Onondaga County (NY) Correctional Facility Re-roof Project: Lessons Learned and Implications for Roof Design

CRRC Membership Meeting

June, 2013 Reno NV

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Director Codes & Regulatory Affairs

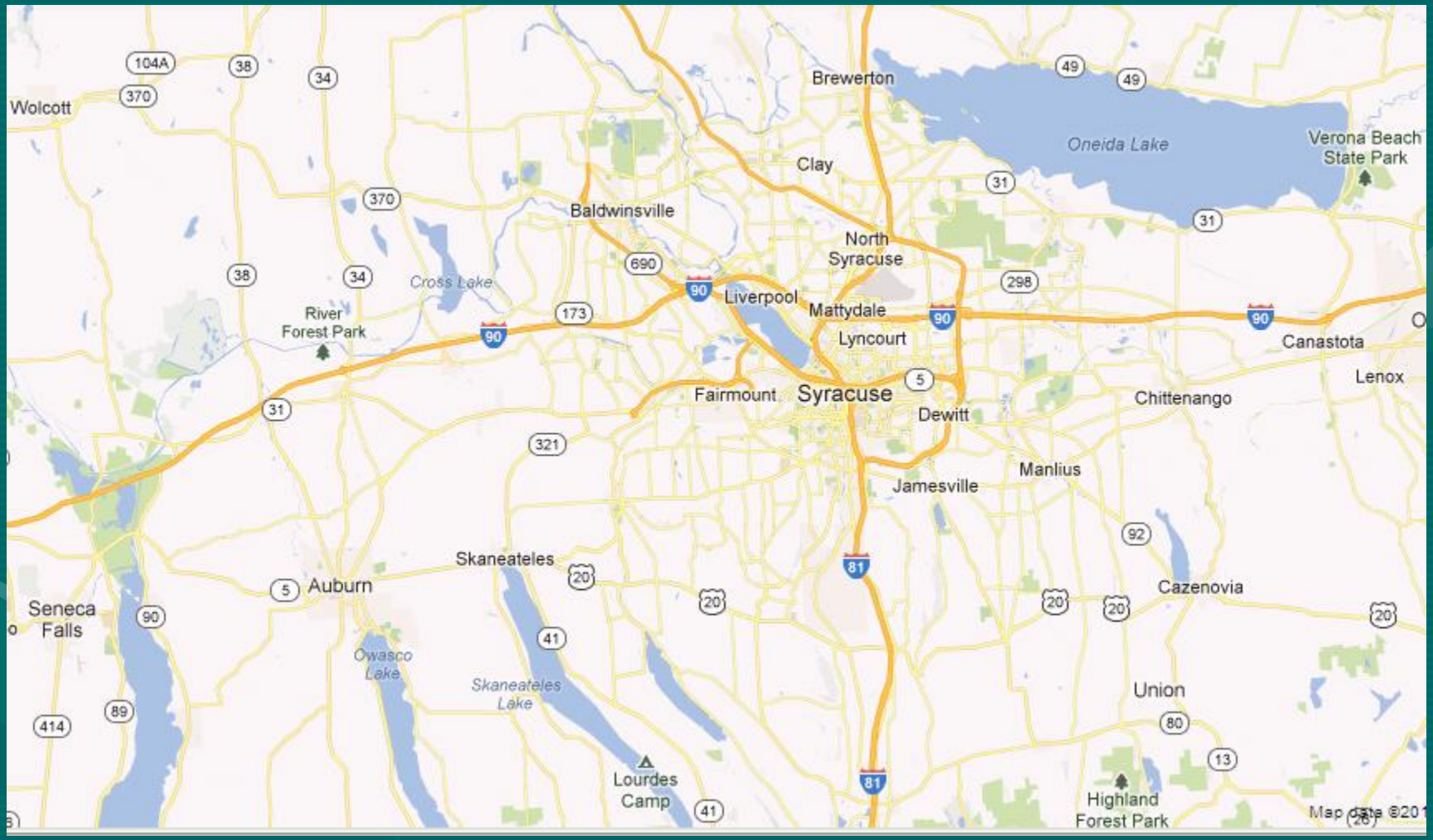
KELLEN Company

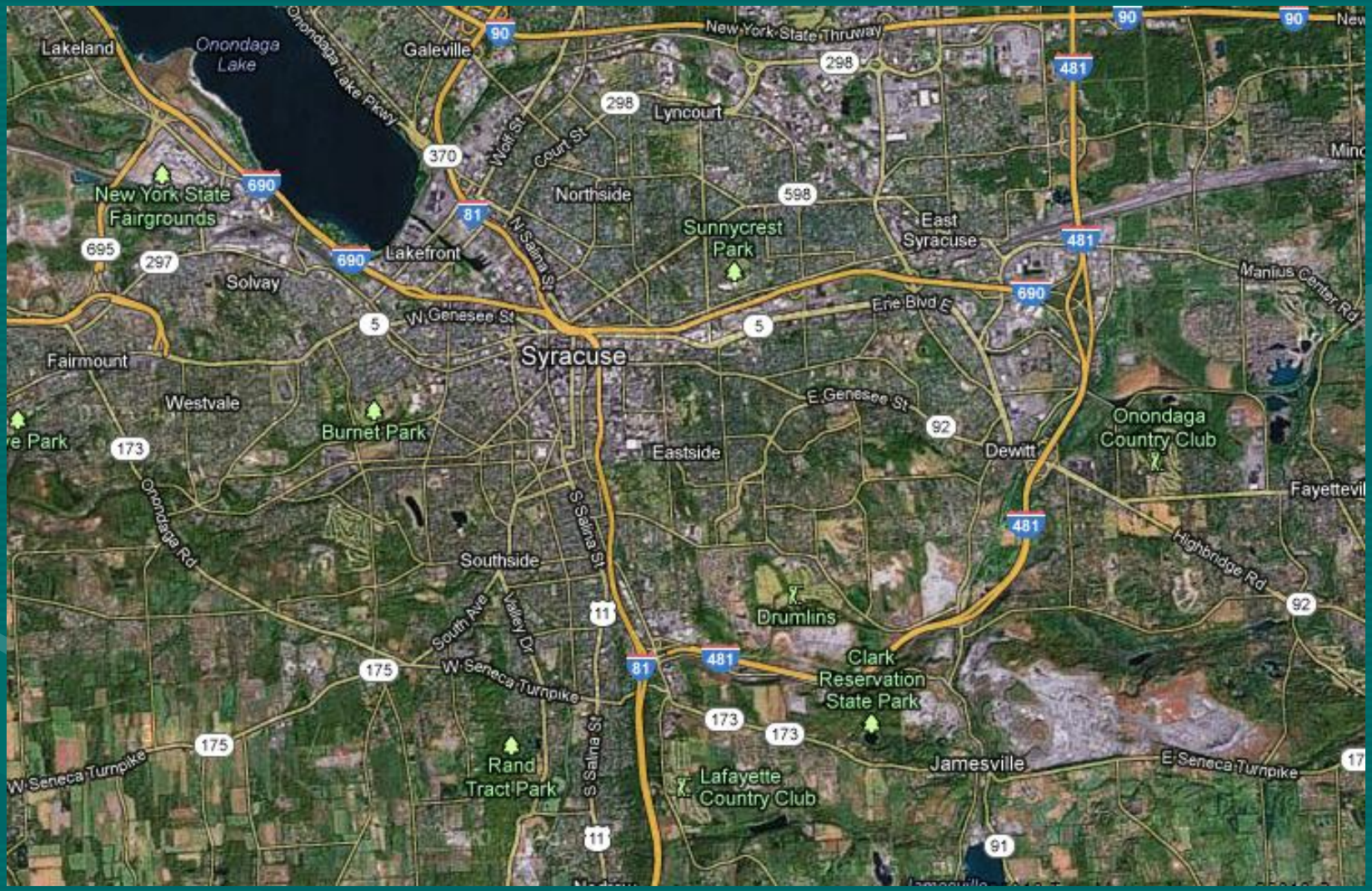
Project Background

- Onondaga County Infrastructure
  - Storm-water Runoff and Sewer Capacity
  - County-Owned Buildings
  - Penitentiary Project Opportunity
- Penitentiary Reroof
  - Cool Roofing
  - Vegetative Roofing
  - High R-Value Roof Assemblies
- CDH Engineering
  - Hugh Henderson

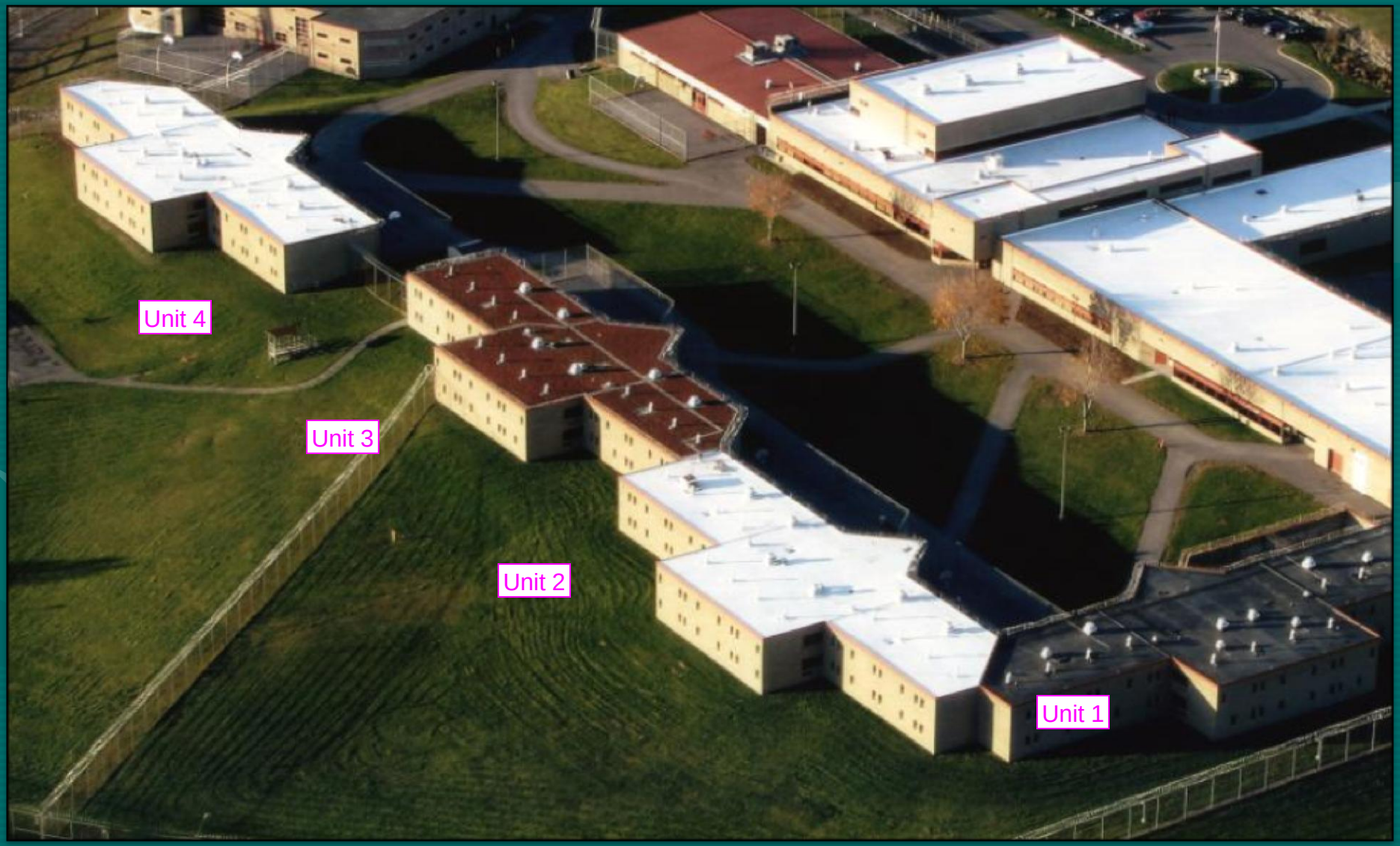
Bigger Picture Issues

- Project Location
  - Climate Zone 5, South of Syracuse NY
- Storm-water and Sanitary Capacity Issues
- Energy Efficiency
  - Cooling vs. Heating
- Building Performance Issues
  - Durability
  - Moisture Management
  - Maintenance Costs


Wolcott
Brewerton
Oneida Lake
Verona Beach State Park
Clay
Baldwinsville
North Syracuse
Cross Lake
River Forest Park
Liverpool
Mattydale
Lyncourt
Canastota
Lenox
Fairmount
Syracuse
Dewitt
Chittenango
Manlius
Jamesville
Skaneateles
Auburn
Seneca Falls
Owasco Lake
Skaneateles Lake
Cazenovia
Union
Lourdes Camp
Highland Forest Park


Lakeland
Onondaga Lake
Onondaga Lake Pkwy
Galeville
New York State Thruway
Lyncourt
Wolf St
Court St
Northside
New York State Fairgrounds
Lakefront
N Salina St
Sunnycrest Park
East Syracuse
Solvay
W Genesee St
Erie Blvd E
Manlius Center Rd
Syracuse
Fairmount
Westvale
Burnet Park
E Genesee St
Eastside
Dewitt
Onondaga Country Club
Fayettevil
Onondaga Rd
S Salina St
Southside
Highbridge Rd
Drumlins
South Ave
Valley Dr
W Seneca Turnpike
Clark Reservation State Park
Rand Tract Park
Lafayette Country Club
Jamesville
E Seneca Turnpike

Aerial View of Campus



Project Details

- Location
  - Climate
  - Elevation
- Building Size
- Building Occupancy
  - Human Factors
- Maintenance

Project Details

- Side-by-Side Comparison of Roofing Systems
  - UNIT 1: EPDM w/ 4” of Foam Insulation
  - UNIT 2: TPO w/ 4” of Foam Insulation
  - UNIT 3: Vegetative Roof w/ 4” of Foam Insulation
  - UNIT 4: TPO w/ 8” of Foam Insulation
- Measured Performance Impacts
  - Thermal Transfer / Energy Cost Impacts
  - Water Retention Performance

Roof Assemblies

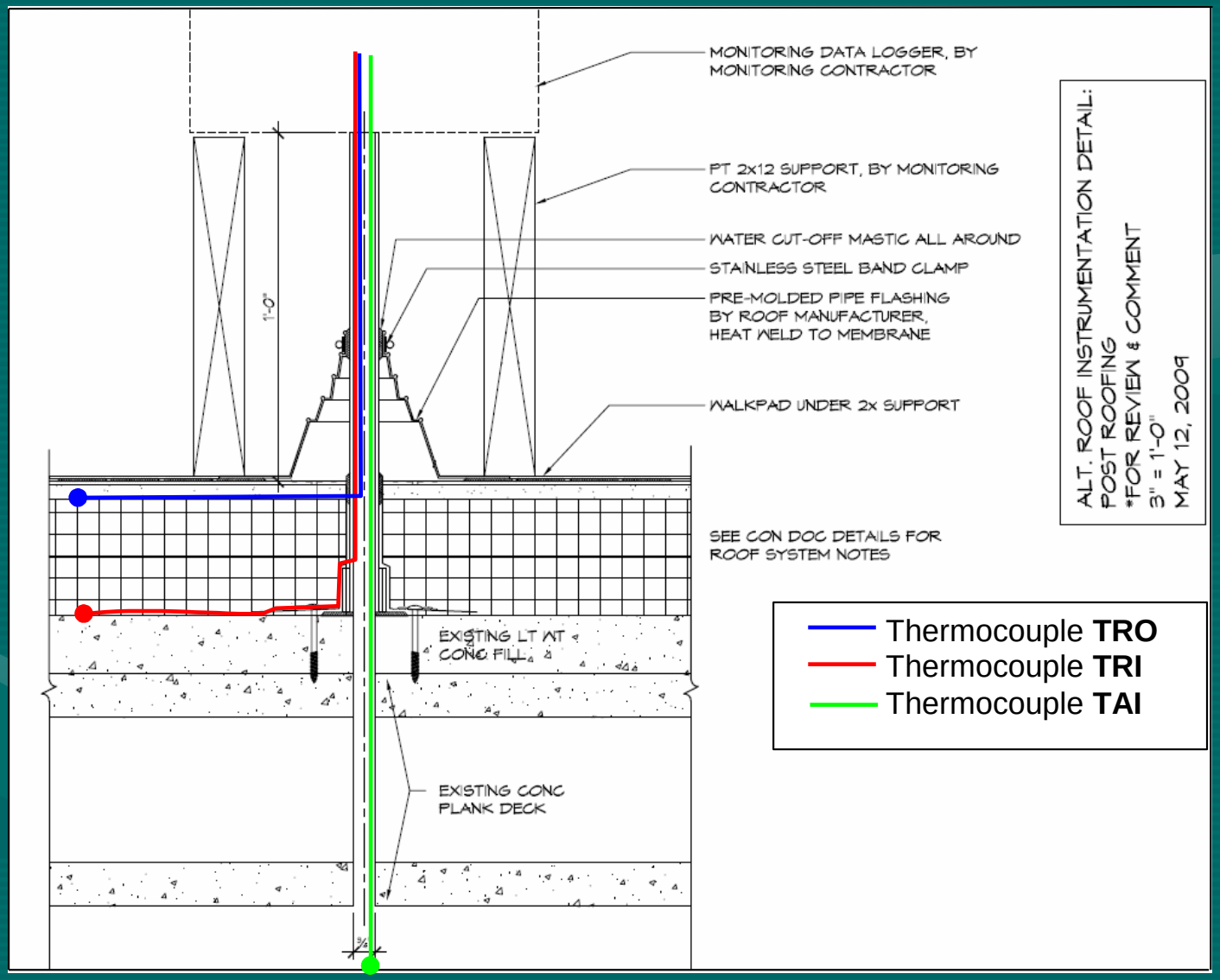
Location	Insulation	Surface
Unit 1	4 inches Poly Iso[1] foam board (R22)	EPDM rubber[2]
Unit 2	4 inches Poly Iso[1] foam board (R22)	TPO White[3]
Unit 3	4 inches Poly Iso[1] foam board (R22 + vegetative layer)	EPDM w/ Vegetative Assembly on top
Unit 4	8 inches Poly Iso[1] foam board (R45)	TPO White[3]

Notes: 1- Polyisocyanurate foam board applied in 2-inch layers
2- Black EPDM (Ethylene Propylene Diene Monomer) single-ply rubber roof membrane
3- White TPO (Thermoplastic Polyolefin) roof membrane

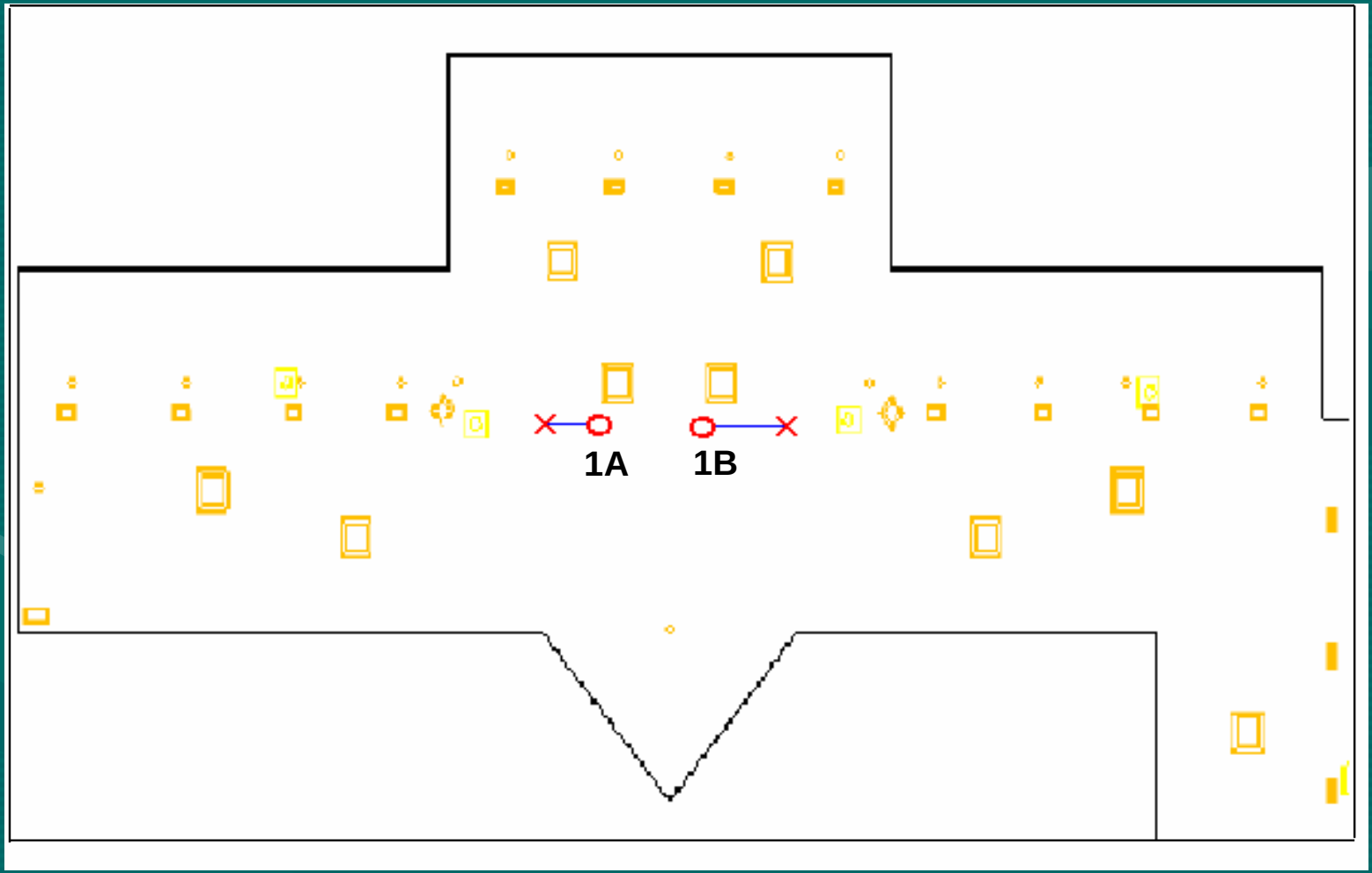
Approach

- Install dataloggers to continuously monitor performance
  - Two independent locations on each roof
  - Collect data continuously at 15-minute intervals
  - Directly measure temperature differences through roof assembly
  - Direct measurement of HVAC energy use was not practical
- Presentation and Analysis
  - Present data on internet (password protected)
  - Others can use data for independent data analysis

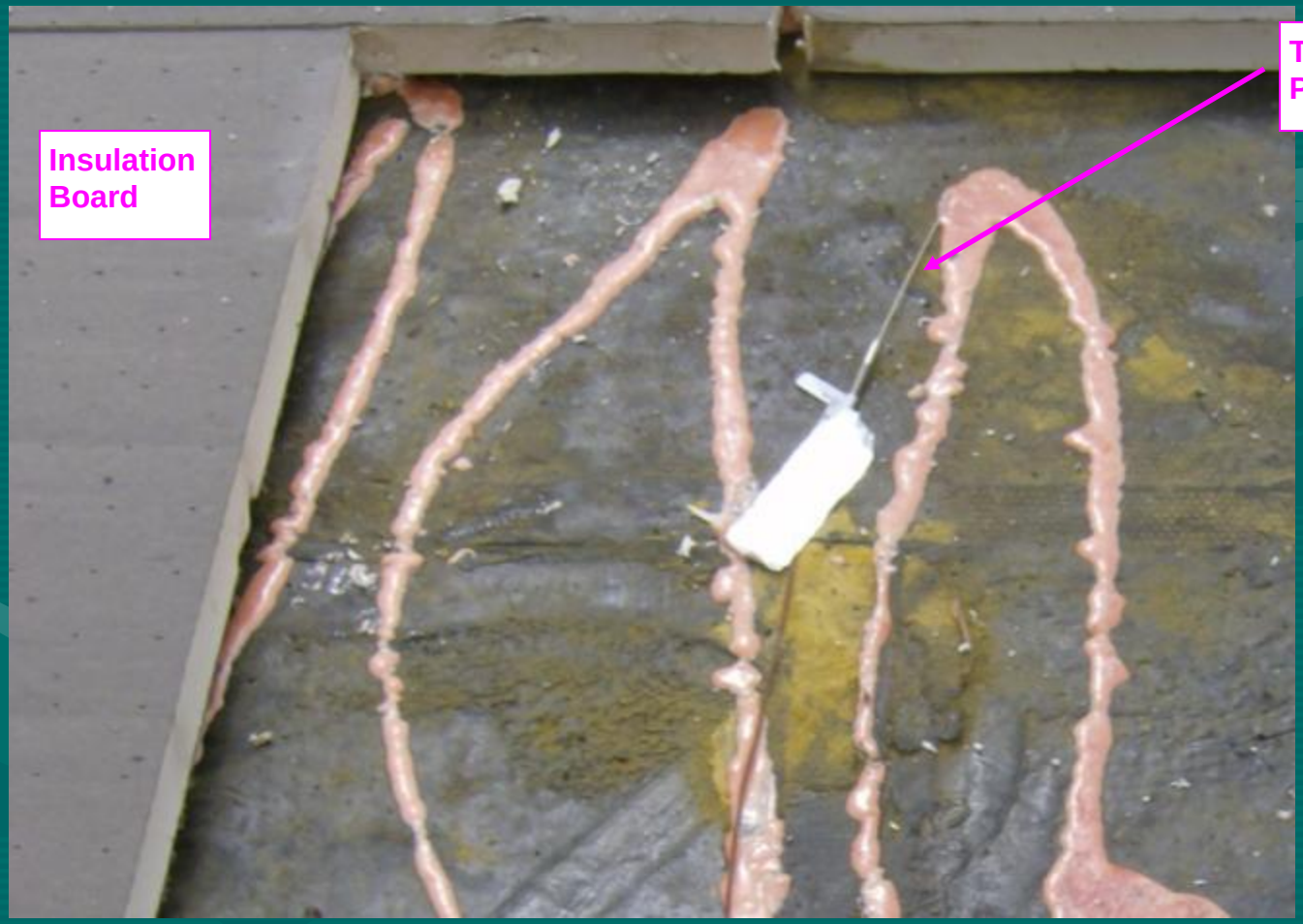
Roof Sensor Location/Station



A & B Stations on Each Unit

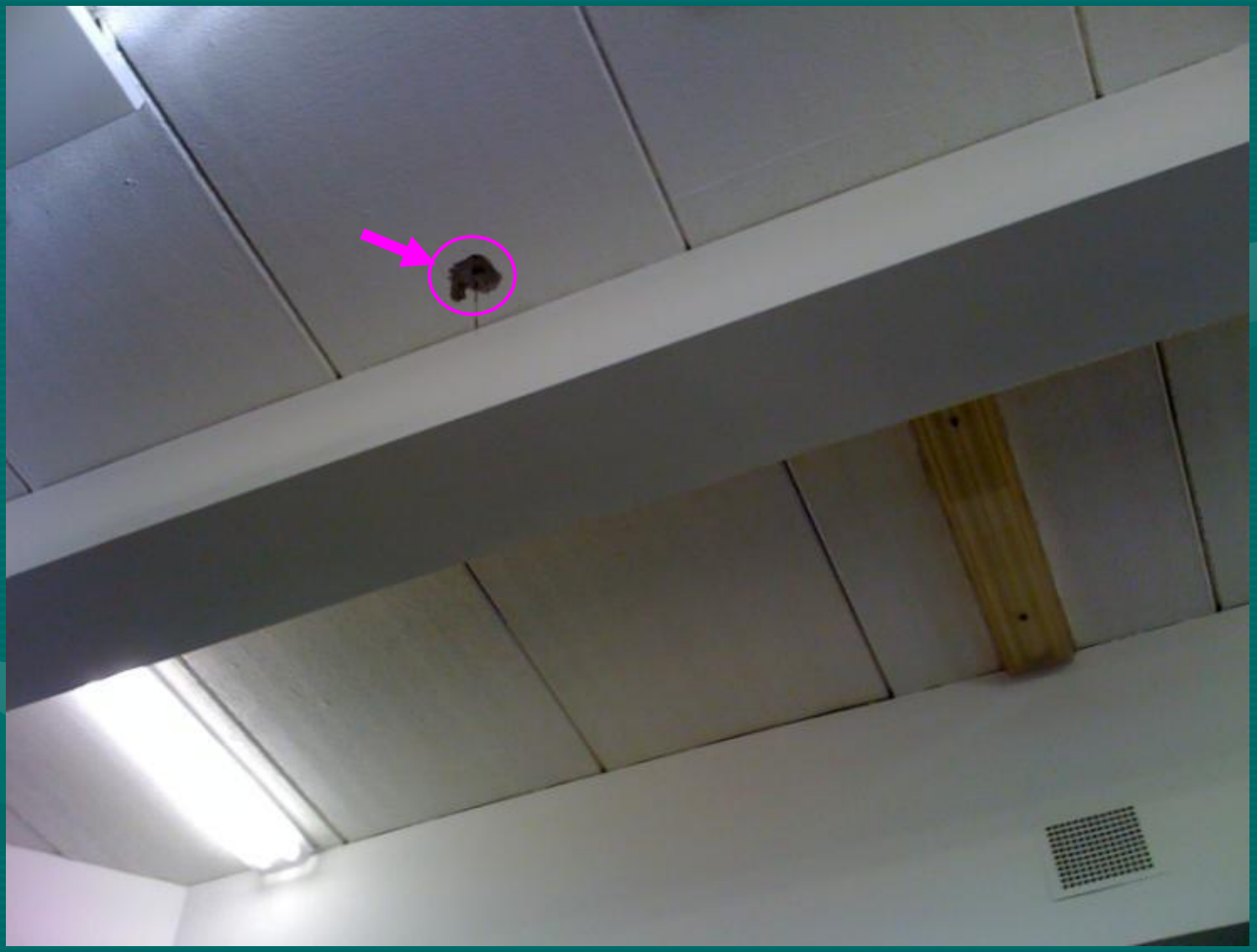


Sensors Installed During Construction

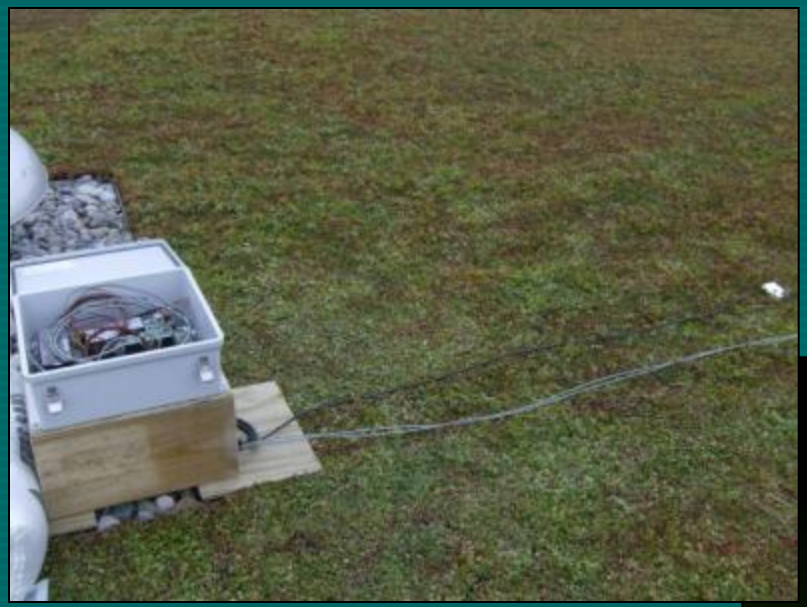


Thermocouple on Top of Insulation (station 1B)

Indoor Thermocouple



Vegetative Roof

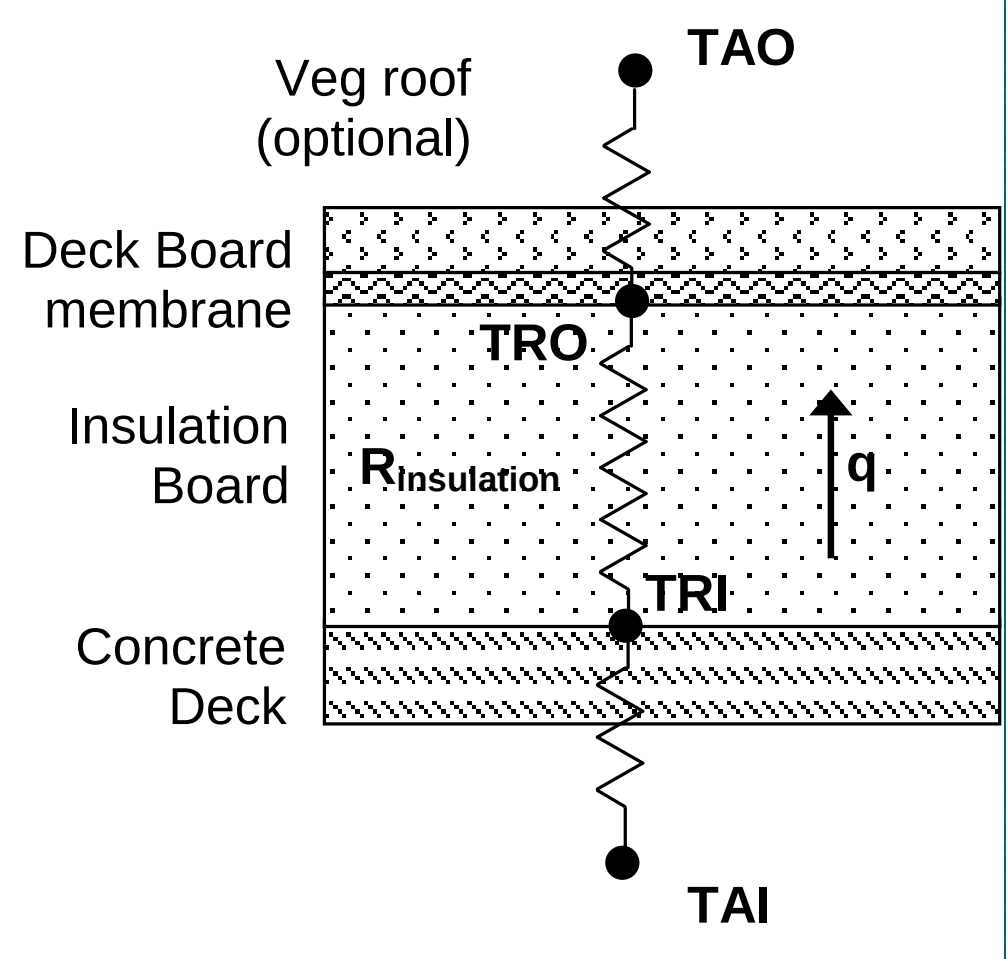


Instrumentation

Point	Description	Instrument	Eng Units	Locations
TRO	Roof Temperature (on top of insulation, under roof brd)	Type-T Thermocouple	ºF	At each station
TRI	Roof Temperature (under roof insulation, above deck)	Type-T Thermocouple	ºF	At each station
TAI	Indoor Temperature (just below the roof)	Type-T Thermocouple	ºF	At each station

Point	Description	Instrument	Eng Units	Locations
TAO	Outdoor Temperature	Type-T Thermocouple	ºF	Station 2A
ISH	Solar Insulation (horizontal)	Licor LI200x	W/m^2	Station 2A
TGR	Green Roof Temperature (in middle of soil layer)	Type-T Thermocouple	ºF	Station 3A
MGR	Green Roof Moisture Content (in middle of soil layer)	Campbell Scientific CS616	0-1	Station 3A
RAIN	Rainfall	Texas Electronics 525	Inches	Station 2A
WF	Water Flow from Green Roof Mockup	Hydrolynx 5050	Gal/h	Station 2A

Heat Transfer Analysis



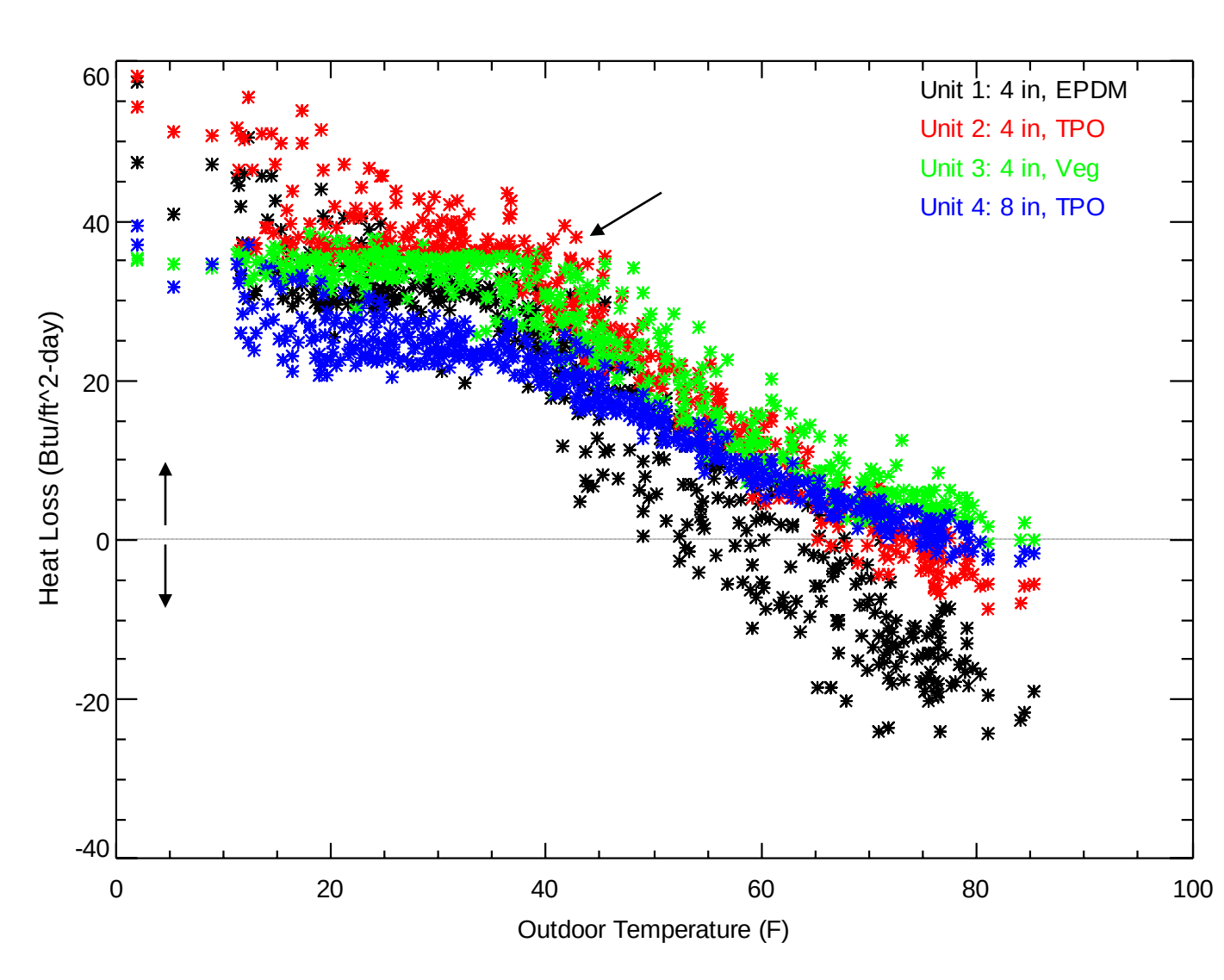
Where:

$R_{insulation}$ - R-value for Insulation layer (^oF-h-ft^2/Btu)

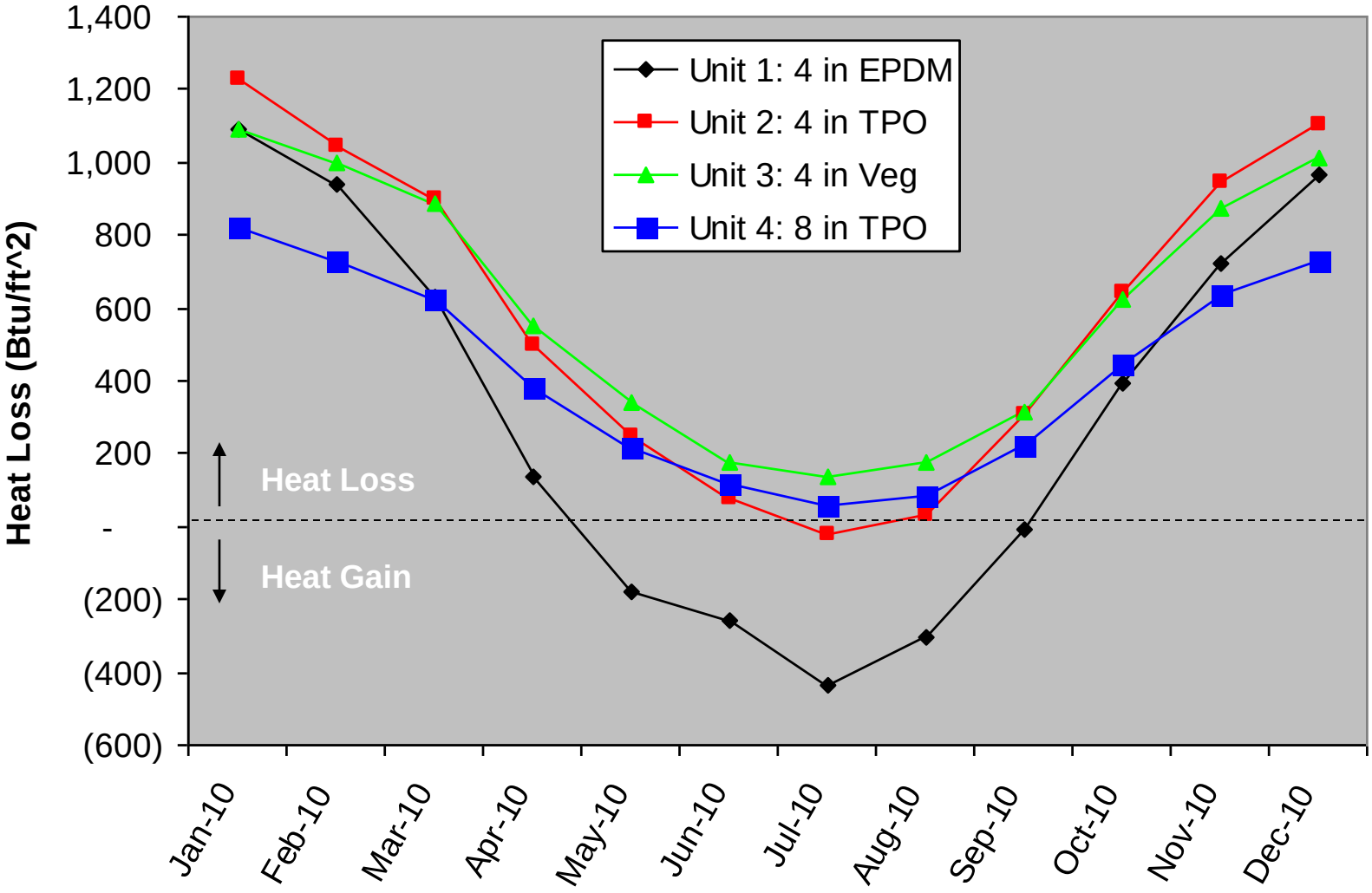
q - Heat flux through the roof assembly (Btu/h-ft^2)

$$q = \frac{(TRI-TRO)}{R_{insulatiion}}$$

Daily Heat Loss



Monthly Heat Loss



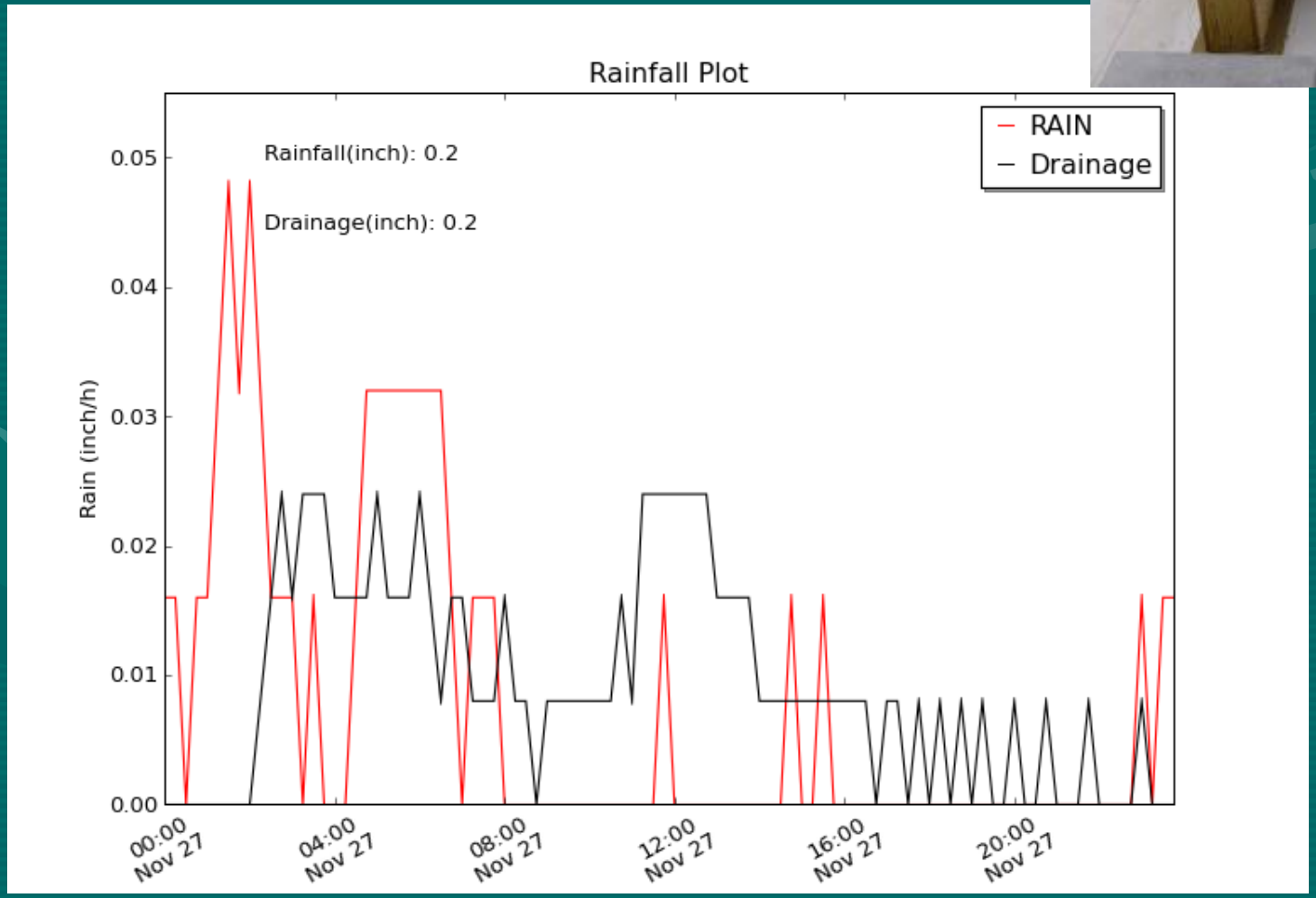
Heating Vs. Cooling Expense

HEATING	Unit 1 4 in EPDM	Unit 2 4 in TPO	Unit 3 4 in Veg	Unit 4 8 in TPO
Annual Heat Load (MMBtu per 1000 sq ft)	4.9	6.4	6.0	4.4
Annual Gas Use (therms per 1000 sq ft)	61.1	79.5	75.4	54.6
Annual Cost per 1000 sq ft	$ 61	$ 80	$ 75	$ 55
Savings per 1000 sq ft		$ (18)	$ (14)	$ 6

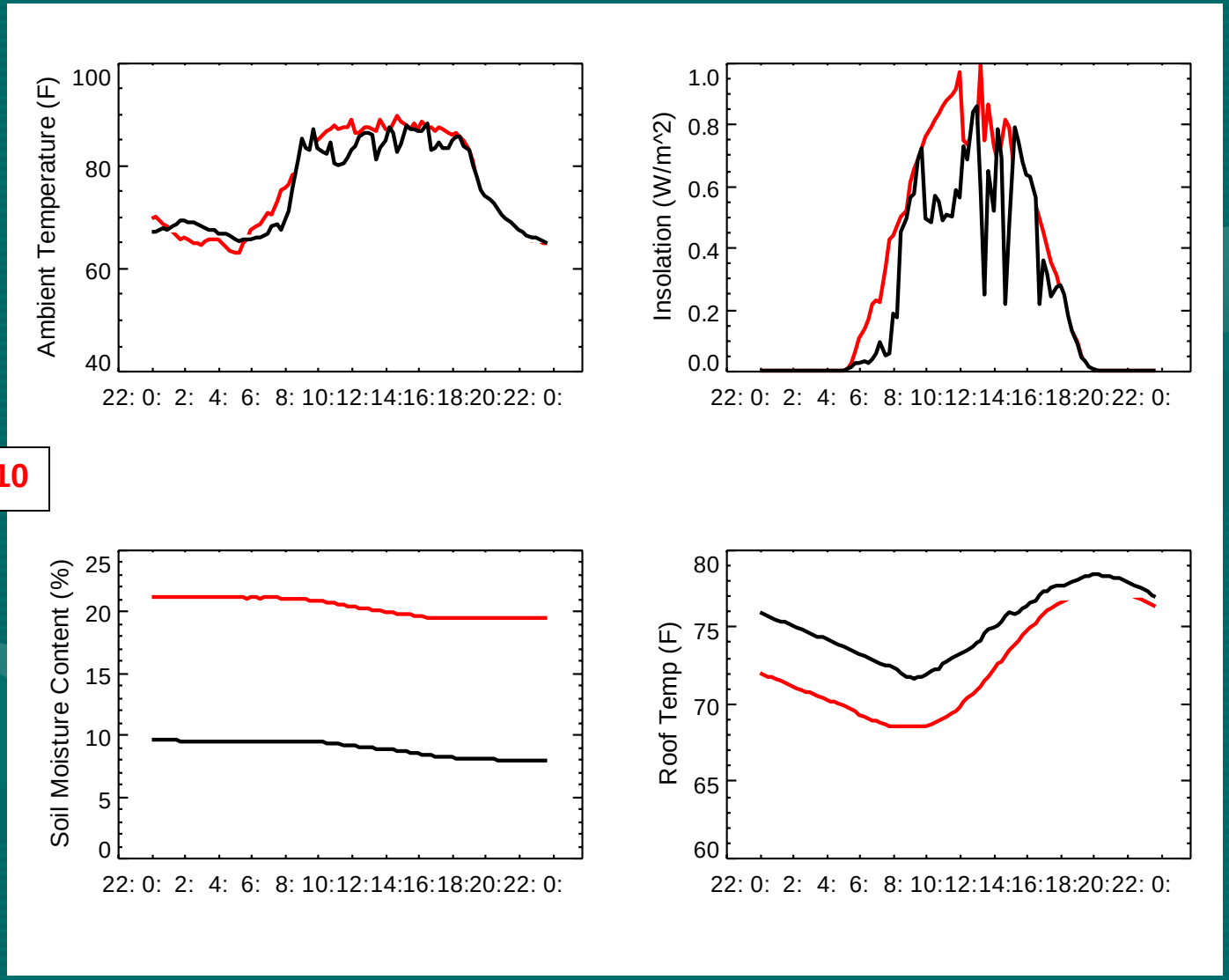
COOLING	Unit 1 4 in EPDM	Unit 2 4 in TPO	Unit 3 4 in Veg	Unit 4 8 in TPO
Reduced Cooling (ton-hrs/yr per 1000 sq ft)		152.6	194.2	157.2
Reduced Cooling Power (kWh/yr per 1000 sq ft)		137.3	174.7	141.5
Savings per 1000 sq ft		$ 16	$ 21	$ 17

COMBINED	Unit 1 4 in EPDM	Unit 2 4 in TPO	Unit 3 4 in Veg	Unit 4 8 in TPO
NET Savings per 1000 sq ft		$ (2)	$ 7	$ 23

Water Retention Testing



Vegetative Roof Provides Evaporative Cooling

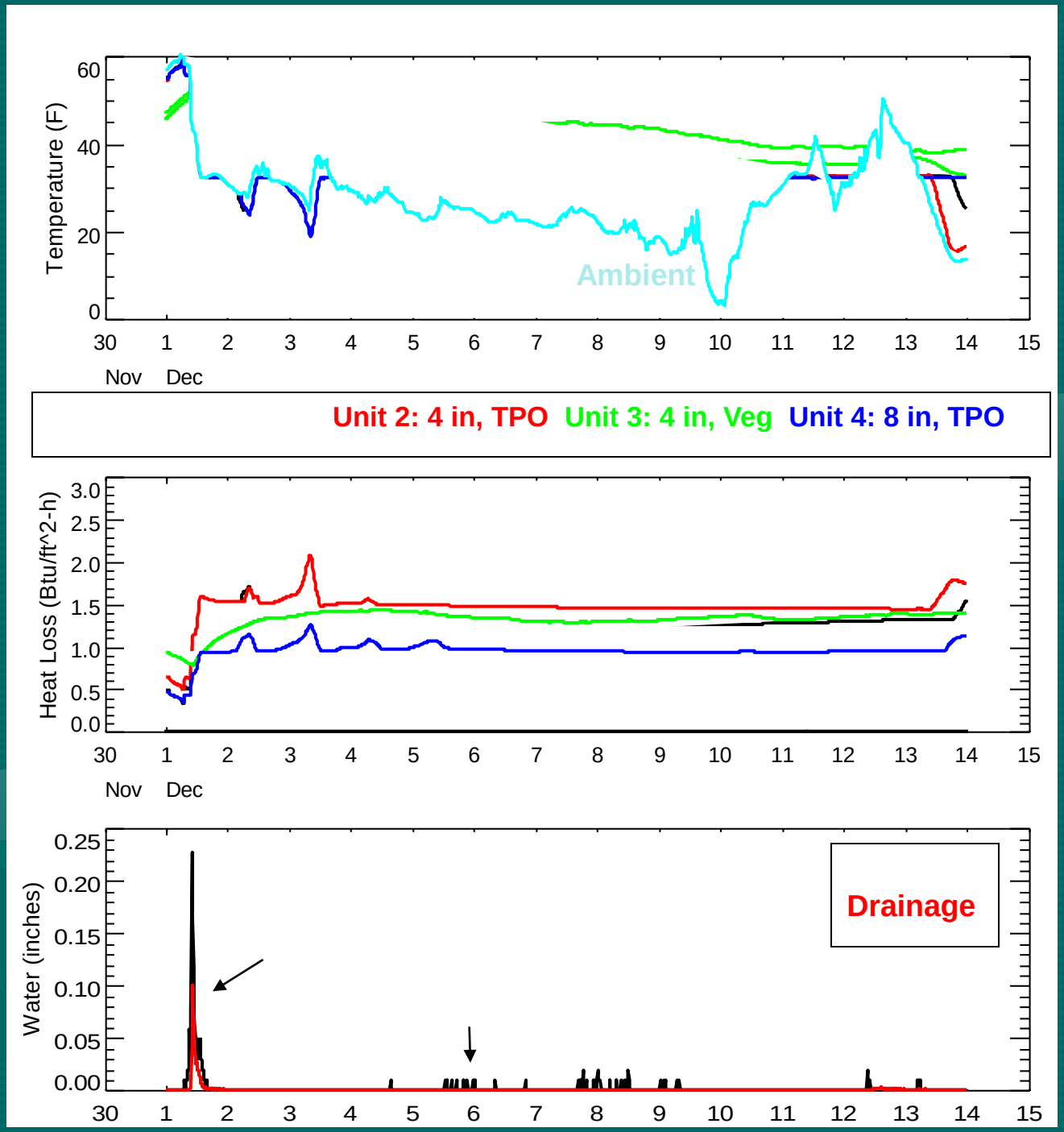


July 27, 2010

Stormwater Management

- Vegetative Roof Provided Manageable Stormwater Flow
- Evaporative Cooling Effect
- Some Thermal Effects
- Maintenance Issues TBD

Impact of Snow & Rain



OC Conclusions From Jamesville

- Reflective Roofing is Energy Neutral
- Vegetative Roof Retains 75-80% of Stormwater
  - Additional Cooling Season Benefits
- Insulation Saves Heating Energy
- Additional Study Needed:
  - Reflectance/Durability/Maintenance
  - Vegetative Roof Maintenance Costs
  - Building Performance
  - Snow and Ice Effects

The Cool Roofing Debate

- Energy Efficiency
  - Heating vs. Cooling
  - Expanded Reflectance Requirements in Code
- Heat Island Mitigation
- Roof Assembly Performance and Durability
  - Condensation
  - Wetting/Drying Cycles

Next Steps

- Project Will Continue For Total of Six Years
- Reflectance Measurements Will be Collected
- Additional Consideration for Solar Effects and Accumulation of Snow and Ice

Questions?

Thanks to Hugh Henderson
CDH Engineering
Cazenovia, NY