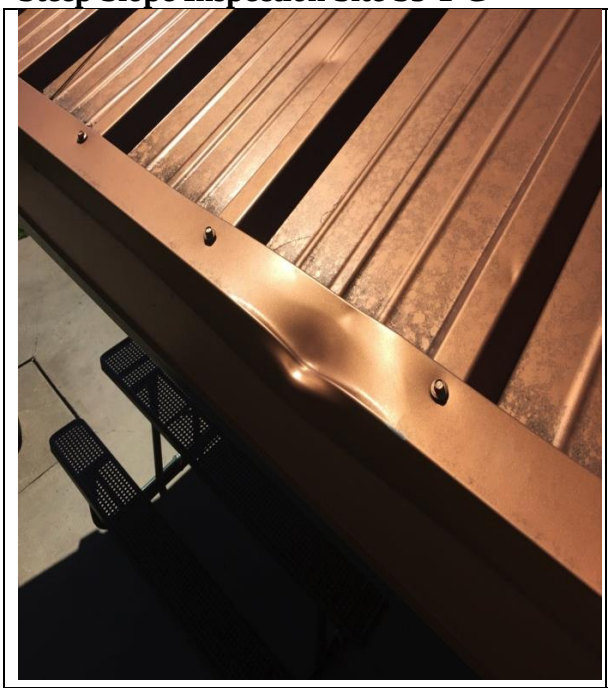
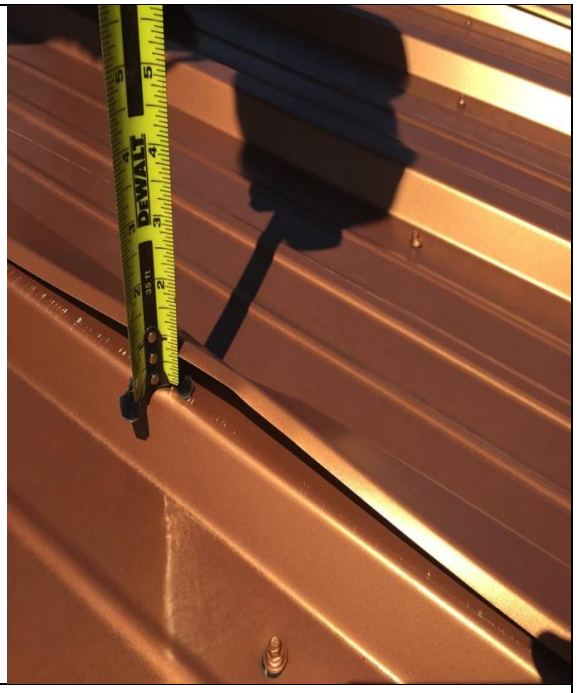
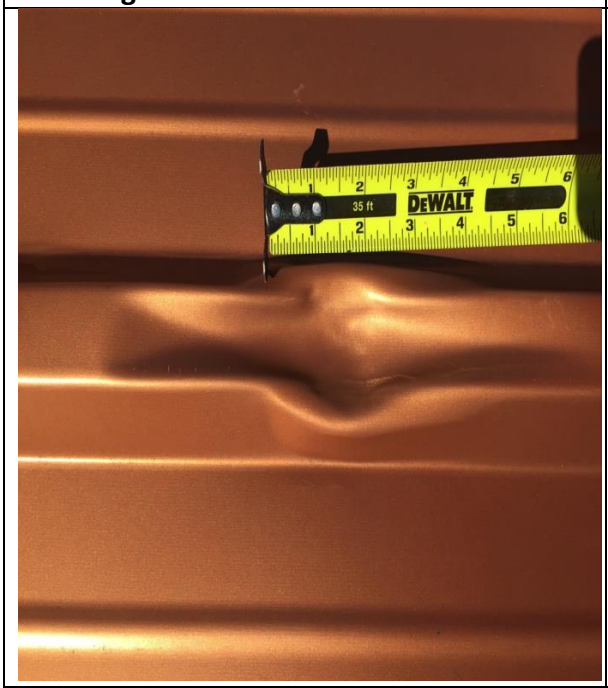
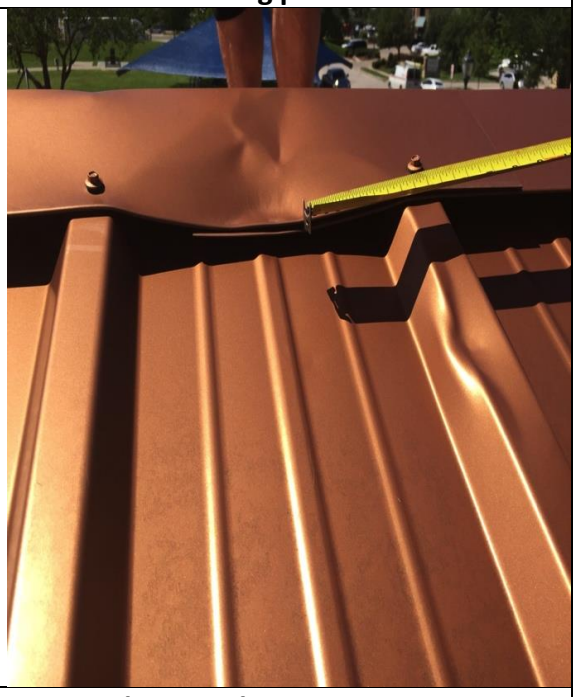
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-1-C**
Site Latitude	**33.0133**
Site Longitude	**-96.5425**
Area Size (Square feet)	**1000**
Approximate Age (Years)	**8<10**
General Condition	**Good**
Slope	**5<6**
Roof Type	**Metal**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**3<3.5**
Typical or Mean Hail Size (Inches)	**1.75<2.0**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**5**
Types of Hail Damage Observed	**Dent**
Comments Regarding Inspection	**"Inner" dents to 3.25" with "Outer" dents to 8" in ribs. Luder's Strains at some of the largest dents. Only a few dents had visible cracking of paint. Several overlap seams had been opened by large dents.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-C

	
Eave edge	**Hit on seam causing panel to lift**
	
Hit on rib 2”	**Hit on ridge metal**

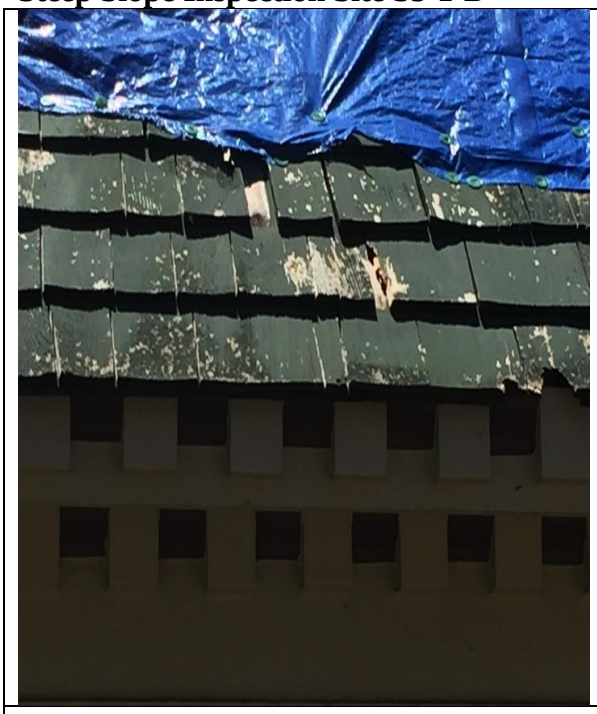
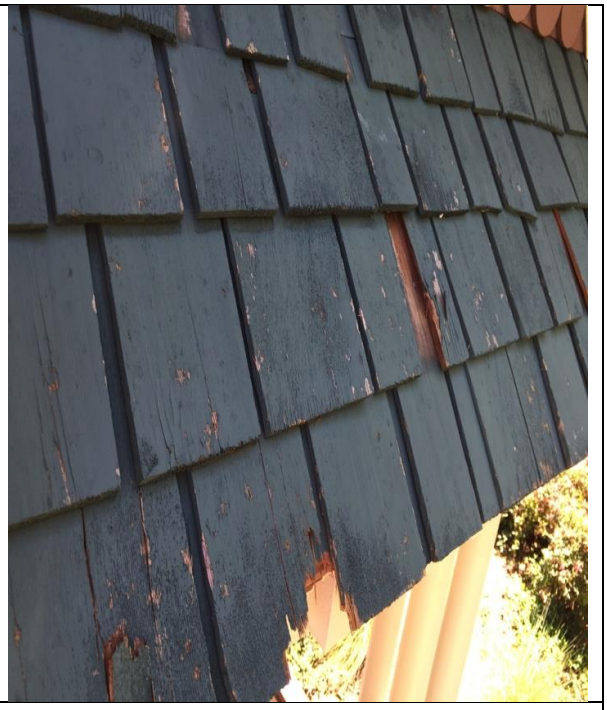
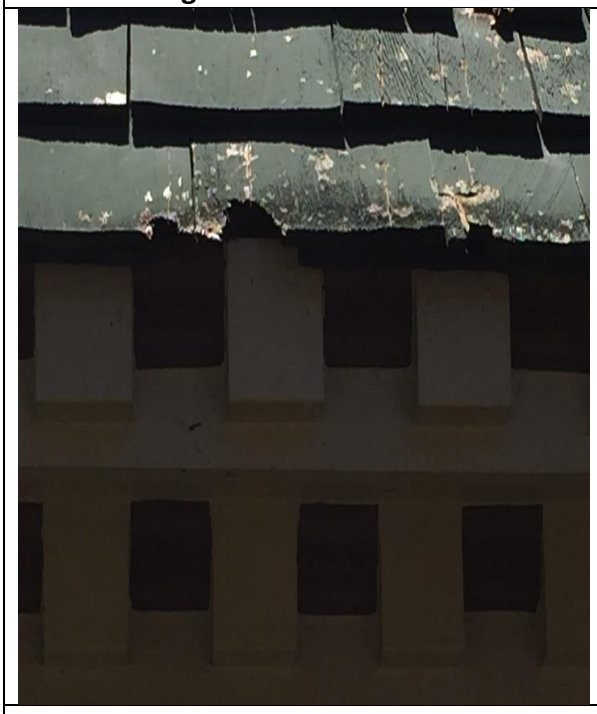
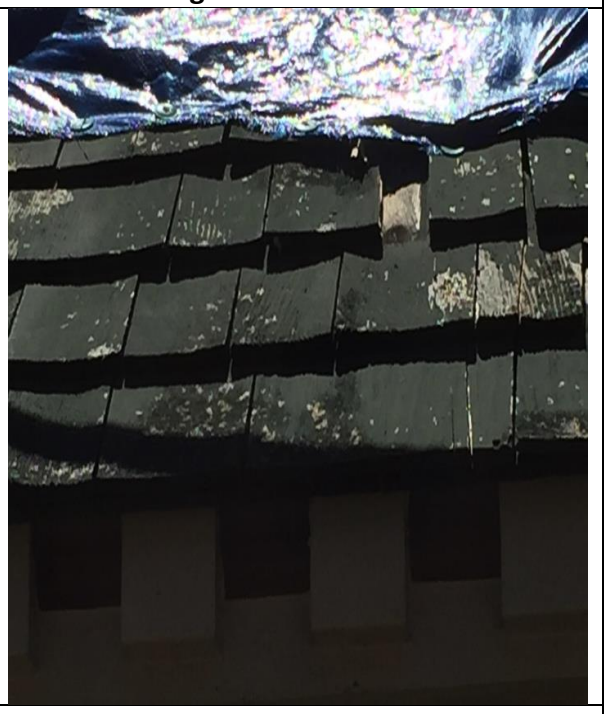
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-1-D**
Site Latitude	**33.0163**
Site Longitude	**-96.5391**
Area Size (Square feet)	**400**
Approximate Age (Years)	**>15**
General Condition	**Fair**
Slope	**12:12**
Roof Type	**Cedar Shingles**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**3.5<4.0**
Typical or Mean Hail Size (Inches)	**1.5<1.75**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**5**
Types of Hail Damage Observed	**Cracked/Broken Shingles**
Comments Regarding Inspection	**Main House built 1905 (inspected by other team). Cedar shingles had been painted; many broken pieces on ground. Cedar fishscale siding also broken on N and W sides**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-D

	
Eave on the gazebo	**North side of gazebo**
	
Close up of eave	**Another picture of eave**

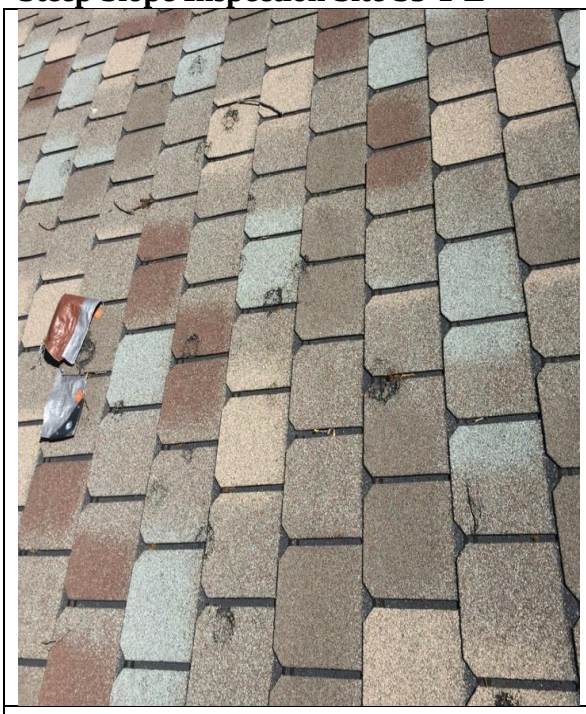
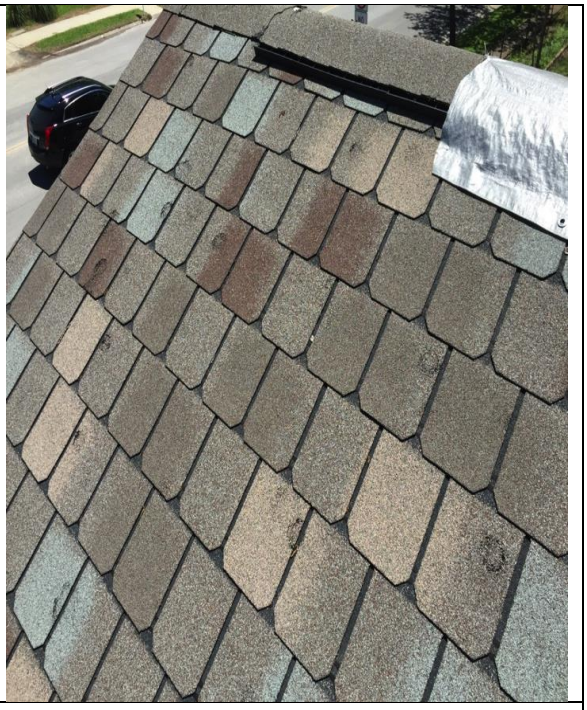
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-1-E**
Site Latitude	**33.0166**
Site Longitude	**-96.5394**
Area Size (Square feet)	**2100**
Approximate Age (Years)	**8<10**
General Condition	**Good**
Slope	**7<8**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Class 4**
Apparent Maximum Hail Size – (Diameter inches)	**3.5<4.0**
Typical or Mean Hail Size (Inches)	**1.5<1.75**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Yes**
Overall Damage Rating	**5**
Types of Hail Damage Observed	**Granule/Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Shingle had fewer damage areas per square than "non IR" shingles in the area, but the 2"-4" diameter hits caused damage. Label on back of shingle confirmed Class 4.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-E

	
Picture of multiple hits	**Multiple hits**
	
3” Hail	**4” Hit**

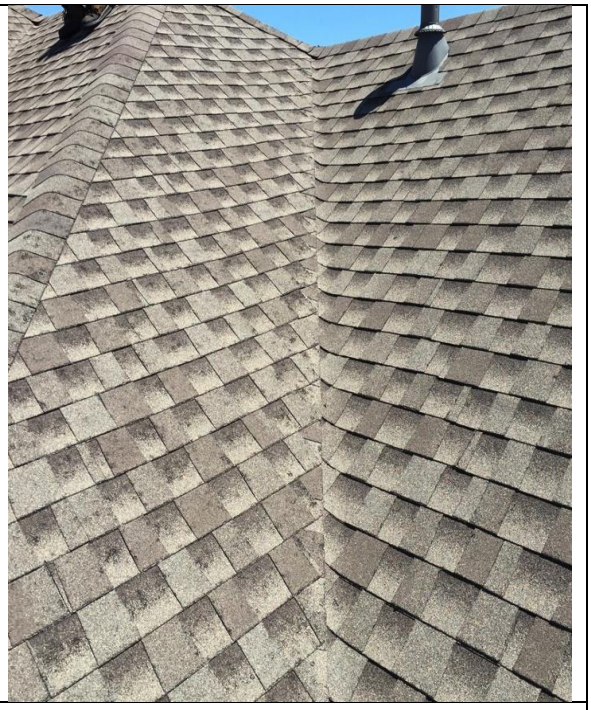
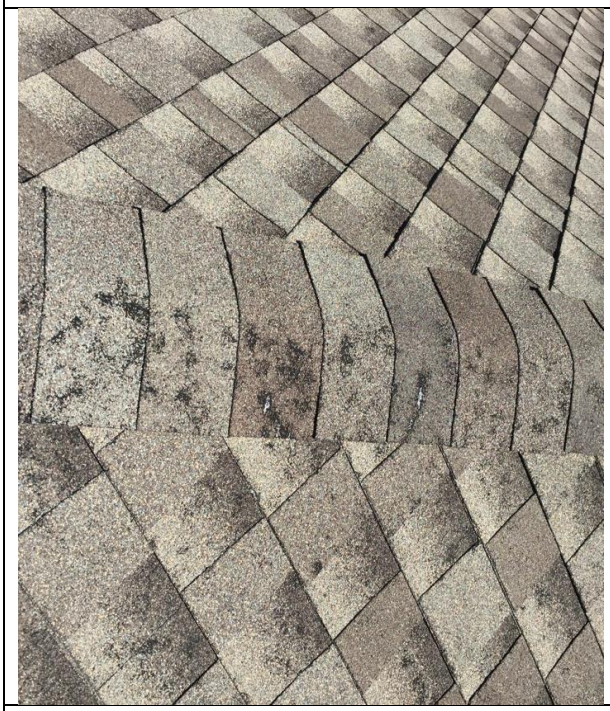
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-1-G**
Site Latitude	**33.0008**
Site Longitude	**-96.6127**
Area Size (Square feet)	**2800**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**7<8**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.75<2.0**
Typical or Mean Hail Size (Inches)	**0.75<1.0**
Apparent Angle of Impact (Degrees)	**30<45**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Spots with significant granule loss that were 3/4-inch across or larger had fractured or ruptured fg mat. Most significant damage on ridges and hips. Wind-driven hail as low-sloped section (1:12 pitch) had little damage.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-1-G

	
West side is right hand side of ridge 1.75 to 2.0 inch hail	**West side is on the left of the valley, north facing is on the right of the valley**
	
Closer view of west facing roof, north facing roof on left side of ridge	**2” Bruise**

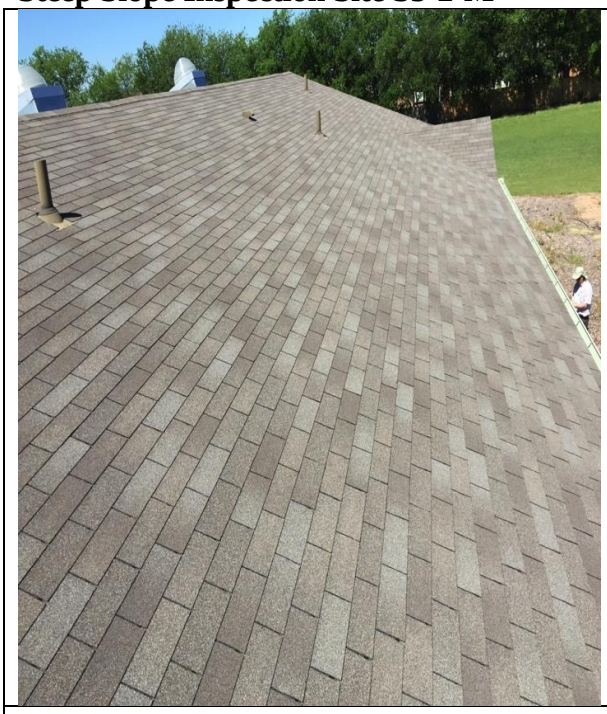
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-2-M**
Site Latitude	**33.0169**
Site Longitude	**-96.6161**
Area Size (Square feet)	**2000**
Approximate Age (Years)	**<3**
General Condition	**Good**
Slope	**4<5**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.25<1.5**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley**
Comments Regarding Inspection	**Spalling of granules and asphalt in certain shingles with blistering. Otherwise, very minimal damage. Blistering most prevalent on west slope**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-2-M

	
Overall	**Overall of hits west facing small section**
	
Less than 1”	**Less than 1”**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S3-2-O**
Site Latitude	**32.9792**
Site Longitude	**-96.5752**
Area Size (Square feet)	**4000**
Approximate Age (Years)	**10<12**
General Condition	**Fair**
Slope	**8<9**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**30<45**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Vinyl siding west side-multiple fractures**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S3-2-O

	
West side damage to shingles	**Damage to siding on west side as well**
	
Close up of damage through shingle	**Obvious hits are marked**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

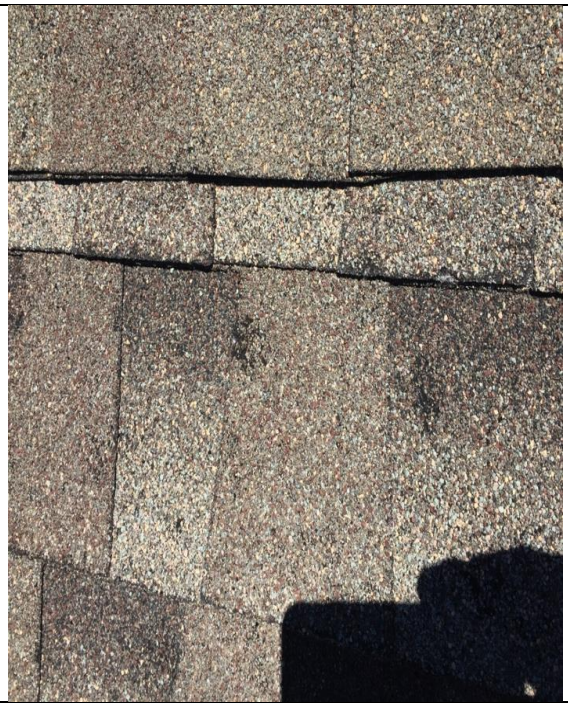
Steep Slope Inspection Site

Inspection Number	**S3-2-P**
Site Latitude	**33.0288**
Site Longitude	**-96.7361**
Area Size (Square feet)	**3200**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**7<8**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**1<1.25**
Apparent Angle of Impact (Degrees)	**30<45**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**temp protection over 2 broken skylights. Intense shingle damage S and W slopes; isolated damage N and E slopes. Nearly all hip and ridge shingles fractured.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Investigation Site S3-2-P

West facing slope



Close up west facing slope hits

2” Hit

Hit on ridge 1.5” plus

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 4 Steep Slope Summary Report

Overview

Team S-4 investigated 25 roofs over a three-day period spanning from May 3 through May 5, 2016. Day 1 focused on properties located in and around Garland, Texas which experienced impact from hail ranging between ½-inch to 1.5-inch in size. The flat concrete tile on the municipal court house showed no signs of damage from this hail event, however, it showed signs of damage that is suspected to be from a previous hail event. The asphalt shingles that were observed at other locations showed moderate to severe damage but no indication of roof leakage from this damage. Several properties visited did not show any visible damage.

Day 2 investigations were conducted in the Murphy area where hail impact damage was more severe and widespread. All of the roofs investigated in the Murphy area were asphalt shingles that experienced impact from hail stones ranging from 1-inch to 2-inch in diameter. None of the roofs investigated were found to have impact resistant shingles but the damage was most severe on the older shingles. Roofs of different ages (7 months versus 15 years old) on adjacent homes that experienced almost identical exposure showed significantly different damage patterns with the older roof being more severely damaged.

Day 3 investigations were performed in the Wylie and Plano areas.
The most severe damage was observed in Wylie area where the roofs were subjected to impact from hailstones estimated to be in the range of 1-inch to 3-inches in diameter. Three asphalt shingle roofs exhibited severe punctures and aggregate loss. The homes also experienced numerous broken windows and heavy damage to metal flue and ventilation caps. A standing seam metal roof exhibited heavy denting with as many as 30 strikes per square foot in evidence.

Investigations in the Plano area were focused on a variety of metal roofing systems that included stone- coated steel, standing seam metal panels and aluminum shingle panels on residential structures. All roofs showed damage in the form of denting caused by hail estimated to range in size from 1 to 2-inches in diameter. The damage was largely cosmetic and did not appear to have any punctures or damage that would result in potential roof leakage.

Team Members

Michael Schwent – Photographer / Contributor
Allan Kidd – Data collector / Field Data Report Writer
Jerry Vandewater – Data collector / Summary Report Writer

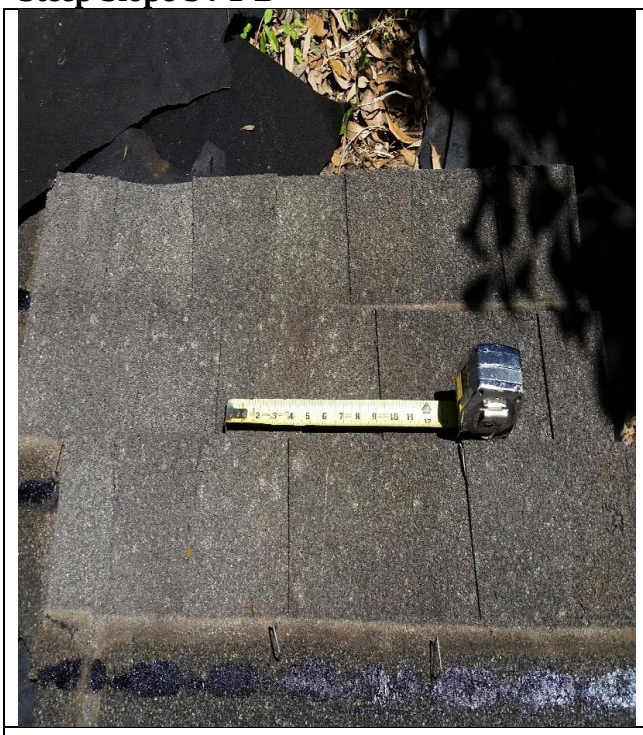
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-1-B**
Site Latitude	**32.9828**
Site Longitude	**-96.6819**
Area Size (Square feet)	**4200**
Approximate Age (Years)	**>15**
General Condition	**Fair**
Slope	**9<10**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**<0.75**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**1**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Roof was damaged in a hail storm 8 years ago and paid for by insurance. The homeowner did not replace the roof then but the roof was being replaced the date of our inspection. Samples and photos were of shingles on the ground and in the dumpster.**

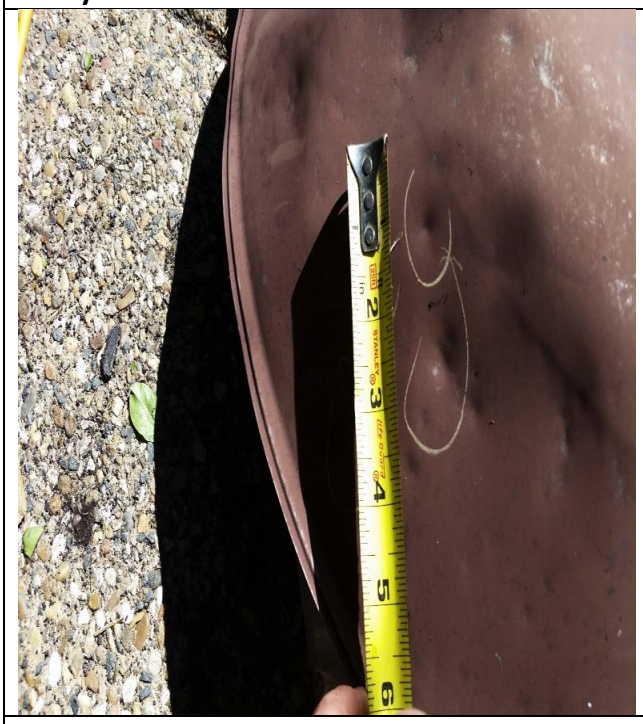
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope S4-1-B

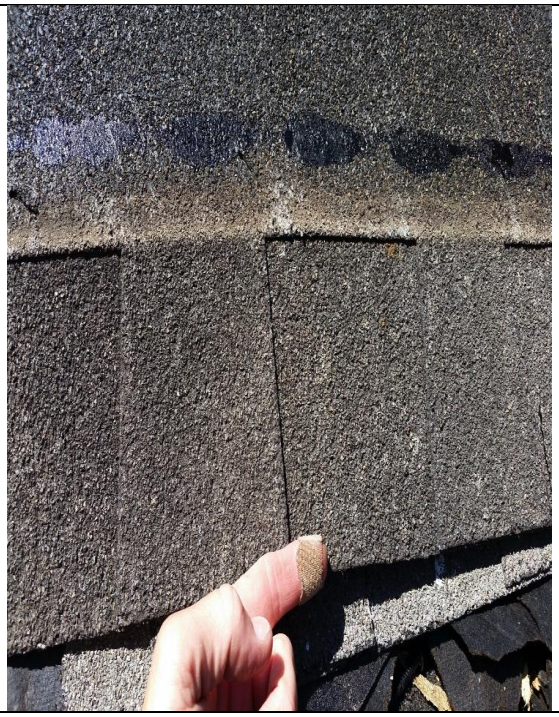


Many hail hits less than ¾ inch

Granule loss from hail hits



Small dents from hail



Shingle breakage. Roof being replaced

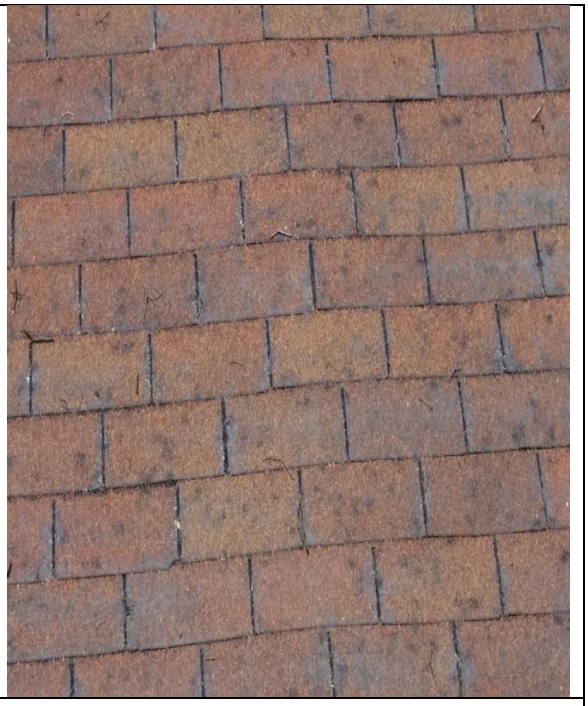
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-1-D**
Site Latitude	**32.9617**
Site Longitude	**-96.6670**
Area Size (Square feet)	**2400**
Approximate Age (Years)	**3<4**
General Condition	**Poor**
Slope	**3<4**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**No**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Significant hail damage to 3 year old roof. Most of the roof slopes are 3/12 with some 1.5/12.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S4-1-D

	
Damaged 3 Tab	**Numerous hail hits**
	
Typical ¾ to 1 ½ inch hail	**Overview**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-2-A**
Site Latitude	**33.0206**
Site Longitude	**-96.6194**
Area Size (Square feet)	**3300**
Approximate Age (Years)	**10<12**
General Condition	**Poor**
Slope	**5<6**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S4-2-A

Overview many hail hits

Hail size 1 ½ to 1 ¾ inch

Many hits by 1 inch or smaller hail

Many small hail hits

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-3-A**
Site Latitude	**33.0429**
Site Longitude	**-96.5729**
Area Size (Square feet)	**1800**
Approximate Age (Years)	**10<12**
General Condition	**Poor**
Slope	**5<6**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Similarly significant damage on all slopes with slightly worse on NW slopes**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S4-3-A

	
Overview up to 2 ¼ inch hail	**Bruised shingle**
	
Bruised shingle	**Broken Window and damaged shutters**

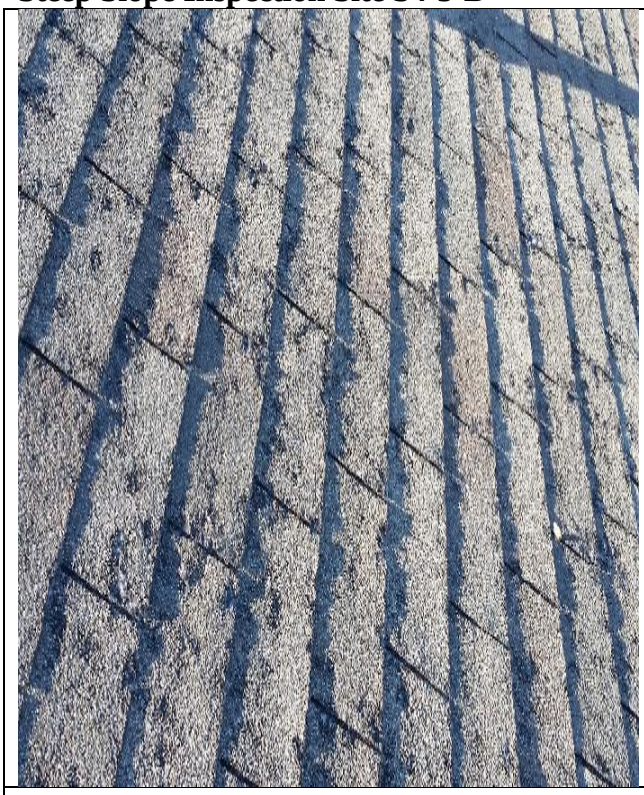
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-3-B**
Site Latitude	**33.0426**
Site Longitude	**-96.5728**
Area Size (Square feet)	**2200**
Approximate Age (Years)	**10<12**
General Condition	**Poor**
Slope	**5<6**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S4-3-B



Numerous hail hits

Hail size up to 2 ¼ inches

Hail damage

Destroyed vent

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-3-C**
Site Latitude	**33.0426**
Site Longitude	**-96.5725**
Area Size (Square feet)	**0**
Approximate Age (Years)	**10<12**
General Condition	**Poor**
Slope	**3<4**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**2<2.25**
Typical or Mean Hail Size (Inches)	**1.25<1.5**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**4**
Types of Hail Damage Observed	**Granule/ Aggregate Loss, Chipped/Broken ridge or valley, Puncture**
Comments Regarding Inspection	**Bldg has metal and shingles. Significant dents on metal**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S4-3-C

Numerous hail hits up to 2 ¼ inch

Shingle damage

Shingle damage

Dents in metal

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

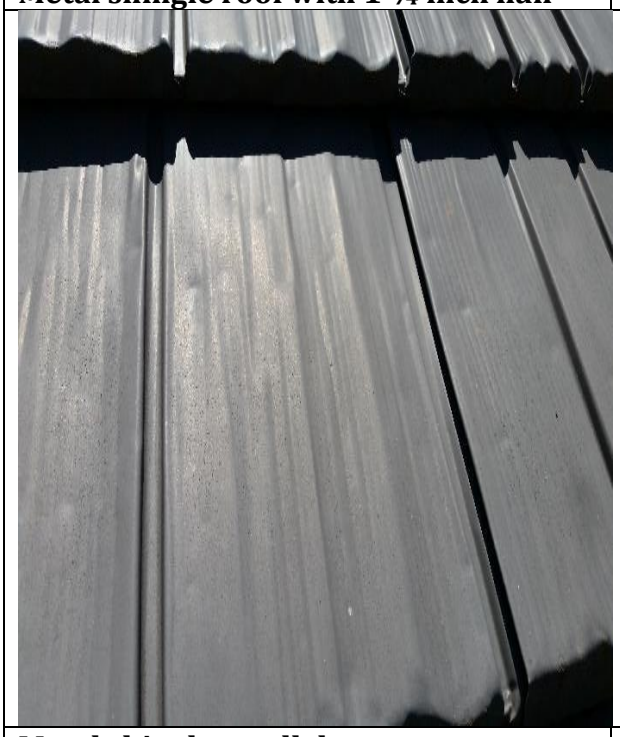
Inspection Number	**S4-3-E**
Site Latitude	**33.0367**
Site Longitude	**-96.8025**
Area Size (Square feet)	**12000**
Approximate Age (Years)	**>15**
General Condition	**Fair**
Slope	**>12**
Roof Type	**Metal**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**No**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Dent (metal roofing)**
Comments Regarding Inspection	**Aluminum interlocking shake over cedar shakes.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

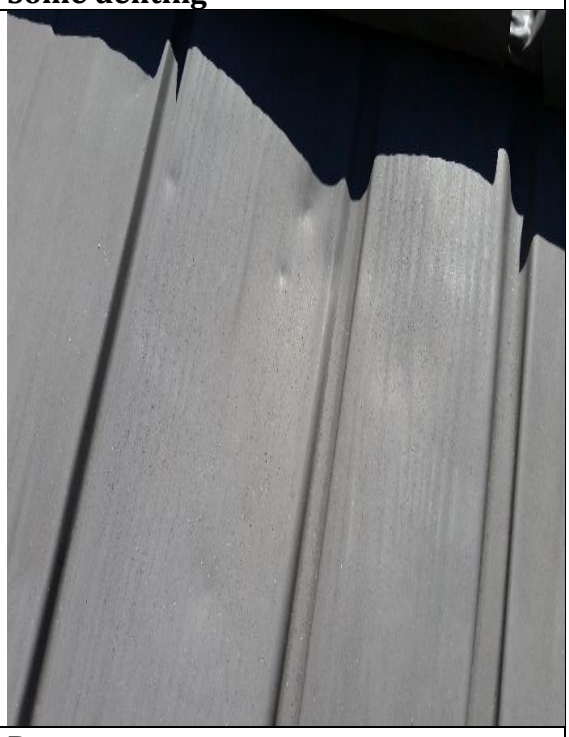
Steep Slope Inspection Site S4-3-E

Metal shingle roof with 1 ¾ inch hail

Some denting



Metal shingle small dents



Dents

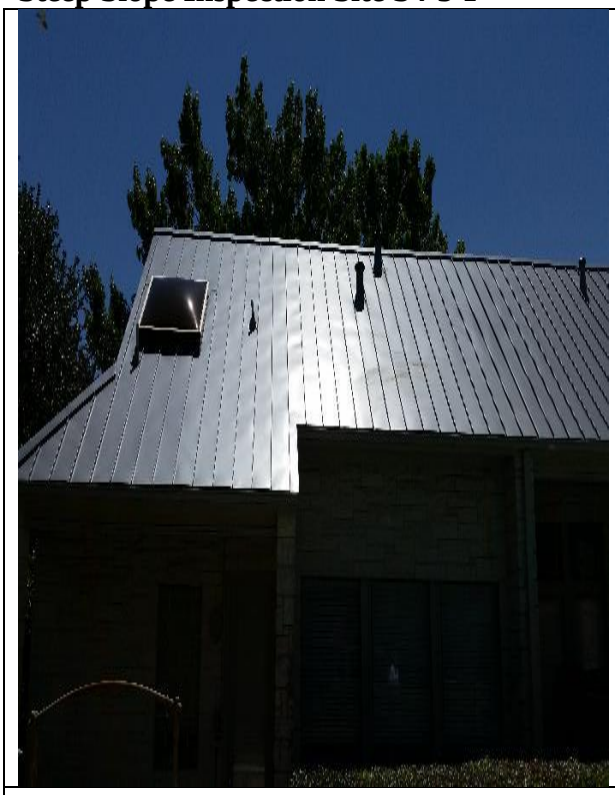
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

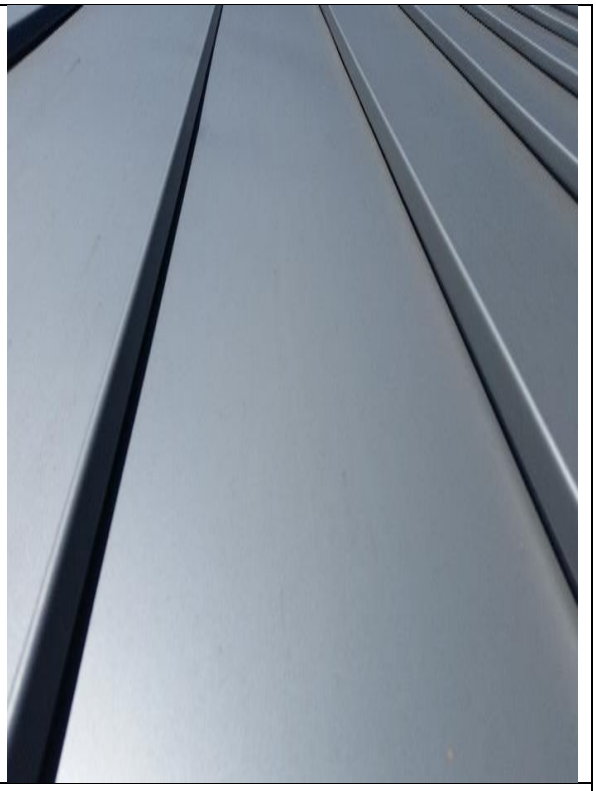
Inspection Number	**S4-3-F**
Site Latitude	**33.0366**
Site Longitude	**-96.8036**
Area Size (Square feet)	**15000**
Approximate Age (Years)	**10<12**
General Condition	**Good**
Slope	**9<10**
Roof Type	**Metal**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**>0.75<1**
Apparent Angle of Impact (Degrees)	**0<15**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Dent (metal roofing)**
Comments Regarding Inspection	**Contractor contends seams were damaged due to hail impact. We did not see evidence of this.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

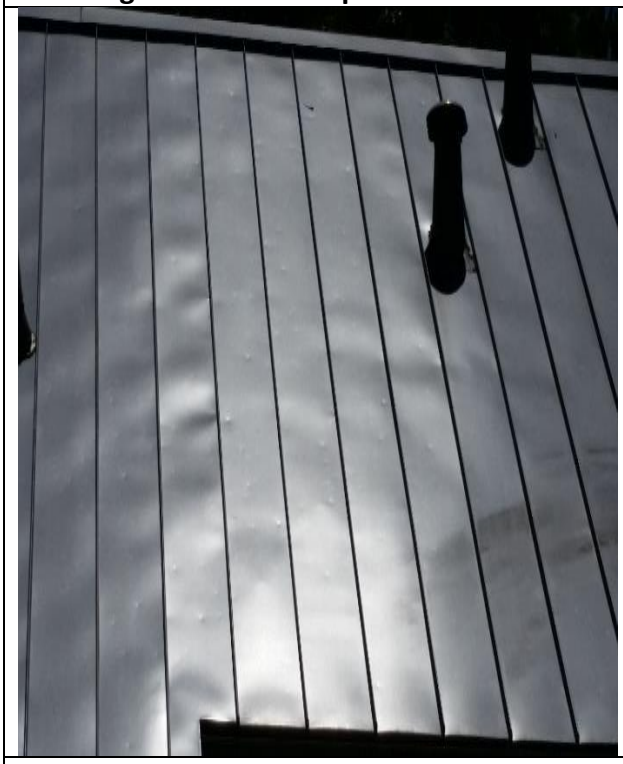
Steep Slope Inspection Site S4-3-F



Standing Seam Metal –up to 1 ¾ inch hail



No damage to this slope



Denting, which may have opened seam

Denting

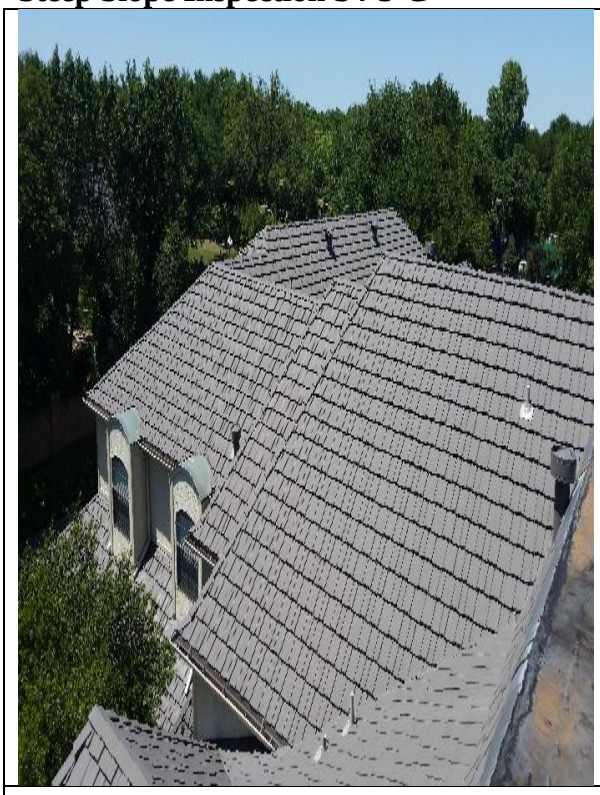
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S4-3-G**
Site Latitude	**33.0291**
Site Longitude	**-96.8149**
Area Size (Square feet)	**120000**
Approximate Age (Years)	**>15**
General Condition	**Good**
Slope	**5<6**
Roof Type	**Metal**
Impact Resistant?	
Apparent Maximum Hail Size – (Diameter inches)	**1.5<1.75**
Typical or Mean Hail Size (Inches)	**1<1.25**
Apparent Angle of Impact (Degrees)	
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Dent (metal roofing)**
Comments Regarding Inspection	**These are foam backed aluminum shakes**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection S4-3-G



Metal shingles with hail up to 1 ¾ inch

Denting of metal

Denting

Many small hail hits

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 5 Steep Slope Summary Report

Overview

Steep Slope Team 5 examined 27 properties in Allen, Lewisville, Parker, Plano, Sachse, and Wylie, Texas. Roofs were accessed at 18 of those properties. Structures included single- and two-family residential units, patio and carport covers, and small storage buildings. Roof coverings included three-tab and laminated composition shingles and metal and plastic panels on carports, patio covers, and sheds.

Property owners reported hailfall on March 23 and April 11, 2016. The team observed evidence of hailstones between 2-1/2 and 3 inches at two locations in Wylie. The sites in Allen, Parker, and Sachse displayed evidence of hail as large as 1 inch, Plano received 1-1/2 inch or smaller hail, and the locations in Lewisville had hail 3/4 inches or less in diameter. The hailstones generally fell from the north, northwest, or west, and the angles of impact varied between 0 and 45 degrees from vertical. One location received hailfall from the southwest.

The severity of damage varied between no damage (Level 0) and moderate/severe damage (Level 4). As was expected, older roof coverings received a greater degree of damage from impacting hailstones. Granule loss was widespread on all but the newest of shingles. One location in Lewisville had metal panel carport and patio covers. The thicker gauge carport panels were not dented by hail, and the thinner gauge patio panels were dented by recent hail measuring less than 3/4 inch across. Where large hail was documented (1-inch or greater), ridge shingles received more damage than field shingles. Several roofs featured valleys with starter/bleeder strips installed along the valley centerlines. This installation results in unsupported portions of shingles near the valley centerline, and these areas were frequently punctured by hailstones.

Team Members

Tim Crawford, Benco Commercial Roofing, data collection
Bill Morgan, Malarkey Roofing Products, data collection and entry
Wade Sticht, CASE Forensics Corp., photography

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 05 Data Reports & Photographs
Steep Slope

Steep Slope Inspection Site

Inspection Number	**S5-1-F**
Site Latitude	**33.0743**
Site Longitude	**-96.6507**
Area Size (Square feet)	**3500**
Approximate Age (Years)	
General Condition	**Poor**
Slope	**7<8**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**>0.75<1.0**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Older three tabs, probably previous hail as well as some previous and current wind damage**

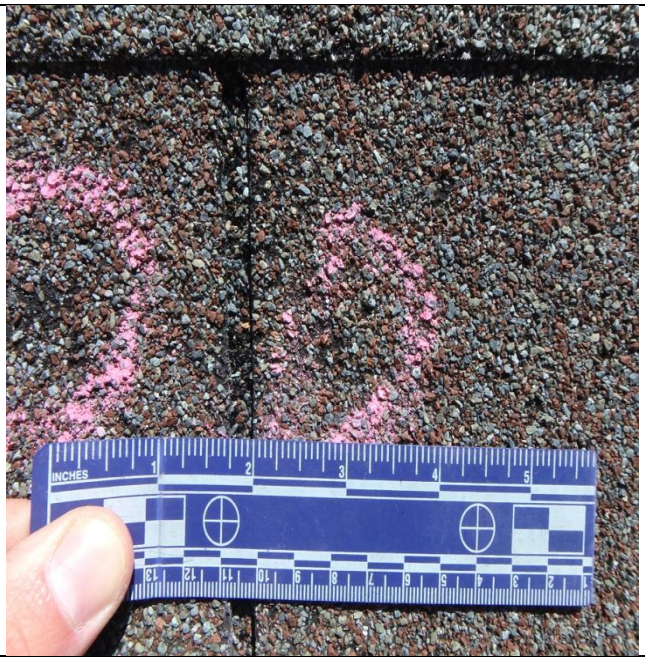
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S5-1F

Numerous spots of missing granules on west-facing shingles

Typical spot of missing granules.

Reinforcing mat is not punctured or bruised.



Typical spot of missing granules.

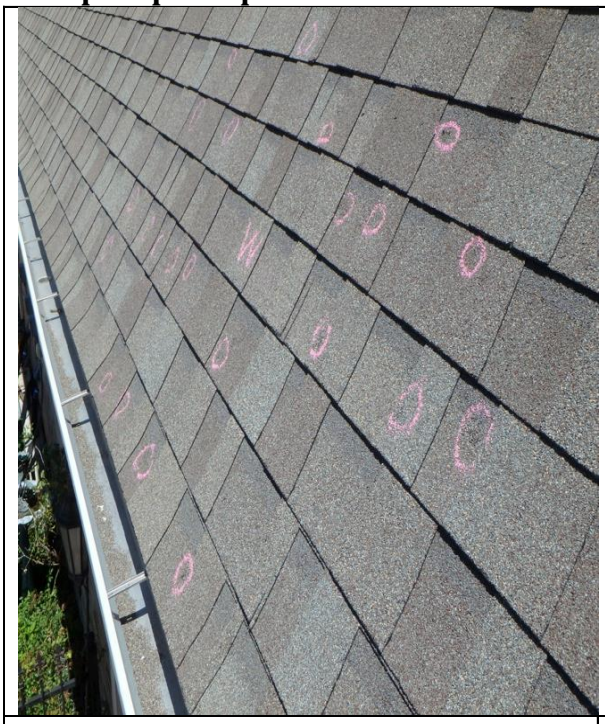
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S5-1-H**
Site Latitude	**33.0500**
Site Longitude	**-96.6008**
Area Size (Square feet)	**5000**
Approximate Age (Years)	
General Condition	**Fair**
Slope	**>12**
Roof Type	**Laminated/Architectural**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.25<1.50**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Yes**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**2**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Roofers sign in yard with likely indication it will be replaced.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S5-1-H



West slope overview

Hail Hits

North Slope overview

Hail Hit with resulting puncture

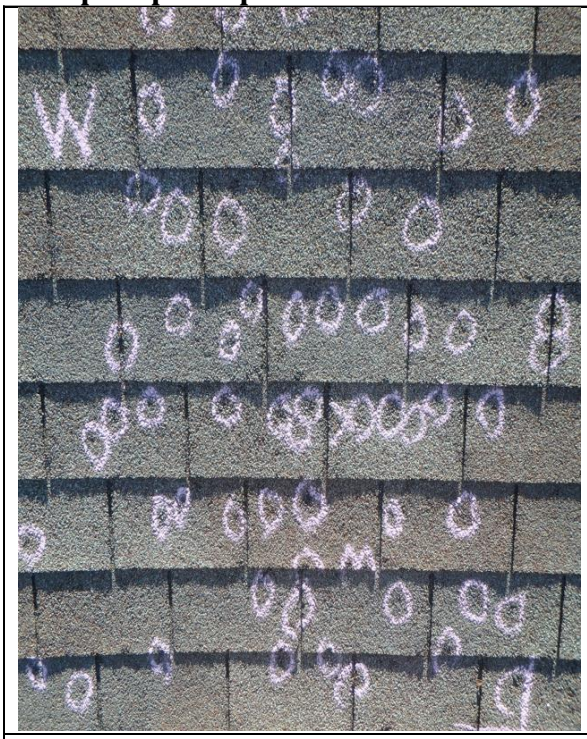
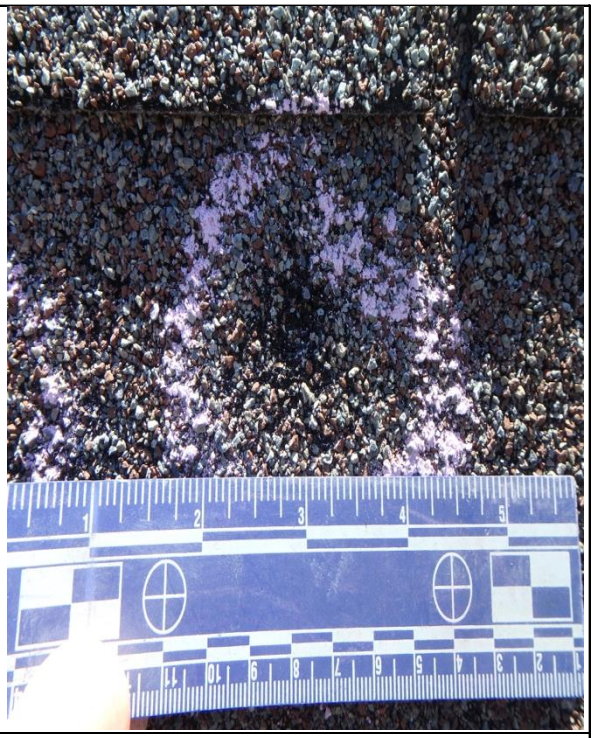
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site

Inspection Number	**S5-2-B**
Site Latitude	**32.9847**
Site Longitude	**-96.5672**
Area Size (Square feet)	**3000**
Approximate Age (Years)	**>15**
General Condition	**Poor**
Slope	**7<8**
Roof Type	**3 tab Fiberglass**
Impact Resistant?	**Unknown**
Apparent Maximum Hail Size – (Diameter inches)	**1.25<1.50**
Typical or Mean Hail Size (Inches)	**<0.75**
Apparent Angle of Impact (Degrees)	**15<30**
Is the Roof Scheduled for Replacement?	**Unknown**
Is There Known Roof Leakage from This Hailstorm?	**Unknown**
Overall Damage Rating	**3**
Types of Hail Damage Observed	**Granule/ Aggregate Loss**
Comments Regarding Inspection	**Was supposed to be hail pad on site but did not find one. Owner was not home so could not determine status of the hail pad.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Steep Slope Inspection Site S5-2-B

	
West slope overview	**Puncture Hit**
	
Puncture	**Punctured shingle**

Appendix C: Team Summary Low Slope Inspection Reports

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team 1 Low Slope Summary Report

Overview

Team L-1 observed 7 roofs, primarily concentrated in the Wylie and Allen areas. Hail sizes ranged from less than .75 inch to 3.5 inches. Hail fall came generally from the NW and had impact angles between 45* and 60*. The damage varied from no apparent damage to severe damage.

Roof types:

3- PVC Single Ply Roof Systems (two at 6yrs and one at 2yrs old)
1- Gravel surfaced Built-up Roof (21yrs old)
2- Trapezoidal Standing Seam Metal Roofs (5-10yrs old)
1- TPO Single Ply Roof System (11yrs old)

Two PVC roofs had no apparent damage, based on our observation and small hail size calculation of less than 1.5" and inclusion of high density cover board within the roof system. One PVC roof showed significant damage with leaks subjected to max hail size calculated at 2.5". Gravel Surfaced Built-up roof showed no visible damage to the field area with minor damage to the flashing materials. This roof was subject to 3.5" hail. The two metal roofs showed significant damage and reported leaks, these roofs were subjected to 2" and 2.5" hail. Damage was typically dents and deformed areas with the occasional dislodging from the clip system. The TPO roof showed major damage and large punctures through the membrane. It was subject to 2.5" hail and did not contain a high density cover board within the roof system.

Team Members:

Darin Lasater – Data collector and Driver
Dan Scheerer – Data collector and Report writer
Jonas Houchin – Photographer and Comic relief

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**School**
Inspection Number	**L1-1-A**
Zip	**75098**
Site Latitude	**33.0154**
Site Longitude	**-96.5388**
Area Size (Square feet)	**7000**
Approximate Age (Years)	**>12<15**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Built Up Roof**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**3.5**
Total Impact Per Square Feet of Horizontal Surface	**>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**2**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Granule or Aggregate Displacement**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L1-1-A

Overview 3 ½ ” hail, gravel BUR & Tile

Gravel movement from large hail

Large hail hit

Metal coping dent

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	School
Inspection Number	L1-1-B
Site Latitude	33.0154
Site Longitude	-96.5388
Area Size (Square feet)	10000
Approximate Age (Years)	>12<15
General Condition	Good
Slope	1/4"
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	3.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Yes
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacemnt

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L1-1-B

Overview Gravel Ballasted Roof

Large hail hit with gravel displacement

Large hail hit

Several large hail hits

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L1-1-C**
Site Latitude	**33.0086**
Site Longitude	**-96.5932**
Area Size (Square feet)	**230000**
Approximate Age (Years)	**>6<9**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**2**
Total Impact Per Square Feet of Horizontal Surface	**>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**Yes**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**5**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Fracture/Rupture**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-1-C

	
Overview	**Cracks in Membrane Around Fasteners**
	
Two Inch Hail and Small Hail	**Hail Damage**

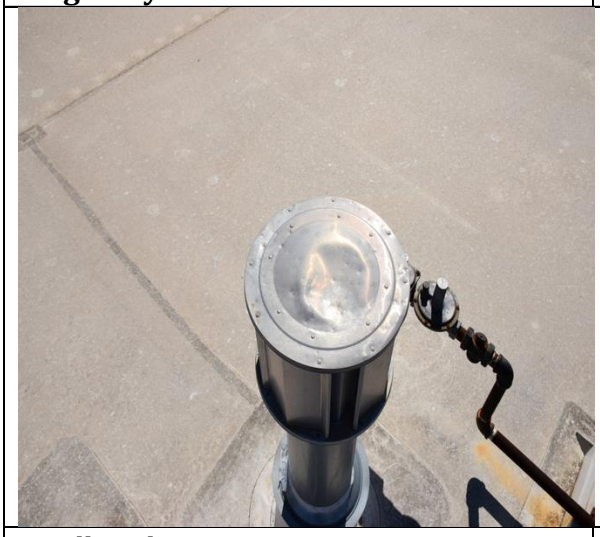
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L1-2-D**
Site Latitude	**33.0992**
Site Longitude	**-96.6816**
Area Size (Square feet)	**146000**
Approximate Age (Years)	**<3**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**1**
Total Impact Per Square Feet of Horizontal Surface	**5>10**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**No**
Percentage of roof scheduled for replacement	**0**
Overall Damage	**0**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**none**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-2-D

	
Single Ply Overview	**Apparent Bullet Hole**
	
Small Hail	Small Hail

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L1-2-E**
Site Latitude	**33.1239**
Site Longitude	**-96.6624**
Area Size (Square feet)	**140000**
Approximate Age (Years)	**>6<9**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**0.75**
Total Impact Per Square Feet of Horizontal Surface	**5>10**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**No**
Percentage of roof scheduled for replacement	**0**
Overall Damage	**0**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**none, just spatter**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-2-E Retail Store

Overview

Hail Size

Rust Spots Over Fasteners

Hail Hits on Fastener Without Damage

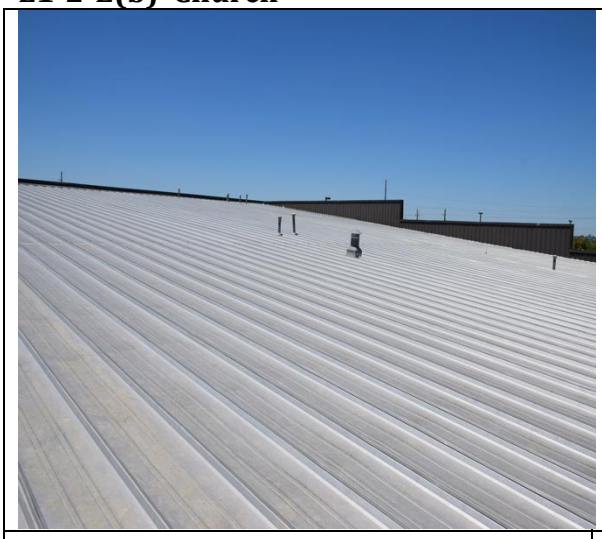
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Church**
Inspection Number	**L1-2-E(b)**
Zip	**75098**
Site Latitude	**33.0178**
Site Longitude	**-96.5533**
Area Size (Square feet)	**16000**
Approximate Age (Years)	**>9<12**
General Condition	**Fair**
Slope	**1 to 2/12**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**3.5**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**5**
Metal Roof Damage	**5**
Predominate Type of Hail Damage Observed	**Denting panel, bending seams**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-2-E(b) Church



Overview

Dent Causing a Leak

Dents Causing Leaks

Dents Causing Leaks

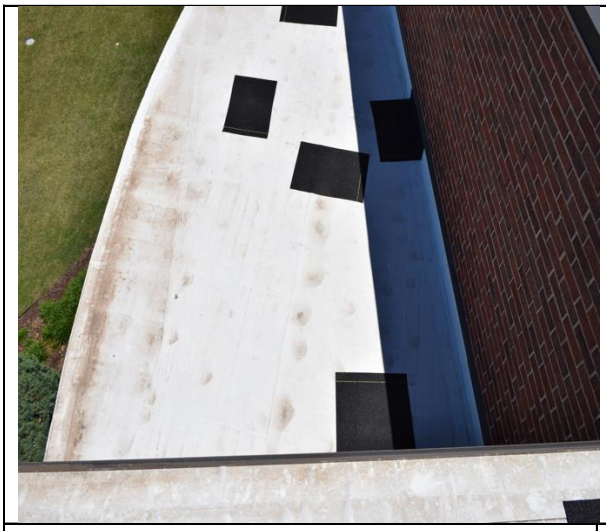
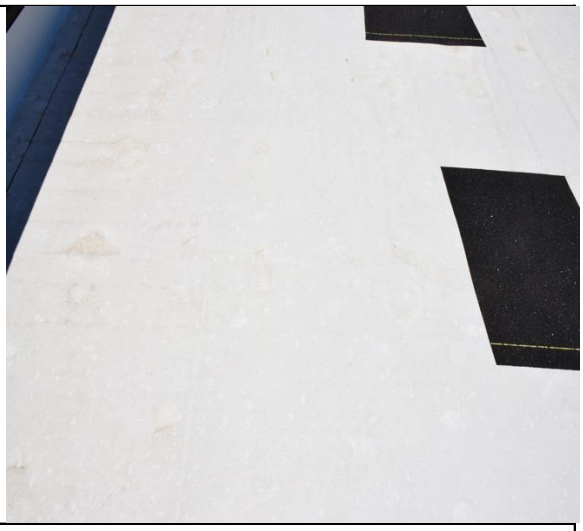
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	church
Inspection Number	L1-2-F
Site Latitude	33.0178
Site Longitude	-96.5533
Area Size (Square feet)	300
Approximate Age (Years)	>9<12
General Condition	Good
Slope	Dead Flat
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	3.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	Yes
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Yes
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Fracture/Rupture

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-2-F

	
Roof Overview –Black Temporary Patches	**More Patches**
	
Hail Damage Cut	**Hail Damage Cut**

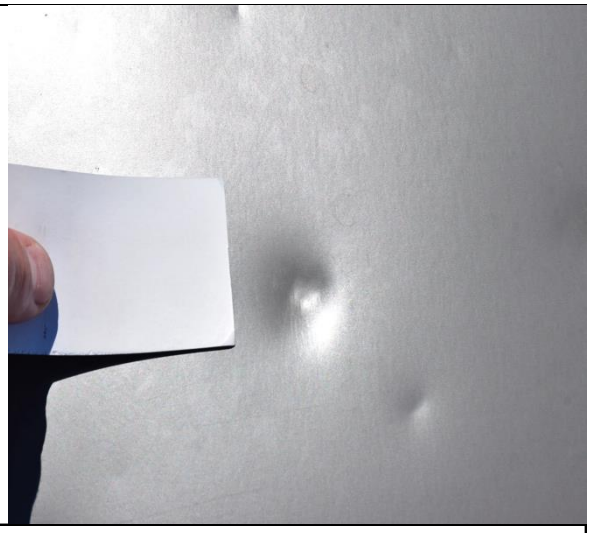
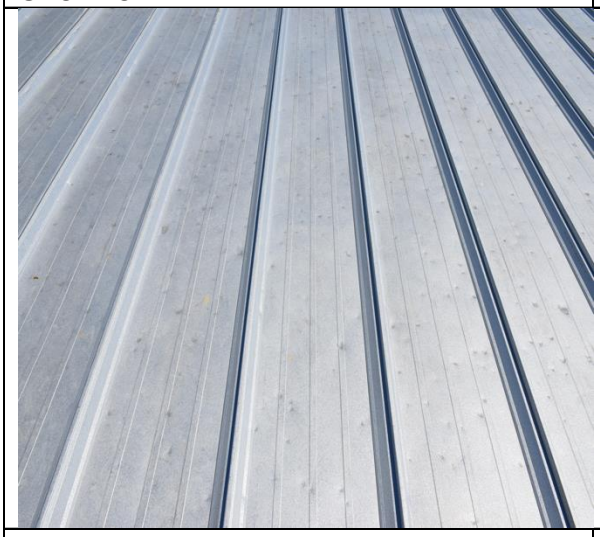
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L1-2-G**
Site Latitude	**33.0000**
Site Longitude	**-96.5558**
Area Size (Square feet)	**5000**
Approximate Age (Years)	**>6<9**
General Condition	**Fair**
Slope	**1 to 2/12**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**2.5**
Total Impact Per Square Feet of Horizontal Surface	**15>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**5**
Metal Roof Damage	**5**
Predominate Type of Hail Damage Observed	**denting panel, rotating seams**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L1-2-G

	
Overview	**Typical Dent**
	
Many Hail Hits	**Many Dents From Hail Hits**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Team 2 Summary Report

Overview

Our team inspected several roofs in Wylie, which was hit with one storm with moderately sized hail that came from the north, and another storm two weeks later from the west that carried large hail stones up to 3” in diameter.

We looked at a variety of low slope systems including modified bitumen, single-ply and metal, as well as an asphalt shingle roof and a wood shingle system.
Roofs that were hit with 2.5”-3.0” hail suffered severe damage, regardless of the roof type. Occupants in the City of Wylie Public Safety Building had to be moved to a temporary facility due to leaks in the mod bit roof on their facility. A fire station with asphalt shingles had dozens of hits per square and the wood shingles on the historical city-owned house were punctured in multiple places.

On buildings that were hit with small to moderate size hail, those with rigid cover boards fared better than those without.

Team Members

CJ Sharp, Report Writer
Mark Kubena, Photographer
Joel Loper, Data Collector

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

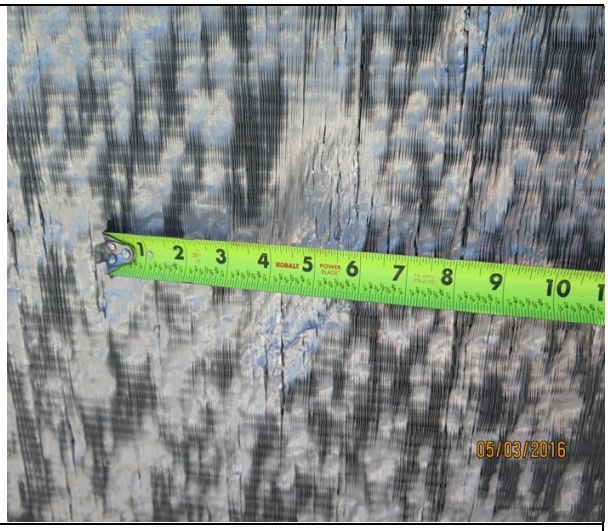
Low Slope Inspection Site

Facility Name	**Municipal**
Inspection Number	**L2-1-A**
Site Latitude	**33.0245**
Site Longitude	**96.5145**
Area Size (Square feet)	**33600**
Approximate Age (Years)	**>15**
General Condition	**Good**
Slope	**1/2"**
Roof Cover Type	**Modified Bitumen**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**3**
Total Impact Per Square Feet of Horizontal Surface	**Unknown**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**Unknown**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**100**
Overall Damage	**5**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**N/A**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L2-1-A

High Intensity Hail



Large Hail Hit

Large Hail Hit

Large Hail Hit

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Municipal**
Inspection Number	**L2-1-E**
Site Latitude	**33.0010**
Site Longitude	**96.5687**
Area Size (Square feet)	**4000**
Approximate Age (Years)	**3-6 years**
General Condition	**Good**
Slope	**1/2"**
Roof Cover Type	**Single ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**2**
Total Impact Per Square Feet of Horizontal Surface	**20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**no**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**No**
Percentage of roof scheduled for replacement	**0**
Overall Damage	**1**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**N/A**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L2-1-E

	
Overview-Single Ply	**Hail Measure**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Municipal
Inspection Number	L2-1-F
Site Latitude	33.0010
Site Longitude	96.5687
Area Size (Square feet)	3000
Approximate Age (Years)	>15
General Condition	Fair
Slope	1/2"
Roof Cover Type	Built-Up
Substrate Directly Under Membrane	?
Apparent Maximum Hail Size	2.5
Total Impact Per Square Feet of Horizontal Surface	
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	no
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	Unknown
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L2-1-F

	
Intensive Hail	**BUR Damaged only in Previously Scoured Area**
	
BUR Damaged only in Previously Scoured Area	**Intensive Hail**

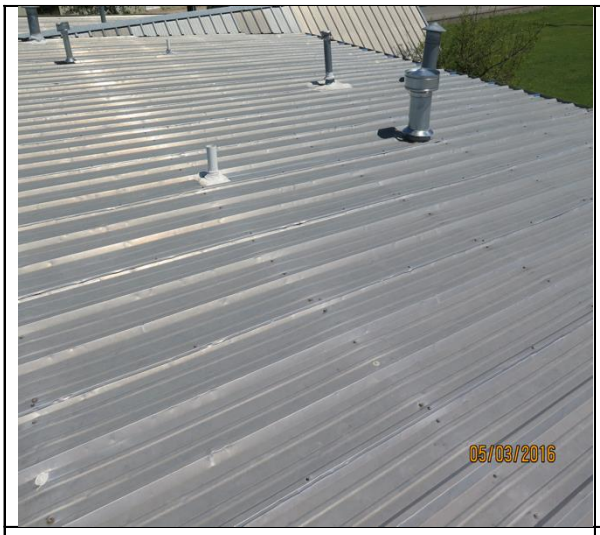
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Municipal**
Inspection Number	**L2-1-G**
Site Latitude	**33.0010**
Site Longitude	**96.5687**
Area Size (Square feet)	**2000**
Approximate Age (Years)	**10+**
General Condition	**Fair**
Slope	**1/1"**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	
Apparent Maximum Hail Size	**2**
Total Impact Per Square Feet of Horizontal Surface	**10**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**3**
Metal Roof Damage	**3**
Predominate Type of Hail Damage Observed	**Dents**

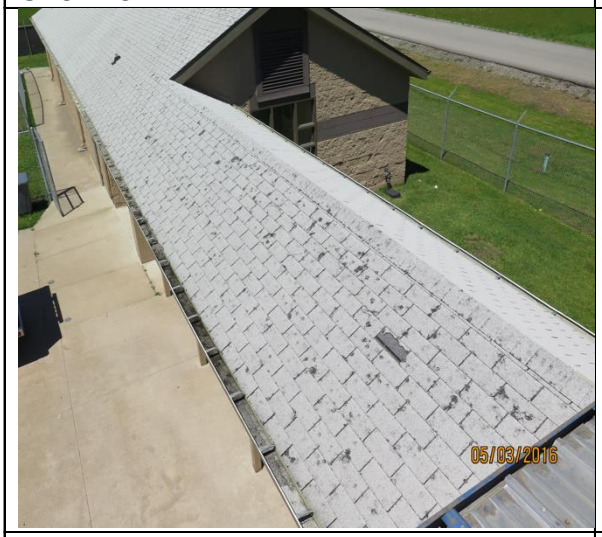
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

L2-1-G



Overview

Hail Damage



Adjacent Asphalt Shingle

Hail Hit

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Municipal
Inspection Number	L2-2-B
Site Latitude	33.0151
Site Longitude	-96.5686
Area Size (Square feet)	85000
Approximate Age (Years)	>6<9
General Condition	Excellent
Slope	1/2"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	2
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	0
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	spatter marks but no damage

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L2-2-B

	
Overview	Frequent Hail Hits
	
Damaged PV Panel	Hail Size 2 ½ inches

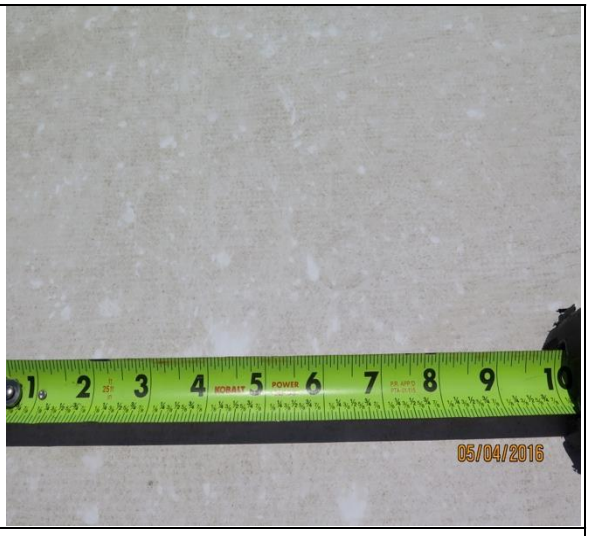
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L2-2-C
Site Latitude	33.1294
Site Longitude	-96.7307
Area Size (Square feet)	212420
Approximate Age (Years)	Unknown
General Condition	Excellent
Slope	1/2"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	0.75
Total Impact Per Square Feet of Horizontal Surface	15>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	0
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	n/a

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L2-2-C

	
Overview	Small Hail ¾ inch

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L2-2-D
Site Latitude	33.2203
Site Longitude	-96.6383
Area Size (Square feet)	214388
Approximate Age (Years)	9
General Condition	Excellent
Slope	1/2"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	0.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	0
Overall Damage	0
Metal Roof Damage	
Predominate Type of Hail Damage Observed	no damage

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L2-2-D

	
Overview	Hail Size ¾ inch

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Office
Inspection Number	L2-3-1
Site Latitude	33.0174
Site Longitude	-96.5298
Area Size (Square feet)	5000
Approximate Age (Years)	>6<9
General Condition	Poor
Slope	1/4"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacemnt

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L2-3-1

	
Serious damage	**Hail Size 1 ½ Inches**
	
Damaged Modified Bitumen	**Hail hit causing a leak**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team L-3 Summary Report
Dallas, TX
May 6, 2016

Overview

Team L-3 observed eight roofs in Collin and Denton counties. The areas covered were in cities of Garland, Denton, Plano and Parker, Texas. The indications of the largest size hail were found in Plano, Texas where the maximum hail size was approximately 1-3/4 inches in diameter. Hail at other locations ranged in size from approximately 1/4-inch to 1-1/2 inches in diameter. Observed impact locations ranged from no damage to punctures through base flashings.

Roof Types:

- Granule Surfaced Modified Bitumen
- Granule Surfaced Cap Sheet Built-up
- Through-fastened Structural Metal Roof Panels
- Foil Faced Modified Bitumen
- Class 4 Impact Resistant Laminated Asphalt Shingles

Hail impacts results varied from no damage to minor granule loss on the modified bitumen and granule surfaced cap sheet roof systems. Impacts on the gravel surfaced built-up roof system were limited to aggregate displacement. Metal roof panels had hail impact marks where the oxidized surface was partially removed as well as minor dents. Fiberglass skylight panels with exposed fiberglass fibers had some fiber removal at the hail impact locations.

The impact resistant shingles had a single location with impact damage. While the majority of the hail stones at this location were typically less than 1-inch in diameter, some 2-inch diameter hail was reported.

Team Members

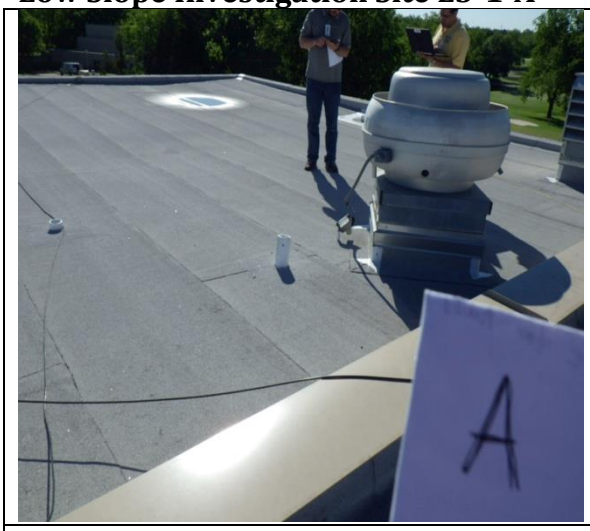
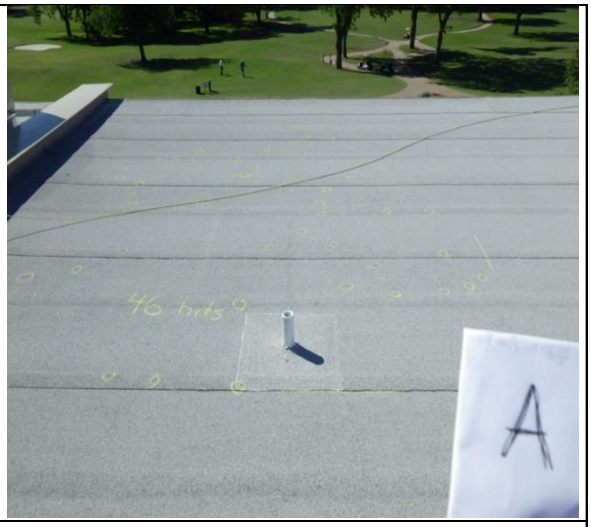
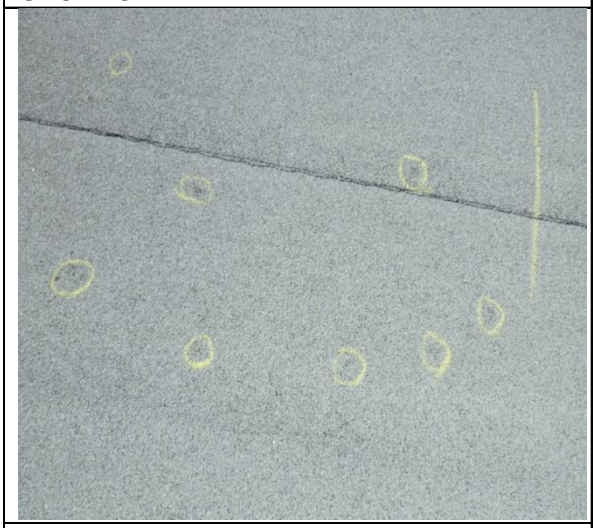
John Gimple – Data Collector
Manuel Baeza – Report Writer
Gasper Montoya - Photographer

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L3-1-A**
Site Latitude	**32.9805**
Site Longitude	**96.6366**
Area Size (Square feet)	**5600**
Approximate Age (Years)	**>3<6**
General Condition	**Excellent**
Slope	**1/4"**
Roof Cover Type	**Modified Bitumen**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**1.25"**
Total Impact Per Square Feet of Horizontal Surface	**>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**No**
Percentage of roof scheduled for replacement	**0**
Overall Damage	**1**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Granule or Aggregate Displacemnt**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Investigation Site L3-1-A

	
Overview	**Hit Frequency 46 /100 square feet**
	
Small Hail	**Hail Size 1 inch**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L3-1-B
Site Latitude	32.9805
Site Longitude	96.6366
Area Size (Square feet)	300
Approximate Age (Years)	>9<12
General Condition	Fair
Slope	1/8"
Roof Cover Type	Metal
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.25
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	0
Overall Damage	2
Metal Roof Damage	2
Predominate Type of Hail Damage Observed	Minor Dents

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Municipal
Inspection Number	L3-1-C
Site Latitude	32.9119
Site Longitude	96.6422
Area Size (Square feet)	20500
Approximate Age (Years)	>9<12
General Condition	Fair
Slope	1/4"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	<0.25
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	0
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	None

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L3-1-C
Site Latitude	32.9772
Site Longitude	96.6338
Area Size (Square feet)	2000
Approximate Age (Years)	>15
General Condition	Poor
Slope	Dead Flat
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.25
Total Impact Per Square Feet of Horizontal Surface	0
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Dent Marks

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Hail Investigation Site L3-1-C

Overview

Hits & Size

Hits

Aged BUR

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Municipal
Inspection Number	L3-1-D
Site Latitude	35.9208
Site Longitude	96.6172
Area Size (Square feet)	5200
Approximate Age (Years)	>9<12
General Condition	Fair
Slope	1/8"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	<0.25
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	
Overall Damage	0
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacement

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	School
Inspection Number	L3-2-A
Site Latitude	33.0225
Site Longitude	96.7922
Area Size (Square feet)	17000
Approximate Age (Years)	>9<12
General Condition	Good
Slope	1/4"
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	15>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	less than 10
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacement

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L3-2-A

	
Overview Gravel Surfaced BUR	**Hail hits on gravel**
	
Hail Size 1 ½ to 2 inches	**Hit on flashing**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	School
Inspection Number	L3-2-B
Site Latitude	33.0225
Site Longitude	96.7922
Area Size (Square feet)	3500
Approximate Age (Years)	>15
General Condition	Fair
Slope	1/8"
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	15>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	No
Percentage of roof scheduled for replacement	less than 10
Overall Damage	3
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Puncture

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Municipal**
Inspection Number	**L3-4-I**
Site Latitude	**33.0545**
Site Longitude	**-96.6218**
Area Size (Square feet)	**3600**
Approximate Age (Years)	**>12<15**
General Condition	**Fair**
Slope	**1 to 2/12**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**1.25**
Total Impact Per Square Feet of Horizontal Surface	**>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**No**
Percentage of roof scheduled for replacement	**0**
Overall Damage	**0**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**metal denting**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Team L4 Summary

Investigation Dates: May 3 – May 5, 2016

Team L4 investigated 9 – 10 roofs per day. They included gravel surfaced BUR, Modified Bitumen, Sprayed Polyurethane, metal (both coated R-panel and standing seam), and single-ply (TPO, EPDM, and PVC). Most of the hail damage seen was from ¾ inch diameter to 3 inch+ diameter.

We found that most roofs can survive the smaller diameter hail referenced above, while almost all roofs hit by 3inch hail will suffer some damage. Based on spatter, smaller hail hits tended to be of denser distribution than larger hail, i.e. more hits per square foot. It was also noted that despite being hit by the smaller size hail, almost all HVAC coils facing the direction of the storm were badly damaged. Some coils were completely flattened due to the density of the hits.

Team Members:

Bert Nunez, Data Collector
Jon Jensen, Report Writer
Phil Mayfield, Photographer

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L4-1-A**
Site Latitude	**33.0.6**
Site Longitude	**96.4029**
Area Size (Square feet)	**13224**
Approximate Age (Years)	**<3**
General Condition	**Excellent**
Slope	**1/4"**
Roof Cover Type	**Sprayed Polyurethane Foam**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**1.5**
Total Impact Per Square Feet of Horizontal Surface	**>20**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**5**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Puncture**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-1-A

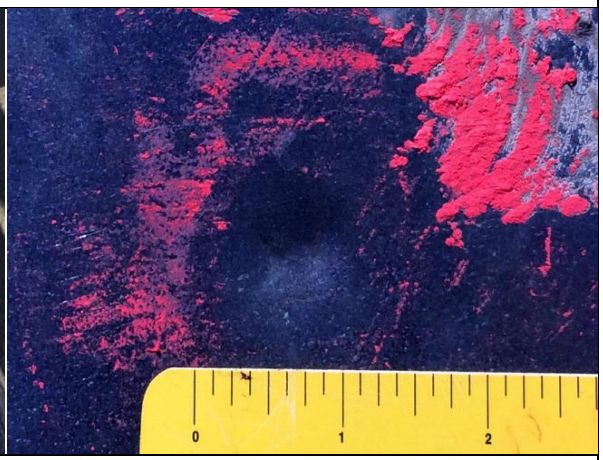
Roof system sprayed-in-place polyurethane foam covered w embedded granules.

A 10’x10’ square was used to mark visible hail damage.

High density hits (one or more p.s.f. is pictured here, the largest punctures measures approx.. 1-1.25” in diameter.

This is a close-up view of a typical puncture.

Hail spatter clearly visible on metal HVAC duct. Note the spatter serves to indicate both size and direction of hail impact.



Rubbing a straight piece of chalk over indentations in this steel HVAC duct helps measure outside diameter. This indentation is approx. 1.5 inches in dia.

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Church
Inspection Number	L4-1-B
Site Latitude	33.00.09
Site Longitude	96.4031
Area Size (Square feet)	57630
Approximate Age (Years)	>3<6
General Condition	Excellent
Slope	1/4"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	0
Overall Damage	1
Metal Roof Damage	
Predominate Type of Hail Damage Observed	spatter, dents on exhaust fans, metal coping

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RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Office**
Inspection Number	**L4-1-C**
Site Latitude	**33.00.12**
Site Longitude	**96.40.44**
Area Size (Square feet)	**31000**
Approximate Age (Years)	**>15**
General Condition	**Fair**
Slope	**1/4"**
Roof Cover Type	**Built Up Roof**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**1.5**
Total Impact Per Square Feet of Horizontal Surface	**0**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**3**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Fracture/Rupture**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-1-C

	
The gravel surfacing of this built-up roof membrane apparently served as adequate protection from damage in the field.	**This is a close-up view of damaged cooling fins.**
	
Spatter on the side of this HVAC unit indicates hail direction of approximately 60 degrees from horizontal. Spatter size is ½" to 1".	**The only visible evidence of hail damage to the roof system was the base flashings, which were temporarily patched until proper repairs could be scheduled.**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L4-1-D
Site Latitude	33.0028
Site Longitude	96.4135
Area Size (Square feet)	40000
Approximate Age (Years)	>15
General Condition	Poor
Slope	1/4"
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	Unknown
Overall Damage	0
Metal Roof Damage	
Predominate Type of Hail Damage Observed	dents in light gauge metal

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-1-D

	
Although this built-up roof membrane appeared to be over ten years old, the gravel surfacing was likely a big factor in preventing hail damage to the membrane.	**Predictably, sheet metal appurtenances (1) and HVAC cooling fins (2) exhibited the most prominent evidence of hail activity.**

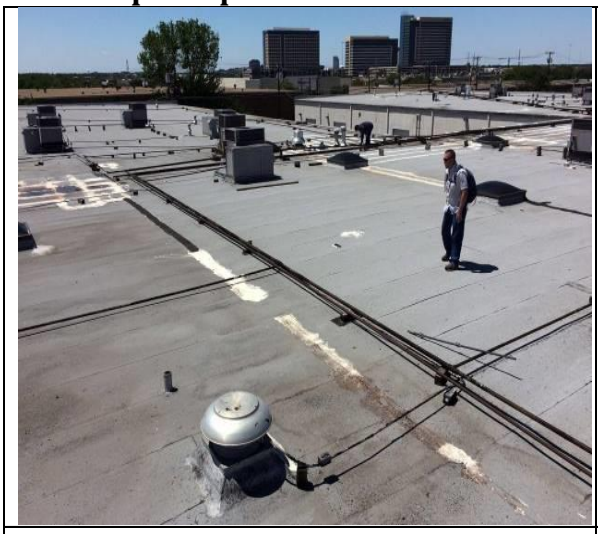
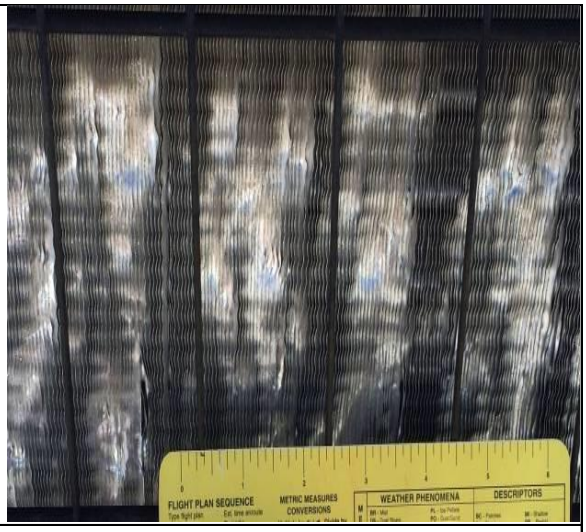
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Warehouse
Inspection Number	L4-1-E
Site Latitude	33.0033
Site Longitude	96.4134
Area Size (Square feet)	60500
Approximate Age (Years)	>15
General Condition	Poor
Slope	1/4"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	Unknown
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Fracture/Rupture

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-1-E

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>This roof is covered with modified bituminous (MB) membranes of varying ages. Older sections have been patched, prior to the April 11th hail storm, with white mastic.</td><td>Indentations shown here are around 1-inch in diameter.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Anomalies consistent with hail impact were marked within a 10’x10’ area.</td><td>These anomalies were typical of those shown in photo 7, above.</td></tr>
</table>

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

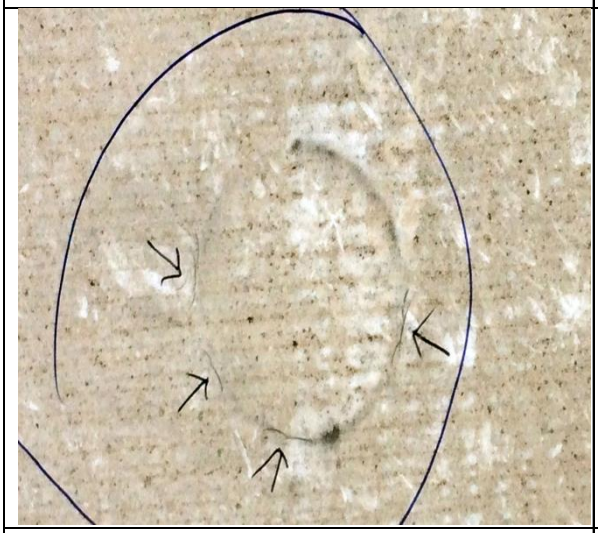
Facility Name	Commercial/Retail
Inspection Number	L4-1-F
Site Latitude	33.5757
Site Longitude	96.3848
Area Size (Square feet)	177000
Approximate Age (Years)	>15
General Condition	Fair
Slope	1/2"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	1.25
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	Yes
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Yes
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Fracture/Rupture

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-1-F

This PVC membrane was in the process of being replaced during our inspection.

Dozens of cuts and fractures were found in this 10'x10' test area. Also note the white spatter.



The small cuts, each from separate hail stones, are along the edge of an underlying fastener plate.

This fracture is a classic hail signature on thermoplastic membranes.

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Vacant warehouse**
Inspection Number	**L4-1-G**
Site Latitude	**33.0025**
Site Longitude	**96.325**
Area Size (Square feet)	**31600**
Approximate Age (Years)	**>15**
General Condition	**Poor**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**3**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**2**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Broken Skylights**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Sites L4-1-G

	
L4-1-G No apparent damage to PVC membrane	**Another view, showing multiple hail hits on air handler**

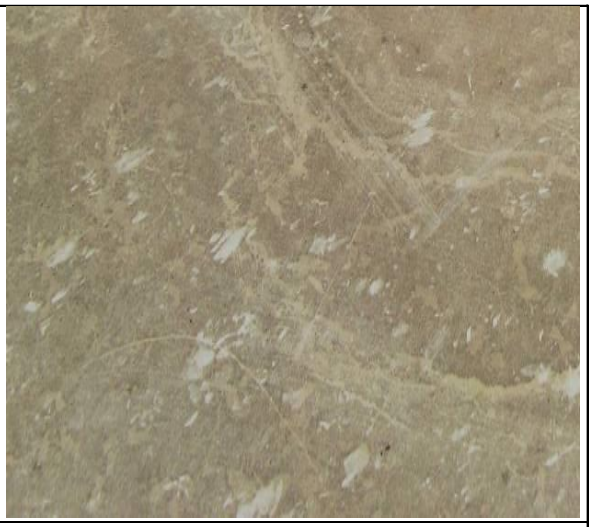
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L4-1-H
Site Latitude	32.5754
Site Longitude	96.385
Area Size (Square feet)	21300
Approximate Age (Years)	>9<12
General Condition	Good
Slope	1/4"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	0
Overall Damage	0
Metal Roof Damage	
Predominate Type of Hail Damage Observed	denting on light gauge metal

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Sites L4-1-H

	
L4-1-H Next door to G No damage to PVC	**Some of these spatter marks indicate hail of approximately one inch in diameter.**

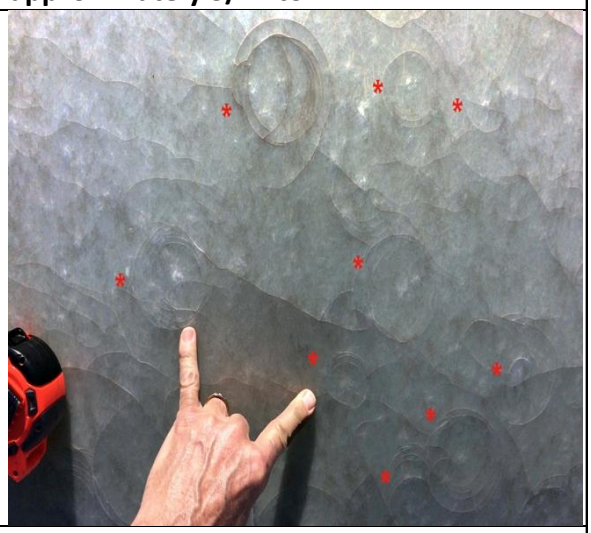
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L4-2-A**
Site Latitude	**32.56.23**
Site Longitude	**96.41.45**
Area Size (Square feet)	**144430**
Approximate Age (Years)	**>6<9**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**0.75**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**0**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**see above**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-2-A

	
No membrane damage was found on this site visit.	**This photo shows the PVC membrane covered with a film of dirt interrupted by hail spatter. Spatter width is approximately 3/4" to 1".**
	
The three asterisks form a triangle between the top of the parapet, the bottom, and the distance from the wall where the pattern of hail spatter begins. The parapet height is approximately the same distance as the distance of spatter from the wall, indicating a 45 degree angle of hail fall	**This is a closer view of one of the plastic skylight lenses, with circular hail impact marks marked.**

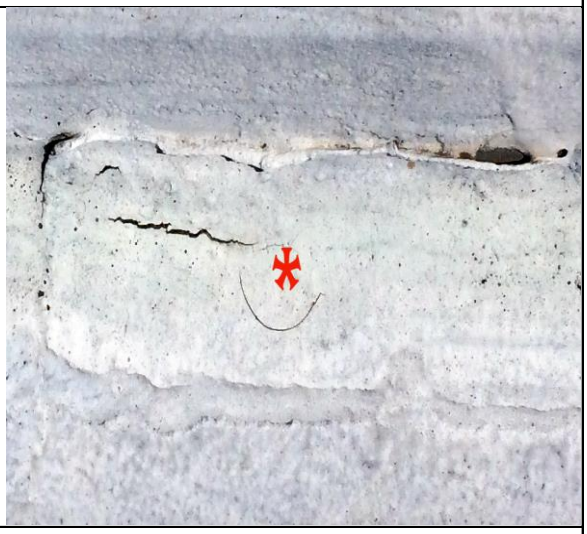
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L4-2-D**
Zip	**75048**
Site Latitude	**32.5827**
Site Longitude	**96.3551**
Area Size (Square feet)	**9700**
Approximate Age (Years)	**>15**
General Condition	**Poor**
Slope	**1 to 2/12**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**0.75**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**0**
Metal Roof Damage	**1**
Predominate Type of Hail Damage Observed	**Disbonding of Surface Coating**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-2-D

	
This building was covered by an R-panel roof with white coating. No indentations were observed in the metal panels.	**The only damage to the roof system was fracturing and displaced coating.**
	
Most visible damage appeared to be at angles where the coating may not have been well bonded or where air pockets had formed	**The asterisk marks a semi-circular impact mark typical of what is often caused by hail strikes. Hail size was ¾ to 1 inch.**

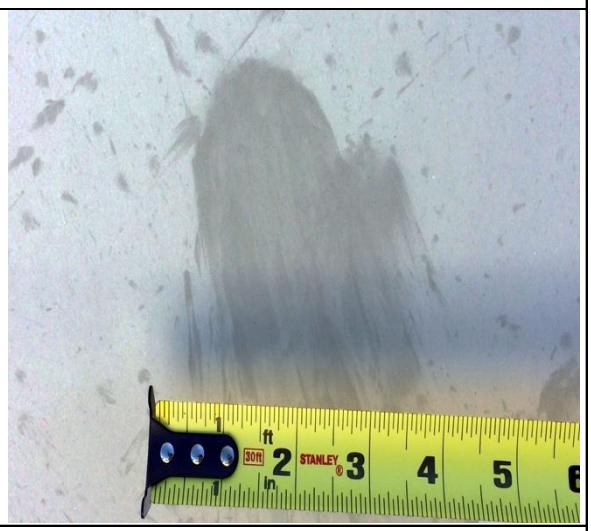
RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L4-2-E
Site Latitude	33.00.20
Site Longitude	96.33.16
Area Size (Square feet)	7000
Approximate Age (Years)	>3<6
General Condition	Good
Slope	1/4"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	4
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Yes
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacemnt

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-2-E

	
Many holes in this modified bituminous (MB) roof membrane had been patched recently with a white mastic .	**Visible damage was encircled within a 10'x10' area.**
	
The black scuff marks appear to be only an inch or two in diameter, although hail size was 3-4 inches.	**Hail 3" & larger was common on this roof**

RICOWI Hailstorm Investigation
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Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L4-2-F
Site Latitude	33.00.25
Site Longitude	96.33.06
Area Size (Square feet)	16680
Approximate Age (Years)	>6<9
General Condition	Good
Slope	1/4"
Roof Cover Type	Built Up Roof
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	4
Total Impact Per Square Feet of Horizontal Surface	1>5
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	No
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	Unknown
Overall Damage	3
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacemnt

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North Texas – April 11, 2016

Low Slope Inspection Site

Facility Name	**Church**
Inspection Number	**L4-3-B**
Zip	**75074**
Site Latitude	**33.0028**
Site Longitude	**96.4145**
Area Size (Square feet)	**15625**
Approximate Age (Years)	**>9<12**
General Condition	**Fair**
Slope	**1/4"**
Roof Cover Type	**Modified Bitumen**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**1.5>2**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**1**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**spatter HVAC coils**

RICOWI Hailstorm Investigation
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Low Slope Inspection site L4-3-B

Note the great difference in hail-damaged cooling fins on the west and north sides.

Dark spots consistent with hail impact have been marked with pink chalk on the MB surface.

Marks consistent with 1 ½ to 2 Inch hail

Based on the slant of the spatter, the angle of hailfall is as shown by the yellow tape, approximately 60 degrees, clockwise, from left to right.

RICOWI Hailstorm Investigation
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Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L4-3-F**
Site Latitude	**33.0029**
Site Longitude	**96.3427**
Area Size (Square feet)	**18000**
Approximate Age (Years)	**>3<6**
General Condition	**Good**
Slope	**1/4"**
Roof Cover Type	**Single Ply**
Substrate Directly Under Membrane	**High Compressive**
Apparent Maximum Hail Size	**2.5**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**No**
Is the roof scheduled for replacement	**Unknown**
Percentage of roof scheduled for replacement	**Unknown**
Overall Damage	**3**
Metal Roof Damage	
Predominate Type of Hail Damage Observed	**Puncture**

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site L4-3-F

	
This TPO roof appeared to be five to ten years old.	**Hundreds of spatter marks**
	
This is a close-up view of some of the 2 inch hail spatter on the roof surface	**Small applications of sealant were applied as emergency repairs to punctures, soon after the hail storm.**

RICOWI Hailstorm Investigation
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Low Slope Inspection Site

Facility Name	**Commercial/Retail**
Inspection Number	**L4-3-J**
Site Latitude	**33.0023**
Site Longitude	**96.3316**
Area Size (Square feet)	**3850**
Approximate Age (Years)	**>6<9**
General Condition	**Fair**
Slope	**1 to 2/12**
Roof Cover Type	**Metal**
Substrate Directly Under Membrane	**Low Compressive**
Apparent Maximum Hail Size	**3.5**
Total Impact Per Square Feet of Horizontal Surface	**1>5**
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	**No**
Is there known roof leakage following this hailstorm?	**Yes**
Is the roof scheduled for replacement	**Yes**
Percentage of roof scheduled for replacement	**50 to 100**
Overall Damage	**5**
Metal Roof Damage	**5**
Predominate Type of Hail Damage Observed	**dents in metal**

RICOWI Hailstorm Investigation
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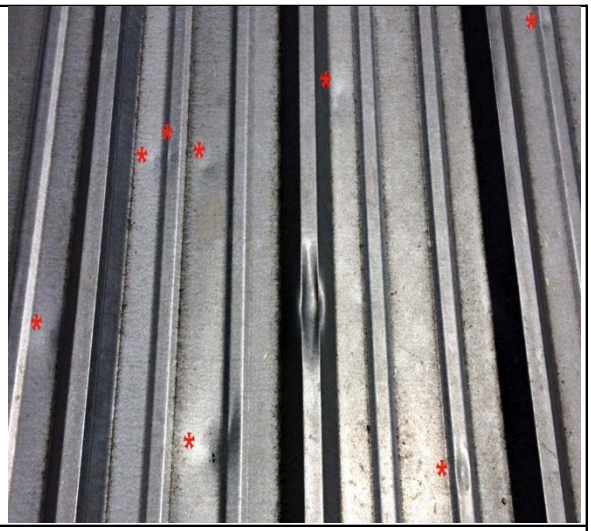
Low Slope Inspection Site L4-3-J

This R-panel metal roof experienced 3-4" diameter hail. The parapets have been covered temporarily with peel-and-stick membrane due to the damaged EIFS beneath it.



In addition to indentations in the flat portions and minor ribs, the major ribs have been significantly deformed by hail impact.

Both minor and major indentations are visible in this photo.

This is a typical 4 inch hail hit

RICOWI Hailstorm Investigation
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Low Slope Inspection Site

Facility Name	Commercial/Retail
Inspection Number	L5-1-A
Site Latitude	33o 02' 12.55" N
Site Longitude	96o 42' 28.02" W
Area Size (Square feet)	120900
Approximate Age (Years)	>12<15
General Condition	Good
Slope	1/4"
Roof Cover Type	Single Ply
Substrate Directly Under Membrane	High Compressive
Apparent Maximum Hail Size	1.5
Total Impact Per Square Feet of Horizontal Surface	>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	Yes
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Yes
Percentage of roof scheduled for replacement	50 to 100
Overall Damage	5
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Fracture/Rupture

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Low Slope Inspection Site L5-1-A

Overview

Hail Size 1 ½ inches

Dent in High Density Gypsum board

Multiple hits

Hits on fasteners

Puncture on fastener.

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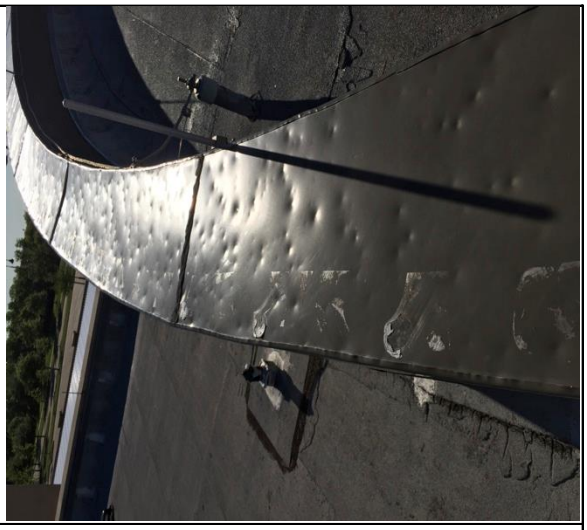
Low Slope Inspection Site

Facility Name	Municipal
Inspection Number	S3-1-H
Site Latitude	33.0180
Site Longitude	-96.6105
Area Size (Square feet)	5000
Approximate Age (Years)	>9<12
General Condition	Fair
Slope	1/4"
Roof Cover Type	Modified Bitumen
Substrate Directly Under Membrane	Low Compressive
Apparent Maximum Hail Size	1.25
Total Impact Per Square Feet of Horizontal Surface	15>20
Are there direct hits on mechanical fasteners or other cutting edges on roof membranes?	No
Is there known roof leakage following this hailstorm?	Yes
Is the roof scheduled for replacement	Unknown
Percentage of roof scheduled for replacement	Unknown
Overall Damage	2
Metal Roof Damage	
Predominate Type of Hail Damage Observed	Granule or Aggregate Displacemnt

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Low Slope Inspection Site S3-1-H

	
Over all atrium roof	**Hits on coping around atrium roof**
	
Accumulation of granules from cap sheet	**Approximate 1" hit**

APPENDIX D: CoreLogic Maps

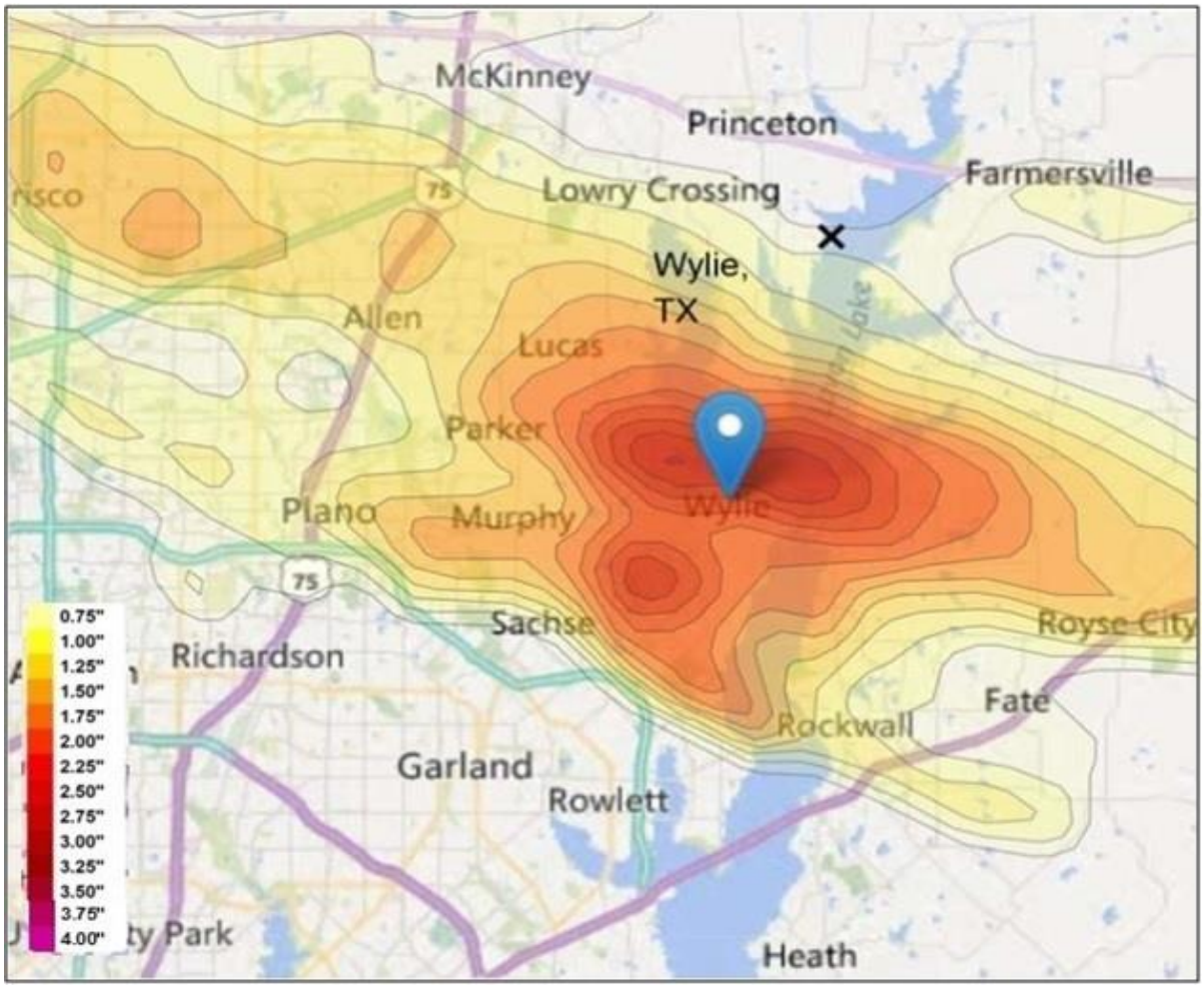


Figure 1. Zoomed view of eastern Collin County where hail size was largest (courtesy of CoreLogic®).

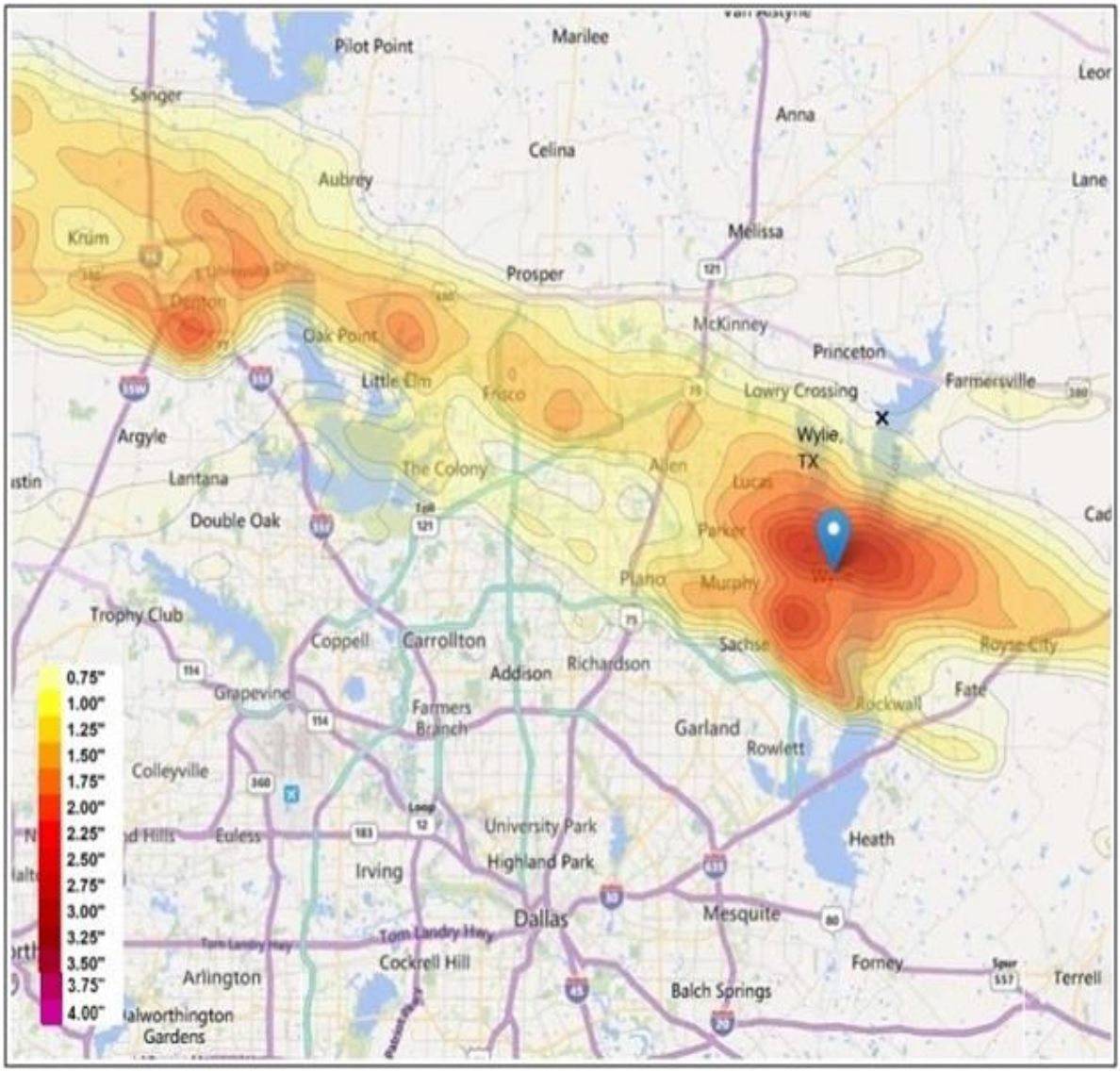


Figure 2. Wide view of hail size analysis of April 11, 2016 storm (CoreLogic®).

APPENDIX E:

Storm Event Database

Storm Events Database

Search Results for Denton County, Texas

Event Types: Hail

13 events were reported between 04/11/2016 and 04/11/2016 (1 days)

Summary Info:

Number of County/Zone areas affected:	1
Number of Days with Event:	1
Number of Days with Event and Death:	0
Number of Days with Event and Death or Injury:	0
Number of Days with Event and Property Damage:	1
Number of Days with Event and Crop Damage:	0
Number of Event Types reported:	1

Column Definitions:
'Mag': Magnitude, 'Dth': Deaths, 'Inj': Injuries, 'PrD': Property Damage, 'CrD': Crop Damage

*Click on **Location** below to display details.*
Available Event Types have changed over time. Please refer to the Database Details for more information.

Select: All Hail ▼ Sort By: Date/Time (Oldest) ▼

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	52.700M	0.00K
JUSTIN	DENTON CO.	TX	04/11/2016	06:32	CST-6	Hail	0.75 in.	0	0	0.00K	0.00K
KRUM	DENTON CO.	TX	04/11/2016	16:10	CST-6	Hail	1.75 in.	0	0	100.00K	0.00K
PONDER PALMER ARPT	DENTON CO.	TX	04/11/2016	16:12	CST-6	Hail	2.50 in.	0	0	200.00K	0.00K
DENTON	DENTON CO.	TX	04/11/2016	16:14	CST-6	Hail	1.75 in.	0	0	150.00K	0.00K
DENTON	DENTON CO.	TX	04/11/2016	16:15	CST-6	Hail	1.75 in.	0	0	150.00K	0.00K
DENTON	DENTON CO.	TX	04/11/2016	16:20	CST-6	Hail	4.00 in.	0	0	50.000M	0.00K
MAYHILL	DENTON CO.	TX	04/11/2016	16:20	CST-6	Hail	1.75 in.	0	0	100.00K	0.00K
CORINTH	DENTON CO.	TX	04/11/2016	16:23	CST-6	Hail	1.00 in.	0	0	0.00K	0.00K
DENTON	DENTON CO.	TX	04/11/2016	16:25	CST-6	Hail	2.50 in.	0	0	500.00K	0.00K
MAYHILL	DENTON CO.	TX	04/11/2016	16:25	CST-6	Hail	2.75 in.	0	0	500.00K	0.00K
MINGO	DENTON CO.	TX	04/11/2016	16:26	CST-6	Hail	1.00 in.	0	0	0.00K	0.00K
CORINTH	DENTON CO.	TX	04/11/2016	16:30	CST-6	Hail	2.75 in.	0	0	500.00K	0.00K
LITTLE ELM	DENTON CO.	TX	04/11/2016	16:37	CST-6	Hail	2.75 in.	0	0	500.00K	0.00K
Totals:								0	0	52.700M	0.00K

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Storm Events Database

Search Results for Collin County, Texas

Event Types: Hail

21 events were reported between 04/11/2016 and 04/11/2016 (1 days)

Summary Info:

Number of County/Zone areas affected:	1
Number of Days with Event:	1
Number of Days with Event and Death:	0
Number of Days with Event and Death or Injury:	0
Number of Days with Event and Property Damage:	1
Number of Days with Event and Crop Damage:	0
Number of Event Types reported:	1

Column Definitions:
'Mag': Magnitude, 'Dth': Deaths, 'Inj': Injuries, 'PrD': Property Damage, 'CrD': Crop Damage

*Click on **Location** below to display details.*
Available Event Types have changed over time. Please refer to the Database Details for more information.

Select: All Hail ▼ Sort By: Date/Time (Oldest) ▼

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	226.150M	0.00K
FARMERSVILLE	COLLIN CO.	TX	04/11/2016	14:51	CST-6	Hail	0.75 in.	0	0	0.00K	0.00K
FRISCO	COLLIN CO.	TX	04/11/2016	16:30	CST-6	Hail	1.50 in.	0	0	100.00K	0.00K
FRISCO	COLLIN CO.	TX	04/11/2016	16:42	CST-6	Hail	1.00 in.	0	0	0.00K	0.00K
PLANO	COLLIN CO.	TX	04/11/2016	16:45	CST-6	Hail	1.75 in.	0	0	100.00K	0.00K
FRISCO	COLLIN CO.	TX	04/11/2016	16:48	CST-6	Hail	2.00 in.	0	0	1.000M	0.00K
ALLEN	COLLIN CO.	TX	04/11/2016	16:50	CST-6	Hail	2.00 in.	0	0	500.00K	0.00K
PLANO	COLLIN CO.	TX	04/11/2016	16:50	CST-6	Hail	2.50 in.	0	0	1.000M	0.00K
ALLEN	COLLIN CO.	TX	04/11/2016	16:54	CST-6	Hail	1.50 in.	0	0	500.00K	0.00K
MCKINNEY	COLLIN CO.	TX	04/11/2016	16:55	CST-6	Hail	1.25 in.	0	0	50.00K	0.00K
FOREST GROVE	COLLIN CO.	TX	04/11/2016	16:56	CST-6	Hail	2.00 in.	0	0	5.000M	0.00K
PLANO	COLLIN CO.	TX	04/11/2016	16:57	CST-6	Hail	2.00 in.	0	0	1.000M	0.00K
PARKER	COLLIN CO.	TX	04/11/2016	17:03	CST-6	Hail	2.00 in.	0	0	250.00K	0.00K
LUCAS	COLLIN CO.	TX	04/11/2016	17:03	CST-6	Hail	1.75 in.	0	0	250.00K	0.00K
ALLEN	COLLIN CO.	TX	04/11/2016	17:03	CST-6	Hail	2.00 in.	0	0	1.000M	0.00K
PLANO	COLLIN CO.	TX	04/11/2016	17:07	CST-6	Hail	1.50 in.	0	0	100.00K	0.00K
WYLIE	COLLIN CO.	TX	04/11/2016	17:07	CST-6	Hail	1.50 in.	0	0	50.00K	0.00K
WYLIE	COLLIN CO.	TX	04/11/2016	17:12	CST-6	Hail	2.75 in.	0	0	5.000M	0.00K
WYLIE	COLLIN CO.	TX	04/11/2016	17:15	CST-6	Hail	3.50 in.	0	0	50.000M	0.00K
WYLIE	COLLIN CO.	TX	04/11/2016	17:17	CST-6	Hail	4.25 in.	0	0	100.000M	0.00K
LAVON	COLLIN CO.	TX	04/11/2016	17:18	CST-6	Hail	2.50 in.	0	0	250.00K	0.00K
WYLIE	COLLIN CO.	TX	04/11/2016	17:19	CST-6	Hail	5.25 in.	0	0	60.000M	0.00K
Totals:								0	0	226.150M	0.00K

RICOWI Hailstorm Investigation
North Texas – April 11, 2016

Storm Events Database

Search Results for Rockwall County, Texas

Event Types: Hail

5 events were reported between 04/11/2016 and 04/11/2016 (1 days)

Summary Info:

Number of County/Zone areas affected:	1
Number of Days with Event:	1
Number of Days with Event and Death:	0
Number of Days with Event and Death or Injury:	0
Number of Days with Event and Property Damage:	1
Number of Days with Event and Crop Damage:	0
Number of Event Types reported:	1

Column Definitions:
'Mag': Magnitude, 'Dth': Deaths, 'Inj': Injuries, 'PrD': Property Damage, 'CrD': Crop Damage

*Click on **Location** below to display details.*
Available Event Types have changed over time. Please refer to the Database Details for more information.

Select: All Hail ▼ Sort By: Date/Time (Oldest) ▼

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	62.250M	0.00K
LAKE RAY HUBBARD	ROCKWALL CO.	TX	04/11/2016	17:08	CST-6	Hail	4.00 in.	0	0	50.000M	0.00K
ROCKWALL	ROCKWALL CO.	TX	04/11/2016	17:15	CST-6	Hail	1.00 in.	0	0	0.00K	0.00K
ROCKWALL	ROCKWALL CO.	TX	04/11/2016	17:19	CST-6	Hail	1.75 in.	0	0	250.00K	0.00K
ROCKWALL	ROCKWALL CO.	TX	04/11/2016	17:25	CST-6	Hail	3.00 in.	0	0	10.000M	0.00K
ROYSE CITY	ROCKWALL CO.	TX	04/11/2016	17:36	CST-6	Hail	2.00 in.	0	0	2.000M	0.00K
Totals:								0	0	62.250M	0.00K

APPENDIX F:
2016 RICOWI Hail Investigation Team Members

From left to right:

Front row: Manuel Baez, John Kouba, Allan Kidd Phil Mayfield, Gasper Baeza, Jerry Vandewater Brett Cholewa

Back row: Jeff Cissell, John Gimple, Tim Crawford, Matt Phillips, Joel Loper Michael Schwent, CJ Sharp, Robert White, John Erwin, Stephen Towne, Scott Curry, Bill Morgan, and Doug Thagard

Absent from the Photo:
Peter Parmenter, Bert Nunez, Richard Herzog, Wade Sticht, Edward Mossakowski, Jon Jensen, Mark Kubena, Jonas Houchin, Darin Lasater and Dan Scheerer

2016 RICOWI Hail Team Members

Steep Slope Team 1
Brett Cholewa, Building Envelope Consultants, LTD.
Jeffrey Cissell, PE, Cissell Investigative
Robert White, Malarkey Roofing Products

Steep Slope Team 2
Scott Curry, Malarkey Roofing Products
Doug Thagard, Fontana Paper Mills
Stephen Towne, Bracken Engineering

Steep Slope Team 3
Richard Herzog, Haag Engineering
John Erwin,
John Kouba, Malarkey Roofing Products

Steep SlopeTeam 4
Allan Kidd, HiMark Roof Consultants
Michael Schwent, GAF
Jerry Vandewater, Crown Roof Tiles

Steep SlopeTeam 5
Tim Crawford, Benco Commercial Roofing
Bill Morgan, Malarkey Roofing Products
Wade Sticht, Case Forensics

Low Slope Team 1
Jonas Houchin, Johns Manville
Darin Lasater, Acute Engineering
Dan Scheerer, SFS Intec, Inc.

Low Slope Team 2
Mark Kubena, Insight Engineering
Joel Loper, Conner-Legrand, Inc.
CJ Sharp, Georgia-Pacific Gypsum

Low Slope Team 3
Manuel Baeza, Georgia-Pacific Gypsum
John Gimple, Gimple Roof Engineering
Gasper Montoya, PTBK

Low Slope Team 4
Jon Jensen, Sika Sarnafil
Phil Mayfield, PSM Consultants
Bert Nunez, Benco Commercial Roofing

Low Slope Team 5
Edward Mossakowski, EM & Associates, Inc.
Matthew Phillips, TexasTech

APPENDIX G: Acknowledgements

RICOWI wishes to thank several organizations, corporations, and individuals for making the hail investigations possible. Primarily, RICOWI thanks the Sponsor Members of RICOWI who provided much of the funding for the project and who provided volunteers to the HIP committees and the field investigation: ARMA, CSSB, IBHS, ERA, MBMA, MCA, RCI, SPFA, and SPRI. Thanks to State Farm Insurance for providing additional project funding through a research grant. Additionally, the following Affiliate Members contributed to the HIP project: Haag Engineering Co., ARMKO Industries, Crenshaw Consulting Group, Eagle Roofing, GAF Building Materials, Liberty Mutual Insurance, Malarkey Roofing Products, Performance Roof Systems, and Roof Maintenance Systems.

Thank you to the HIP team members (Appendix F) for their hard work, dedication, and numerous volunteer hours. Thanks to Wade Sticht for his work on the report. Thanks to RICOWI Executive Director Joan Cook for excellent leadership, organization, and support, and to David Roodvoets of DLR Consultants, our HIP Site Coordinator and data base author. Thanks to Hail Committee Chair John Gimple and Past Chair, report co-author, Richard Herzog, Haag Engineering and to the report writers. RICOWI would like to thank peer reviewers Jay Johnson, Thomas Smith, Michael Violette, and Vince Hill for their time and attention to detail.

Thanks to the City of Wylie and staff person Shane Colley, to Selso Mata and Charles Hart of the City of Plano for their assistance. Bert Nunez and the employees of Benco for their assistance with providing names and making contacts with homeowners. We would also like to thank Aspen Mark for their assistance with providing contacts. Thanks to FEMA, the Offices of Emergency Management for their assistance. A special thanks to homeowners that provided access to their homes, and to Don and Sherry Takak for their assistance with photos and contacts.

Thanks to KXAS-TV Channel 5, for providing media coverage for the investigation. We also appreciate TalkItUp Media for assisting with setting up Facebook, Twitter and LinkedIn accounts overnight, and sending out information on the event! Thank you!

The Hilton Garden Inn, Allen TX provided comfortable accommodations and excellent service serving as the HIP investigation headquarters.

Thank you to the people of North Texas for your kindness, hospitality, and willingness to share your experiences with RICOWI.

Report Task Group:
John Gimple, Chair, Hail Investigation Program, Gimple Roof Engineers
Richard Herzog, Hail Investigation Program, Haag Engineering Co.
David Roodvoets, On-Site Coordinator, DLR Consultants
John Kouba, Malarkey Roofing Products
Joan Cook, RICOWI, Inc.