Infrared Thermographic and Nuclear Roof Moisture Analysis

PERFORMED FOR:	**Sample Client**
LOCATION:	**Building X** **Sample Location**
CONDUCTED ON:	**September 30 and October 1, 2, 3, 4, 8 & 18, 2019**
REQUESTED BY:	**Sample Facilities Director**
PERFORMED BY:	**Certified Technician A &** **Certified Technician B**

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Nationwide Service Since 1984

IR ANALYZERS Vector Mapping

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November 5, 2019

Dear Sample Client,

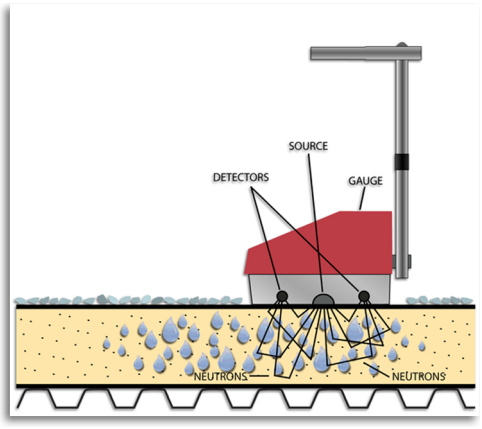
This report summarizes the findings of our Infrared and Nuclear Roof Moisture Analysis of the roofs at Sample Facility, performed on September 30 and October
1, 2, 3, 4, 8 & 18, 2019.

Included is a map of the roof. All of the water-damaged areas of the roofs are marked on the maps. All the wet areas and the locations of the core samples are also marked directly on the roofs surface with long-lasting spray paint. This report also includes descriptions of Infrared Thermography and Nuclear Testing, as well as roof construction details, survey procedures and the weather conditions on the date of the survey.

NUCLEAR ROOF MOISTURE ANALYSIS: THEORY AND OPERATING PRINCIPLES

The Troxler Nuclear Moisture Detector is an extremely accurate and sensitive device specifically designed for performing Non-Destructive Roof Moisture Surveys. The detector can measure even small quantities of moisture, and can read deep into a roofing system. The maximum operating depth is about eight inches. Contradictory to its name, the moisture detector does not directly measure or detect moisture. The instrument locates moisture by seeking out hydrogen atoms. Hydrogen atoms are present in organic materials and are most abundant in water.

A radioactive source of Americum 241: Beryllium is encapsulated and sealed within the instrument. When the instrument is activated, fast neutrons are produced by exposing the Americum to the Beryllium. The fast neutrons collide with the atoms and are "thermalized" or slowed down. The meter measures the rate of collision for a pre-set time period, similar to radar, and displays the count on a digital periodic rate meter. Since all hydrogen-bearing materials contribute to the count rate, the meter must be calibrated for each roof to obtain absolute moisture readings and to keep operator interpretation to a minimum.



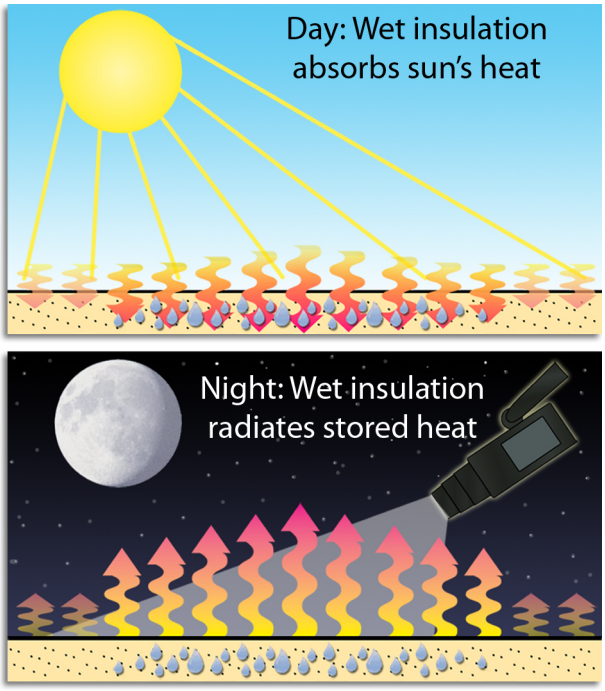
The Roof Moisture Analysis is performed on a grid system at five- or ten-foot intervals. In addition to the readings taken on the defined grid, many other readings are taken on the roof to further identify and define wet areas. A draft map of the roof is made on site. The technician who performed the survey performs the final interpretation of the results, and a final copy of the map is produced at the office.

INFRARED THERMOGRAPHY

All objects emit heat (i.e. infrared radiation). This radiation is constantly being absorbed and re-emitted by ourselves and everything around us. “Infrared scanning” and “thermography” are the terms used to describe the process of making this thermal radiation visible and capable of interpretation.

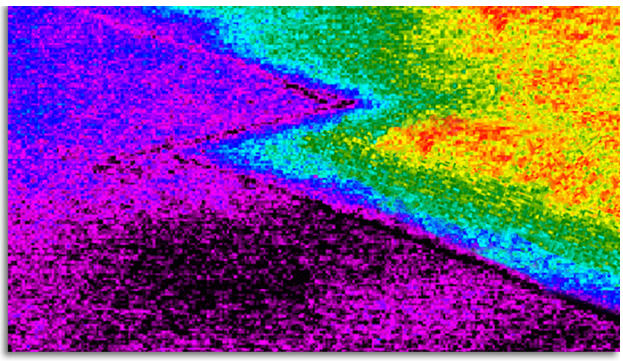
Infrared Roof Moisture Analysis locates areas of wet insulation within a flat roofing system. These areas of wet insulation can be pinpointed with the infrared scanner because wet and dry insulations have different abilities to conduct, absorb and retain heat. The thermal differences between wet and dry insulation are especially evident under two sets of circumstances.

First, wet roof insulation absorbs much more heat than dry insulation. Moisture-damaged insulation also stores more heat over a longer period of time than intact, dry materials. During the day, the sun’s heat steadily raises the temperature of wet insulation in the roofing system. As the roof cools off at night, the areas of wet insulation will stay warm longer than the dry areas. During the evening, this stored “solar gain” is released as radiant heat that is detectable with the infrared camera. As the evening progresses, areas of wet insulation will appear warmer to the camera than adjacent dry roofing.



Second, when there is a significant difference in ambient temperature between the interior and exterior of the building, heat losses from inside the building will be greater through the wet areas due to the reduced R-value of the wet insulation. This is especially true during the heating

season. In both instances, when viewed from the roof side, wet insulation will show up as warmer in the infrared image. Often these two phenomena work together, creating strong, long-lasting thermal images that clearly illustrate the differences between wet and dry insulation.



Thermographic image from infrared camera

Control image, wet sections marked for removal

Our Infrared cameras can also be used in a variety of other Non-Destructive testing applications:

- Infrared Electrical/Mechanical Inspections pinpoint developing problems in power delivery systems. The infrared scanner can “see” hot spots where there are going to be failures before they happen. This Predictive Maintenance approach provides for time to repair these problem areas before they cause equipment damage, unscheduled outages, and down time. Problem areas are pinpointed, prioritized and fully documented.

- Infrared Steam System Inspections pinpoint failing steam traps, malfunctioning heat exchangers and boiler problems. These surveys can save thousands of dollars by reducing energy usage.

- Infrared Heat Loss Analysis locates and documents building heat loss problems. Infrared thermography is the only non-destructive and complete system for locating the causes of frozen pipes, ice dams, missing or wet insulation and high heating costs. Infrared Heat Loss Surveys provide valuable performance of newly constructed buildings and energy retrofits.

INSTRUMENTATION

Your roofs were inspected with a FLIR T420, a professional long wave infrared camera. In combination with the powerful FLIR Tools+ software, the T420 system enables highly detailed image/data processing in the Windows® environment.

FLIR® T-420 Specifications	
Detector	FPA uncooled microbolometer 320 x 240
Spectral band	7.5 to 13 µm
Sensitivity (NETD @ 30°C)	< 0.045°C
Temperature measurement range	-20 to 650° C
Focus range	9" to infinity
FOV (standard lens)	25° x 19°
Zoom	4x continuous
Minimum Focus Distance	0.4 meters
Video/Image Output Format	MPEG-4, USB, Wi-Fi

SURVEY PROCEDURES

The Infra-red Analyzers' Certified Thermographers followed defined survey procedures when inspecting your roof.

GUIDELINES: Every square foot of roofing in the contract was scanned a minimum of two times. All wet areas were marked on the roofs with long-lasting paint. The locations of all physical testing are also marked on the surfaces.

VERIFICATION: Infrared Thermography is a powerful tool for Non-Destructive Testing of flat roofing systems. However, to insure complete accuracy of the survey results, it is necessary to physically verify the presence of moisture within the roofing system. We employ two methods for physical verification of the roof's condition; Core Samples and Moisture Probes. In all, 14 core samples were taken on the roofs to verify the findings of the Infrared Survey.

CORE SAMPLES: When taking a core sample, the Thermographer typically extracts a small section of the roof all the way down to the roof deck. This allows for a complete physical examination of all construction details and roofing materials. The only exception to this practice is when core samples are taken in areas of wet roofing. In these instances, the Thermographer will usually not cut the vapor retarder, as this may allow water to leak into the building.

A core sample of the roof may be taken for several different reasons. First, the insulation can be physically inspected to determine its condition and if it is wet or dry. Second, core samples provide invaluable information about the construction of the roofing system. Of particular interest to the Thermographer is the type and thickness of the membrane, insulation type and thickness, possible presence of vapor retarder, if any, and type of decking and condition of the deck in the area cored. All core sample sites were filled and sealed using the standard repair techniques approved by the National Roofing Contractors' Association.

BOUNDARIES: Every effort is made to have the lines painted on the roof indicate accurately the boundaries of the wet insulation. However, communication between the Thermographer and the helper painting the lines can sometimes result in small inaccuracies. Therefore, the Thermographer will generally mark outside the wet area by about 6" to 12" to provide a reasonable margin of error. In some instances, it may be advisable to calculate a slightly larger area of insulation than what is actually painted on the roof. Additionally, the way water migrates through insulation may not be homogenous, and it may happen that there are a few square feet of dry insulation within the boundaries of the larger wet area. As a practical matter, these small dry spots are not significant, and the Thermographer will just define the overall boundaries of the wet area.

MAPPING: After all the scanning and verification were completed, the roof was mapped. A draft copy of your drawing was made at the site, documenting all the information generated during the inspection. A final copy of the map was plotted in the office using an AutoCAD System. Please note that the measurements displayed in these maps should not be used as a substitute for as-built drawings.

FINDINGS

Forty-six areas of wet insulation were uncovered with the infrared camera inspection.
The total size of the roofs that were inspected with the infrared camera is approximately 176,153 square feet. The total amount of wet insulation equals approximately 5,133 square feet. The amount of wet insulation is approximately 2.9% of the total roof areas.

Six areas of wet insulation were uncovered with the nuclear gauge inspection.

The total size of the roof that was inspected with the nuclear gauge is approximately 176,153 square feet. The total amount of wet insulation equals approximately 5,338 square feet. The amount of wet insulation is approximately 3.0% of the total roof area.

All areas of wet insulation are marked on the roof surface and on the maps provided. Please refer to these maps when reviewing the report.

A large number of smaller areas were outlined on the roof and included on the map but were not assigned numbers.

MAPS

The last part of the bound hard-copy version of this report contains four copies each of a map of the roofs. These scaled drawings were plotted on an AutoCAD system and complete the documentation of the findings of the survey.

This report documents the locations and extent of wet insulation at the time of the inspection. No information regarding the integrity of the roofing system or building is provided or implied in this report. Many factors, including sunlight, precipitation, wind, foot traffic, and building movement and the like can affect a roof over a short period of time. Regular inspections ensure early detection of problems and can extend the life of a roof membrane.

Thank you for using our Infrared Services. Please call me if you have any questions regarding this report, or if I can help in any way.

Sincerely,

XXX
Director of Operations

ROOF CONSTRUCTION

The roof construction details are documented on the following Core Analysis sheet(s). Each core sample provides information about the roof materials at that particular site in the field of the roof. The age of the roof, and the amount of traffic on the roof may affect the thickness of the insulation, and there may be changes in construction from one section of the roof to another. Occasionally, a roof that appears to be homogeneous may actually contain two or more types of insulation or membrane. Therefore, any core sample is only a true picture of the roof construction at the site where it was taken.

CORE A: (Dry)

		Approximate R-Values
	Silicone Membrane w/granular surface	0.02
2”	Sprayed Polyurethane	13.34
	Wood - Unknown Thickness	N/A
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	14.53

*Note: Cores were taken by others

CORE B: (Dry)

		Approximate R-Values
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Wood - Unknown Thickness	N/A
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.20

*Note: Cores were taken by others

CORE C: (Wet)		**Approximate R-Values***
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
1”	Fiberboard	2.70
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	24.24

*Note: R-values may be lower due to moisture content.

*Note: Cores were taken by others

CORE D: (Wet)		**Approximate R-Values***
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
1”	Fiberboard	2.70
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	24.24

*Note: R-values may be lower due to moisture content.

*Note: Cores were taken by others

CORE E: (Wet)		**Approximate R-Values***
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
1”	Fiberboard	2.70
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	24.24

*Note: R-values may be lower due to moisture content.

*Note: Cores were taken by others

CORE F: (Wet)		**Approximate R-Values***
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
1”	Fiberboard	2.70
	Felt	Nominal
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	24.24

*Note: R-values may be lower due to moisture content.

*Note: Cores were taken by others

CORE G: (Wet)		**Approximate R-Values***
	Silicone Membrane w/granular surface	0.02
2”	Sprayed Polyurethane	13.34
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	14.87

*Note: R-values may be lower due to moisture content.

*Note: Cores were taken by others

CORE H: (Dry)		**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
2”	Sprayed Polyurethane	13.34
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	14.87

*Note: Cores were taken by others

CORE I:	**(Dry)**	**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
0.5”	Fiberboard	1.35
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	22.89

*Note: Cores were taken by others

CORE J:	**(Dry)**	**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.54

*Note: Cores were taken by others

CORE K:	**(Dry)**	**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.54

*Note: Cores were taken by others

CORE L:	**(Dry)**	**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.54

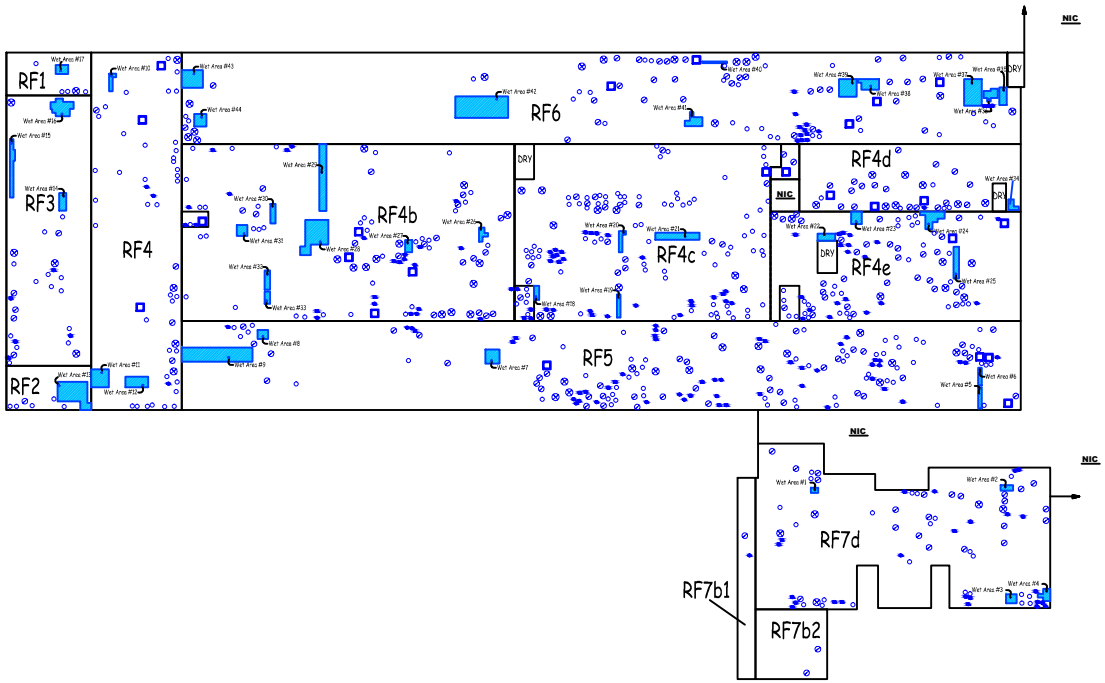
*Note: Cores were taken by others

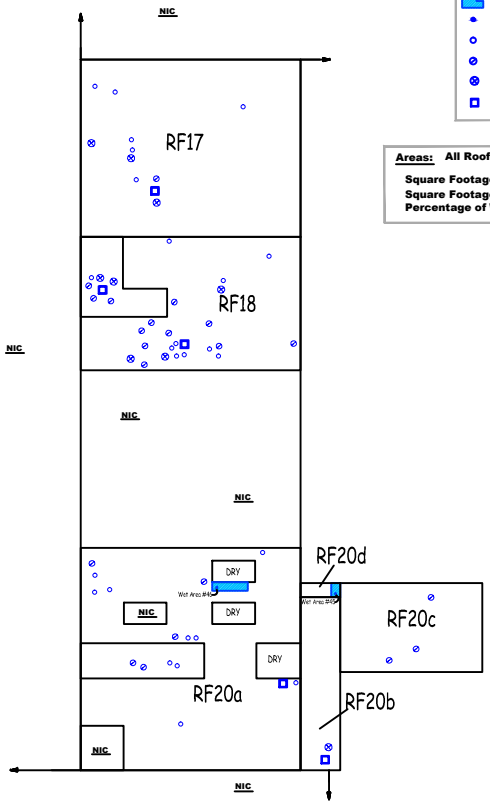
CORE M: (Dry)		**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.54

*Note: Cores were taken by others

CORE N: (Dry)		**Approximate R-Values**
	Silicone Membrane w/granular surface	0.02
3”	Sprayed Polyurethane	20.01
	Multiple-ply Built-up Roof Membrane w/gravel surface	0.34
	Felt	Nominal
	Wood - Unknown Thickness	N/A
	Inside Air Film (still air)	0.92
	Outside Air Film (moving air)	0.25
	Total Estimated Known R-Values:	21.54

*Note: Cores were taken by others





Legend

- CORE SAMPLE
- NIC NOT IN CONTRACT
- WET INSULATION (to scale)
- WET AREA - 6" DIA.
- WET AREA - 1 FT.SQ.
- WET AREA - 2 to 4 SQ. FT.
- WET AREA - 5 to 9 SQ. FT.
- WET AREA - 10 to 16 SQ. FT.

Areas: All Roofs
(in approximate square feet)

Square Footage of Roof Inspected:	176,153
Square Footage of Wet Area:	5,133
Percentage of Wet Area:	2.9%

INFRA-RED ROOF MOISTURE ANALYSIS

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SAMPLE CLIENT
BUILDING X
SAMPLE ADDRESS
SAMPLE ADDRESS

SCALE:	1/32"=1'-0"
DATE:	10-1-4, 8 & 18-19
PAGE:	1 OF 2
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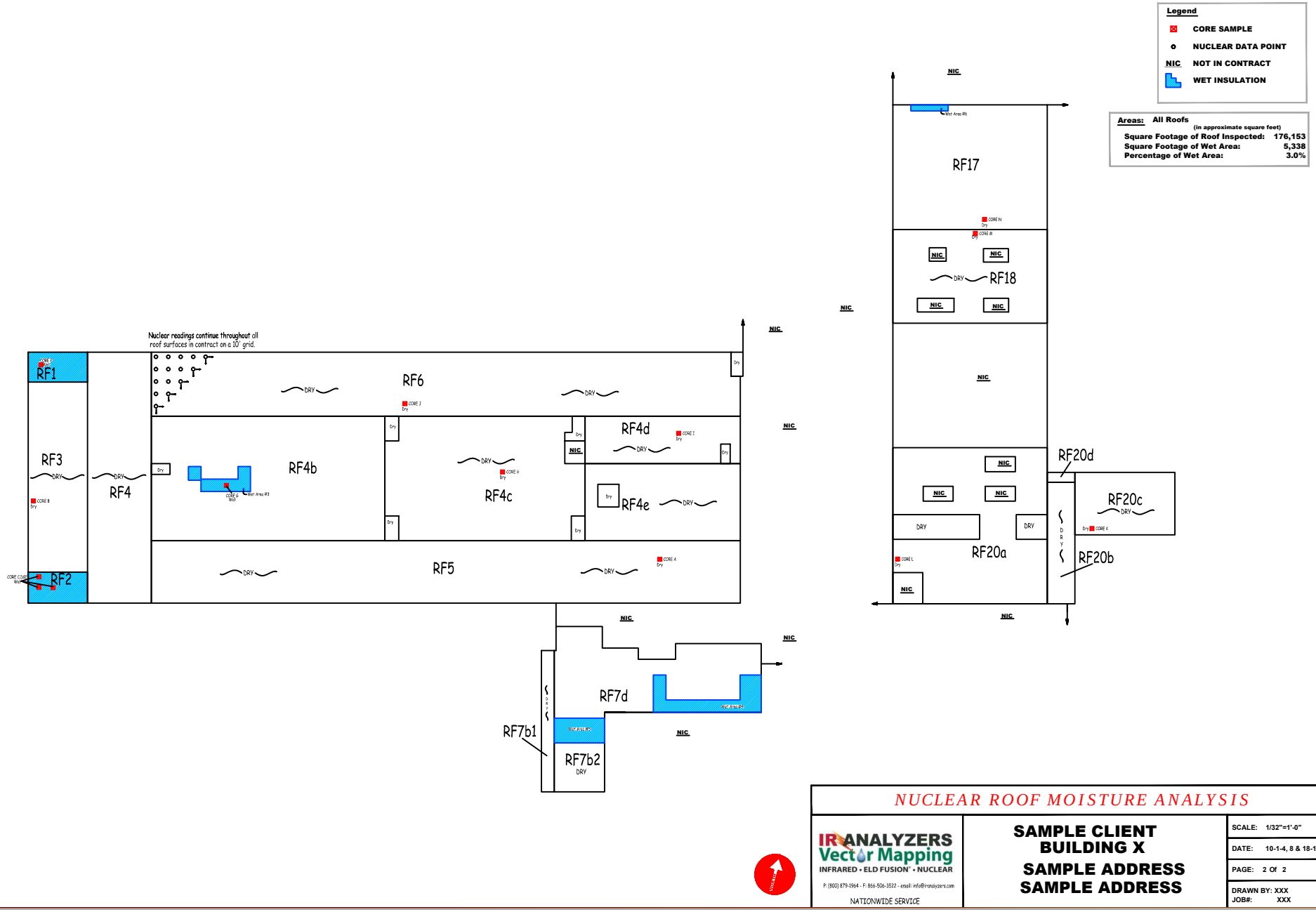
Legend
CORE SAMPLE
NUCLEAR DATA POINT
NIC NOT IN CONTRACT
WET INSULATION
Areas: All Roofs
(in approximate square feet)
Square Footage of Roof Inspected: 176,153
Square Footage of Wet Area: 5,338
Percentage of Wet Area: 3.0%
Nuclear readings continue throughout all roof surfaces in contract on a 10' grid.
RF1
RF2
RF3
RF4
RF4b
RF4c
RF4d
RF4e
RF5
RF6
RF7b1
RF7b2
RF7d
RF17
RF18
RF20a
RF20b
RF20c
RF20d
DRY
NIC
NORTH
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