Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Better Buildings by Design
February 4, 2016

Efficiency Vermont

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Northfield Savings Bank

Jeff Stetter, Gossens Bachman Architects

Middlebury Town Office

Chris Huston, Bread Loaf Corporation

Waterbury Municipal Complex

Ashar Nelson, Vermont Integrated Architecture

Vermont Public Radio

David Roy, Wiemann Lamphere Architects

Waitsfield Town Offices

Bill Maclay, Maclay Architects

Agenda

Welcome & Intro	1:45-1:50pm
Northfield Savings Bank	1:50-2:20pm
Middlebury Town Office	2:20-2:50pm
Waterbury Municipal Complex	2:50-3:20pm
Break	3:20-3:30pm
Vermont Public Radio	3:30-4:00pm
Waitsfield Town Offices	4:00-4:30pm
Efficiency Vermont Summary	4:30-4:45pm
Questions & Discussion	4:45-5:00pm

Introduction

Efficiency Vermont's Net Zero Energy Building Program

- Purpose
- Net Zero Definition
- Government
- Professional Organizations
- Market Status
- EVT Program Requirements

Commercial Net Zero

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Northfield Savings Bank

Central Operations Center

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Northfield Savings Bank

Central Operations Center

- **Agenda**
  - **Client**
  - **Building Design Overview**
  - **Review Building Design Systems**
    - **Roof, Wall, Window, and Floor Assemblies**
  - **Mechanical**
  - **Electrical**
  - **Data Center**
  - **Commissioning**
  - **Envelope Testing**
  - **Modeling and Performance**
  - **Lessons Learned**

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Northfield Savings Bank – Project TEAM

Central Operations Center

- **Mechanical Engineering:** John F. Penney Consulting Services
- **Electrical Engineering:** Bob Kischko, Sylvia Miller, Dubois and King, Inc.
- **EVT Consultant:** Nick Thiltgen, Efficiency Vermont
- **Commissioning Agent:** Elizabeth Ford, John Butterfield Hallam ICS
- **Contractors:** EF Wall, Norway Electric, Brownell Mechanical, Control Tech
- **Civil Engineer:** Ron Lyon, Dubois and King; **Landscape Architect:** John Steele, Dubois and King; **Structural Engineer:** Barb Evans, Knight Consulting Engineers; **Security Consultant:** BSA Security Integrators; **Audio Visual Consultant:** Peter Wild, Geer Sound **Owner's Rep:** Paul Simon, White and Burke; **Clerk of the Works:** Bernie Chenette;

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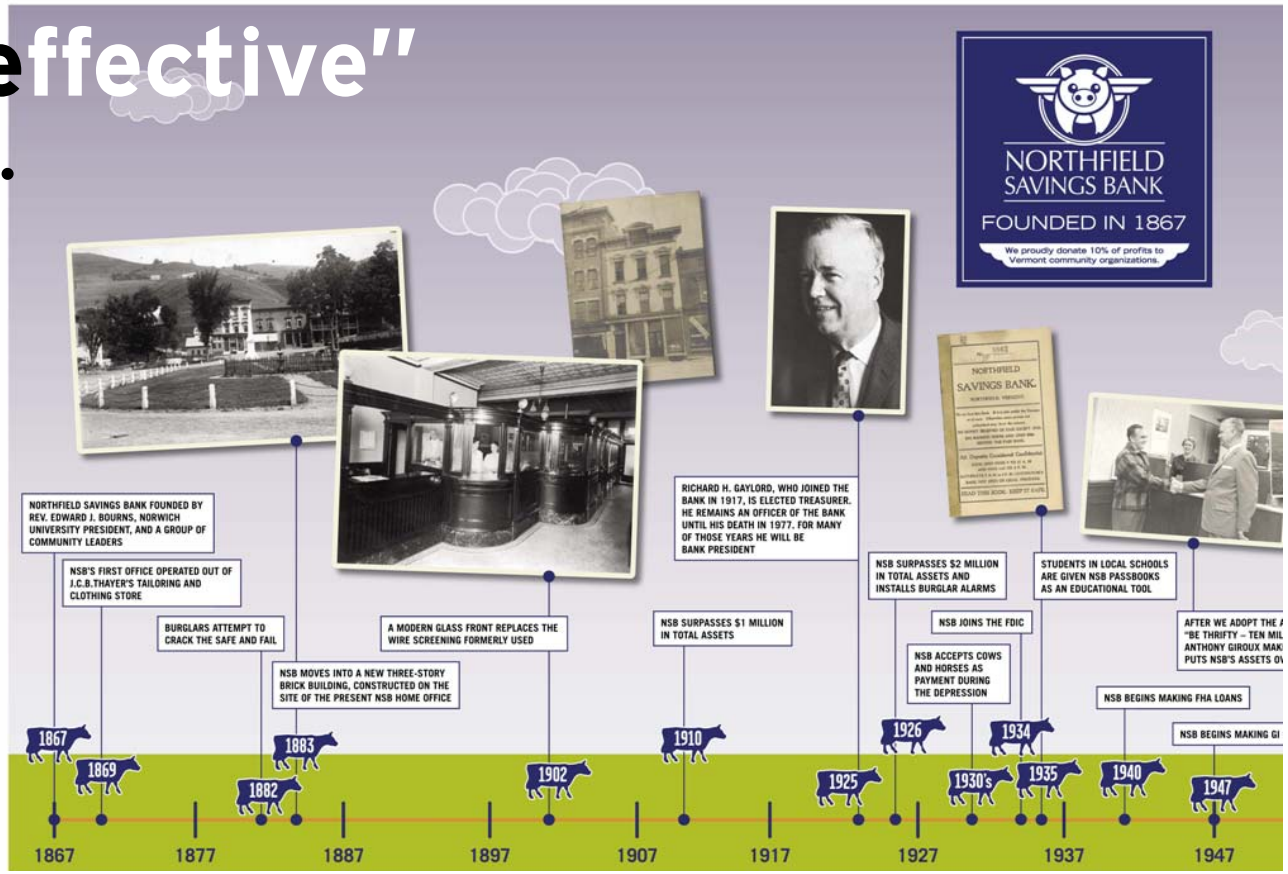
Northfield Savings Bank – Client

Central Operations Center

"The final solution needs to be practical, efficient and cost effective" (and beautiful).

Tom Pelletier,
Former NSB President
(and GBA)



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Northfield Savings Bank – Client

Central Operations Center

"designed to maximize the interior environmental conditions for

indoor air quality and comfort

while being

energy efficient"

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Central Operations Center

This building is

NOT

Net Zero

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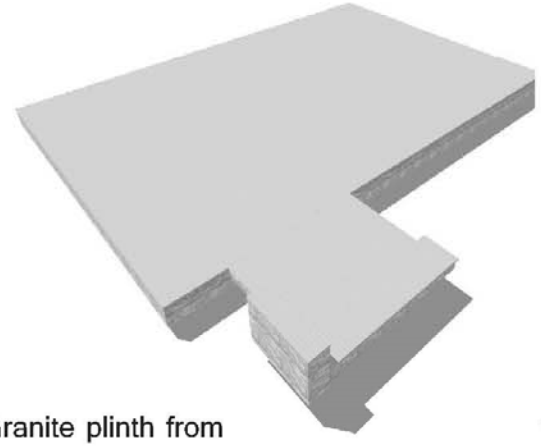
Northfield Savings Bank – Project INFO

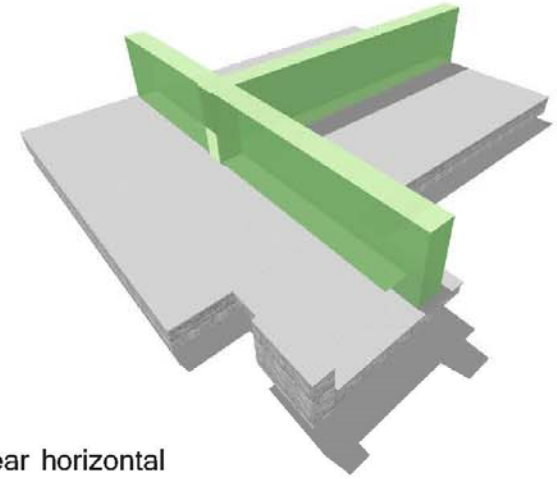
Central Operations Center

Northfield Savings Bank – Project INFO

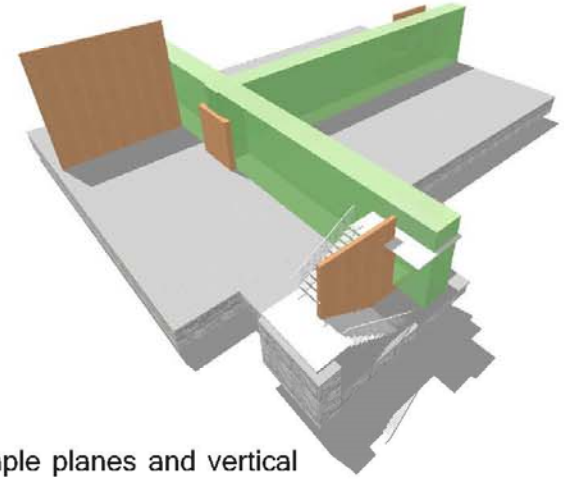
Central Operations Center



Granite plinth from local quarry for durability



Clear horizontal circulation for way-finding and organization



Maple planes and vertical circulation

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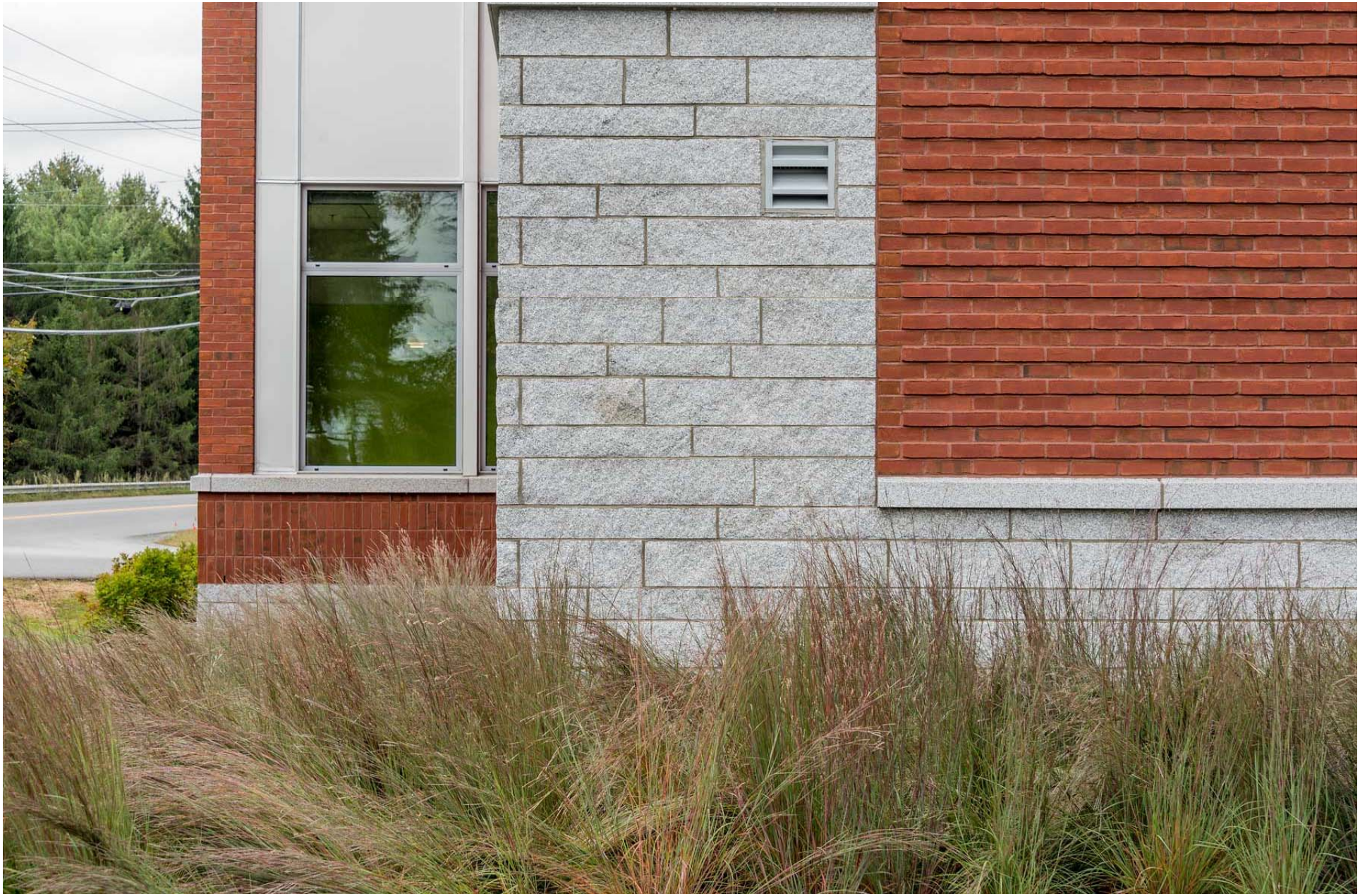

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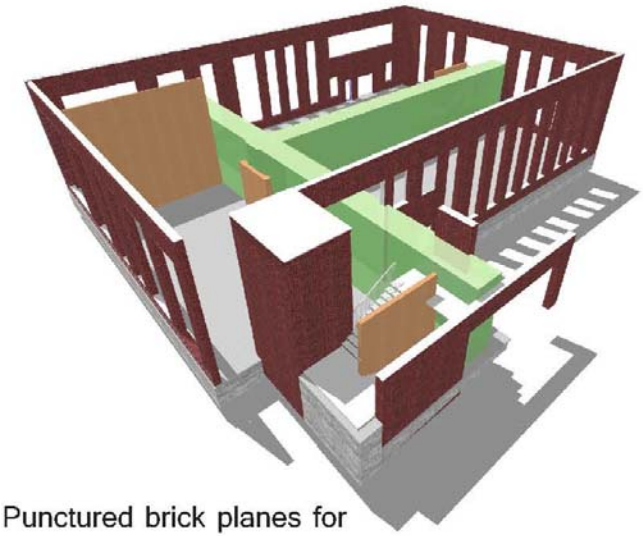
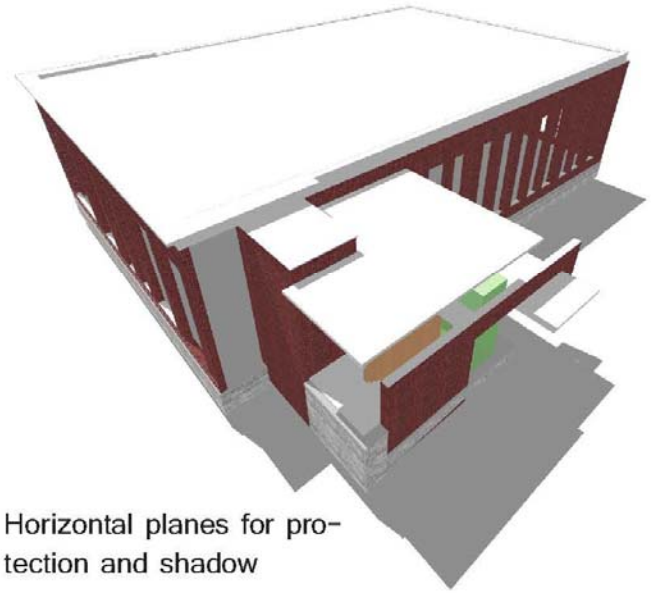


Punctured brick planes for enclosure



Horizontal planes for protection and shadow

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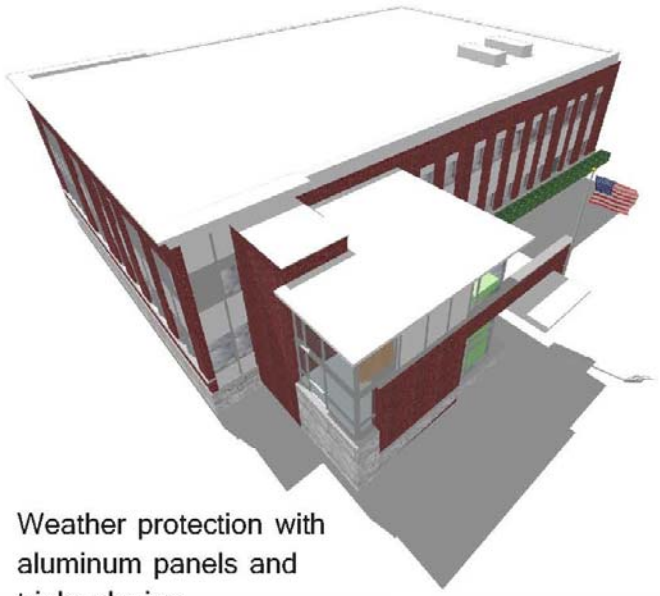
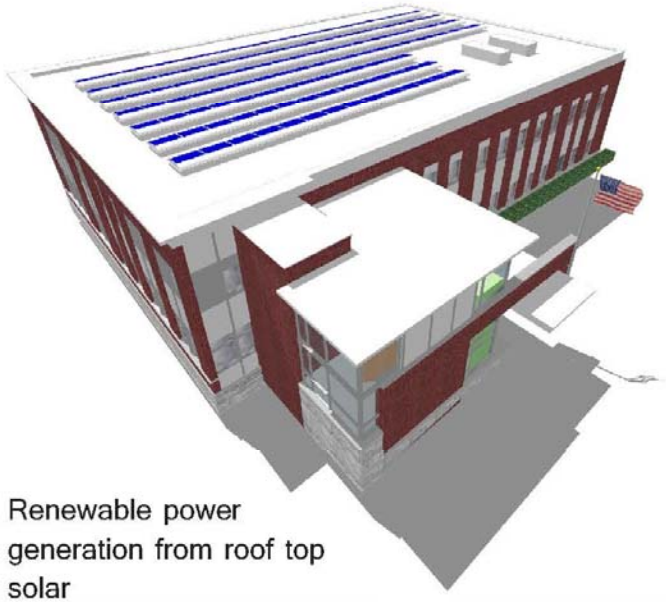


Weather protection with aluminum panels and triple glazing



Renewable power generation from roof top solar

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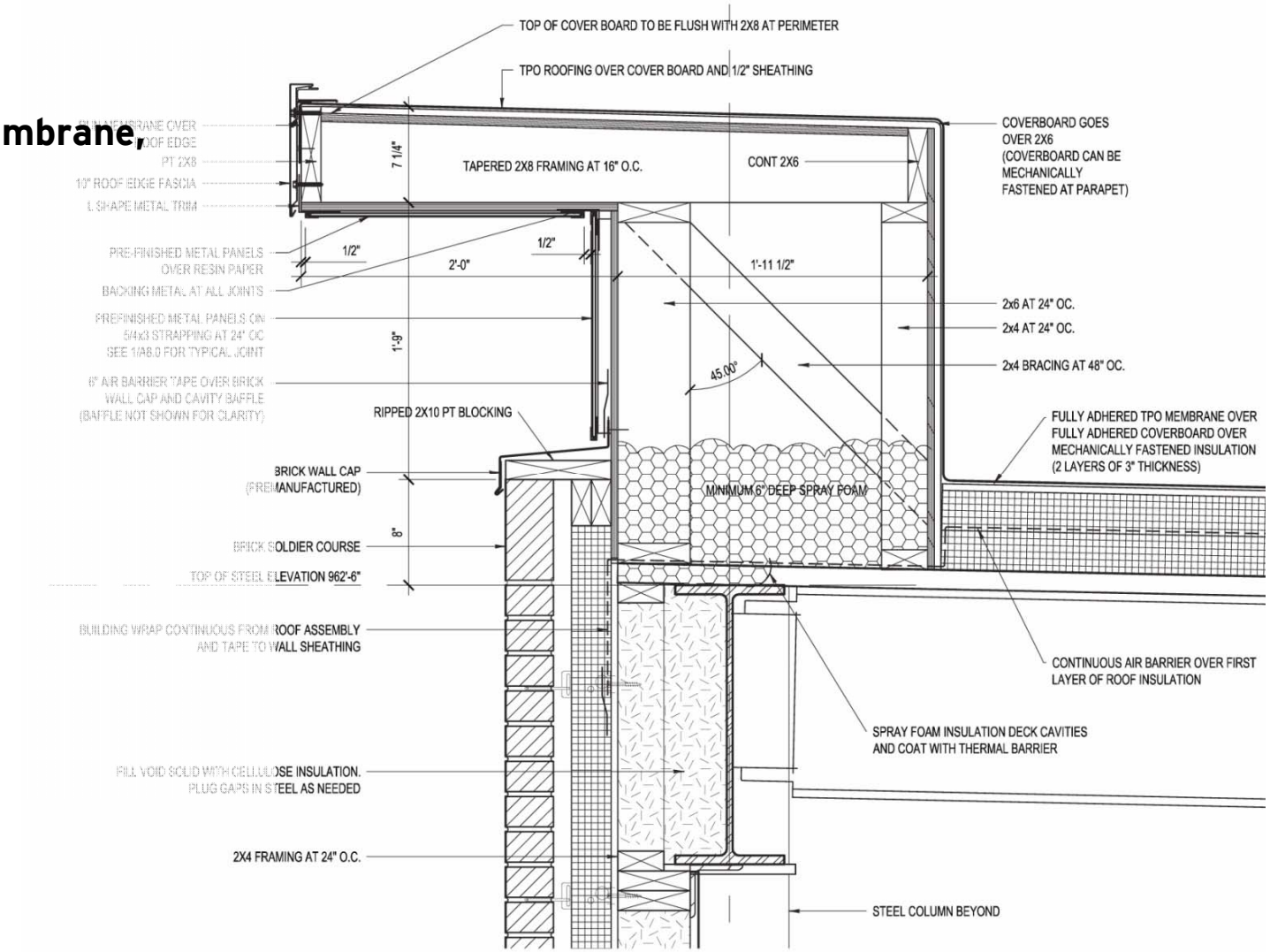
Northfield Savings Bank – ROOF

Central Operations Center

ROOF SYSTEM:

- **80 MIL TPO Membrane,**



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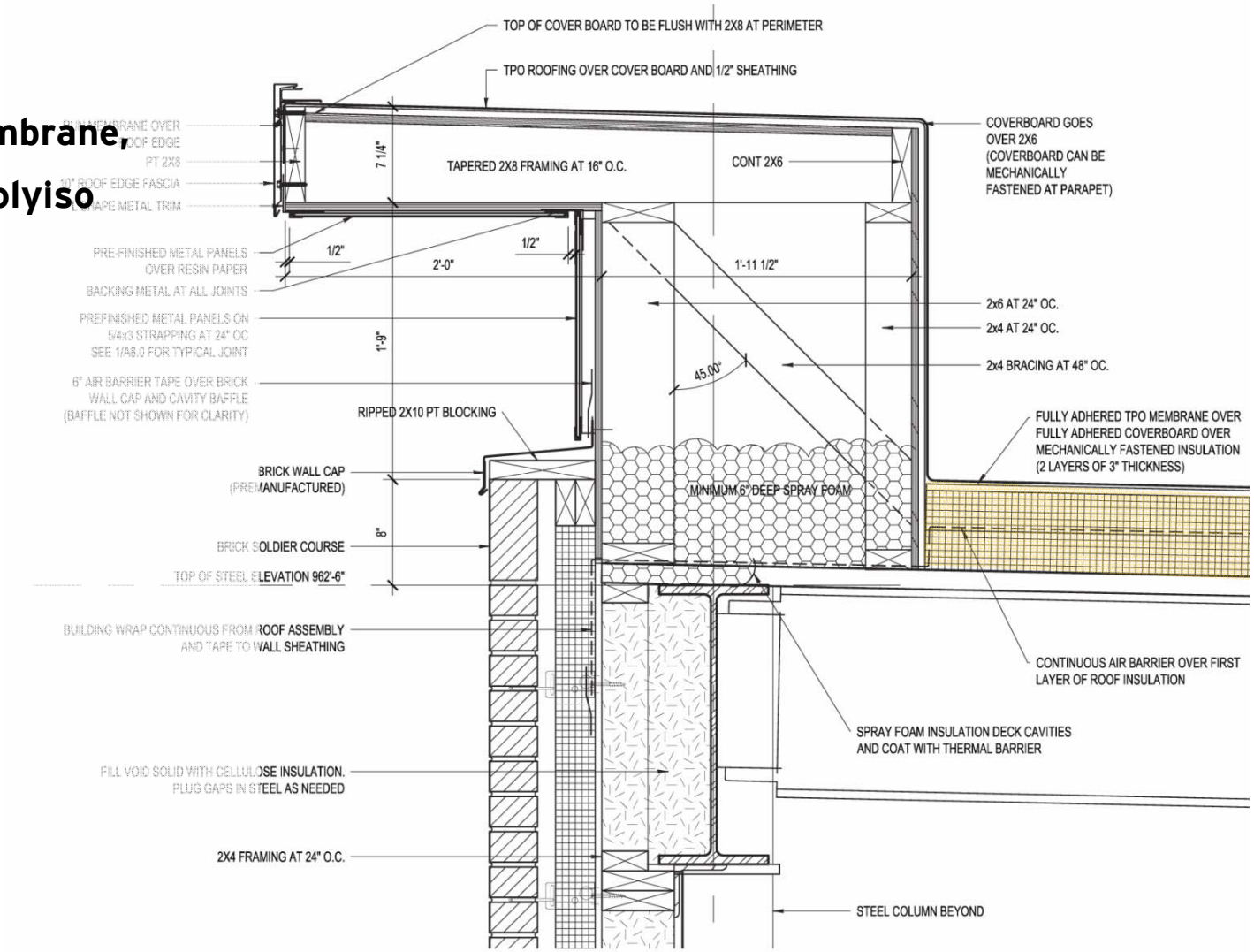
Northfield Savings Bank – ROOF

Central Operations Center

ROOF SYSTEM:

- **80 MIL TPO Membrane,**
- **2 layers of 3" Polyiso**



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Northfield Savings Bank – ROOF

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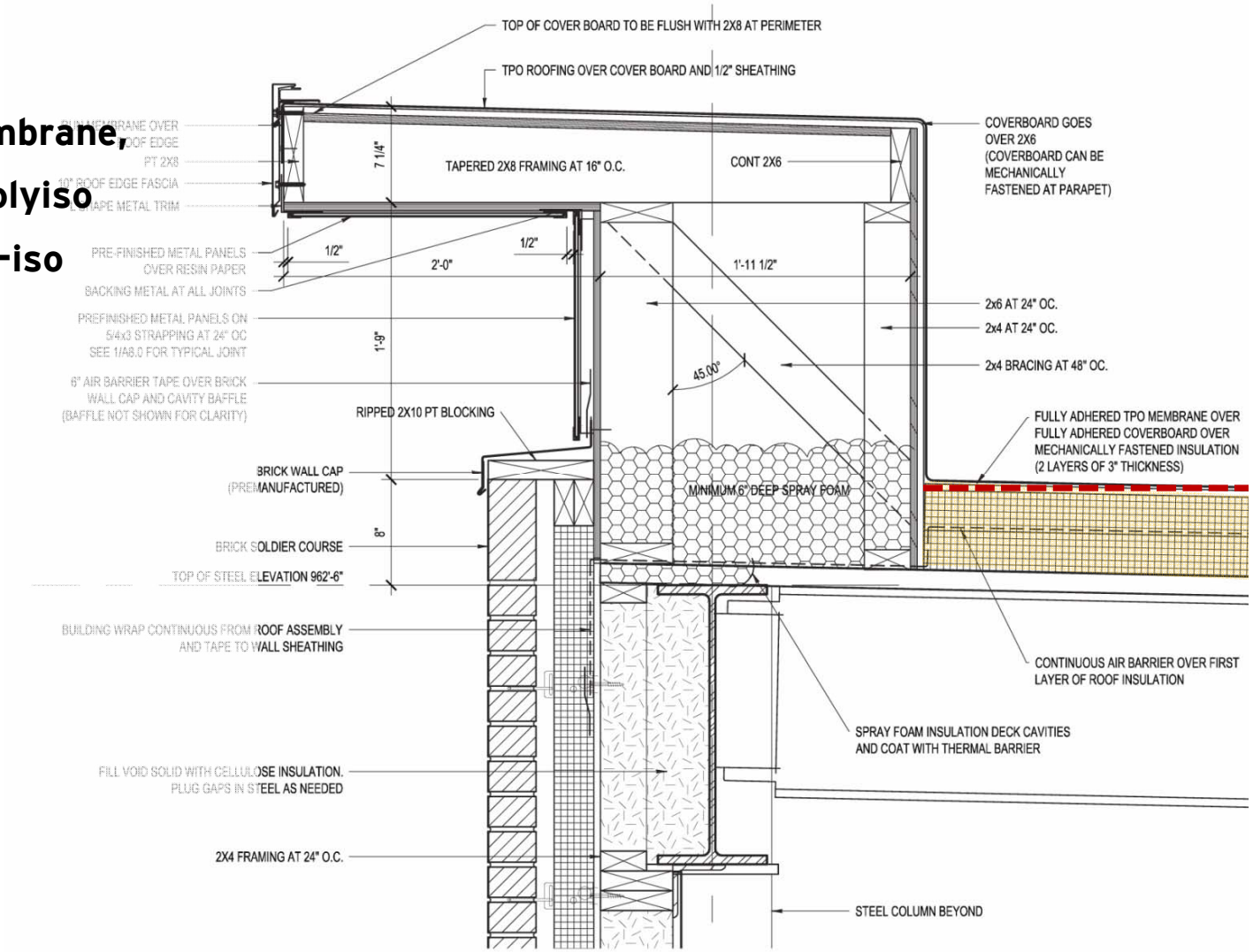
ROOF SYSTEM:

- **80 MIL TPO Membrane,**
- **2 layers of 3" Polyiso**
- **✣" adhered Poly-iso coverboard**



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Northfield Savings Bank – ROOF

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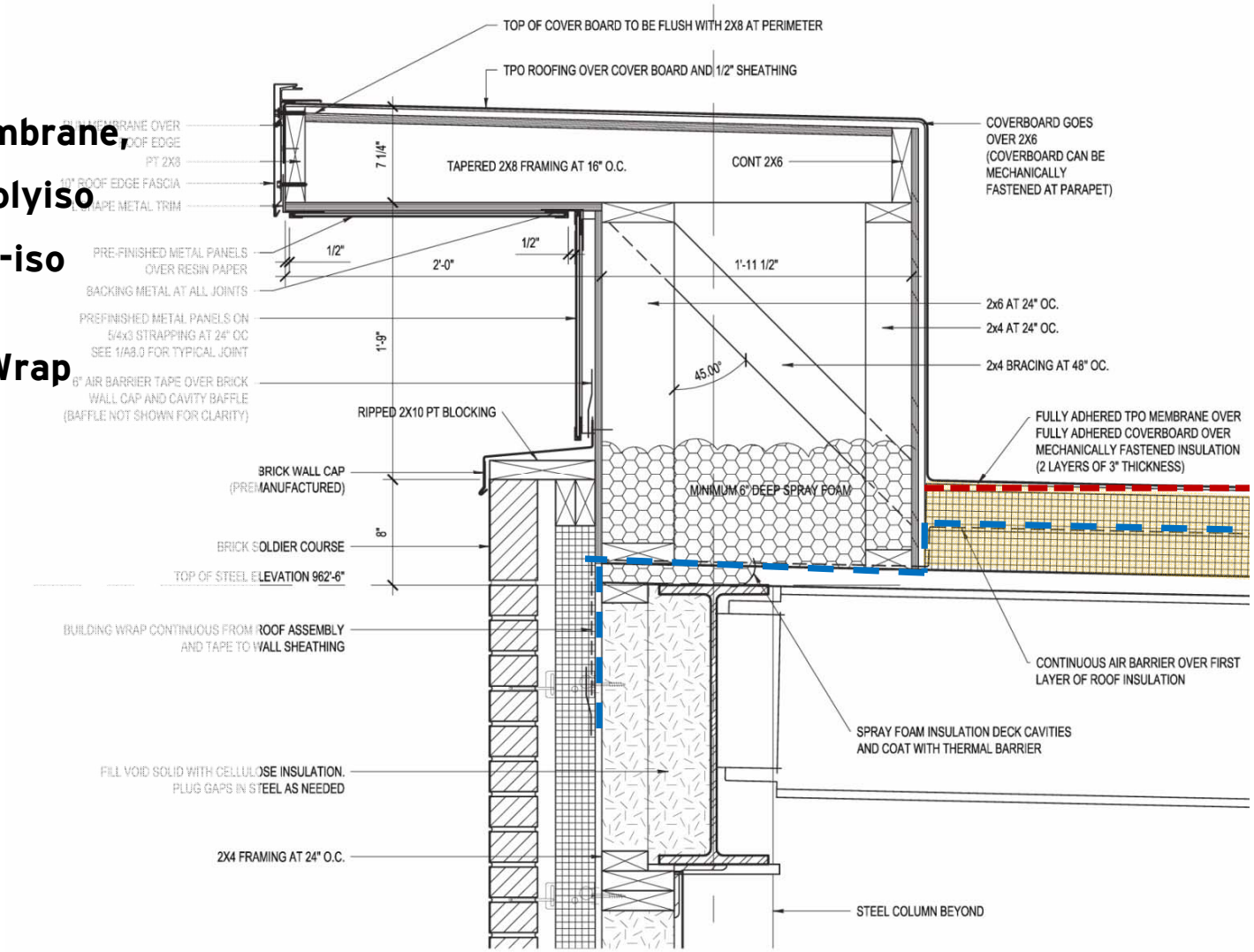
ROOF SYSTEM:

- **80 MIL TPO Membrane,**
- **2 layers of 3" Polyiso**
- **¾" adhered Poly-iso coverboard**
- **Tyvek Building Wrap**



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- **CODE MINIMUM**
  - **R-30**

- **DESIGNED SYSTEM**
  - **R-39**
    - **LTTR of r-5.6 per inch for Polyiso**
  - **Energy Model compared 6" to 9" =**
    - **Decreased energy costs by $113/ year.**
  - **Additional 3" insulation = $17,500.**
    - **154 year simple calc payback.**

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ROOF and WALL SYSTEMS:

- **Air Barrier Continuity**

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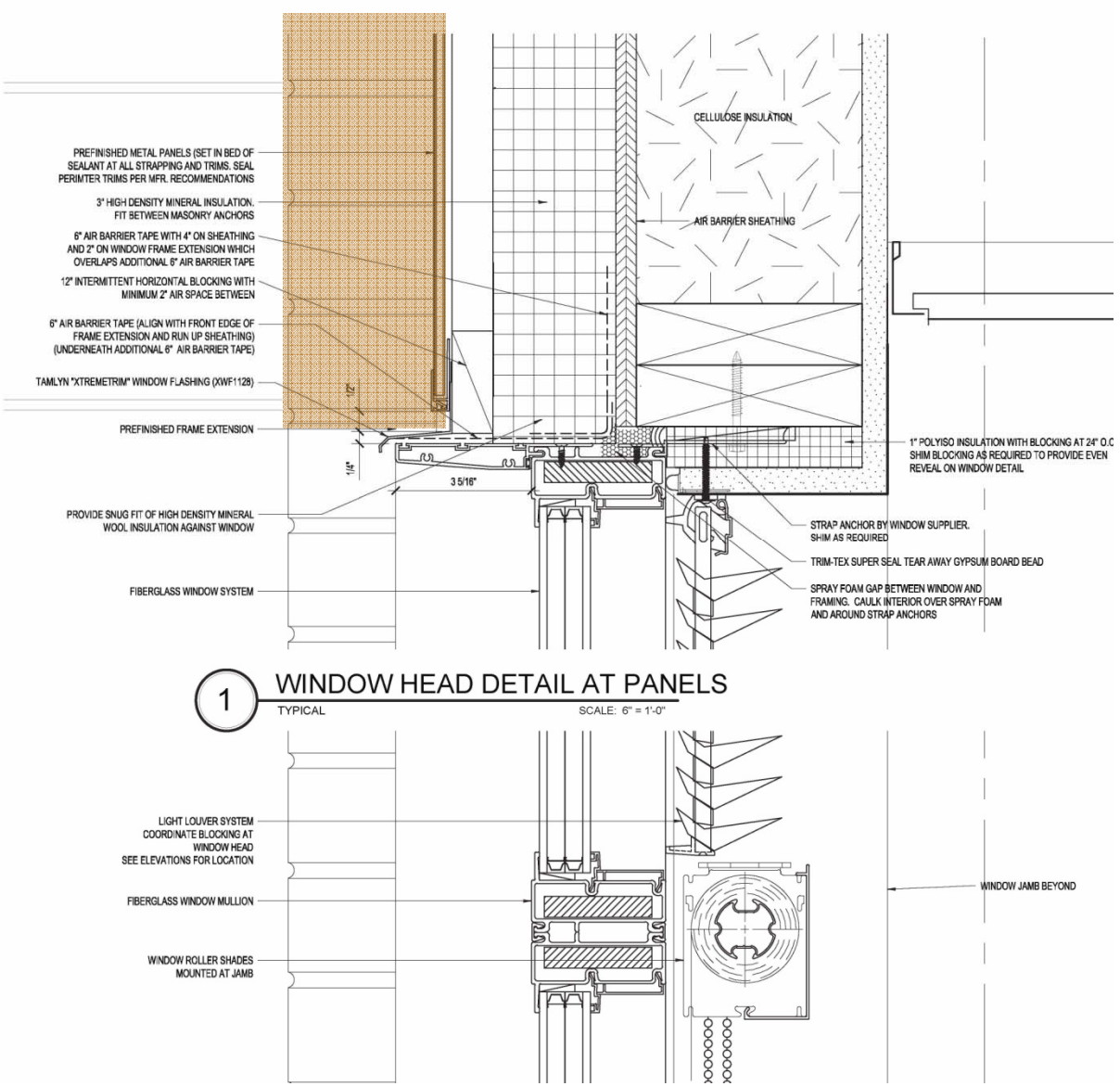
Northfield Savings Bank – Walls

Central Operations Center

WALL SYSTEM:

- **Brick or Aluminum Panel**



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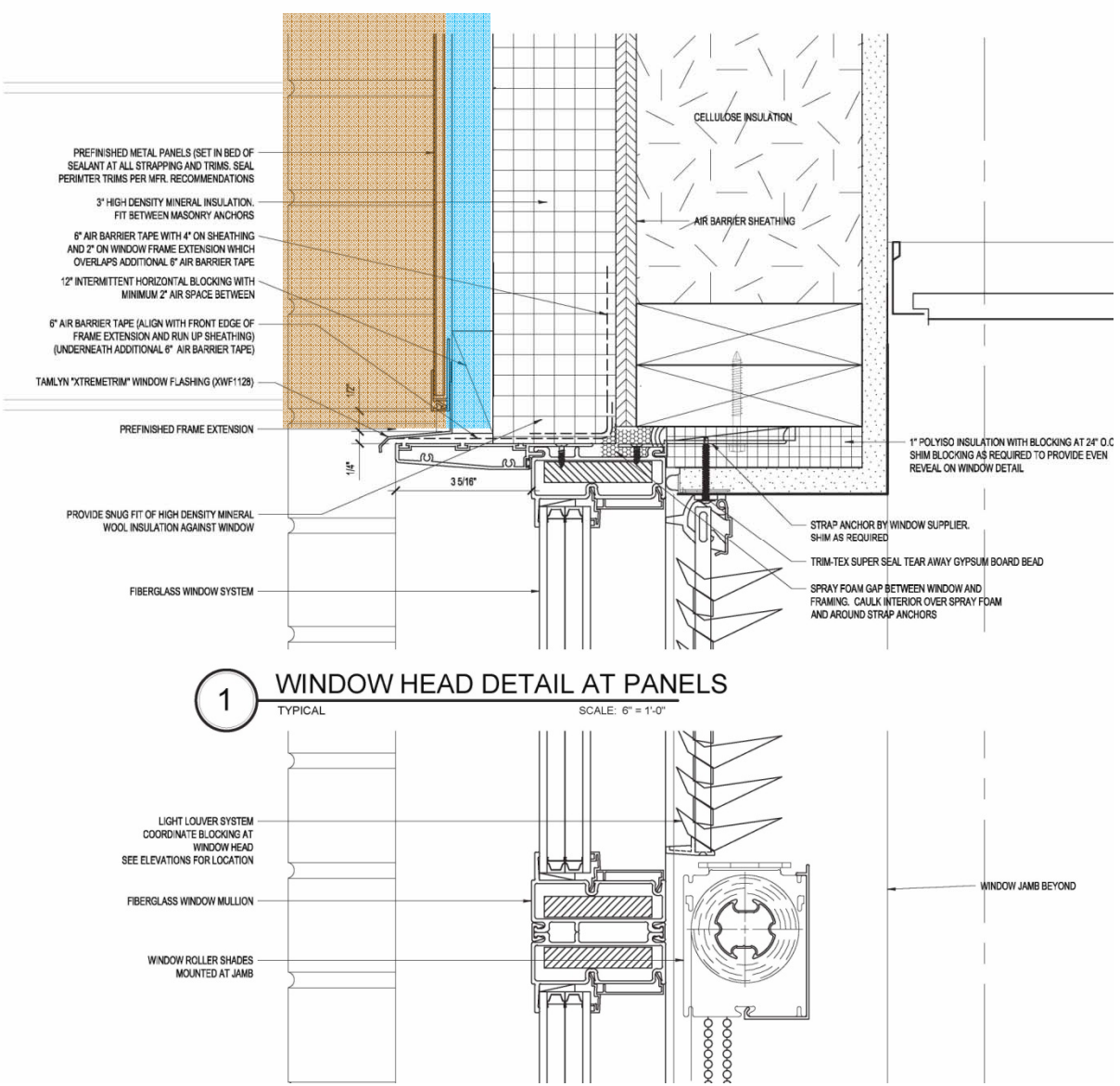
Northfield Savings Bank – Walls

Central Operations Center

WALL SYSTEM:

- **Brick or Aluminum Panel**
- **Drainage and Air Cavity**



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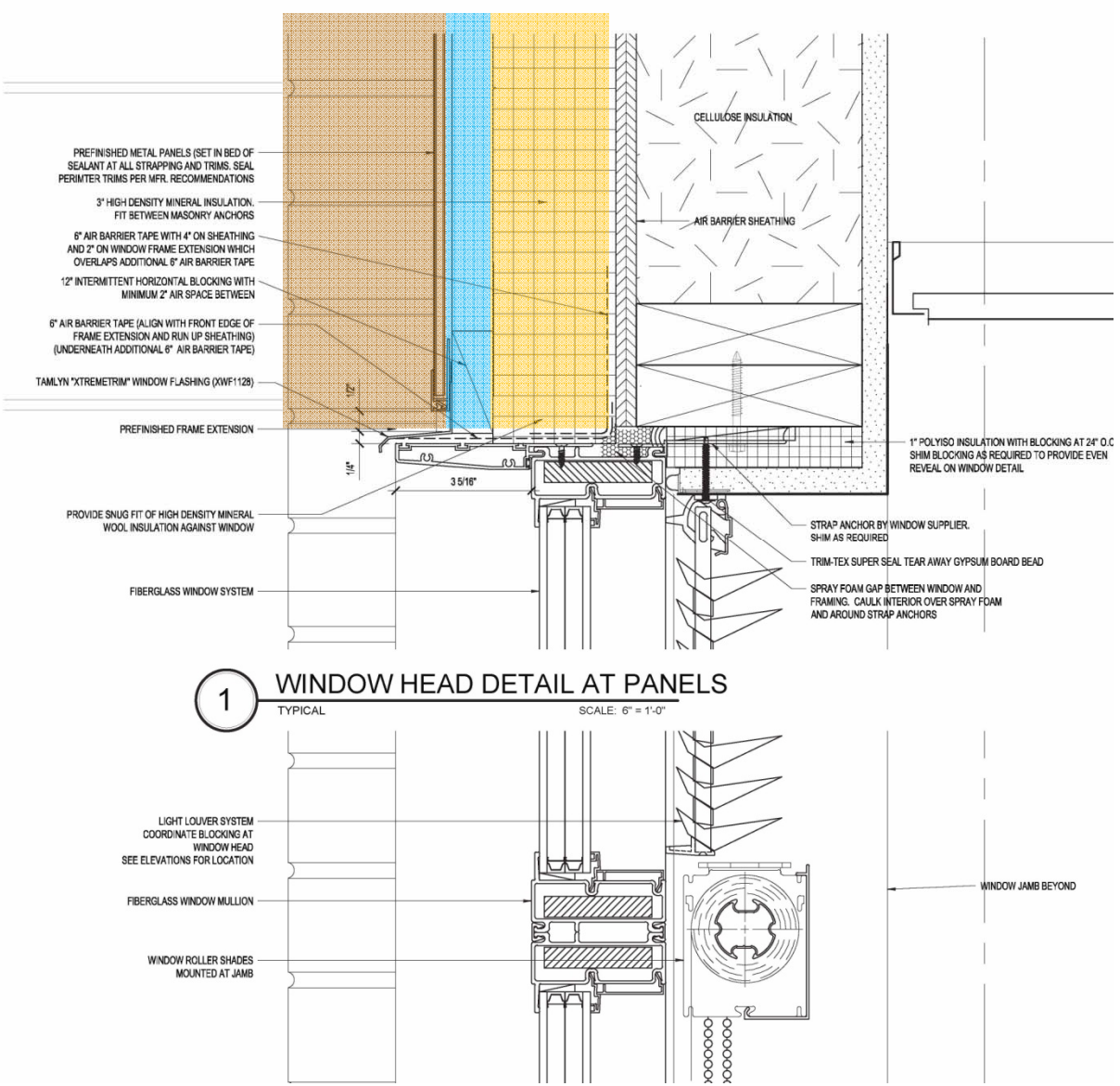
Northfield Savings Bank – Walls

Central Operations Center

WALL SYSTEM:

- **Brick or Aluminum Panel**
- **Drainage and Air Cavity**
- **3" High Density Mineral Wool**



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Northfield Savings Bank – Walls

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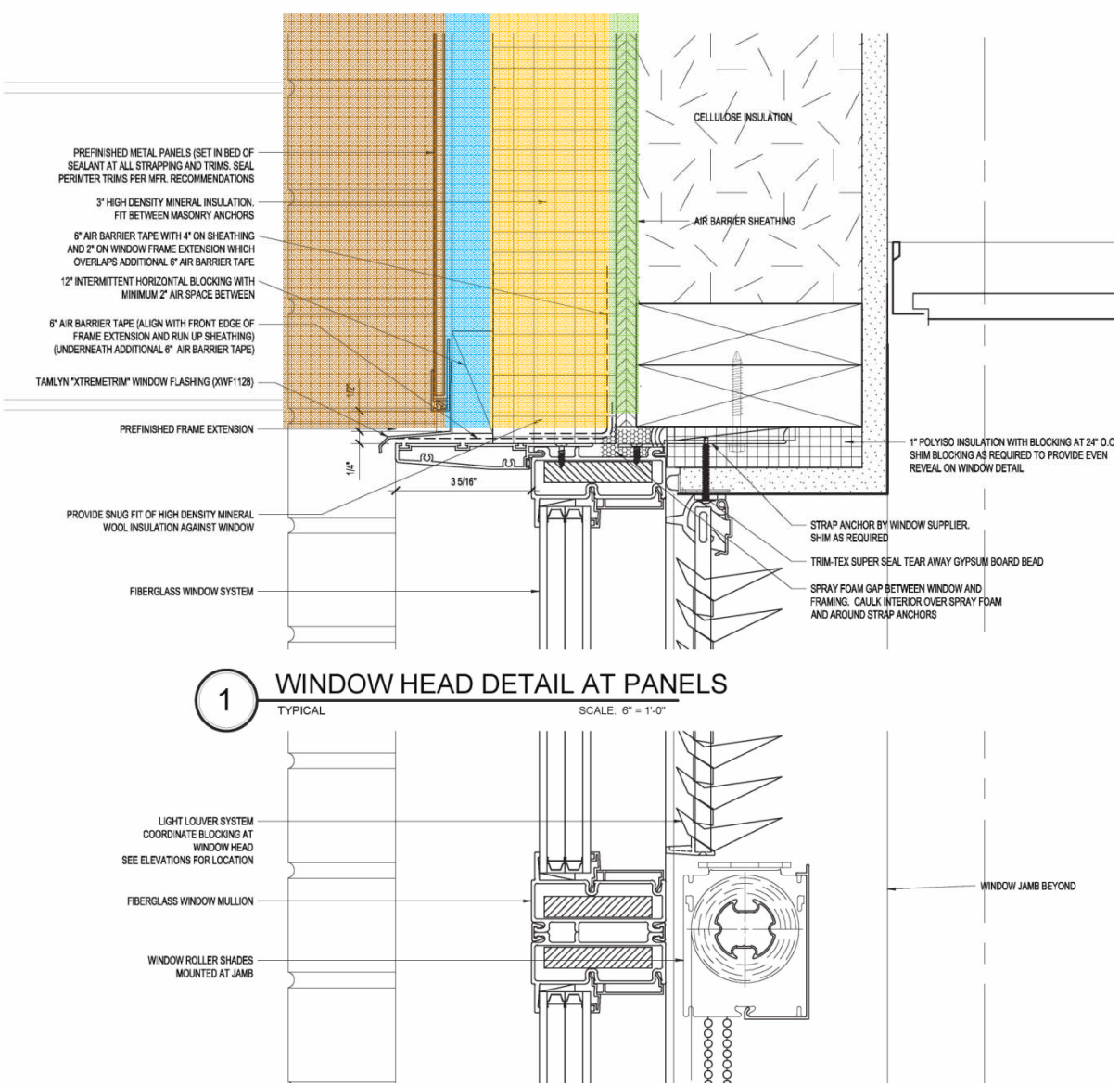
WALL SYSTEM:

- **Brick or Aluminum Panel**
- **Drainage and Air Cavity**
- **3" High Density Mineral Wool**
- **ZIP Sheathing**



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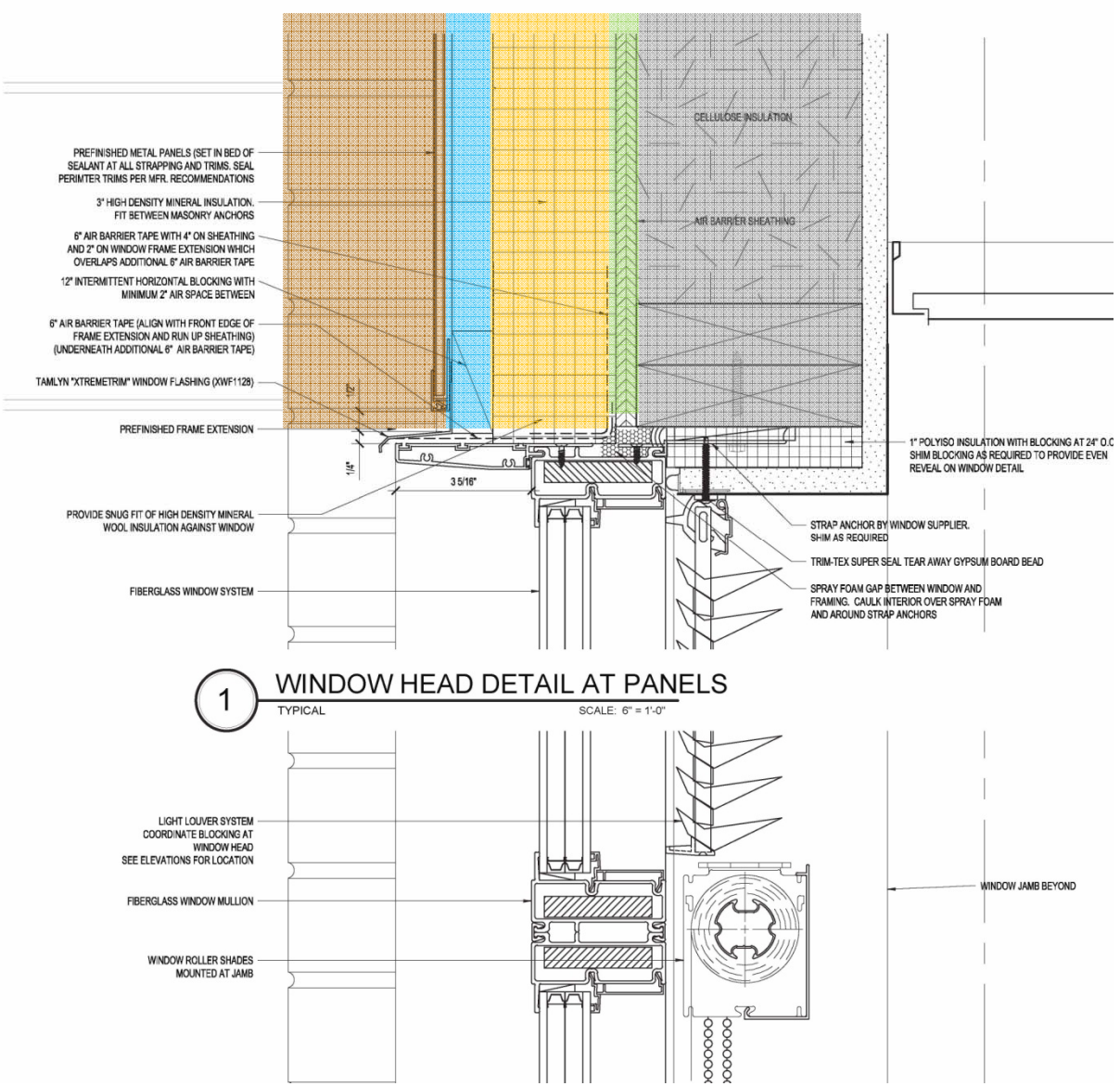
Northfield Savings Bank – Walls

Central Operations Center

WALL SYSTEM:

- **Brick or Aluminum Panel**
- **Drainage and Air Cavity**
- **3″ High Density Mineral Wool**
- **ZIP Sheathing**
- **2x6 Framing 24″oc and Dense Pack Cellulose**



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- **CODE MINIMUM**
  - **Steel Framed R-13 Cavity and R-7.5 Continuous**

- **DESIGNED SYSTEM**
  - **Wood Framed with:**
  - **R-20 Cellulose Cavity:**
  - **R-12 Continuous ROXUL CIS: Vapor Permeable, Non-Combustible, High density, Water Repellant**

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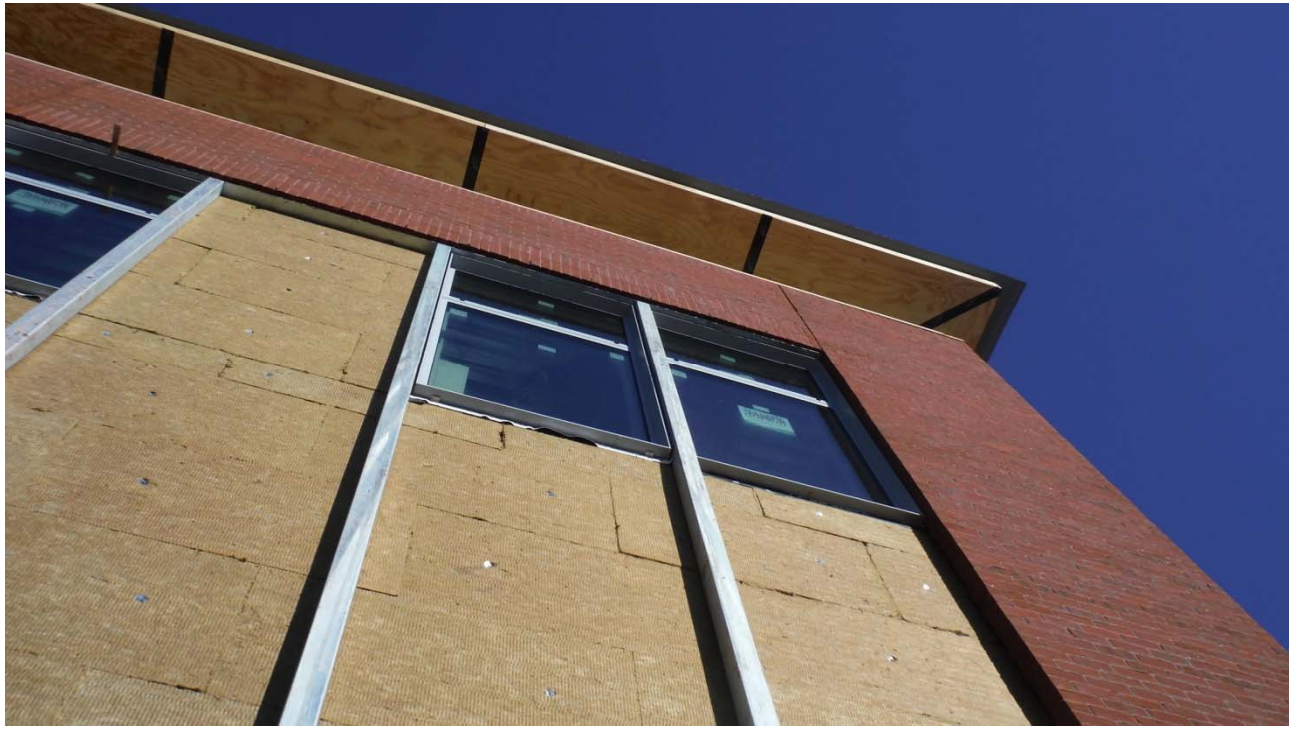
WALL SYSTEM:

- **Reduce Thermal Bridging**



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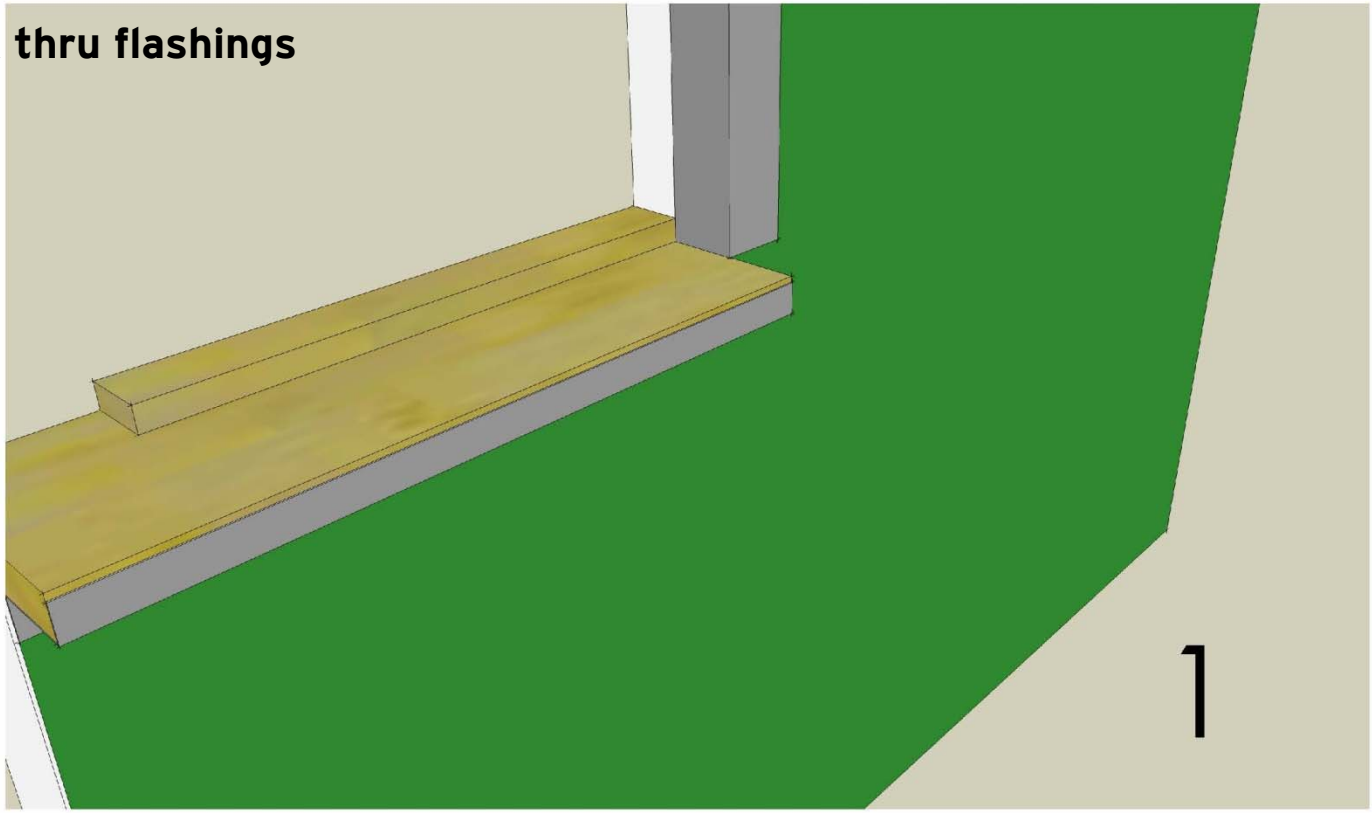
WALL SYSTEM:

- **Work thru flashings**



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Northfield Savings Bank - Walls

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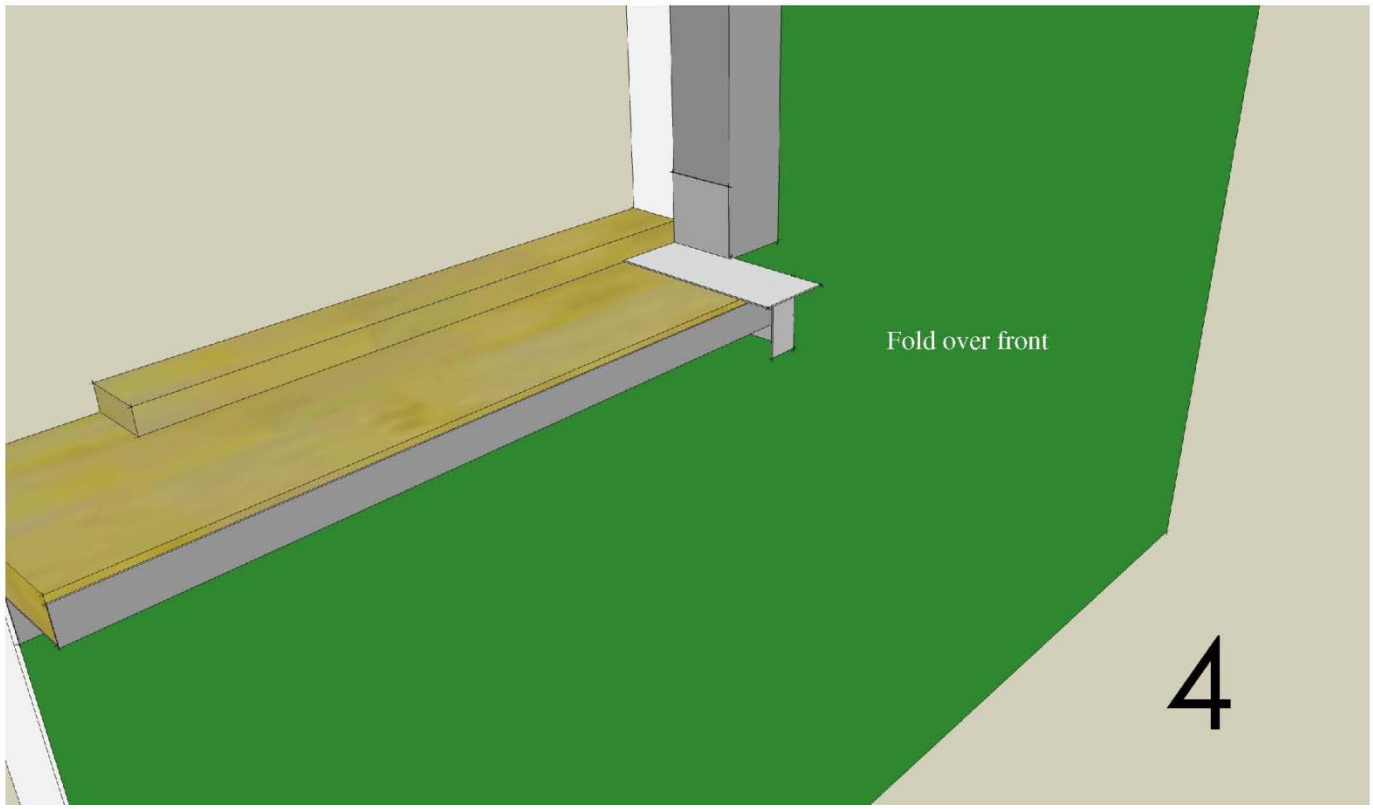

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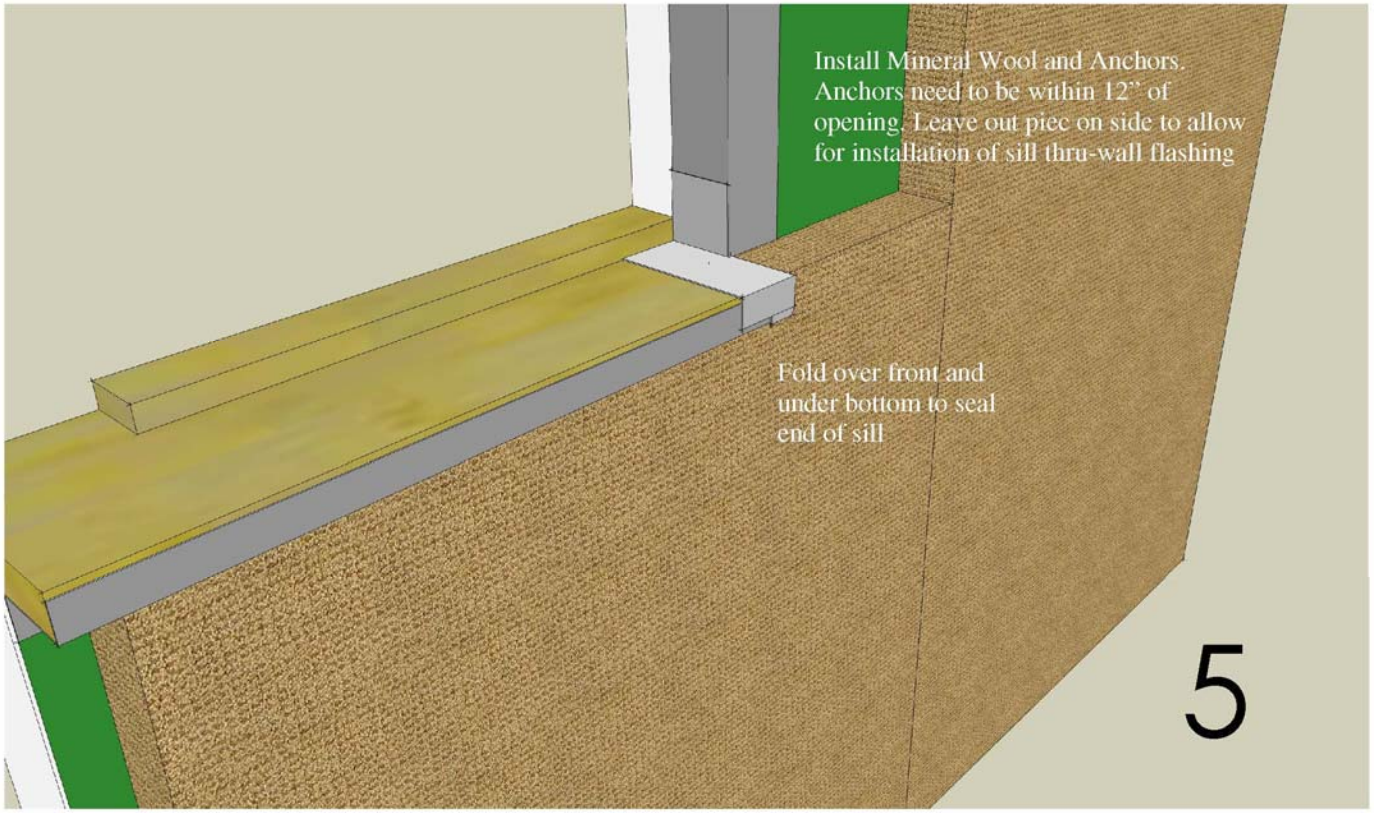

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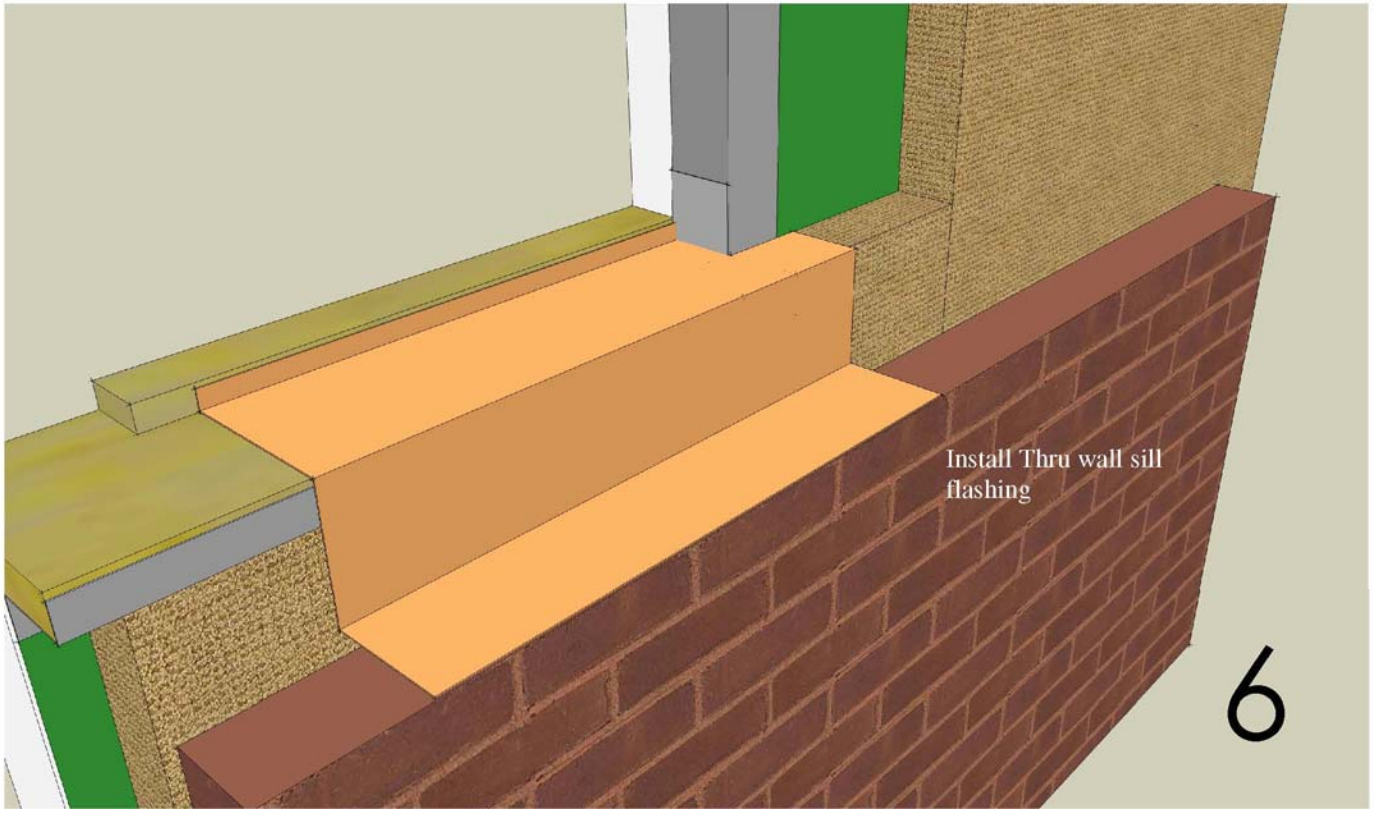

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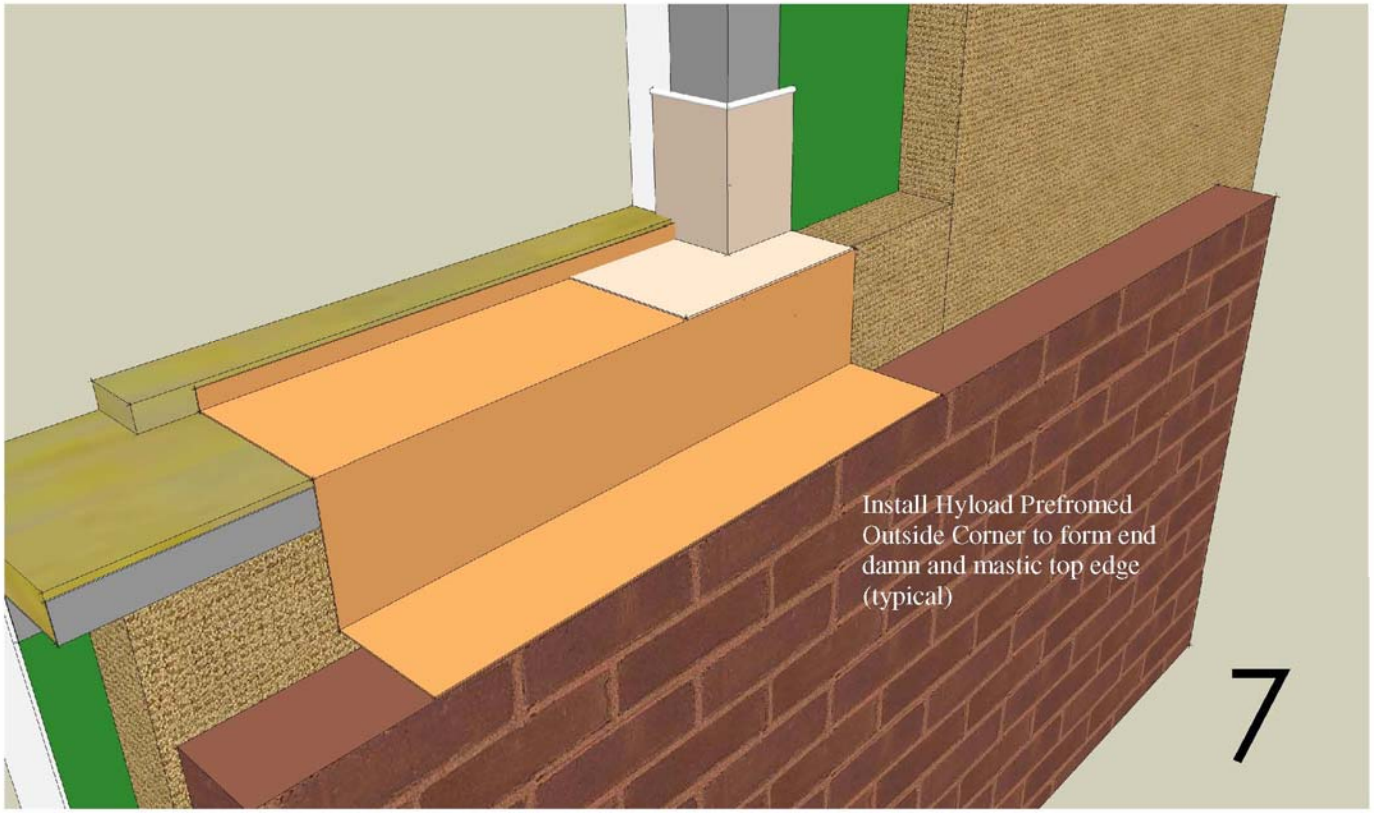

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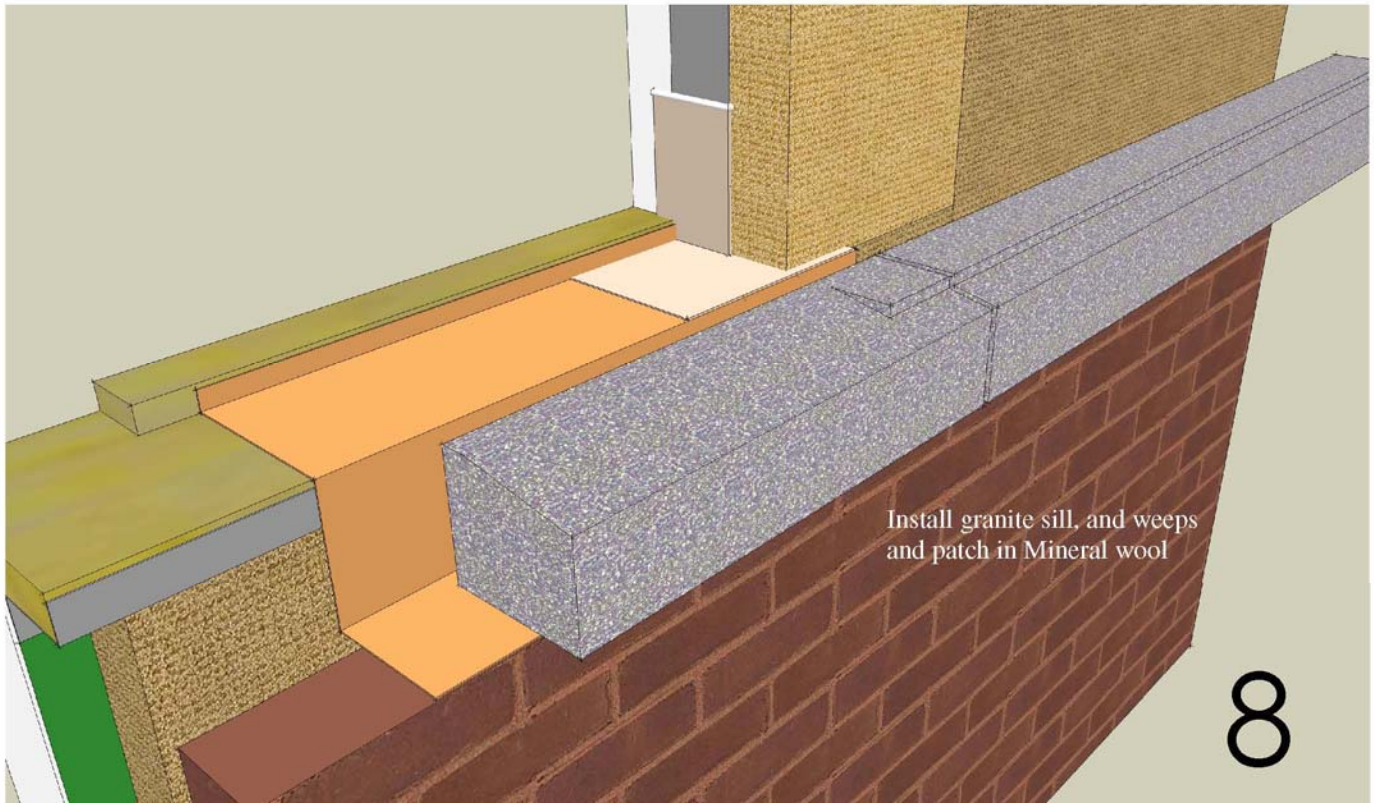

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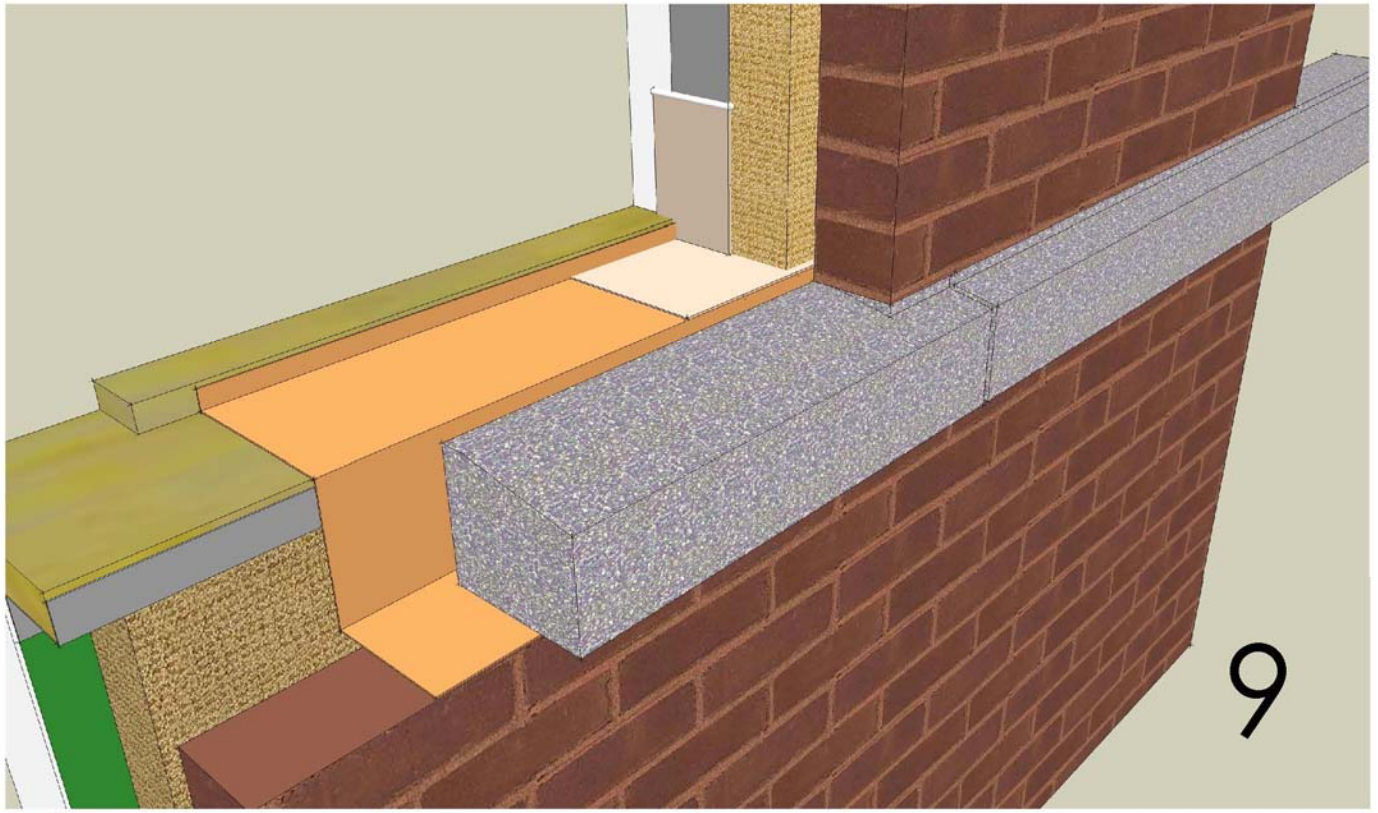

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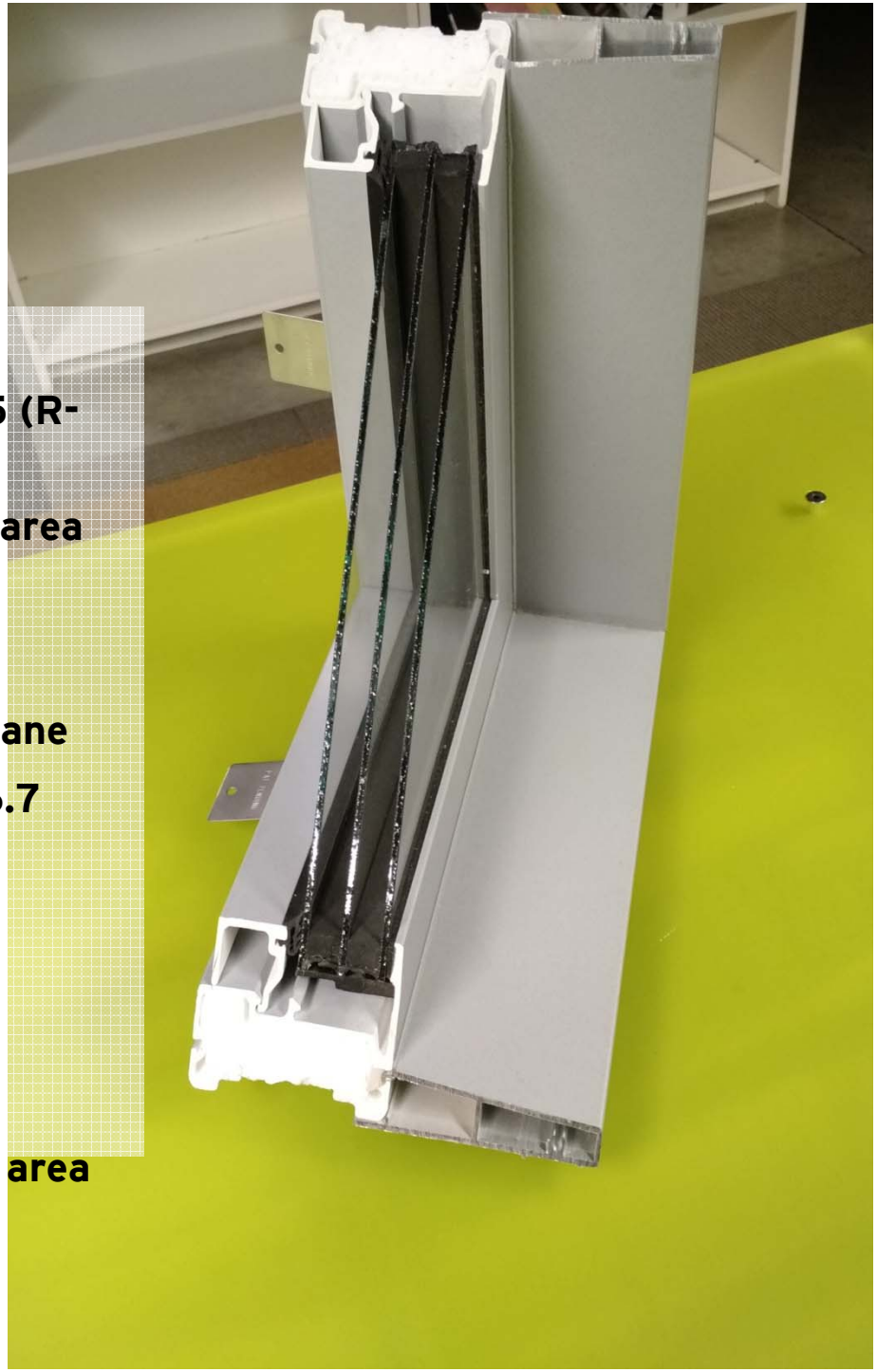
Central Operations Center

- **CODE MINIMUM**
  - **Non-Metal frame rated at U-0.35 (R-2.9) and SHGC-0.40**
  - **Glazing 31% of above Grade wall area**

- **DESIGNED SYSTEM**
  - **Fixed Fiberglass Framed Triple Pane**
  - **NFRC whole window R-Value of 6.7**

    (U Value = .15)
  - **SHGC .28 (less solar heat transmitted)**
  - **PPG Solarban 60 on 2nd and 5th Surfaces**
  - **Glazing 26% of above grade wall area**



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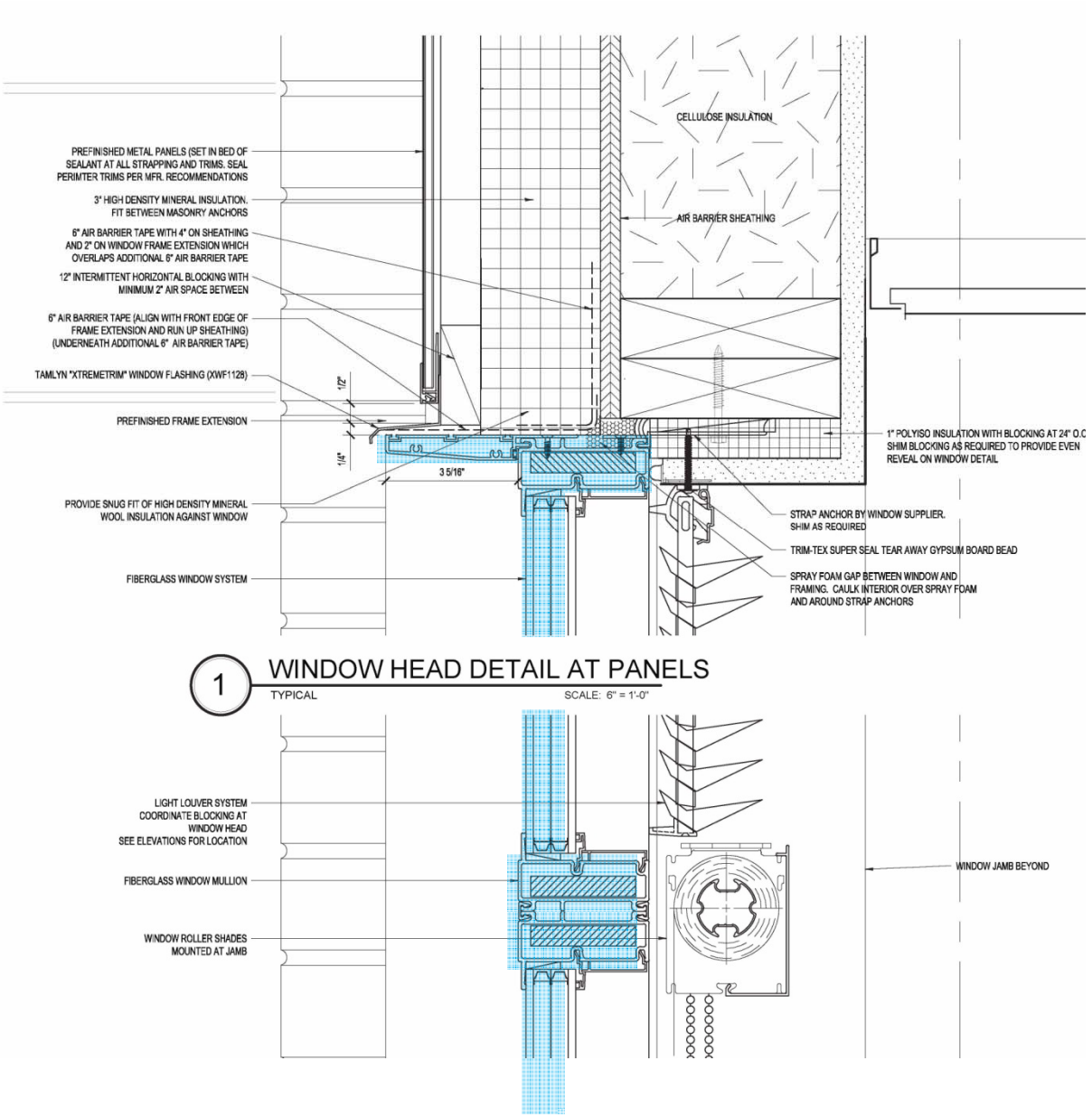
Northfield Savings Bank – Windows

Central Operations Center

DAYLIGHTING SYSTEM:

- **R-6.7 Triple Pane Fiberglass Window System**



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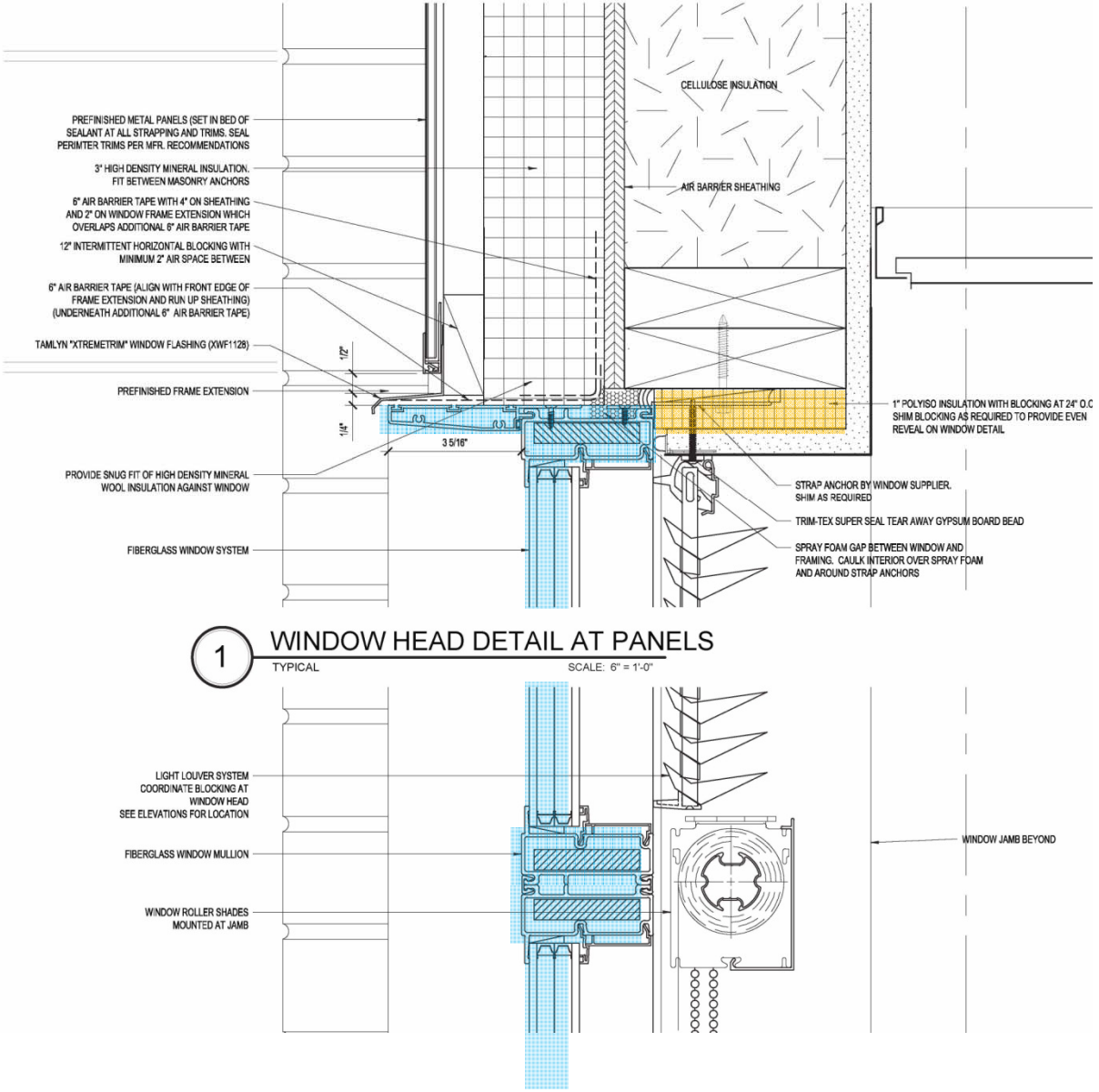
Northfield Savings Bank – Windows

Central Operations Center

DAYLIGHTING SYSTEM:

- **R-6.7 Triple Pane Fiberglass Window System**
- **1" Polyiso at window perimeter**



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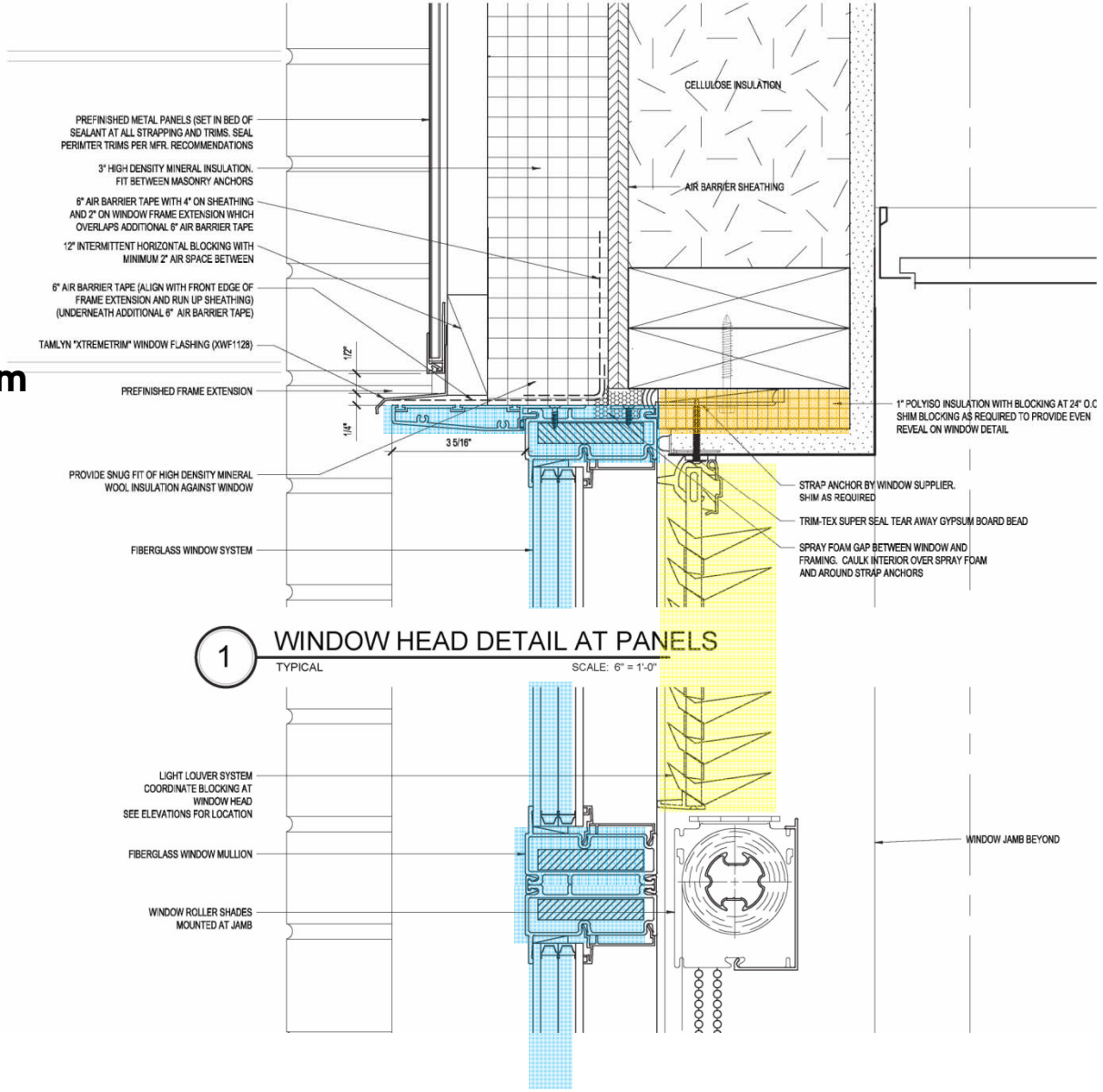
Northfield Savings Bank – Windows

Central Operations Center

DAYLIGHTING SYSTEM:

- **R-6.7 Triple Pane Fiberglass Window System**
- **1" Polyiso at window perimeter**
- **Interior Light louver system**



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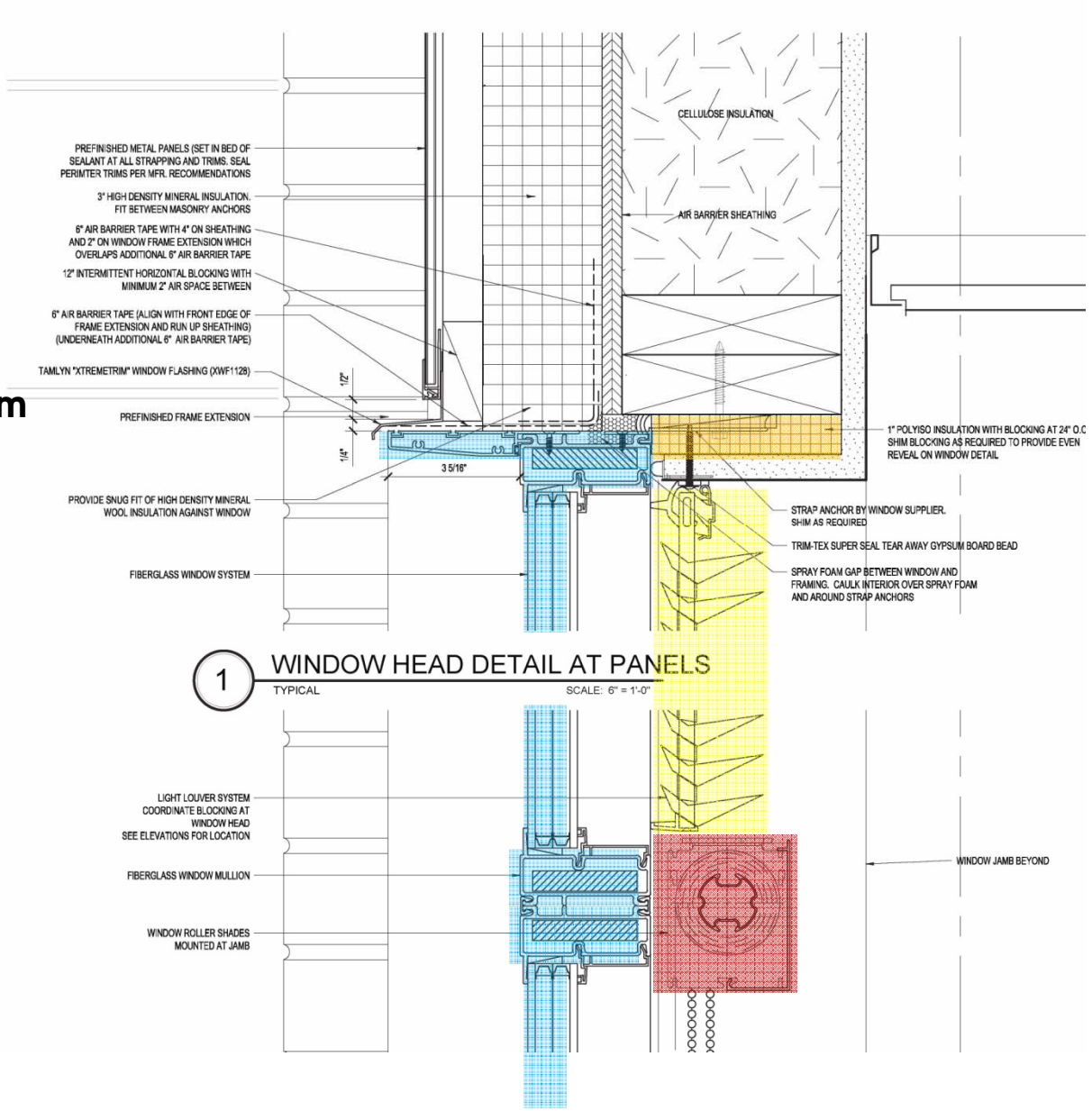
Northfield Savings Bank – Windows

Central Operations Center

DAYLIGHTING SYSTEM:

- **R-6.7 Triple Pane Fiberglass Window System**
- **1" Polyiso at window perimeter**
- **Interior Light louver system**
- **5% Light Filtering Shades**



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Northfield Savings Bank – Daylighting

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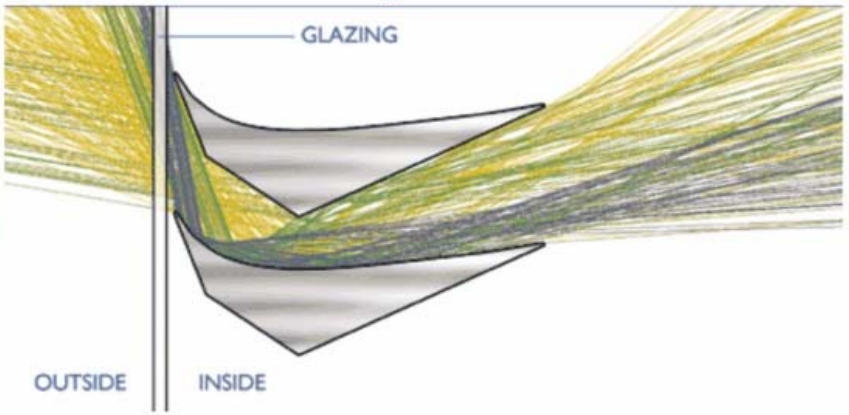
LightLouver Daylighting System

LightLouver Unit

Patented Optical Slat Design



Raytracing diagram illustrating performance under all sun angles

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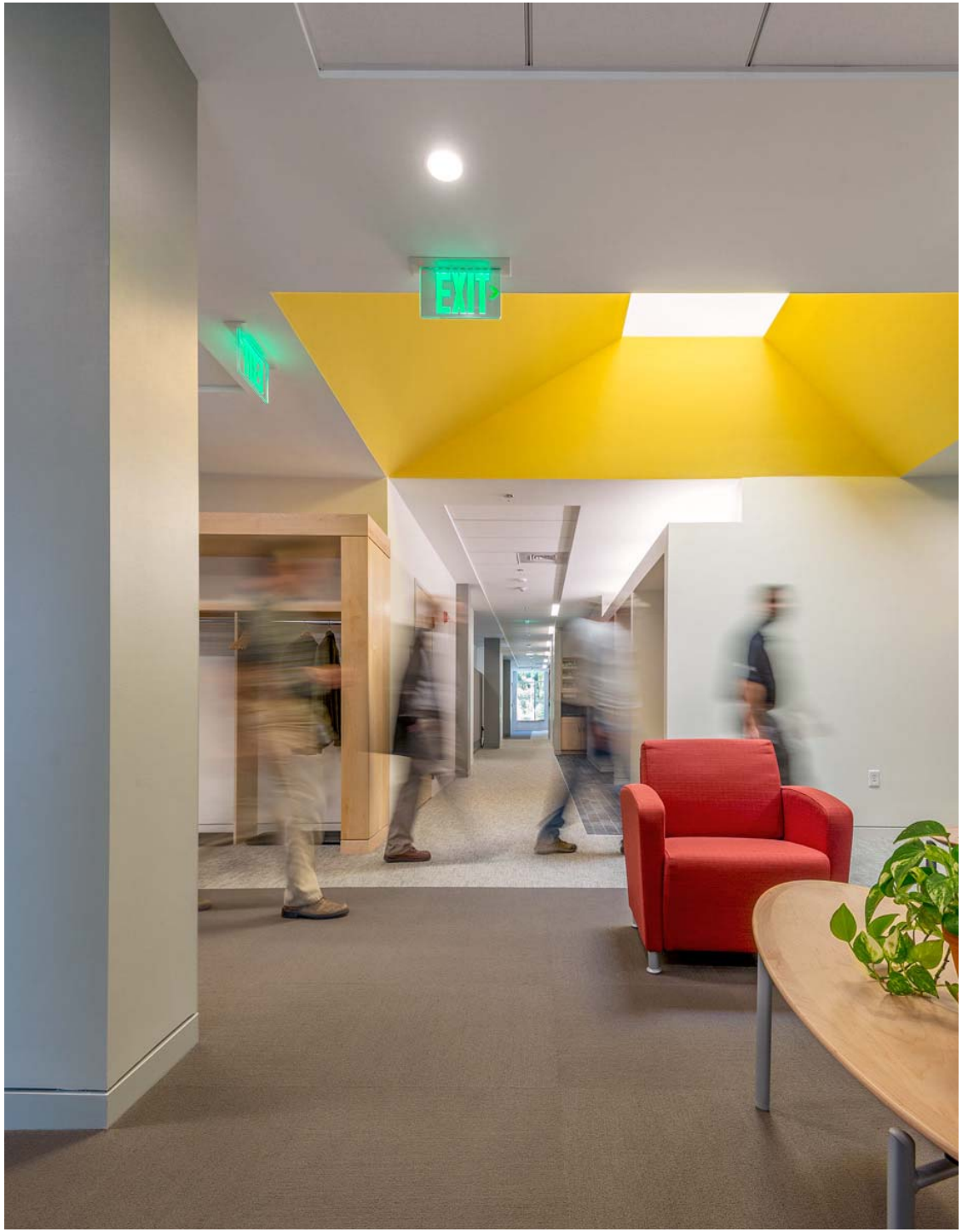

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Northfield Savings Bank – SLAB

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- **CODE MINIMUM**
  - **Slab with R-10 insulation for 48" vertically and nothing under slab**

- **DESIGNED SYSTEM**
  - **R-20 XPS Walls**
  - **R-10 XPS at Slab edge**
  - **R-10 XPS continuous under slab**
  - **Energy Model compared 2" to 4" underslab insulation = Decreased energy costs by $215/ year.**
  - **Additional 2" insulation = $17,100. 80 year payback.**

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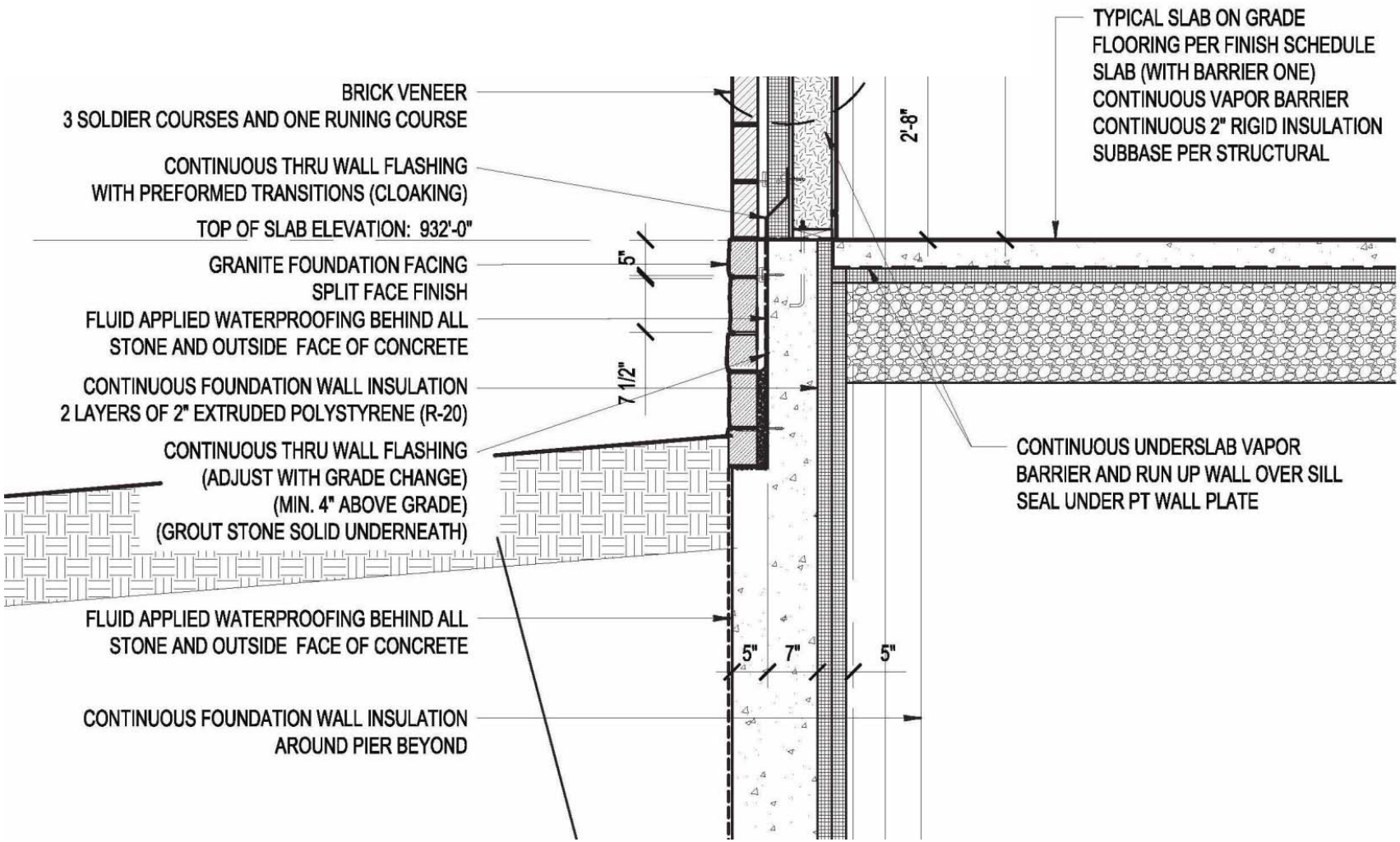

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Northfield Savings Bank – SLAB

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Northfield Savings Bank – MECHANICAL

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	Code-Minimum	*Northfield Savings Bank*	*Notes*
Heating	Propane rooftop units 80% efficiency	(32) Water-Source Heat Pumps, • Average rating of 5.2 COP, • 505 MBh capacity	
		(2) Propane Fired Boilers • Rated at 95.9% efficiency, • 275 MBh capacity	Boilers add heat to water loop if necessary

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Northfield Savings Bank – MECHANICAL

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Northfield Savings Bank – MECHANICAL

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Northfield Savings Bank – MECHANICAL

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	Code-Minimum	*Northfield Savings Bank*	*Notes*
Cooling	Electric DX-cooling rated at 11.0 EER, 11.2 IEER	(32) Water-Source Heat Pumps, • Avg. rating of 16.3 EER, • 37.5 tons total capacity	Cooling tower rejects heat from water loop if necessary
Cooling – Data Center	Electric DX-cooling air-conditioning unit, rated at 11.0 EER	(2) Water-Source Heat Pumps, • Rated at 10.6 EER, • 16 tons total capacity	Heat pumps reject waste heat to water loop for re-use

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	Code-Minimum	*Northfield Savings Bank*	*Notes*
Ventilation	No energy recovery	Energy Recovery Ventilation • 75% recovery effectiveness	Wheel-type ERV
Domestic Hot Water	Gas-fired storage tank, rated at 58% EF	Storage tank • Indirectly heated from boilers • 30 gallon	

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Northfield Savings Bank – MECHANICAL

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Northfield Savings Bank - INTERIOR LIGHTING

Central Operations Center

	Code-Minimum	*Northfield Savings Bank*	*Notes*
Interior Lighting Power	1.01 watts/ sq. ft.	0.67 watts/sq. ft.,	34% reduction

Metering	None	Electrical sub-metering for major end-uses, also propane metering	Data Center and Boiler

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Northfield Savings Bank – ELECTRICAL

Central Operations Center

	Code-Minimum	*Northfield Savings Bank*	*Notes*
Interior Lighting Controls	No daylighting controls	Daylighting controls in perimeter spaces where appropriate	Total of 20 daylighting sensors throughout
	No occupancy sensors	Occupancy sensors in almost all spaces, otherwise time-clock	Total of 84 occupancy sensors throughout
	Dimming controls in many spaces	Dimming controls in many spaces	Total of 47 dimming controls throughout

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NSB - INTERIOR LIGHTING

Central Operations Center

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NSB - INTERIOR LIGHTING

Central Operations Center

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NSB - INTERIOR LIGHTING

Central Operations Center

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Northfield Savings Bank – ELECTRICAL

Central Operations Center

	Code-Minimum	*Northfield Savings Bank*	*Notes*
Exterior Lighting Power	3,500 watts	1,600 watts, • Qualified LED fixtures	55% reduction

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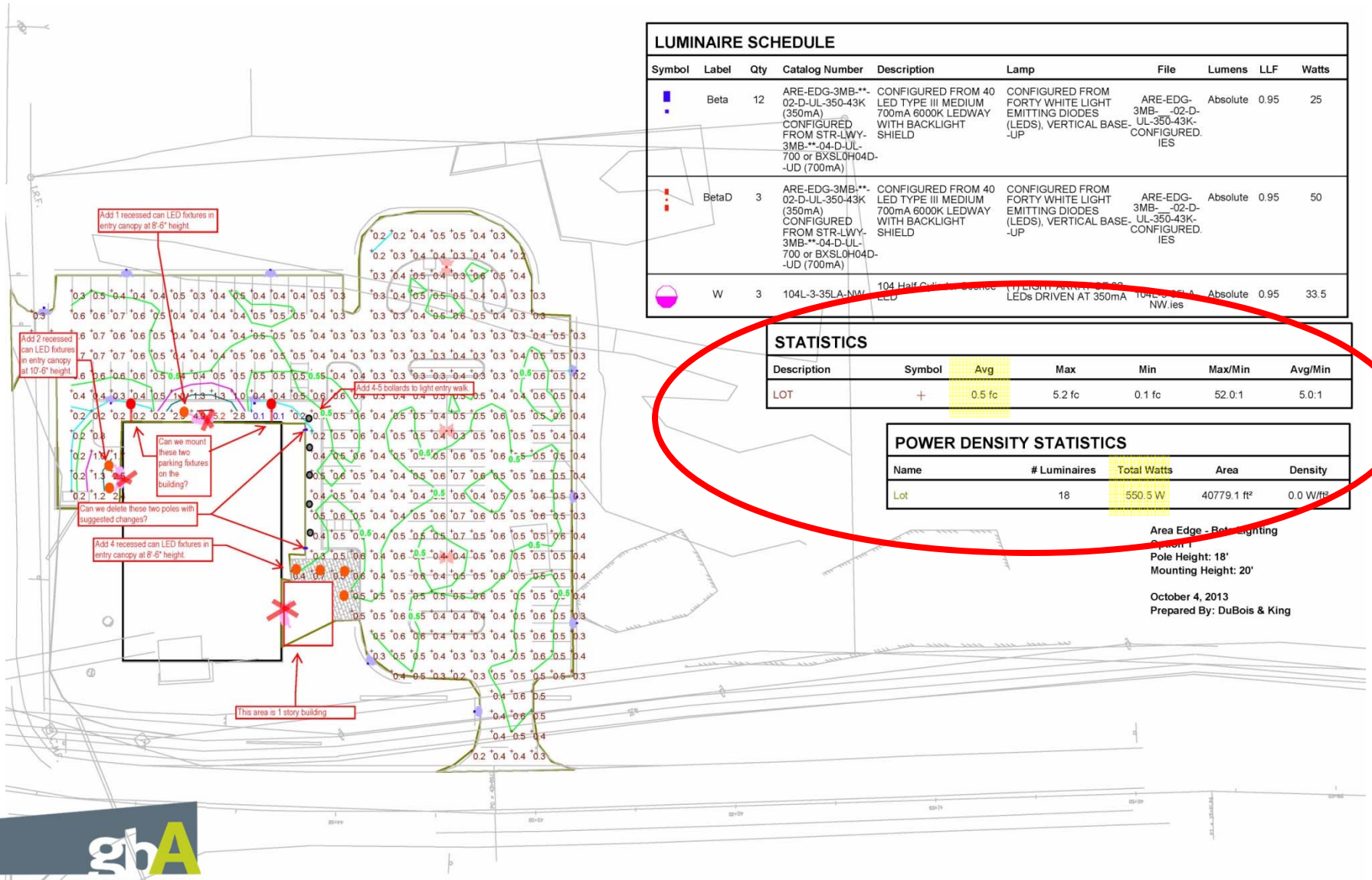
Northfield Savings Bank - ELECTRICAL

Central Operations Center



LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF	Watts
	Beta	12	ARE-EDG-3MB-**-02-D-UL-350-43K (350mA) CONFIGURED FROM STR-LWY-3MB-**-04-D-UL-700 or BXSL0H04D--UD (700mA)	CONFIGURED FROM 40 LED TYPE III MEDIUM 700mA 6000K LEDWAY WITH BACKLIGHT SHIELD	CONFIGURED FROM FORTY WHITE LIGHT EMITTING DIODES (LEDS), VERTICAL BASE--UP	ARE-EDG-3MB-__-02-D-UL-350-43K-CONFIGURED.IES	Absolute	0.95	25
	BetaD	3	ARE-EDG-3MB-**-02-D-UL-350-43K (350mA) CONFIGURED FROM STR-LWY-3MB-**-04-D-UL-700 or BXSL0H04D--UD (700mA)	CONFIGURED FROM 40 LED TYPE III MEDIUM 700mA 6000K LEDWAY WITH BACKLIGHT SHIELD	CONFIGURED FROM FORTY WHITE LIGHT EMITTING DIODES (LEDS), VERTICAL BASE--UP	ARE-EDG-3MB-__-02-D-UL-350-43K-CONFIGURED.IES	Absolute	0.95	50
	W	3	104L-3-35LA-NW-	104 Half Cutoff LED	LEDs DRIVEN AT 350mA	104L-3-35LA-NW.ies	Absolute	0.95	33.5

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
LOT	+	0.5 fc	5.2 fc	0.1 fc	52.0:1	5.0:1

POWER DENSITY STATISTICS

Name	# Luminaires	Total Watts	Area	Density
Lot	18	550.5 W	40779.1 ft²	0.0 W/ft²

Area Edge - Bot Lighting
Option 1
Pole Height: 18'
Mounting Height: 20'

October 4, 2013
Prepared By: DuBois & King

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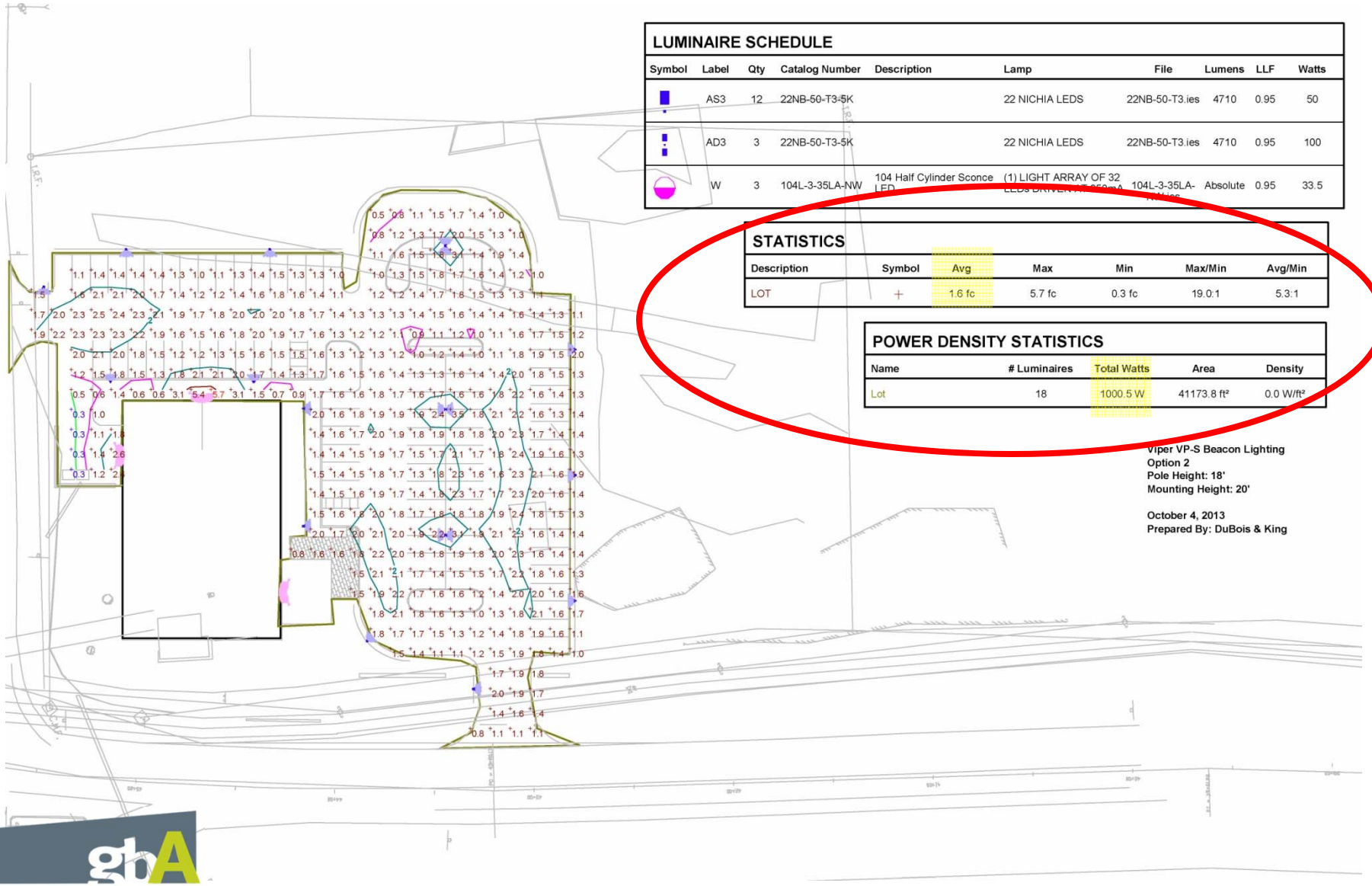
Northfield Savings Bank – ELECTRICAL

Central Operations Center



LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF	Watts
	AS3	12	22NB-50-T3-5K		22 NICHIA LEDS	22NB-50-T3.ies	4710	0.95	50
	AD3	3	22NB-50-T3-5K		22 NICHIA LEDS	22NB-50-T3.ies	4710	0.95	100
	W	3	104L-3-35LA-NW	104 Half Cylinder Sconce LED	(1) LIGHT ARRAY OF 32 LEDS DRIVEN AT 350mA	104L-3-35LA-[illegible]	Absolute	0.95	33.5

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
LOT	+	1.6 fc	5.7 fc	0.3 fc	19.0:1	5.3:1

POWER DENSITY STATISTICS

Name	# Luminaires	Total Watts	Area	Density
Lot	18	1000.5 W	41173.8 ft²	0.0 W/ft²

Viper VP-S Beacon Lighting
Option 2
Pole Height: 18'
Mounting Height: 20'

October 4, 2013
Prepared By: DuBois & King

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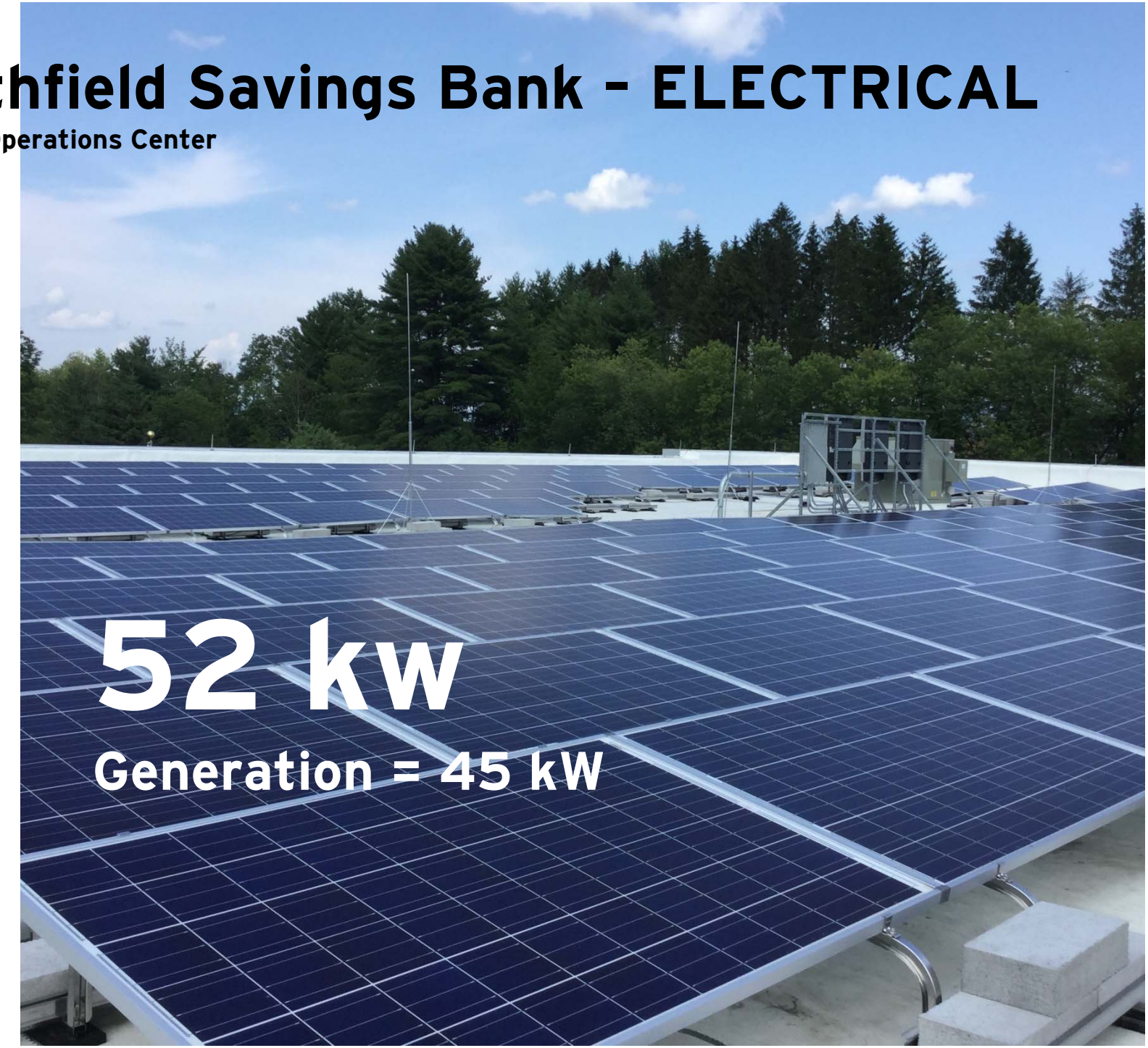
Northfield Savings Bank - ELECTRICAL

Central Operations Center



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Northfield Savings Bank - Data Center

Central Operations Center

33	Switch	740	2,525	
34	Switch	740	2,525	
35	Switch	740	2,525	
36	Switch	740	2,525	
37	Switch	740	2,525	
38	UPS	5,400	18,425	480
		50,450 watts	172,195 BTU	3880 Total

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ARCHITECTURE & PLANNING

Northfield Savings Bank – Data Center

Central Operations Center

	Code-Minimum	*Northfield Savings Bank*	*Notes*
Cooling - Data Center	Electric DX-cooling computer room air-conditioning unit, rated at 11.0 EER	(2) Water-source heat pumps, • rated at 10.6 EER, • 16 tons total capacity	Heat pumps reject waste heat to water loop for re-use

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Northfield Savings Bank – Data Center

Central Operations Center

- **DATA CENTER**
  - **Heat will be rejected to the water loop and either redistributed where called for or rejected thru the cooling tower.**
  - **The data center, centrally located within the building, will reject heat year round.**
  - **Any lack of heat energy within the loop is supplemented by the gas-fired boiler system while any excess heat is rejected through the cooling tower.**
  - **The data center contributes roughly 109,400,000 BTU's during the heating months.**
  - **By recapturing the heat generated by the data center roughly 1200 gallons of LP Gas fuel can be saved annually."**

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Northfield Savings Bank - Commissioning

Central Operations Center

Design Phase and

Construction Phase

Mechanical, Electrical

Issue No.	Description	Company
22	The wall mounted temperature sensors furnished with heat pumps HP-24, 25, 28 and 34 are not fully compatible in communicating with the BAS. 11/19/15: NSB has approved replacement of temperature sensors. CTI to provide pricing and installation.	Control Technologies
25	NSB has expressed concerns with the low energy credits received from GMP for the solar system. Failed inverter units have been replaced. CTI to include solar energy generation on the dashboard.	Control Technologies
31	The building dashboard has not yet been developed by CTI. The following points to be displayed: Main Electrical Service, Solar System, Data Center, Lighting Panel, Mechanical Power Panel, Propane Consumption, Water Usage.	Control Technologies
26	Electrical outlets are missing on the Board Room conference table.	E.F. Wall
27	O&M Manuals and as-built drawings have not yet been delivered to NSB.	E.F. Wall
30	Reception area is cold. Additional heat pump, or supplemental heating coil to be investigated in order to maintain acceptable temperatures in this area.	E.F. Wall
4	Resolve the communication issue between the boilers and the BAS. CTI can monitor certain boiler control points, but cannot download setpoints or run/stop commands. The boilers are therefore operating independently of the rest of the HVAC system; which is controlled by the BAS. 11/19/15: John Penny will contact Emerson Swan to request factory rep boiler startup and support with the communication issue.	John Penny Consulting
20	Install a propane flow totalizer, and interface to the BAS for dashboard display. 11/19/15: NSB has approved totalizer installation. John Penny to provide spec for totalizer unit.	John Penny Consulting
28	Low exhaust airflow rate (1700 CFM per TAB vs 2700 CFM design) has been noted on the TAB report. Low exhaust airflow rates in bathrooms noted. 11/19/15 field observation during training indicated that the ERU exhaust is above design CFM. John Penny to investigate with Brownell Mechanical and TAB contractor.	John Penny Consulting
33	It was decided that Data Center return air will be permanently routed through the ceiling plenum, back to the Stolz units. NSB to investigate whether Stolz offers a return air plenum to run between the suspended ceiling and the top of the Stolz units. Permanent return air grilles and Solz plenums to be installed.	John Penny Consulting
6	The Stoltz computer room air conditioning units (HP-26 & 27) are short cycling, especially when operating in dehumidification mode. Decide whether to make setpoint changes per Hallam's recommendation. 11/19/15: Setpoint changes were made and documented in photos of control panels. Will observe operations before making further changes.	Northfield Savings Bank
24	Verify that the first floor bathroom lighting controls are operating properly. (NSB expressed concerns during 11/19/15 meeting).	Northfield Savings Bank
29	Occupants in some spaces are complaining of cold temperatures. During 11/19/15 training, use of the BAS to analyze room temperatures and heat pump operation was covered. Hallam has offered to provide portable temperature dataloggers if needed. NSB to continue to monitor room temperatures and advise the team.	Northfield Savings Bank
32	When the Stolz units switch over the BAS displays low pressure and high pressure alarms. 11/19/15: John McIntyre from TES made setpoint changes today. NSB to report if alarms persist.	Northfield Savings Bank
34	NSB has expressed concerns that the Data Center ceiling tiles are not rated for computer center use (ie. existing tiles shedding loose material).	Northfield Savings Bank

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Northfield Savings Bank – Air Sealing

Central Operations Center

- **CODE MINIMUM**
  - **Test at .5 cfm/sq. ft of above grade surface area at 50 Pa pressure**

- **DESIGNED SYSTEM**
  - **Third Party testing by Zero by Degrees with goal of .1 CFM/SF of above grade surface area at 50 Pa pressure.**
  - **Test 1: Typical Window Water Penetration Testing**
  - **Test 2: Infrared Testing**
  - **Test 3: Preliminary Blower Door Testing**
  - **Test 4: Final Blower Door Testing**

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Northfield Savings Bank – Air Sealing

Central Operations Center

TEST 1

WATER TESTING

- **Water Testing of Typical Window with - 75 Pascal negative pressure**
- **Water delivered uniformly at 5 gallons/ sf/ hour**

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Northfield Savings Bank - Air Sealing

Central Operations Center

TEST 1

WATER TESTING

At 2.5 minutes into the first test cycle, water began to leak in through the rough opening beneath this lower left shim. Leakage continued through the remainder of the test.

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Northfield Savings Bank - Air Sealing

Central Operations Center

TEST 1

WATER TESTING

The exterior weather seal has not yet been installed on this unit. This seal will be an important piece in the full installation of each window unit.

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Northfield Savings Bank – Air Sealing

Central Operations Center

TEST 2-

INFRARED TESTING

Air leaks where the caulk seal did not get tooled well around the shims/clips and where there are voids or bubbles in the caulk joint itself.

Visible Image

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Northfield Savings Bank - Air Sealing

Central Operations Center

TEST 3- PRELIMINARY BLOWER DOOR

Blower Door Test Results:

The whole building leakage rate was 0.14 cubic feet per minute (CFM) at 50 Pascals of pressure (1.04 lbs./sq. ft) per unit area of exterior above grade shell. Most buildings in the United States are tested at the same level of pressure (50 Pascals) as a means of comparison.

Test Type	Field Measured CFM @ 50Pa.	Adjusted CFM @ 50Pa.	Square Feet of Building Shell	CFM50/SF of Shell
Depressurized	3,027	3,027	21,919	0.138
Pressurized	3,263	3,293	21,919	0.150

The average of the depressurized and pressurized test results was 3,160 CFM50 or 0.144 CFM50/SF. This is the official blower door test result.

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Northfield Savings Bank – Air Sealing

Central Operations Center

TEST 3- PRELIMINARY BLOWER DOOR

CORRECTIONS

- **Vestibule incomplete: airsealing, gasketing, seals around storefront, plywood infills**
- **Door Astragal -recommend removable astragal for compressive seal.**
- **2 Open P traps**
- **Several unsealed conduits**
- **Boiler flues**

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Northfield Savings Bank - Air Sealing

Central Operations Center

TEST 4- FINAL BLOWER DOOR

Blower Door Test Results:

The whole building leakage rate was 0.09 cubic feet per minute (CFM) at 50 Pascals of pressure (1.04 lbs./sq. ft) per unit area of exterior above grade shell. Most buildings in the United States are tested at the same level of pressure (50 Pascals) as a means of comparison.

Test Type	Field Measured CFM @ 50Pa.	Adjusted CFM @ 50Pa.	Square Feet of Building Shell	CFM50/SF of Shell
Depressurized	1,697	1,744	21,919	0.0796
Pressurized	2,276	2,317	21,919	0.1057

The average of the depressurized and pressurized test results was 2,030.5 CFM50 or 0.0926 CFM50/SF. This is the official blower door test result.

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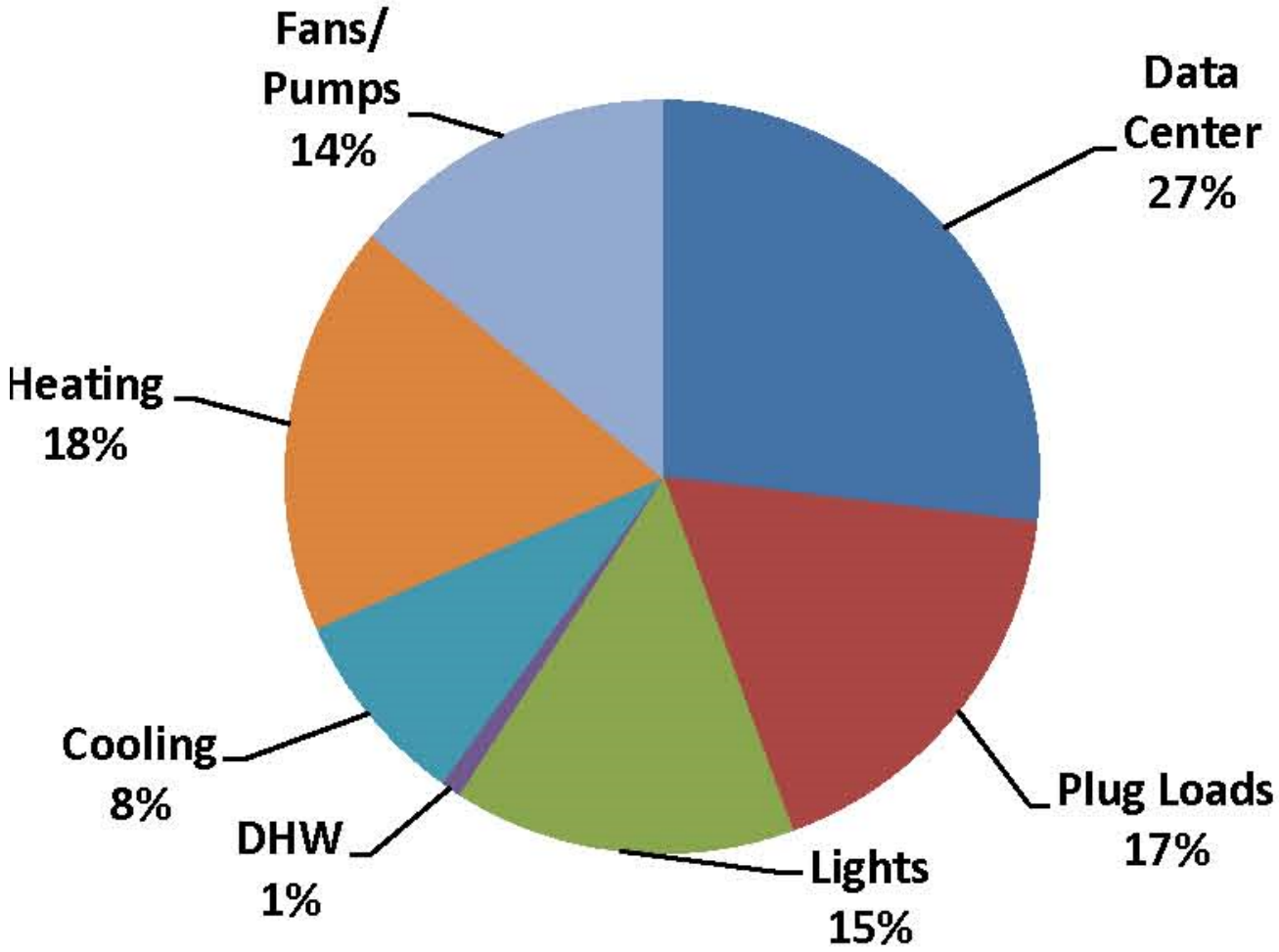
Northfield Savings Bank – Modeling

Central Operations Center

Built to minimum Energy Code Requirements



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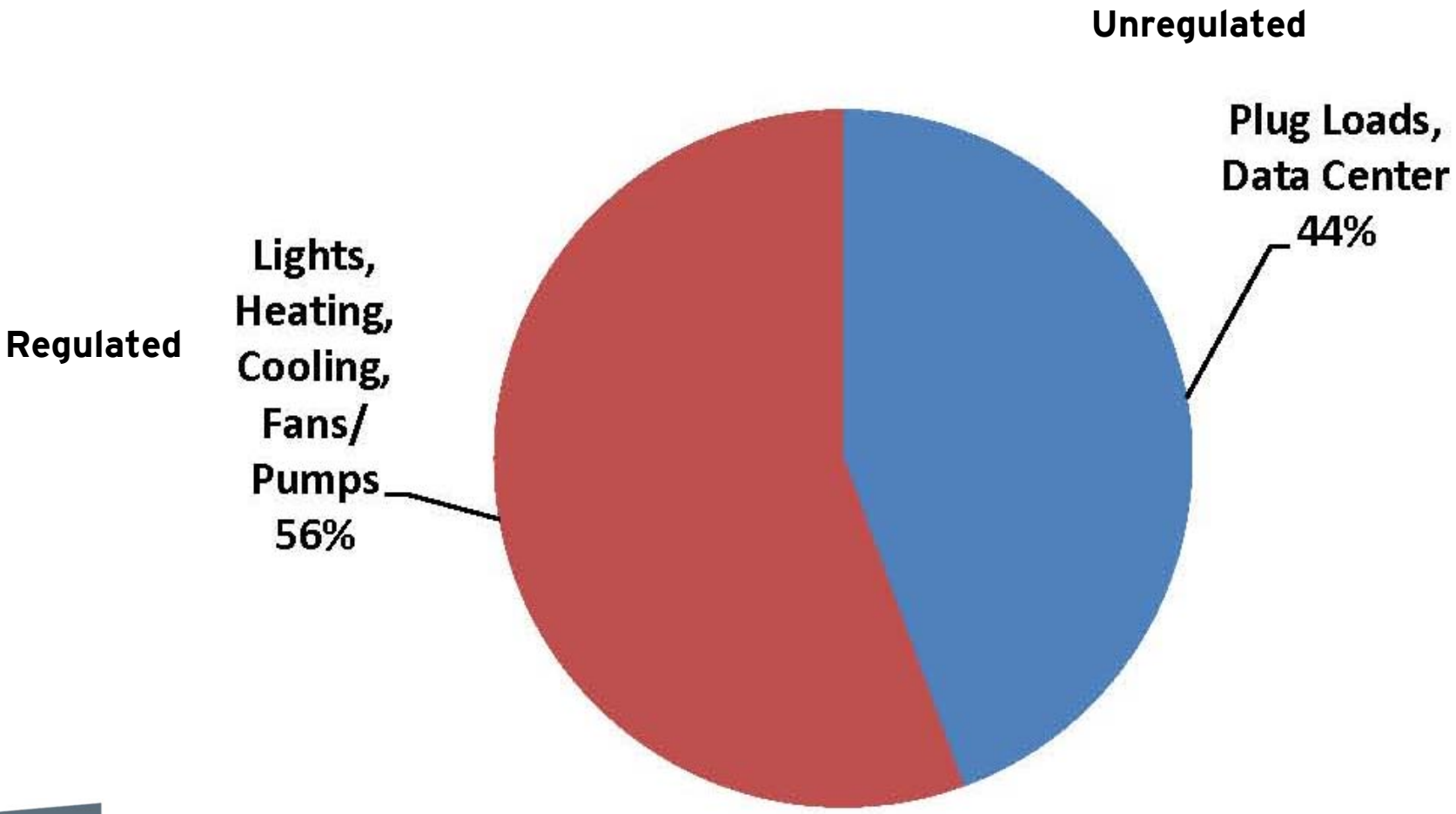
Northfield Savings Bank - Modeling

Central Operations Center



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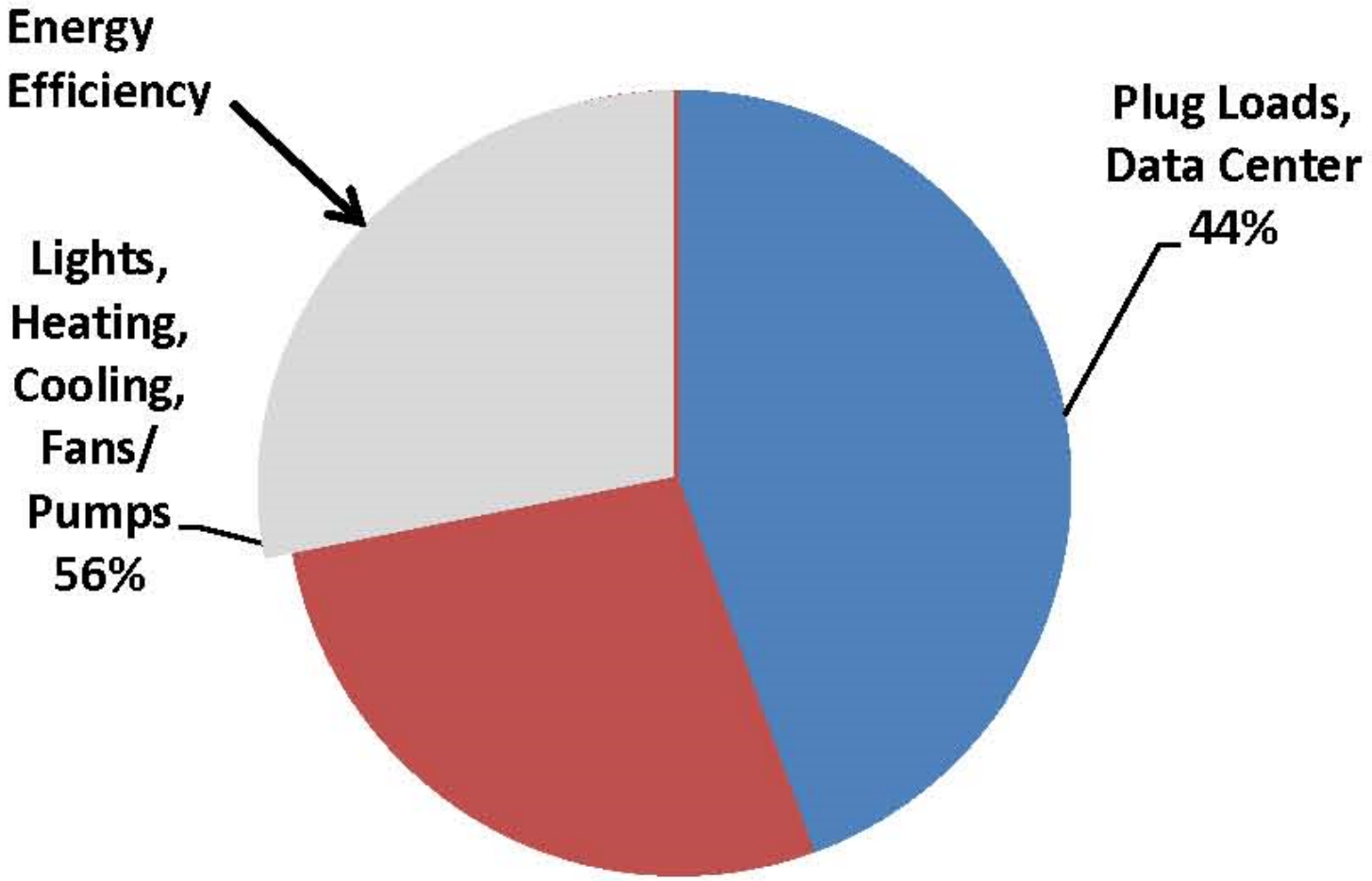
Northfield Savings Bank - Modeling

Central Operations Center

With Energy Efficiency Measures



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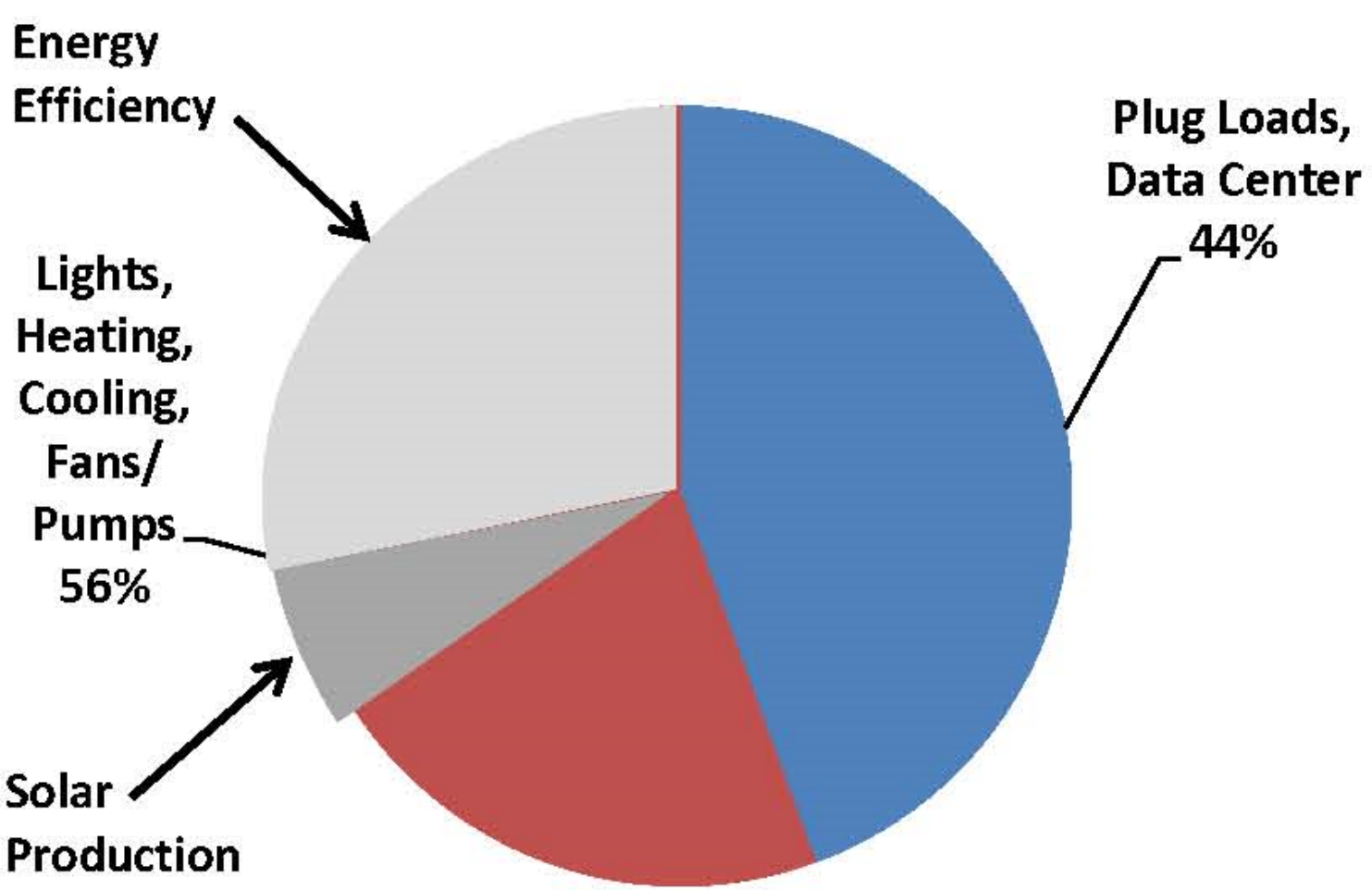
Northfield Savings Bank - Modeling

Central Operations Center



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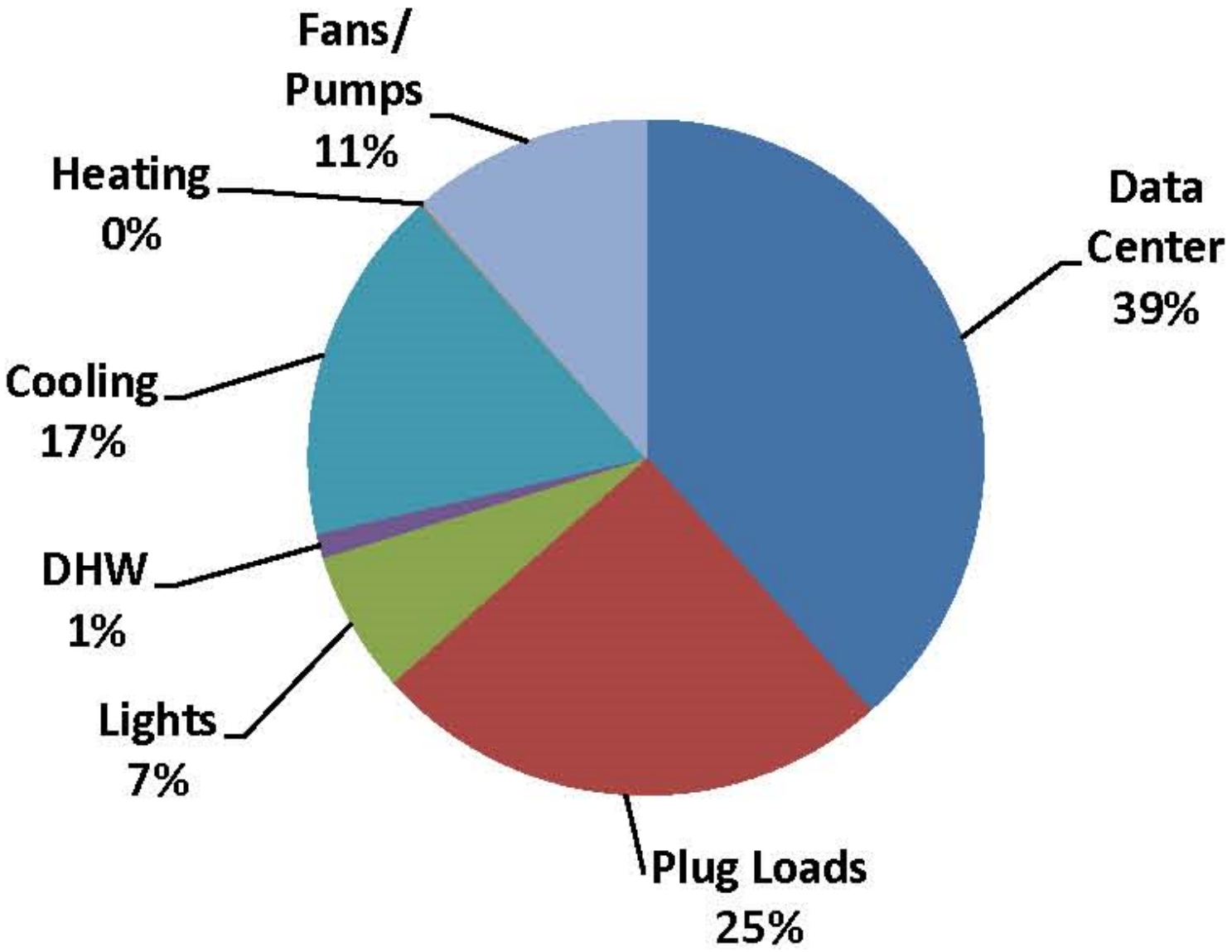
Northfield Savings Bank – Modeling

Central Operations Center



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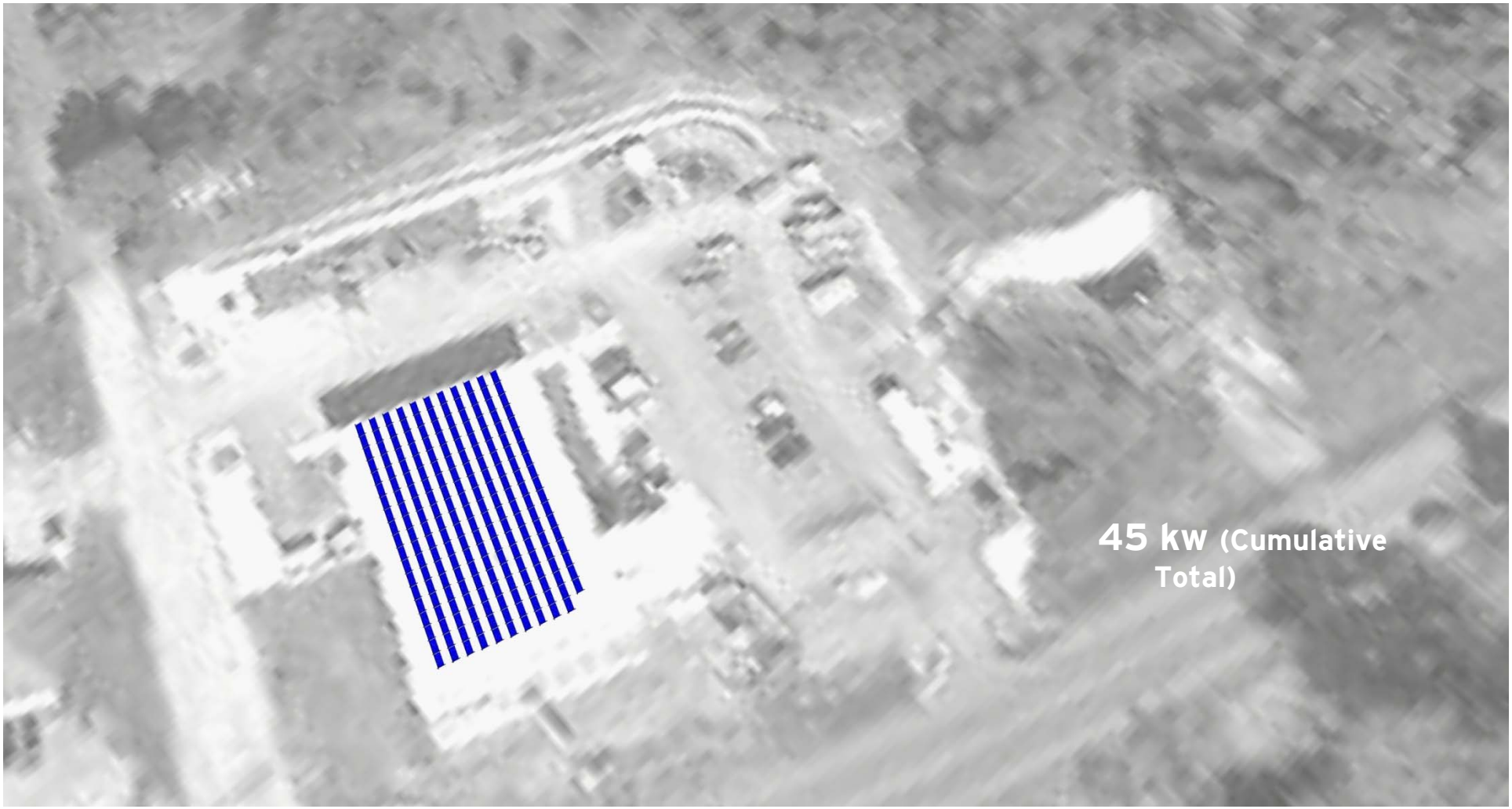
Northfield Savings Bank – Performance

Central Operations Center



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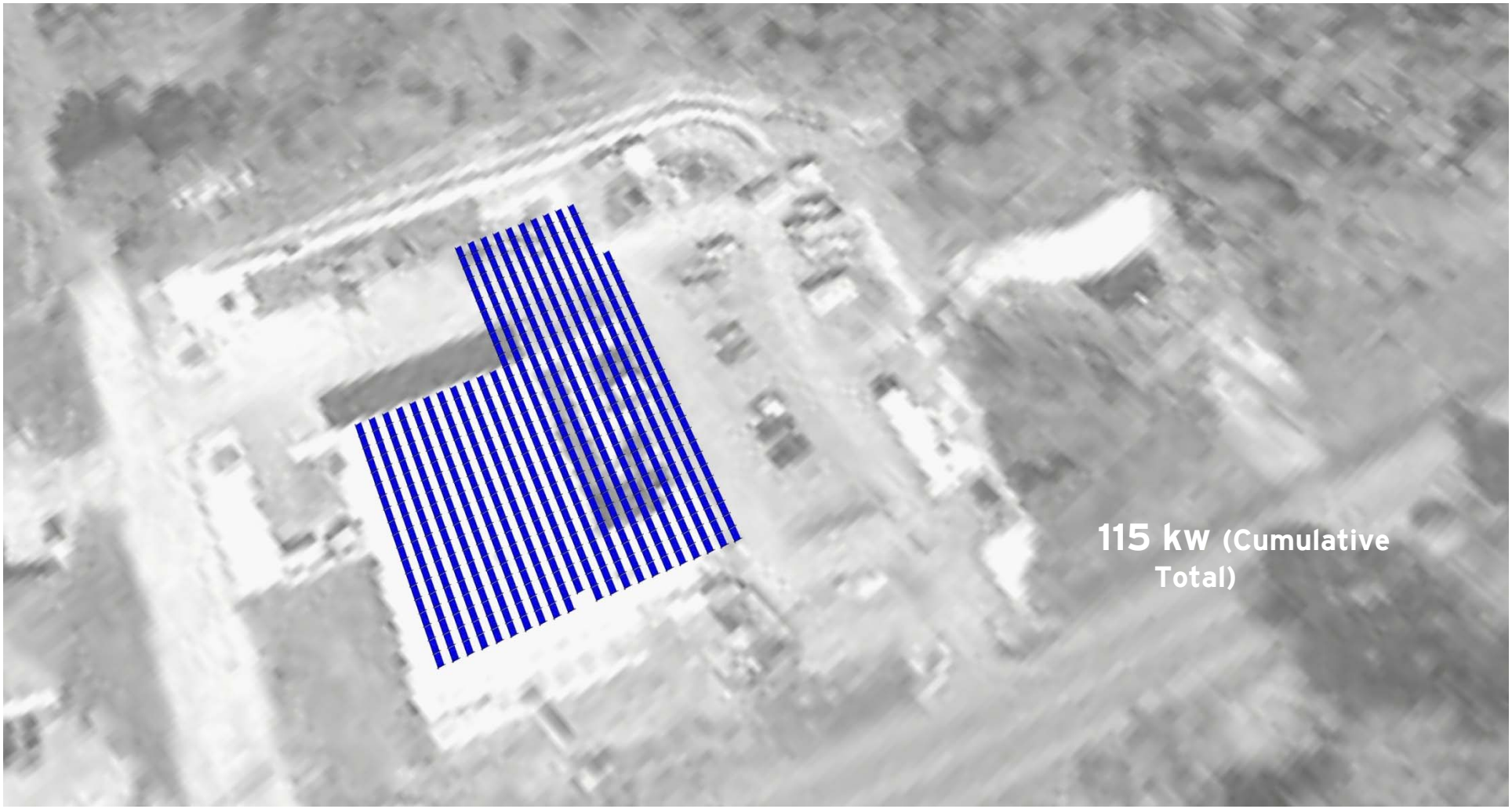
45 kw Generation-

Installed

Northfield Savings Bank – Performance

Central Operations Center



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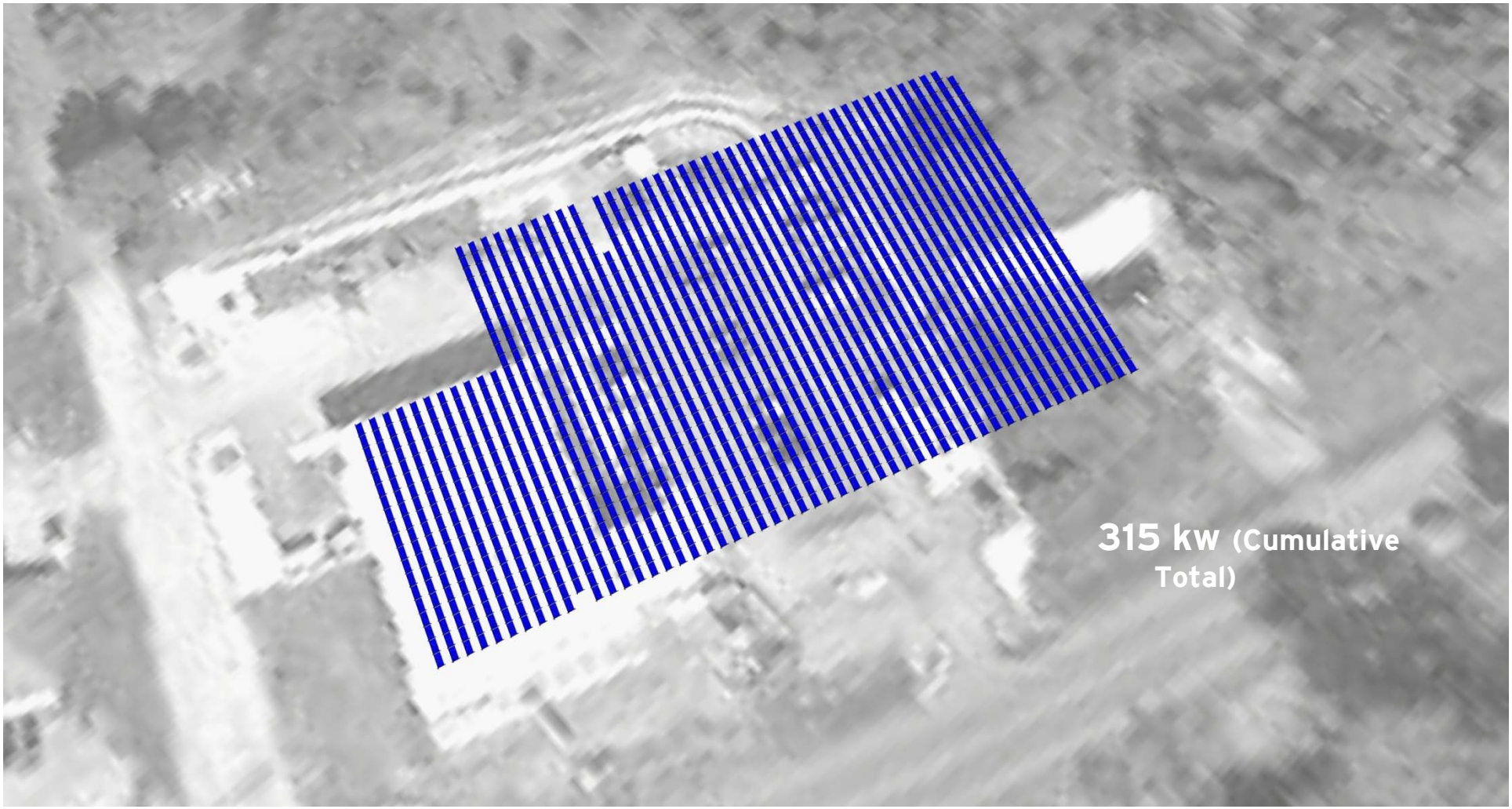
70 kw Generation- Additional

Regulated Loads Net Zero (Lights, Heat, Cooling, Fans, Pumps)

Northfield Savings Bank – Performance

Central Operations Center



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200 kw Generation- Additional

Un-Regulated Loads Net Zero (Plug Loads, Data Center)

Northfield Savings Bank - Performance

Central Operations Center

Data Overview

Site Energy Use Summary	
Electric - Grid (kBtu)	882,500.1 (95%)
Propane (kBtu)	42,700 (5%)
Total Energy (kBtu)	925,200.1

Energy Intensity	
Site (kBtu/ft²)	44.7
Source (kBtu/ft²)	136

National Median Comparison	
National Median Site EUI (kBtu/ft²)	91.7
National Median Source EUI (kBtu/ft²)	279
% Diff from National Median Source EUI	-51.3%

Emissions (based on site energy use)

Greenhouse Gas Emissions (Metric Tons CO2e)	88.1

Power Generation Plant or Distribution Utility:
Green Mountain Power Corp [Gaz Métropolitain & Co LP]

Note: All values are annualized to a 12-month period. Source Energy includes energy used in generation and transmission to enable an equitable assessment.

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Northfield Savings Bank - Performance

Central Operations Center

Data Overview

Site Energy Use Summary	
Electric - Grid (kBtu)	882,500.1 (95%)
Propane (kBtu)	42,700 (5%)
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Emissions (based on site energy use)

Greenhouse Gas Emissions (Metric Tons CO2e): 88.1

Power Generation Plant or Distribution Utility:
Green Mountain Power Corp [Gaz Métropolitain & Co LP]

Note: All values are annualized to a 12-month period. Source Energy includes energy used in generation and transmission to enable an equitable assessment.

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Northfield Savings Bank - LESSON 1

Central Operations Center

1. OWNER PRIORITIES:

Sometimes saving every btu or kwh is not the Owner's top priority...
Need to understand the Owner's needs.

a) Reliability of systems

b) Security

c) Comfortable and productive work environment

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Northfield Savings Bank - LESSON 2

Central Operations Center

2. ENGAGE EVT EARLY IN THE PROCESS.

Nick was critical in making EFFICIENCY happen.

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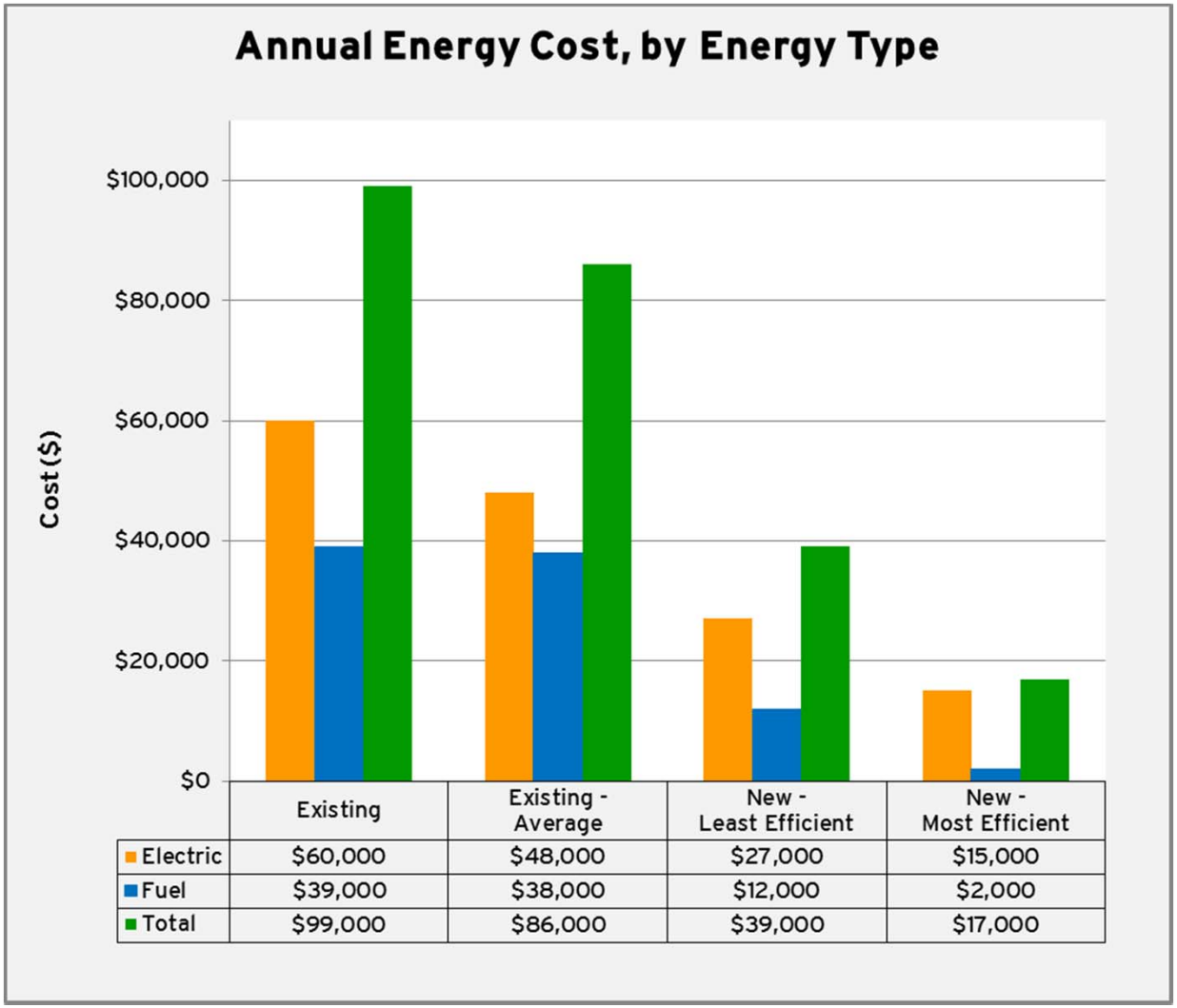
Northfield Savings Bank - LESSON 2

Central Operations Center



	Existing	Existing - Average	New - Least Efficient	New - Most Efficient
Electric	$60,000	$48,000	$27,000	$15,000
Fuel	$39,000	$38,000	$12,000	$2,000
Total	$99,000	$86,000	$39,000	$17,000

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Northfield Savings Bank - LESSON 3

Central Operations Center

3. CONTROLS AND COMPLEX SYSTEMS

It takes time to integrate multiple complex systems.

Commissioning Agent is critical in this process.

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Northfield Savings Bank - LESSON 4

Central Operations Center

4. BASIS OF DESIGN

How to pin moving targets?

Owner and consultant coordination is critical to success.

For example, Discrepancy about the amount of equipment in the data center and how much heat it is putting off. Is equipment oversized? Still working thru this.

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Northfield Savings Bank - LESSON 5

Central Operations Center

5. COORDINATE WITH ENERGY MODELER

Insist on review of inputs and outputs.

Try different scenarios to maximize building systems

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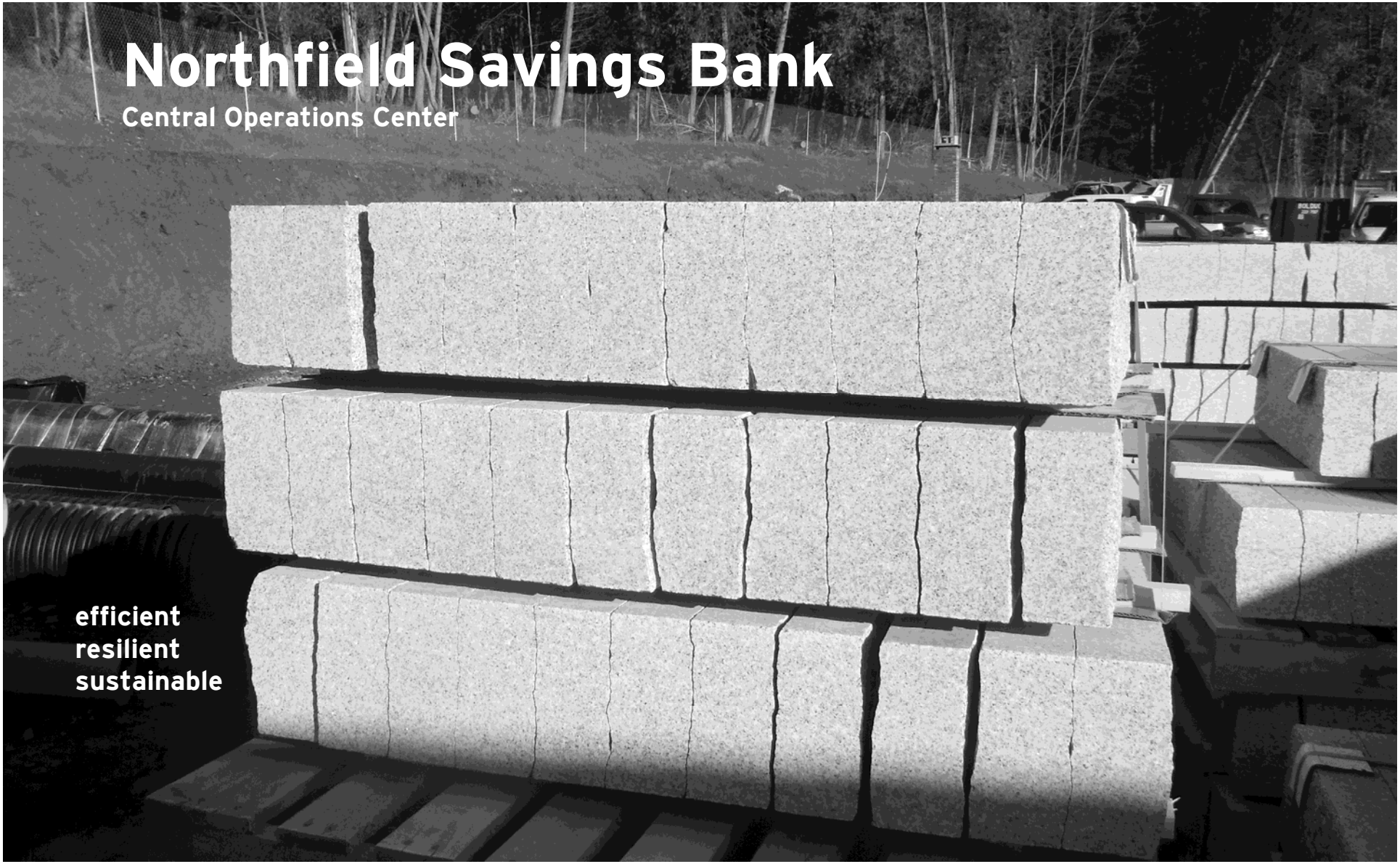

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Thank You

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Northfield Savings Bank

Jeff Stetter, Gossens Bachman Architects

Middlebury Town Office

Chris Huston, Bread Loaf Corporation

Waterbury Municipal Complex

Ashar Nelson, Vermont Integrated Architecture

Vermont Public Radio

David Roy, Wiemann Lamphere Architects

Waitsfield Town Offices

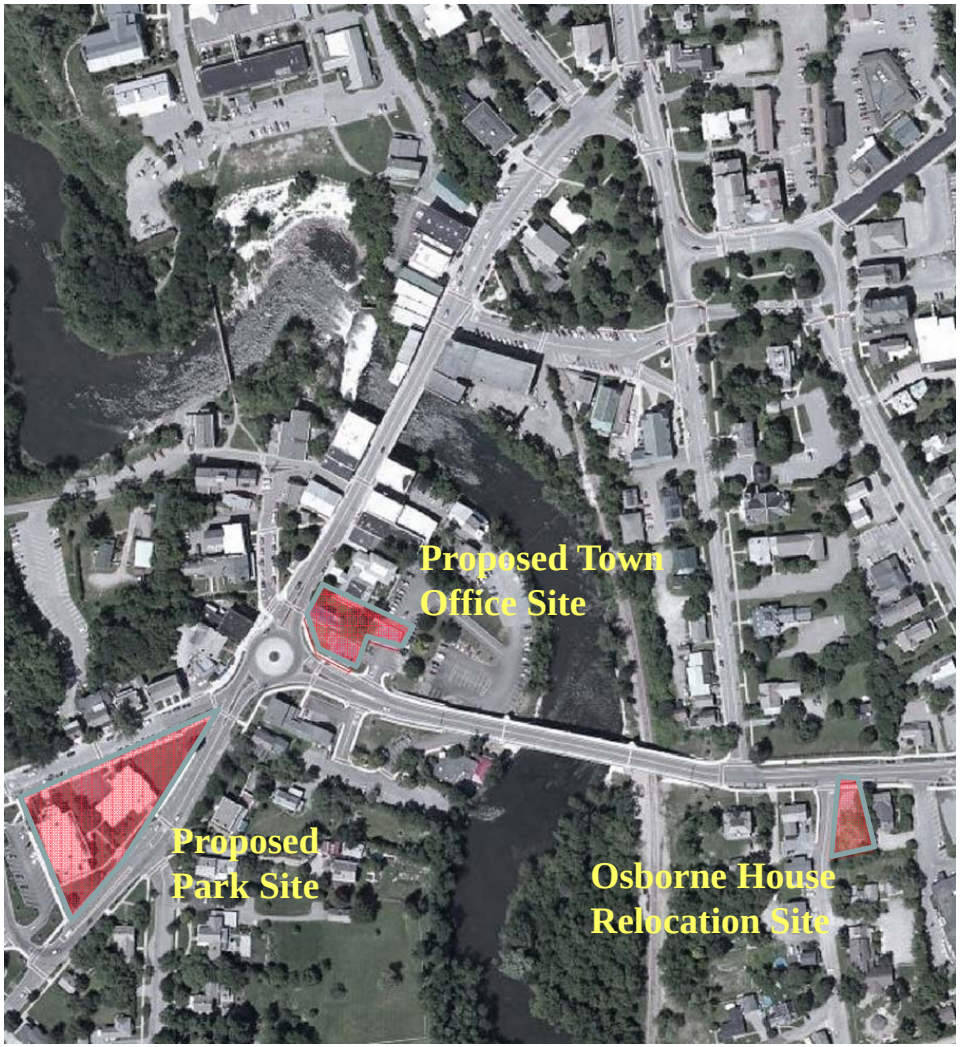
Bill Maclay, Maclay Architects

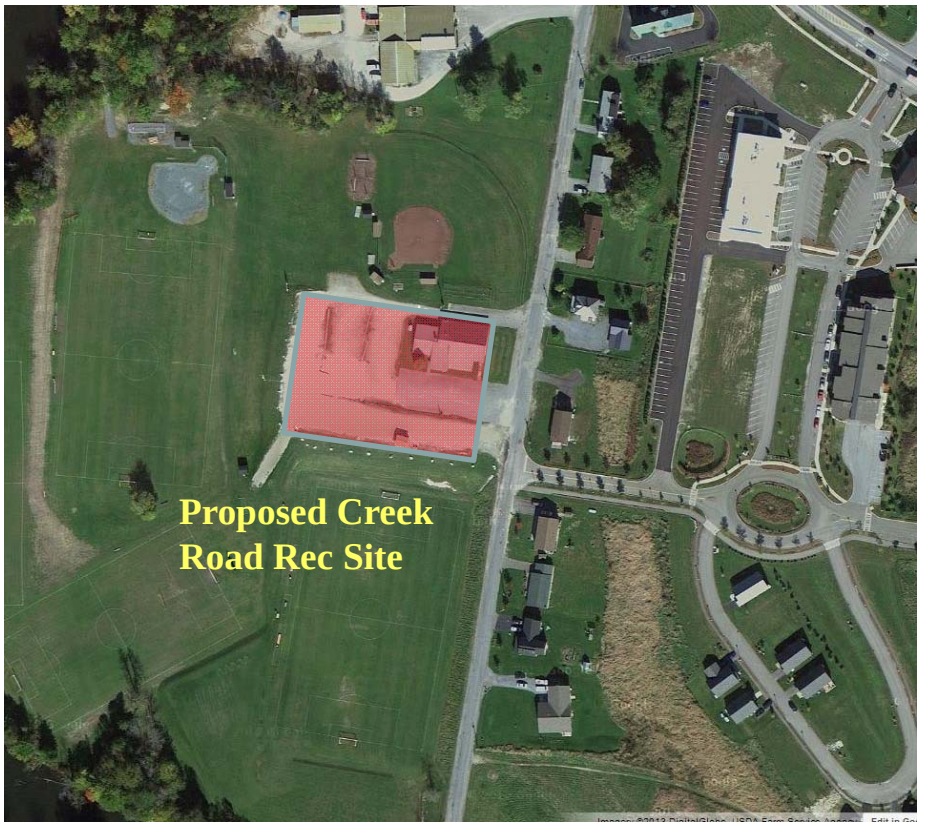
Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont





With a total project cost of $6.5 M and a donation of $4.5 M from Middlebury College, the Town of Middlebury was able to construct a new Town Office and Recreation Facility. In addition, the existing historic Osbourne House was moved and the existing municipal building will be raised to create a new park.

Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

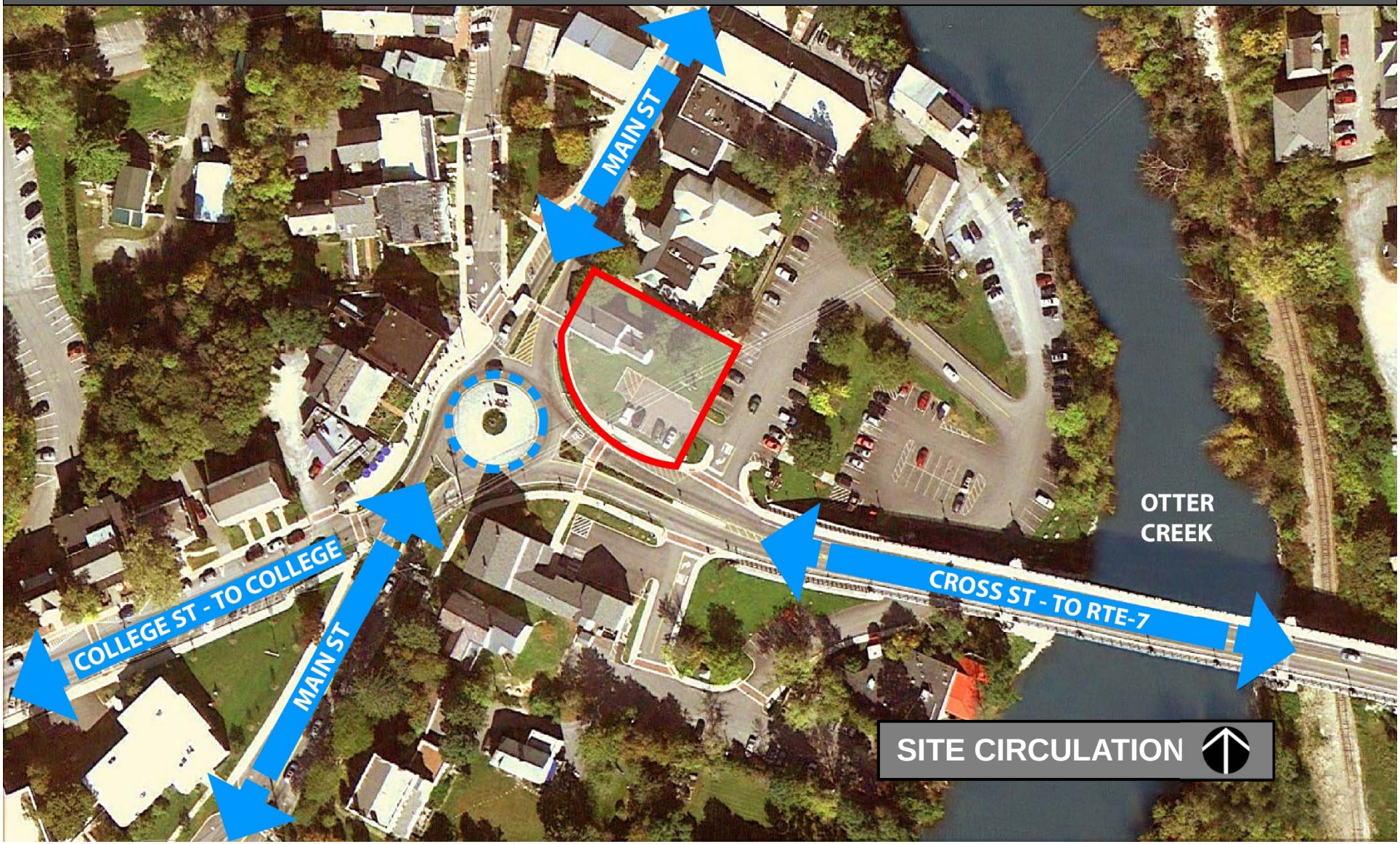
Efficiency Vermont

Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

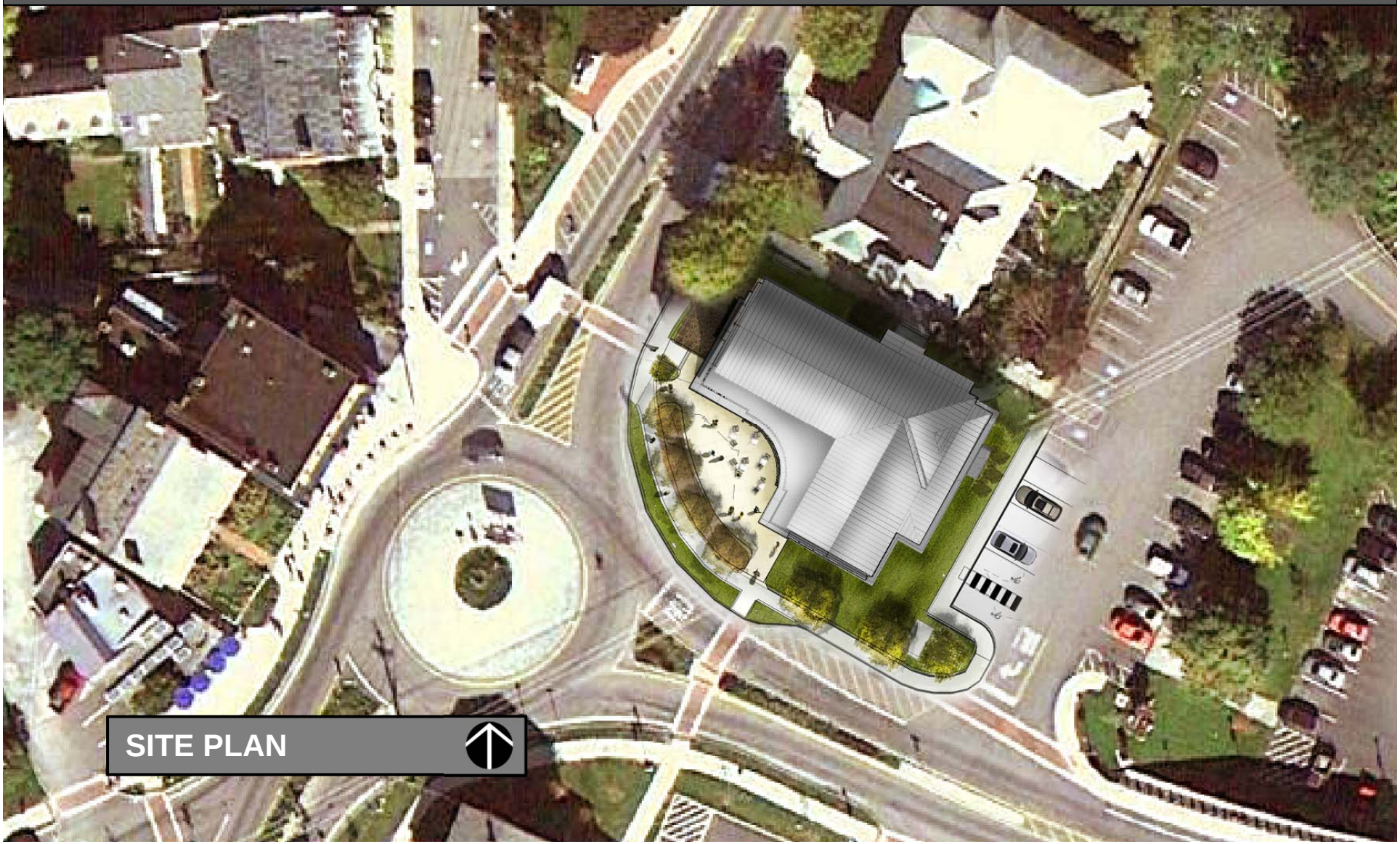


Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

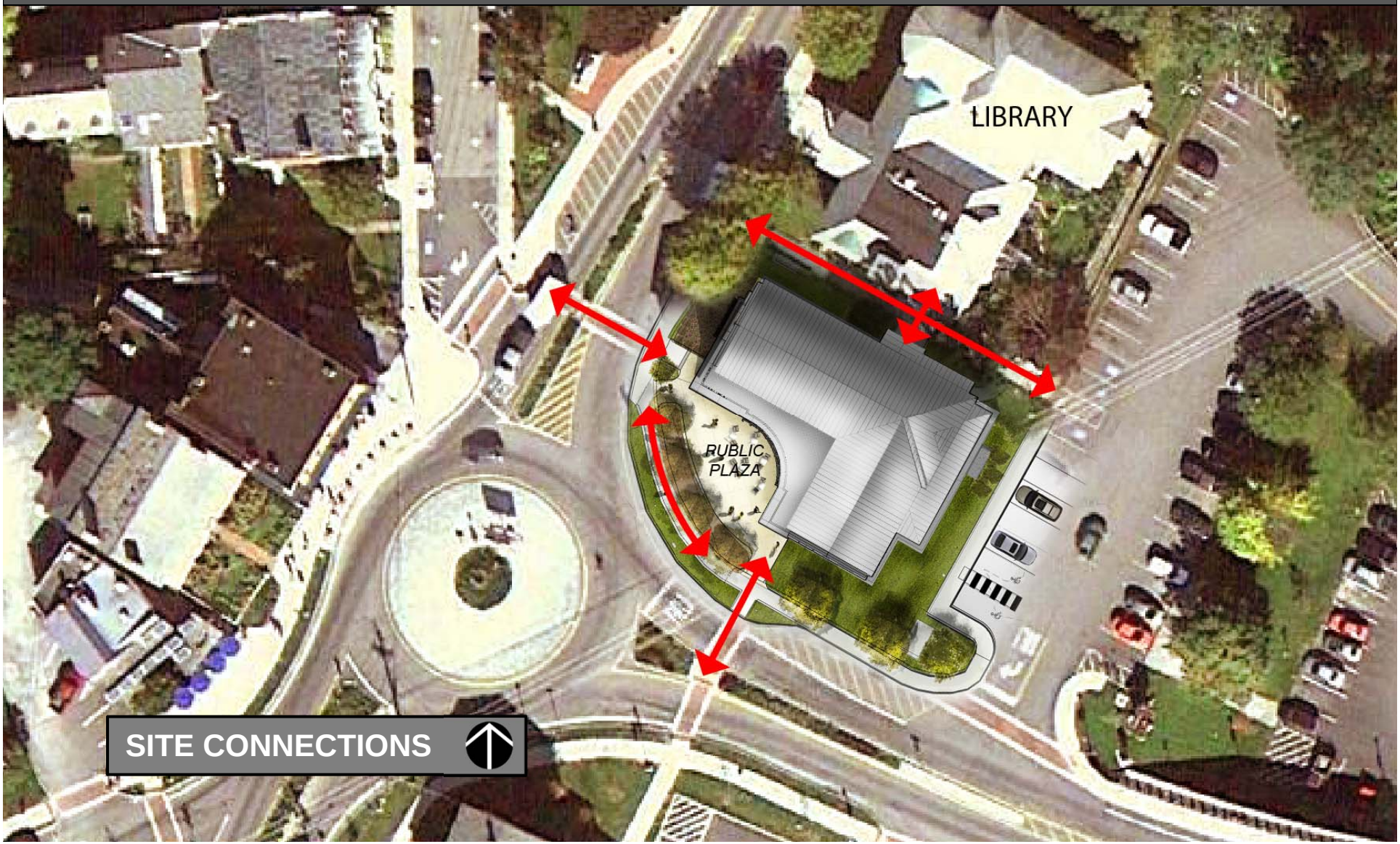


Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

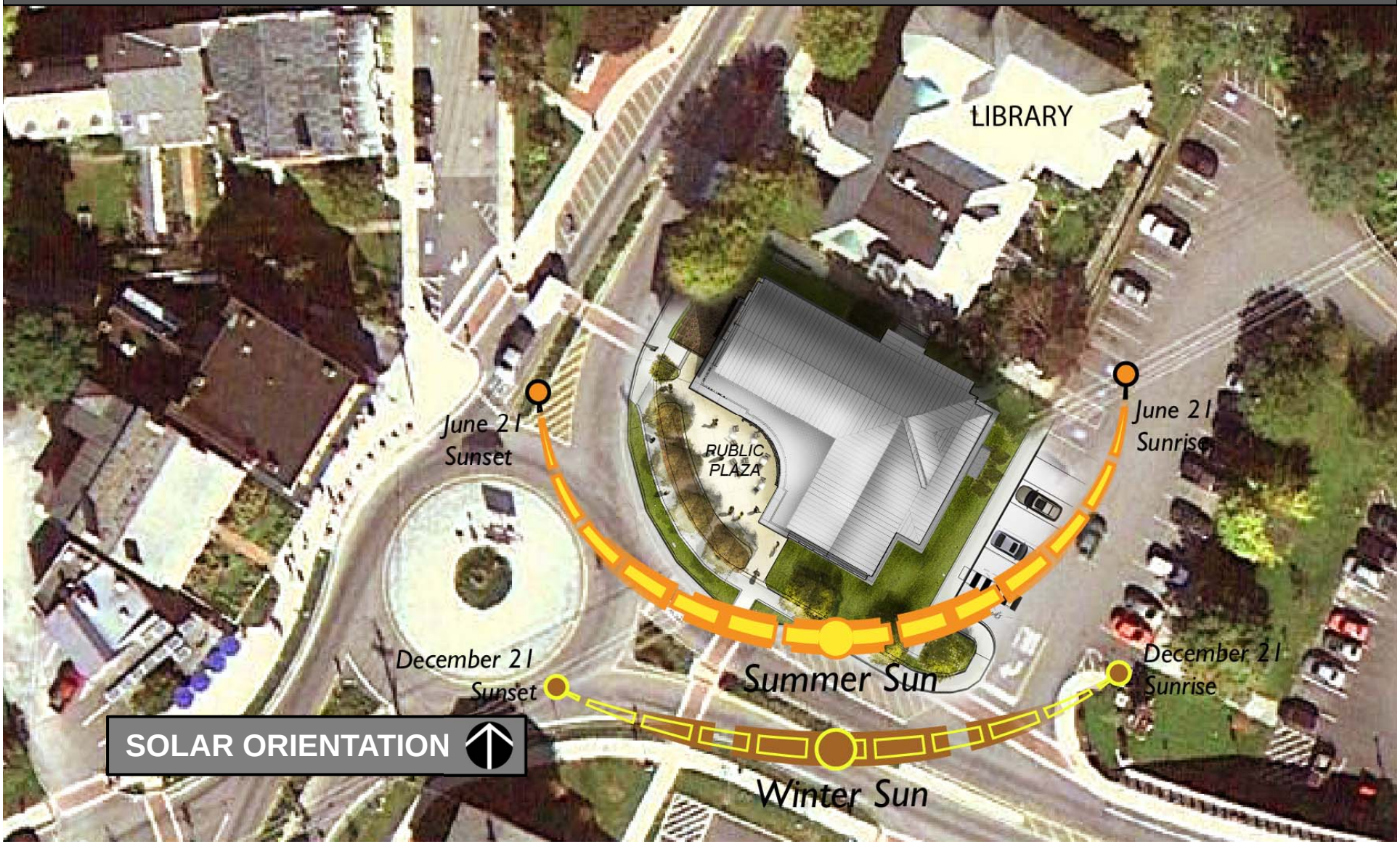


Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont



Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

Middlebury Town Offices

Project Information

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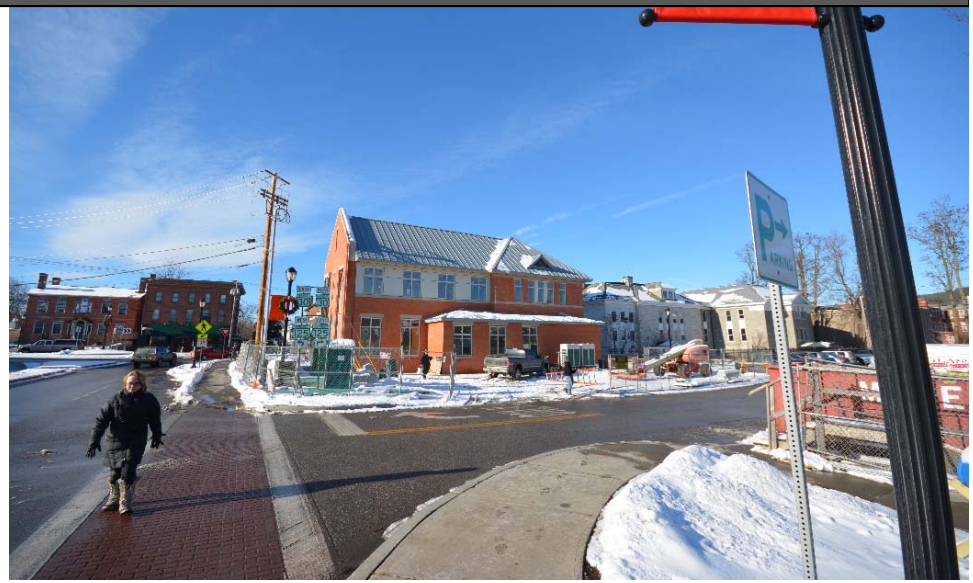
Efficiency Vermont



Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

NORTH

SOUTH

WEST

EAST

Glazing Percentage : 37%

Middlebury Town Offices

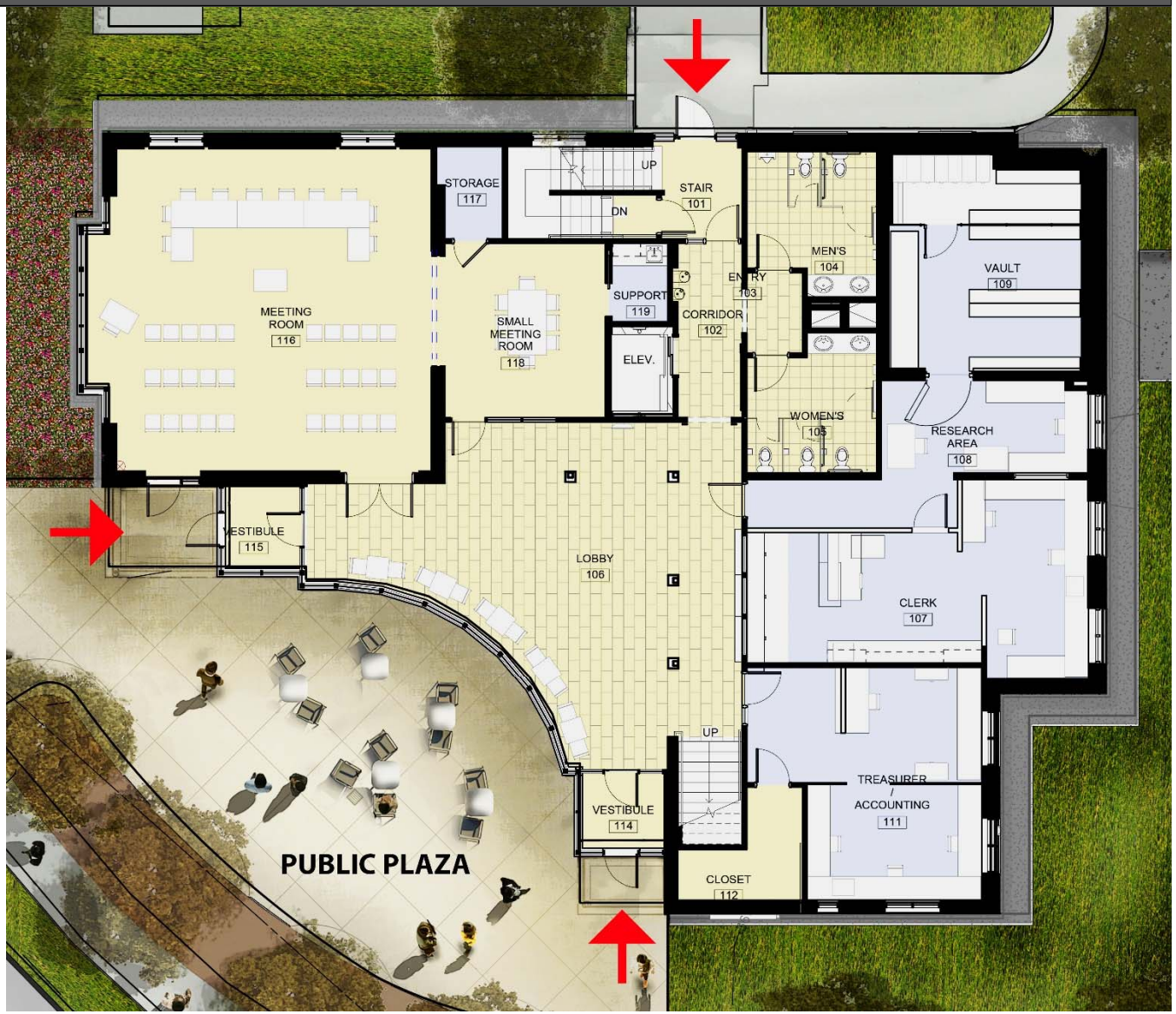
Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

1ST Floor

- Floor Area: 4,882 gross sqft.
- Program
  - Main Lobby/Reception
  - Small Meeting Room
  - Select Board Conference Room
  - Treasurer
  - Town Clerk
  - Vault
  - Public Restrooms
- Simple building orientation and wayfinding
- Partial Basement: 1,361 sqft.



Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

2nd Floor

- Floor Area: 3,437 gross sqft.
- Program
  - Upper Lobby
  - Town Manager
  - Planning / Zoning
  - Listers
  - Staff Restrooms
  - Staff Kitchen
  - Copy/Mail
- L-Shaped layout provides access to natural light and views

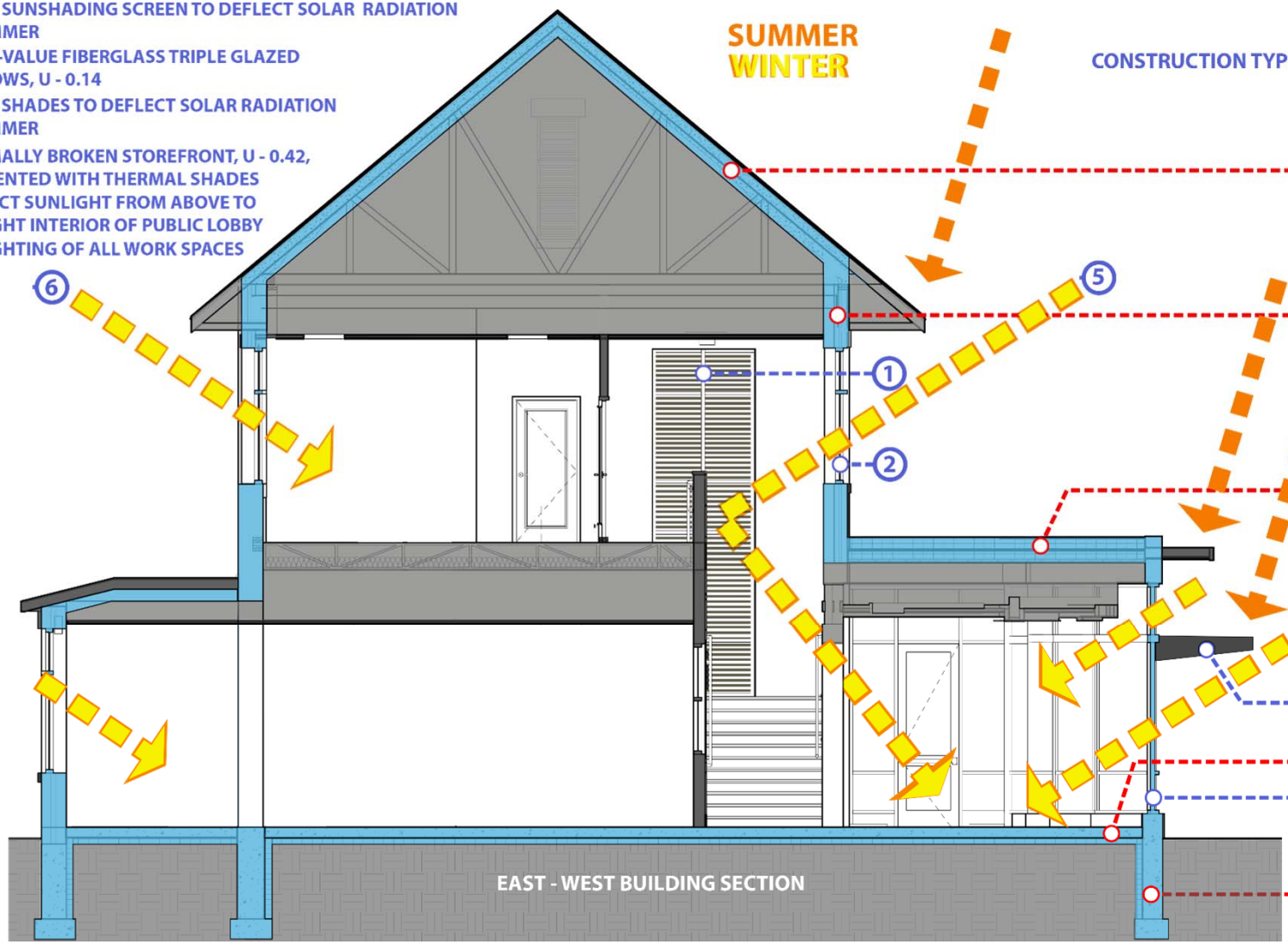
Middlebury Town Offices

Project Information

BreadLoaf Architects Planners Builders

Efficiency Vermont

1 WOOD SUNSHADING SCREEN TO DEFLECT SOLAR RADIATION IN SUMMER
2 LOW U-VALUE FIBERGLASS TRIPLE GLAZED WINDOWS, U - 0.14
3 SOLAR SHADES TO DEFLECT SOLAR RADIATION IN SUMMER
4 THERMALLY BROKEN STOREFRONT, U - 0.42, AUGMENTED WITH THERMAL SHADES
5 INDIRECT SUNLIGHT FROM ABOVE TO DAYLIGHT INTERIOR OF PUBLIC LOBBY
6 DAYLIGHTING OF ALL WORK SPACES



CONSTRUCTION TYPE: 5B - WOOD FRAME

R 69
ROOF ASSEMBLY:
STANDING SEAM MTL ROOF
30# FELT PAPER
5/8" ROOF SHEATHING
PRE-ENGINEERED WD TRUSS
10" SPRAY FOAM INSUL

R 44
WALL ASSEMBLY:
3 5/8" BRICK VENEER
AIR SPACE
2 3/8" SPRAY INSUL
1/2" WALL SHEATHING
4" SPRAY INSULATON
2X6 WOOD STUDS, 16"O.C.
5/8" GWB

R 60
ROOF ASSEMBLY:
MEMBRANE ROOFING
RIGID ROOF INSUL
METAL DECK
STEEL BEAM ROOF JOISTS

R 10
SLAB ASSEMBLY:
4" CONC. SLAB
1 LAYERS 2" XPS, INSUL

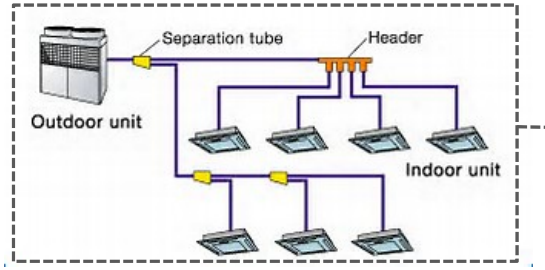
R 20
FOUNDATION ASSEMBLY:
2 LAYERS 2" XPS, INSUL
CONCRETE FOUNDATION WALL
EXTENDED TO TOP OF SLAB

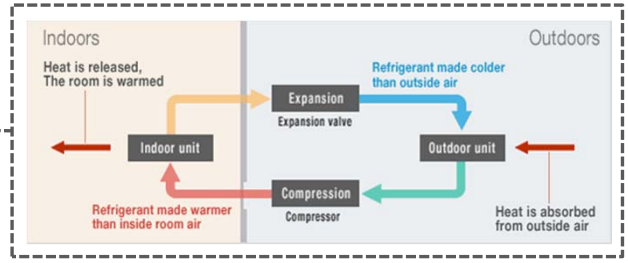
Middlebury Town Offices

Mechanical

BreadLoaf Architects Planners Builders

Efficiency Vermont



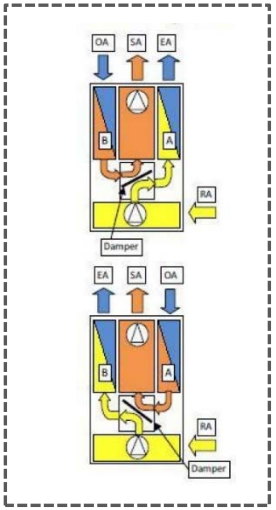


Mechanical

- Air Source Heat Pump - Performance Rated per AHRI 1230 Standards
  - EER (Energy Efficiency Ratio) - (D - 11.1) (ND - 12.5)
  - IEER (Integrated Energy Efficiency Ratio) - (D - 21.8) (ND - 26.7)
  - SCHE (Simultaneous Cooling and Heating Efficiency) - (D - 25.5) (ND – 31)
  - COP (Low Heating Mode) - (D - 2.45) (ND - 2.62)
- Combination of ducted and 13 ceiling cassette type units
- No Supplemental or Back-up Heat
- Controls – Trane DDC (Direct Digital Control)
- Energy Recovery Unit – Temp Eff – 90% Efficient
- CO2 Based Demand Ventilation
- Dedicated indoor 1,000 CFM Outside Air System with VAV Zone Controls, system to have override to shut down when OA is below -13 during non occupied hours.
- Fixed Windows
- Heat Pump Water Heater

+

D - Ducted
ND - Non-Ducted



TEMPEFF SYSTEM

Middlebury Town Offices

Mechanical

Efficiency Vermont

Middlebury Town Offices

Electrical

BreadLoaf Architects Planners Builders

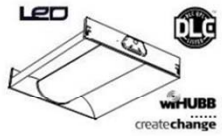
Efficiency Vermont

Electrical

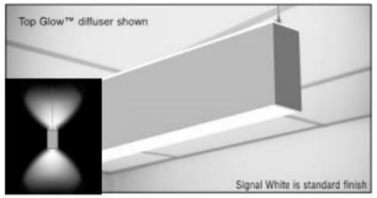
- All LED lighting (Exception: Basement)
  - Exterior
  - Interior
- Light power density – Target = 1 W/sf
  Actual = .66 W/sf
- Illumination levels – Avg. 40 footcandles in all work areas
- Occupancy Sensors – Used in every room except Lobby
- Daylight Sensors – Used in Lobby only
- Transfer switch for roll up/future emergency generator installed
- Dimming on fixtures in selected areas

Recessed LED Can
- Various Sizes
- 120V

Surface Mounted LED Strip
- 4’ – 0”
- 120V



Surface Mounted LED Troffer
- 2’ x 2’
- 120V



LED Strip Pendant
- 4’ – 0”
- 120V

LED Recessed Strip
- Length Varies
- 120V

Middlebury Town Offices

Energy Charrette

BreadLoaf Architects Planners Builders

Efficiency Vermont

Purpose: To gather the integrated design team along with town representatives, the Commissioning Agent, and Efficiency Vermont in an intensive design work shop in which all participants focus on ideas for energy and resource efficiency and conservation.

Keys to Effectiveness

- Selection of the right team members
- Well led charrette with common direction
- Contribution from all parties involved
- All disciplines together as early as possible
- Multiple strategies outlined and discussed
- Ability to determine what does and does not work, early in process

Middlebury Town Offices

Project Team

BreadLoaf Architects Planners Builders

Efficiency Vermont

Client

- Town of Middlebury

Design and Engineering Team

- Chris Huston, BLC, VP of Architecture
- John Dale, BLC, Project Architect
- Mike Deslandes, BLC, Senior Estimator
- Bob Eaton, BLC, Project Manager
- John Johnston, BLC, VP of MEP Services
- VHV, Mechanical Engineer
- Mike's Electric, Electric Engineer
- DuBois & King, Energy Modeling Consultant
- Zero by Degrees, Envelope Commissioning

Efficiency Vermont

- Nick Thiltgen, Efficiency Vermont
- Charlie Carpenter, Efficiency Vermont

Commissioning Agent

- Glenn Thomas, Thomas Engineering Associates

Middlebury Town Offices

Energy Efficiency

BreadLoaf Architects Planners Builders

Efficiency Vermont

The Town of Middlebury had a long standing goal to be a leader in energy efficiency. Bread Loaf and its consultants explored many different strategies to achieve this goal. These were reviewed at the charrette, and as a result of additional funding from Middlebury College, many were employed.

Explored:

- Daylighting Strategies
- Low U-value Windows
- Short/Long Term Monitoring
- Solar Shades
- Thermal Shades
- Window Blankets
- Reduction in Glazing
- Envelope Insulation Upgrades
- Pellet Stove for supplemental heat
- Geothermal - Ground Source Heat Pump
- Pint/Flush - Urinal/Toilet
- LED Lighting
- Occupancy Sensors
- Daylight Sensors
- Air Sealing
- Storefront Upgrades

Adopted:

- Daylighting Strategies
- Low U-value Windows
- Short/Long Term Monitoring
- Envelope Insulation Upgrades
- Solar Shades
- Thermal Shades
- Pint/Flush - Urinal/Toilet
- LED Lighting
- Occupancy Sensors
- Air Sealing
- No Backup Heat System
- Heat Pump Water Heater

Middlebury Town Offices

Energy Efficiency

BreadLoaf Architects Planners Builders

Efficiency Vermont

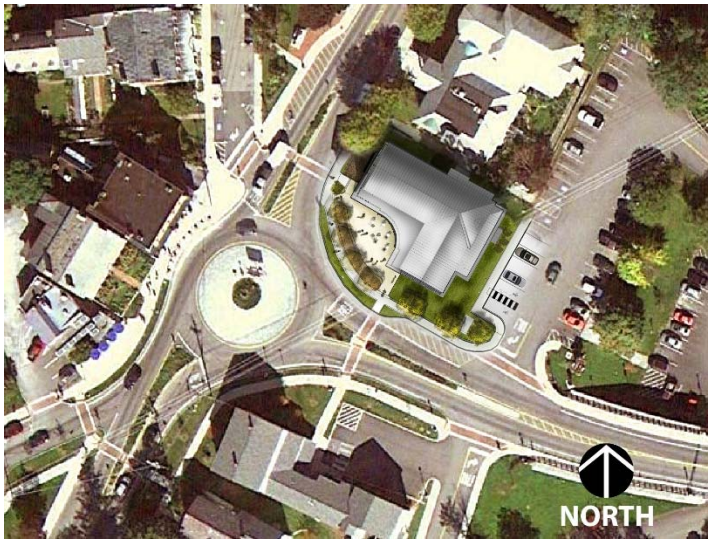
Middlebury Town Offices

Renewable Energy Generation

BreadLoaf Architects Planners Builders

Efficiency Vermont

Possibility of on site renewable energy production from solar was explored but due to site restrictions and associated upfront costs, these would not have been feasible or cost effective.



- Solution: Renewable energy will be generated from an offsite solar farm located 6 miles away in New Haven VT

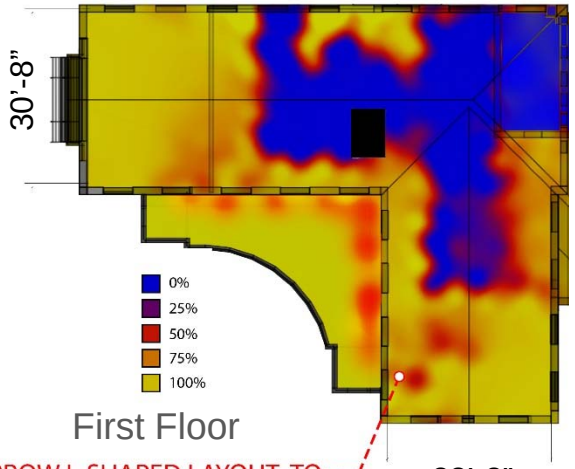
- This installation will be able to provide 220 kW (DC) to the offices, more than necessary to offset the new building consumption

Middlebury Town Offices

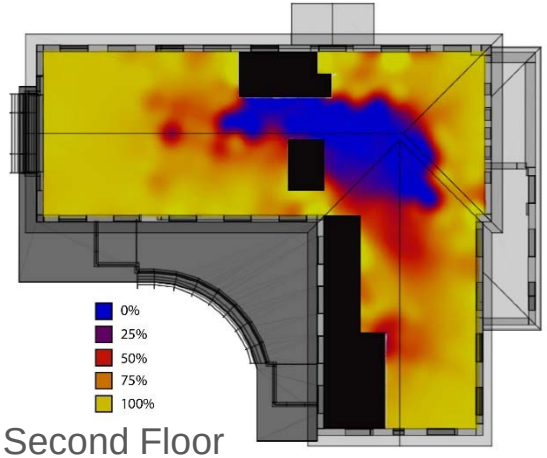
Energy Modeling

BreadLoaf Architects Planners Builders

Efficiency Vermont



First Floor



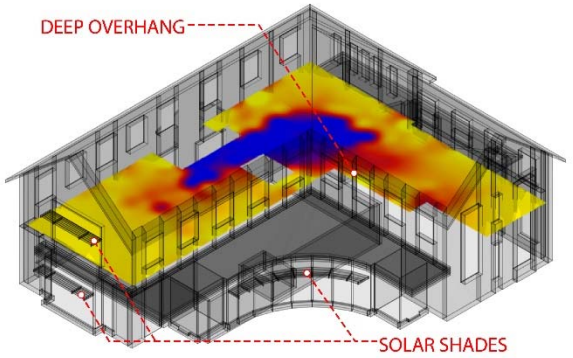
Second Floor

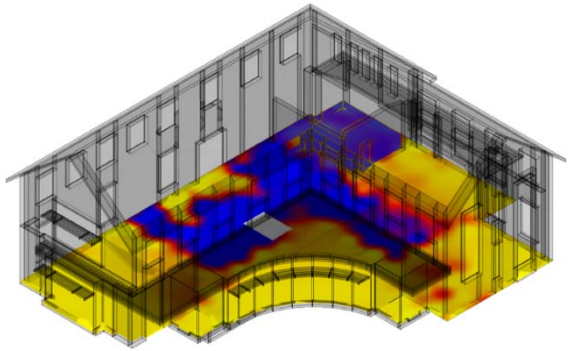
- Many unknown variables required for calculations
- Assumptions have to be made
- Questionable accuracy early in design process
- Costly and time consuming

Target EUI – (Energy Use Intensity) = .15 kBtu/ft

Electricity Usage = $15,000

With no backup heat, building must be resilient
- R-20 Foundation
- R-44 Wall
- R-69 Roof Insulation





Daylighting Analysis

Daylighting Analysis: Percentage of occupied hours where luminance is at least 28 footcandles, measured 3’- 0” above the floor plate.

Middlebury Town Offices

BreadLoaf Architects Planners Builders

Efficiency Vermont

- Exterior Solar Shades
- Floor to Ceiling Glazing
- Efficient LED Lighting

Middlebury Town Offices

BreadLoaf Architects Planners Builders

Efficiency Vermont

- Exterior Solar Shades
- Efficient LED Lighting
- Floor to Ceiling Glazing w/ Solar Shades

Middlebury Town Offices

BreadLoaf Architects Planners Builders

Efficiency Vermont

- Exterior Solar Shades
- Visual Dashboard Monitoring
- Floor to Ceiling Glazing w/ Thermal Shades

Middlebury Town Offices

Energy Monitoring/Commissioning

BreadLoaf Architects Planners Builders

Efficiency Vermont

Mechanical Commissioning

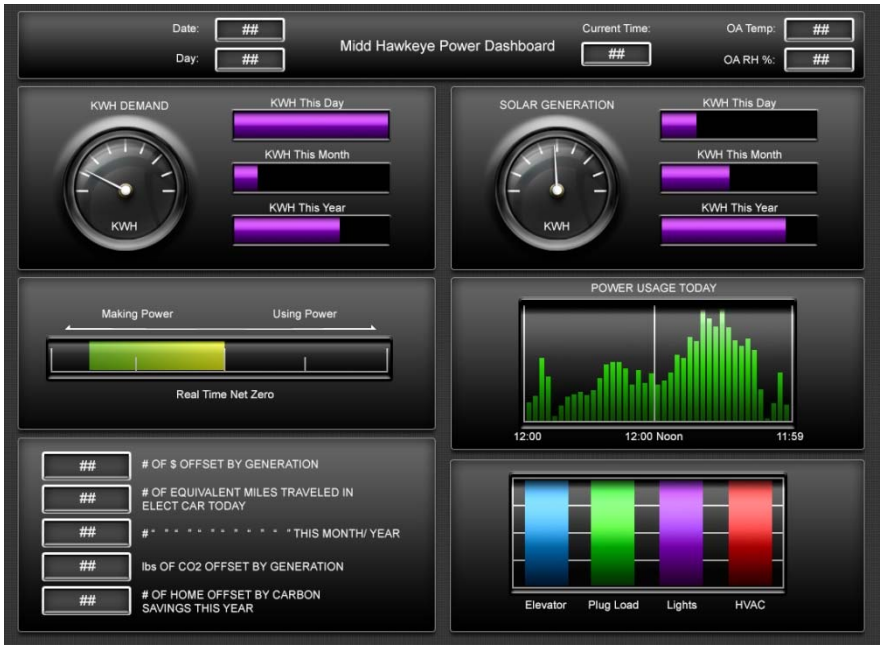
Systems to be Commissioned:

- Refrigeration Systems
- Heating Systems
- Air Handling Systems
- Energy recovery systems
- HVAC controls systems
- Plumbing and water systems

- Difficult to obtain consistent scope of services and associated fee for mechanical commissioning agent

Monitoring

- Who is responsible for analyzing data for the entire year required by NZEB program?
- Visual Dashboard - Public Building as teaching tool, but costly



Dashboard Example

Middlebury Town Offices

Energy Monitoring/Commissioning

BreadLoaf Architects Planners Builders

Efficiency Vermont

Envelope Commissioning

Design and Construction

- Air sealing detail reviews during design phases
- Kick off meeting with all key subs on site is critical to success
- Regular testing and inspection identified many small issues that may have otherwise gone unnoticed.
- Corrections and modifications were able to be made in a timely manner
- Blower door testing – Target .15 cfm50/sf
- Fog / Infrared testing

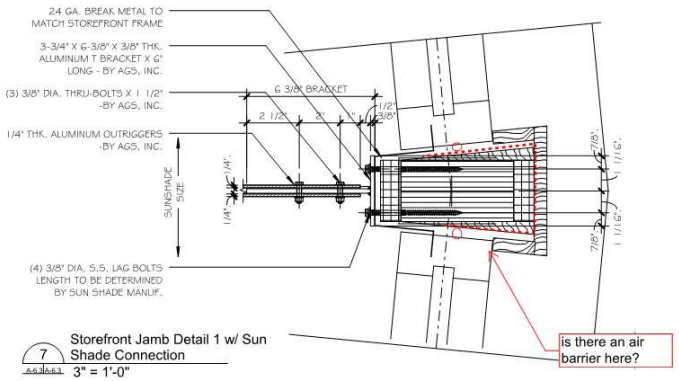
Extremely effective and valuable service

Middlebury Town Offices

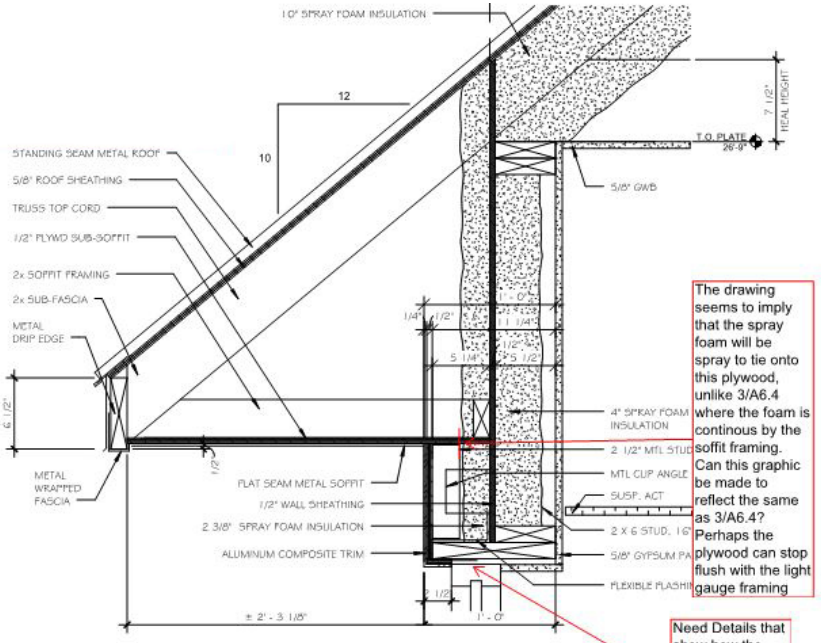
Energy Monitoring/Commissioning

BreadLoaf Architects Planners Builders

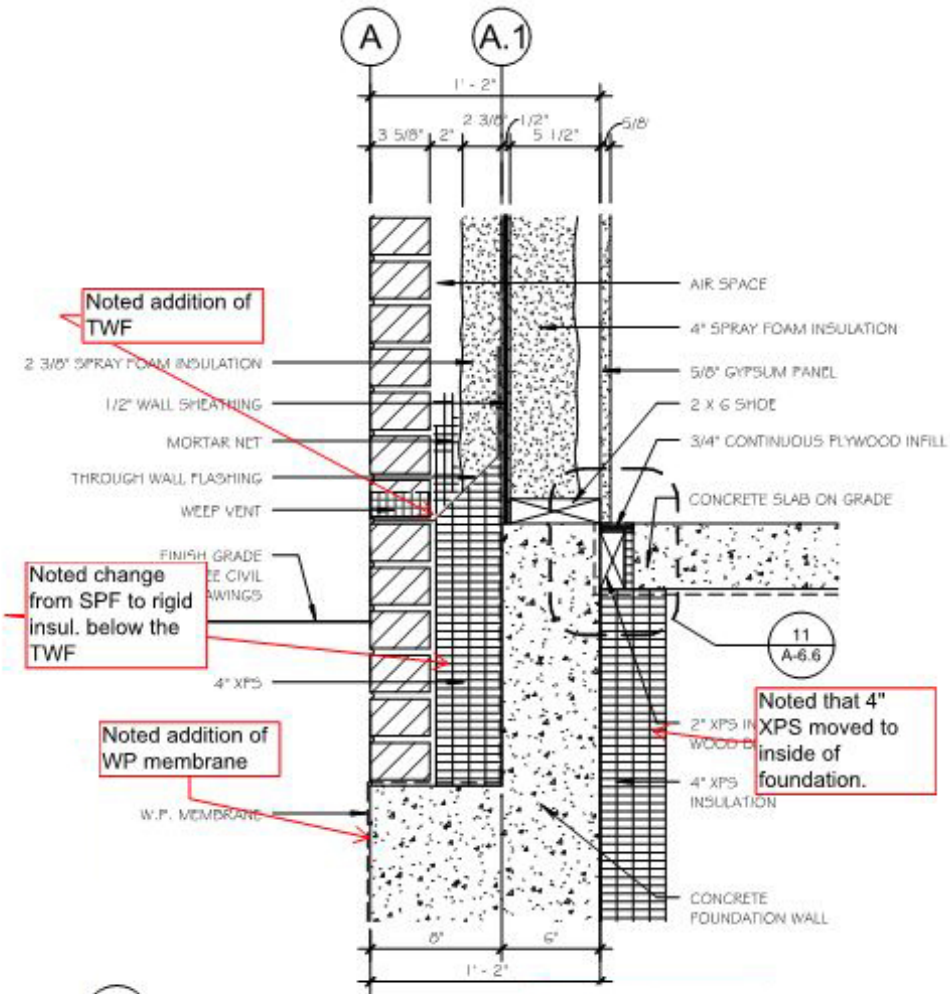
Efficiency Vermont



7 Storefront Jamb Detail 1 w/ Sun Shade Connection
3" = 1'-0"



9 Metal Panel Roof Detail
1 1/2" = 1'-0"



1 Brick Veneer Base Detail 1
1 1/2" = 1'-0"

Middlebury Town Offices

Construction Costs

BreadLoaf Architects Planners Builders

Efficiency Vermont

Gross SF: 9,680 SF
Construction Cost : $3,078,000
Cost Per SF: $318.00

Premium – Net Zero Construction Costs
$230,000 = 7.5% or $24/SF

INCLUDES:
- **Thermal Envelope**
- **Windows**
- **Sun Shades**
- **Dashboard/Monitoring**
- **Mechanical/Elec Systems**

Premium – Consulting Services
$57,500 = 1.8% or $6/SF

INCLUDES:
- **Envelope Commissioning**
- **Town Retained Mechanical Commissioning Agent**
- **Mechanical/Electrical Engineering**
- **Architect and Preconstruction Estimating**

Existing Municipal Building:

- Heating fuel annually at a cost of approx. $25,000
- Electricity annually at a cost of approx. $15,000

Annual Total = $40,000

* Total above represents half of existing utility costs

$287,500 cost premium to design and build net zero (without PV array), based on existing building heat and electricity costs would only require 7.2 years payback period.

Middlebury Town Offices

Project Challenges

BreadLoaf Architects Planners Builders

Efficiency Vermont

Challenges:

- Total budget set at $6.5 million for new Town Offices and New Recreation Center before project team was selected

- A challenge was to satisfy the complex public/admin programming demands on a fixed budget. The new building needed to provide, within a limited size, the following aspects.
  - Public Space
  - Comfort
  - Spatial Flexibility
  - Storage

- Building systems/environment would need to require minimal amount of physical management

- New building needed to be high quality, durable construction and notable, on a predetermined budget

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Northfield Savings Bank

Jeff Stetter, Gossens Bachman Architects

Middlebury Town Office

Chris Huston, Bread Loaf Corporation

Waterbury Municipal Complex

Ashar Nelson, Vermont Integrated Architecture

Vermont Public Radio

David Roy, Wiemann Lamphere Architects

Waitsfield Town Offices

Bill Maclay, Maclay Architects

Waterbury Municipal Complex

VERMONT INTEGRATED ARCHITECTURE, PC

PROJECT INTRODUCTION

Waterbury Municipal Complex

Better Buildings by Design Conference

February 4, 2016

Project Team:
V.I.A. – Architectural Design & Services
Phelps Engineering, Inc. – Civil Engineering
Engineering Ventures, P.C. – Structural Engineering
LN Consulting, Inc. – MEP & Fire Engineering
ReArch Company – Construction Manager
Liz Pritchett Associates – Historic Preservation Consulting

VERMONT INTEGRATED ARCHITECTURE, PC

PROJECT OVERVIEW

Waterbury Municipal Complex

VERMONT INTEGRATED ARCHITECTURE, PC

EXISTING CONDITIONS

Waterbury Municipal Complex

SCHEME A

VERMONT INTEGRATED ARCHITECTURE, PC

DESIGN OPTIONS

Waterbury Municipal Complex

PREFERRED OPTION

VERMONT INTEGRATED ARCHITECTURE, PC

DESIGN OPTIONS

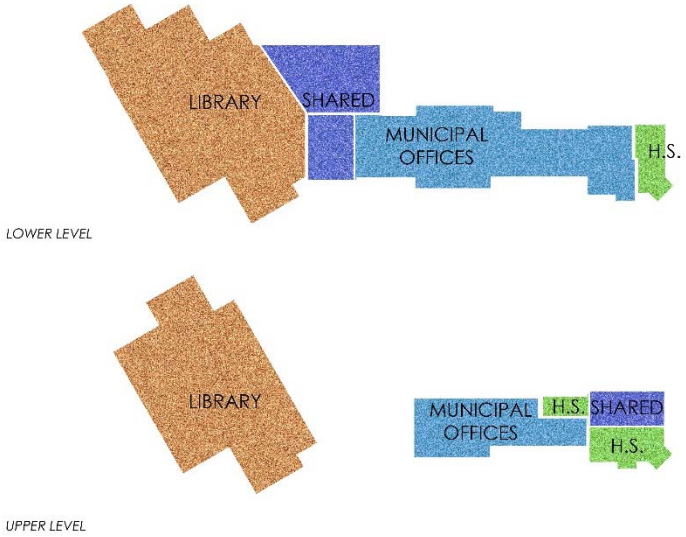
Waterbury Municipal Complex

PREFERRED OPTION

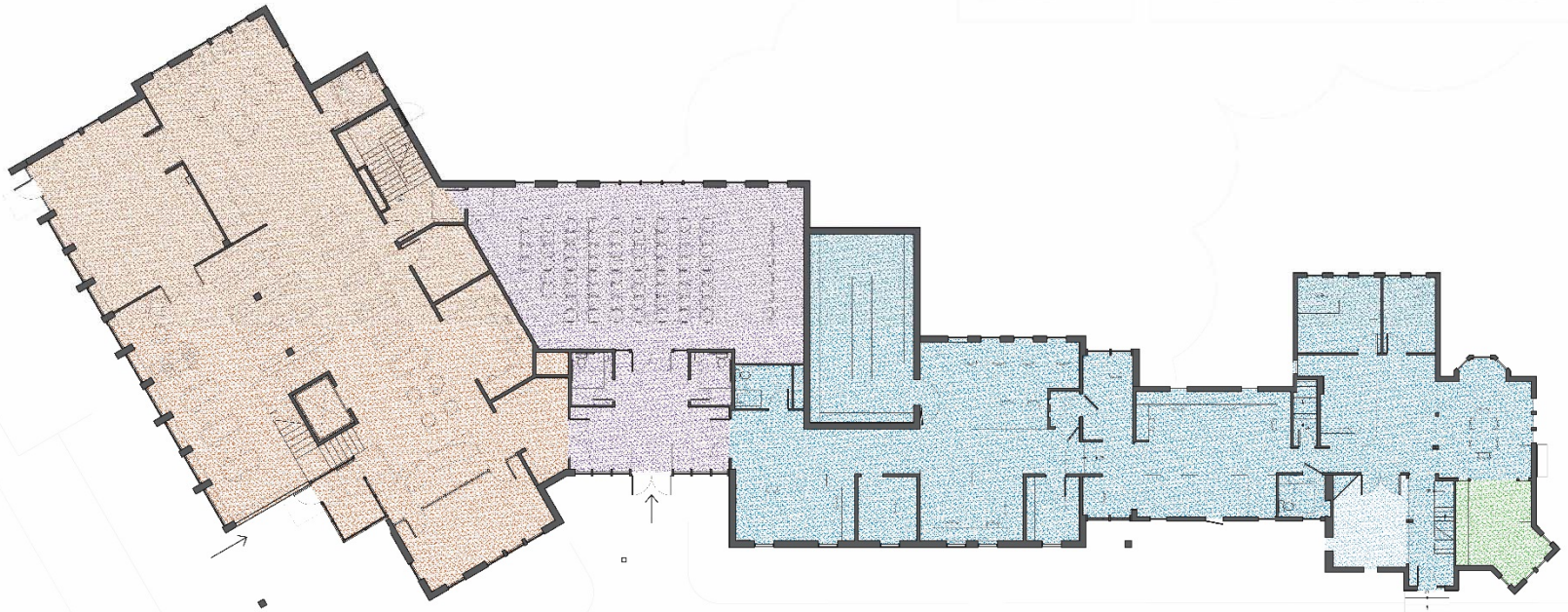
VERMONT INTEGRATED ARCHITECTURE, PC

DESIGN OPTIONS

Waterbury Municipal Complex



	Proposed	Option A	Final SF
Municipal Offices	5,444 gsf	5,300 gsf	5,083 gsf
Library	9,322 gsf	9,105 gsf	7,469 gsf
Historical Society	1,428 gsf	1,780 gsf	1,431 gsf
Shared	2,574 gsf	2,828 gsf	2,739 gsf
Total Gross Area	18,768 gsf	19,013 gsf	16,722gsf

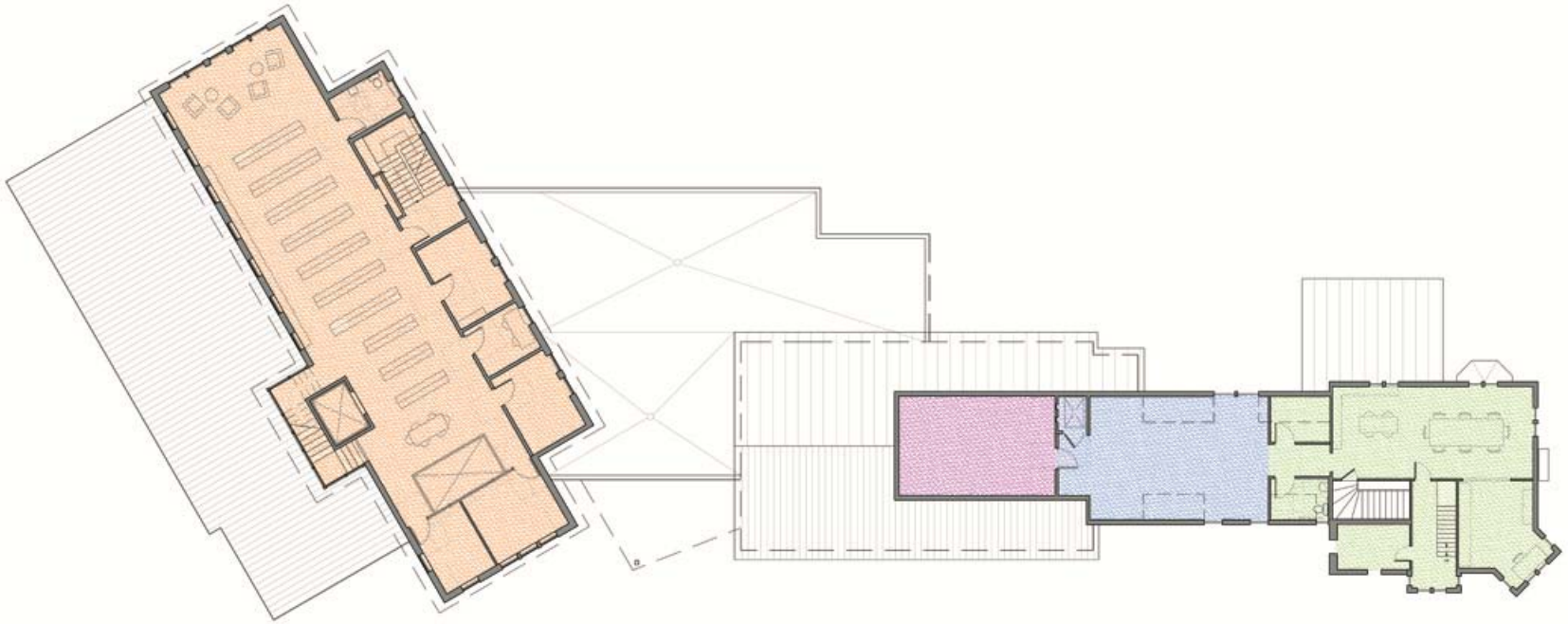


MAIN FLOOR

VERMONT INTEGRATED ARCHITECTURE, PC

PROGRAM

Waterbury Municipal Complex



SECOND FLOOR

BUILDING USE:
- MUNICIPAL OFFICES
- LIBRARY
- HISTORICAL SOCIETY

CODE OCCUPANCY: ASSEMBLY

HOURS OF USE: 8:00 AM – 5:00 PM
with FREQUENT EVENING EVENTS

FLOOR AREA: 16,700 S/F

GLAZING %: 15.3%

R-VALUES:
- FND. AND SLABS: R-20
- EXTERIOR WALLS: R-40
- ROOFS: R-60 +

GLAZING U-VALUE:
- DESIGN: U=0.20
- CONSTRUCTED: U=0.27

EUI (DESIGN): 21 kBTU/SF/YR

MECHANICAL SYSTEMS

Conditioning:
VRV Heat Pump Systems and Propane supplemental heat (Boiler and Hot Water Baseboard)
IEER: 18.30-16.60
COP: 3.2
COP @ 17 deg; 2.3-2.1

Ventilation (and De-Humidification):
Energy Recovery Ventilation with VAV Distribution
EFFICIENCY:
MAIN UNITS: 70-75%
SM. UNITS: +/- 75%

Controls:
Direct Digital Controls

ELECTRICAL SYSTEMS

LED Lighting

Daylight Dimming and Occupancy Sensing

.50 Watts/SF (Design)

Waterbury Municipal Complex

VERMONT INTEGRATED ARCHITECTURE, PC

NET ZERO CHALLENGES & LESSONS LEARNED

Waterbury Municipal Complex

Better Buildings by Design Conference

February 4, 2016

VERMONT INTEGRATED ARCHITECTURE, PC

EDUCATION

Waterbury Municipal Complex

The top 5 priorities highlighted by the questionnaire results:

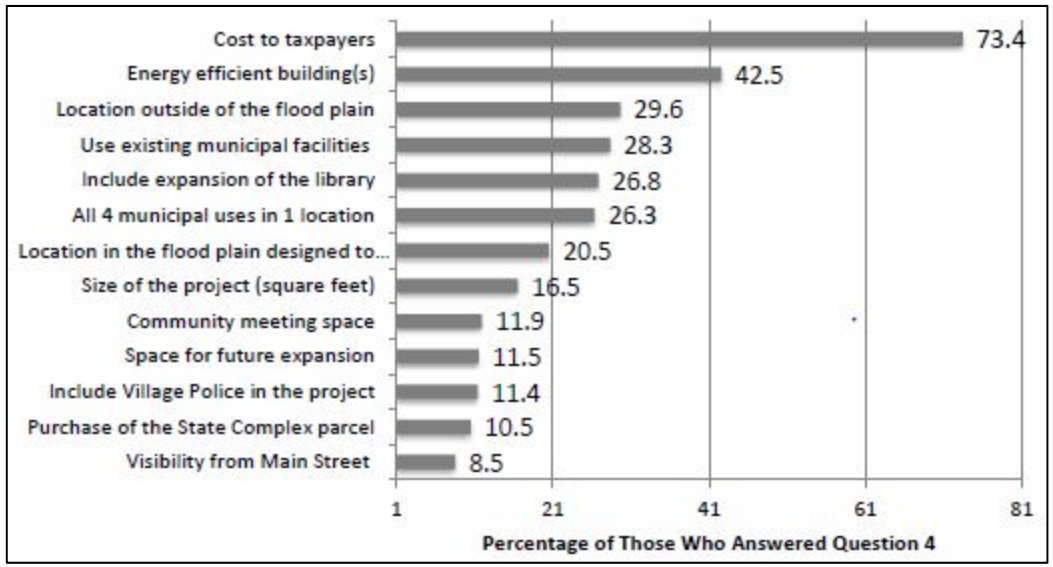
1 - Cost to taxpayers

2 - Energy efficient building(s)

3 - Location outside the flood plain

4 - Use existing municipal facilities

5 - Include expansion of the library



Sustainability & Energy Efficiency Goals
- New Building Orientation/Solar Exposure
- Reuse of Existing Building
- Walkable to Downtown
- Minimize Building Footprint
- Minimize Impervious Surfaces
- Bio-Retention/Rain Gardens
- Maximize Building Envelope (R=20, 40, 60)
- Maximize Daylight
- LED Lighting
- Photovoltaic (Solar Panel) Ready
- Water-Conserving Plumbing Fixtures
- High- Efficiency Mechanical Systems
- Energy-Recovery Ventilation
- Use of Local Materials & People
- Include Healthy – No-VOC Materials
- Use of High Recycled-Content Materials

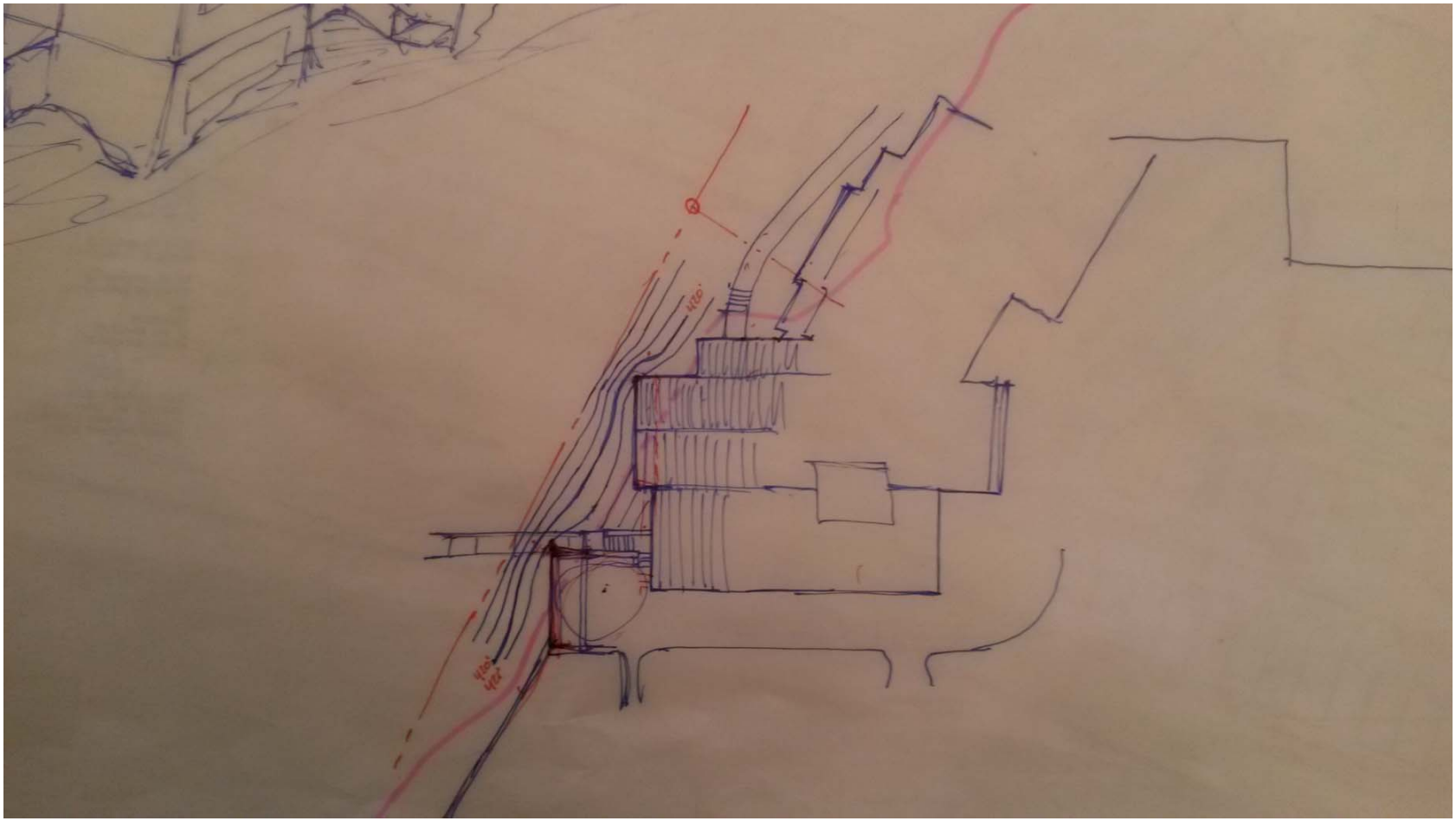
PROJECT OBJECTIVES ACHIEVED

Reduced the cost and size with superior energy efficiency

Used municipal property with no police station

Situated above the flood plain

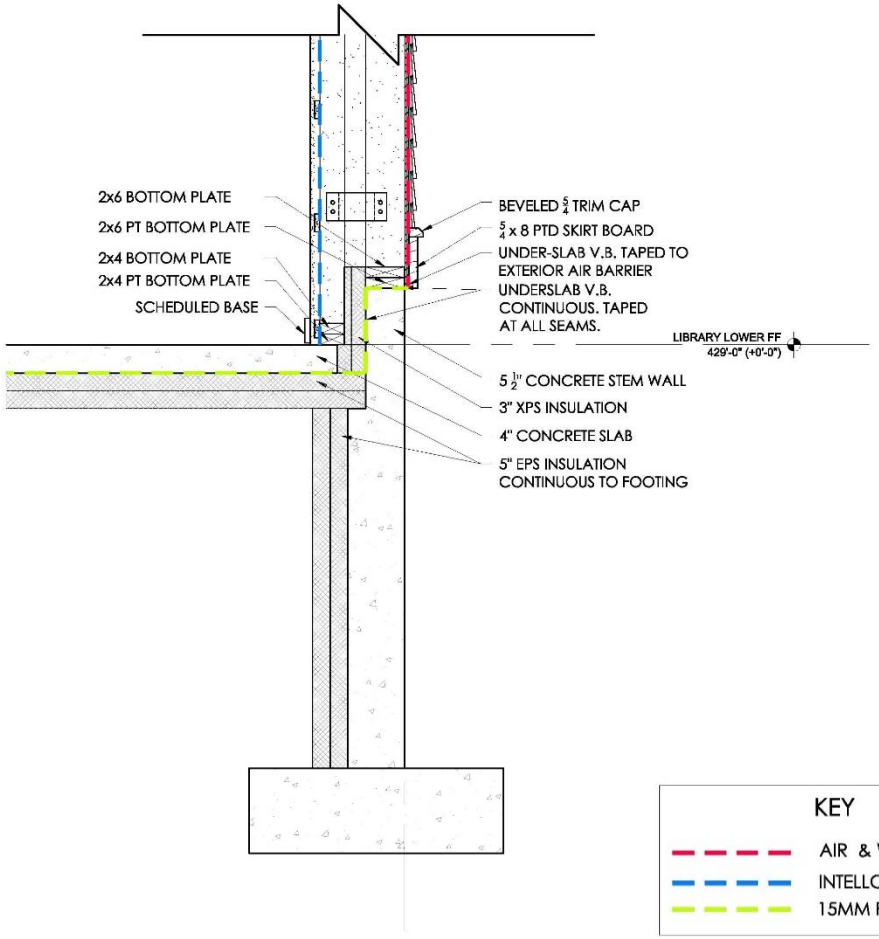
Maximized Value



VERMONT INTEGRATED ARCHITECTURE, PC

PROCESS

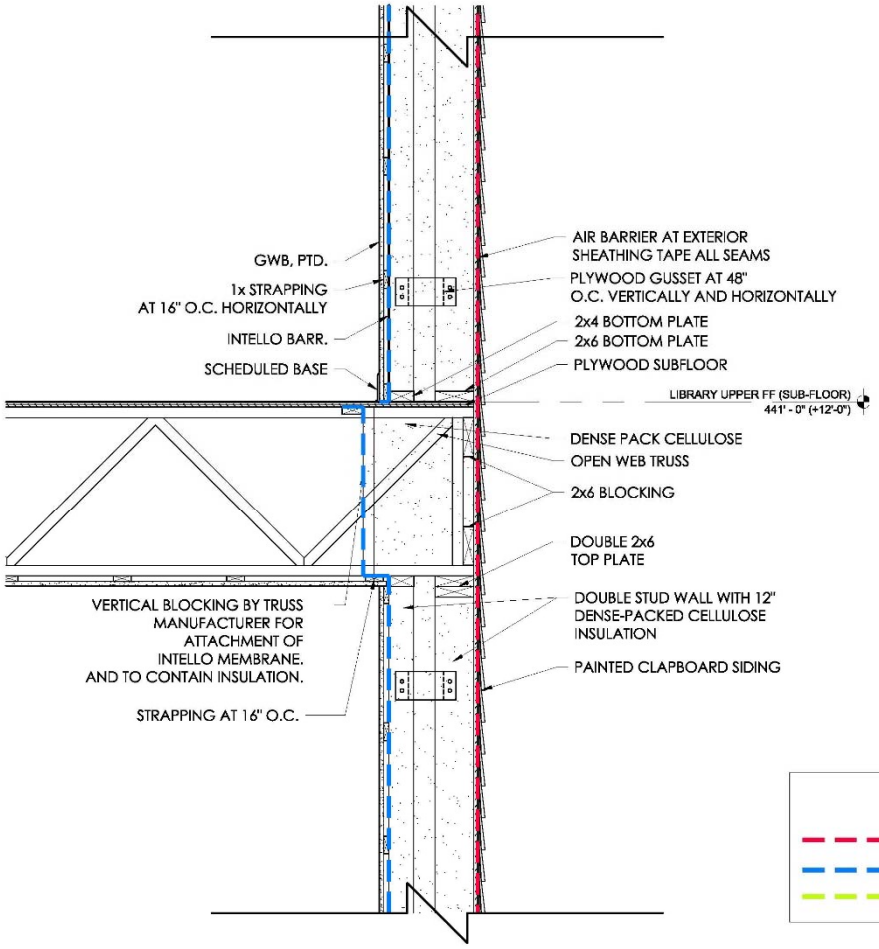
Waterbury Municipal Complex



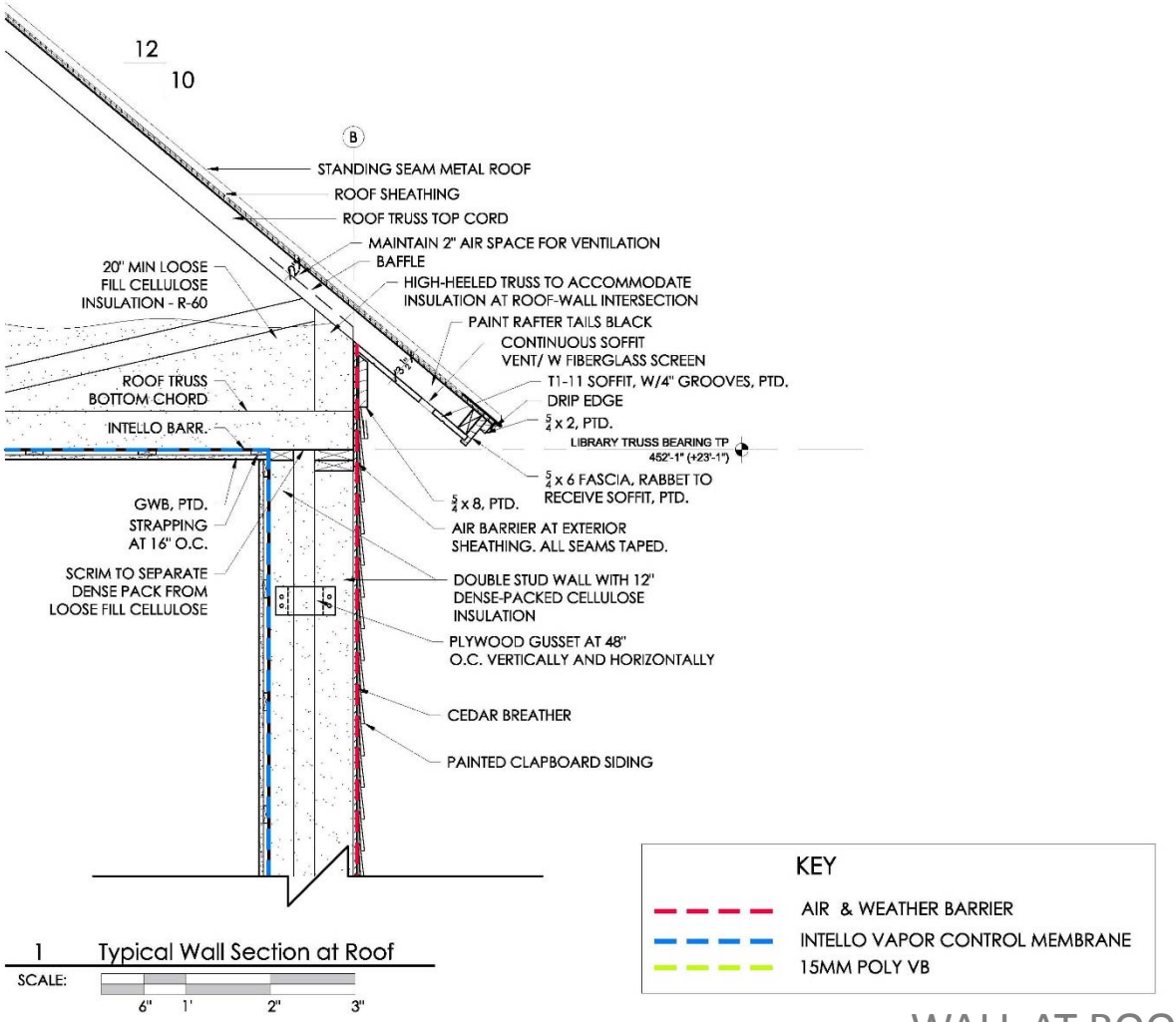
1 Typical Wall Section at Slab

SCALE: 6" 1' 2" 3"

WALL AT FOUNDATION



WALL AT 2ND FLOOR


12
10
B
STANDING SEAM METAL ROOF
ROOF SHEATHING
ROOF TRUSS TOP CORD
MAINTAIN 2" AIR SPACE FOR VENTILATION
BAFFLE
20" MIN LOOSE FILL CELLULOSE INSULATION - R-60
HIGH-HEELED TRUSS TO ACCOMMODATE INSULATION AT ROOF-WALL INTERSECTION
PAINT RAFTER TAILS BLACK
CONTINUOUS SOFFIT VENT/ W FIBERGLASS SCREEN
T1-11 SOFFIT, W/4" GROOVES, PTD.
ROOF TRUSS BOTTOM CHORD
DRIP EDGE
5/4 x 2, PTD.
INTELLO BARR.
LIBRARY TRUSS BEARING TP 452'-1" (+23'-1")
5/4 x 6 FASCIA, RABBET TO RECEIVE SOFFIT, PTD.
5/4 x 8, PTD.
GWB, PTD.
STRAPPING AT 16" O.C.
AIR BARRIER AT EXTERIOR SHEATHING. ALL SEAMS TAPED.
SCRIM TO SEPARATE DENSE PACK FROM LOOSE FILL CELLULOSE
DOUBLE STUD WALL WITH 12" DENSE-PACKED CELLULOSE INSULATION
PLYWOOD GUSSET AT 48" O.C. VERTICALLY AND HORIZONTALLY
CEDAR BREATHER
PAINTED CLAPBOARD SIDING
KEY
AIR & WEATHER BARRIER
INTELLO VAPOR CONTROL MEMBRANE
15MM POLY VB
1 Typical Wall Section at Roof
SCALE:
6" 1' 2" 3"

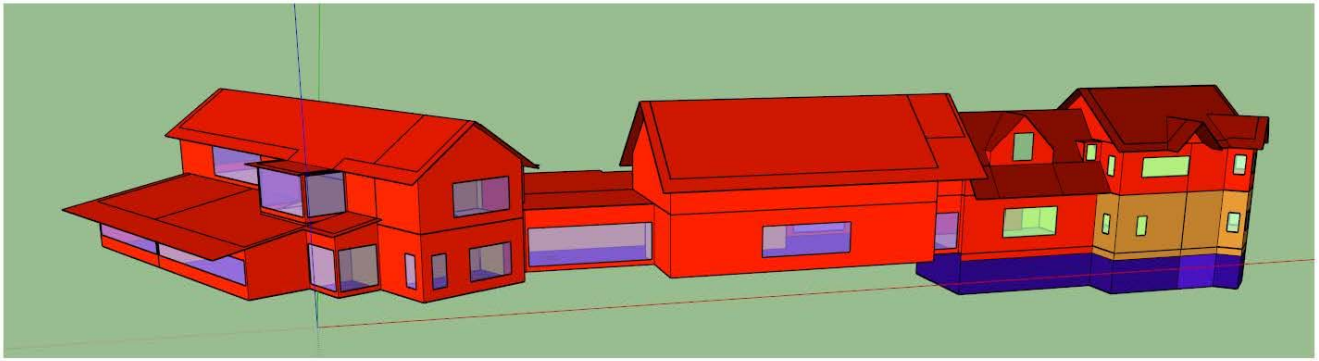
WALL AT ROOF

SECOND LAW

KAREN WALKERMAN
802-238-0980
karen@secondlaw.biz

energy modeling and consulting services

Waterbury Municipal Complex Proposed Design Energy Model



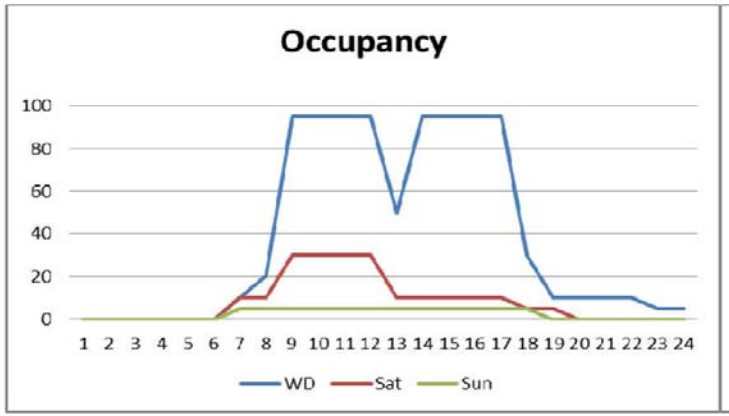
Second Law has completed an energy model of the proposed renovation and expansion to the Waterbury Municipal Complex. The energy model was created using EnergyPlus Version 8.1. The model is based on design drawings provided to Second Law by Vermont Integrated Architects (VIA) and on descriptions of mechanical systems provided by LN Consulting. The energy model reflects building geometry, orientation and constructions.

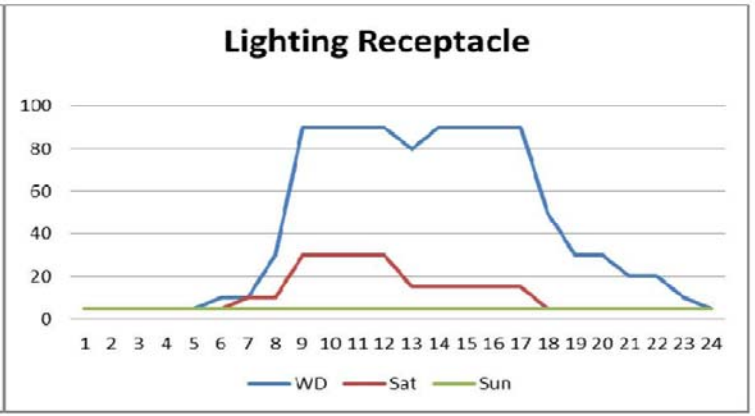
Building Envelope (Construction Assemblies)

Name	Description	Base Building U-Factor (Btu/h-ft2-F)	Base Building Envelope R-Value	Improved Envelope U-Factor (Btu/h-ft2-F)	Improved Building Envelope R-Value	Code Max U-Value	Gross Area (ft2)	Window Area (ft2)	Net Area (ft2)	Window To Wall Ratio
Old Underground Floor Construction	Existing Concrete Floor	F-Factor 0.73	N/A	F-Factor 0.73	N/A	F-Factor 0.73 (pre-existing construction)	1,821	-	1,821	N/A
Concrete Wall	Existing Concrete Wall with R-20 Added Insulation	U – 0.269	2	0.043	23.0	U – 0.269 (pre-existing construction)	261	43	218	17%
Existing Brick Wall	Existing Brick Wall, wood framing, air cavity, plaster	U – 0.24	N/A	0.240	4.2	U – 0.24 (pre-existing construction)	1,177	104	1,073	9%
Existing Ext Wall Construction	Second floor wall construciton on original building - wood siding, wood framing - infilled with insulation	U – 0.26	N/A	0.043	23.4	U – 0.26 (pre-existing construction)	3,251	316	2,935	10%
Existing Roof	Existing Roof on original building - proposed addition of R-60 Insulation	U – 0.288	N/A	0.016	62.4	U – 0.288 (pre-existing construction)	2,333	-	2,333	N/A
Ext Wall Construction	Exterior wall for new building - proposed R-40 construction. Final wall details to be determined.	U – 0.049	R-20	0.023	43.3	U - 0.049	9,836	2,217	7,619	23%
Old Underground Wall Construction	Existing Concrete Wall with R-20 Added Insulation	C-Factor 0.048	N/A	C-Factor 1.14	N/A	C-Factor 0.048 (pre-existing construction)	1,278	-	1,278	N/A
Roof Construction	Roof Construction for New building - metal surface, proposed R-60 construction - final details not yet determiend	U – 0.023	R-30	0.016	62.4	U - 0.032	9,012	-	9,012	N/A
Thick Concrete Wall	Existing Concrete Wall, 2' exterior stone with R-20 Added Insulation	U – 0.269		0.043	23.2	U – 0.269 (pre-existing construction)	88	-	88	N/A
Underground Floor Construction	Slab fully insulated with R-20 under slab	F-Factor - 0.480	N/A	F-Factor - 0.261	N/A	F-Factor - 0.480	7,947	-	7,947	N/A

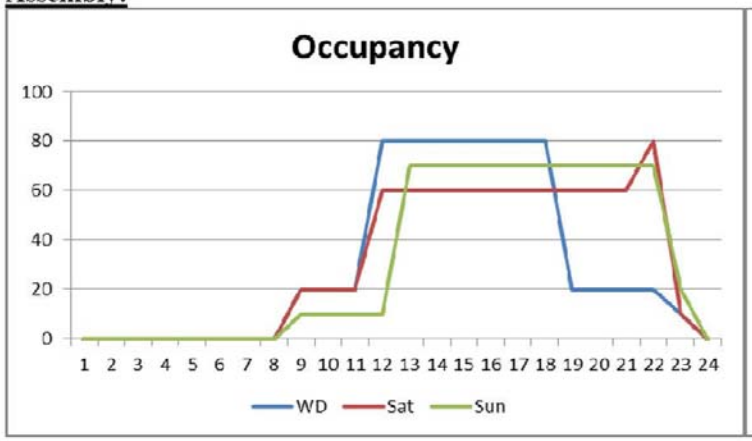
Schedules:

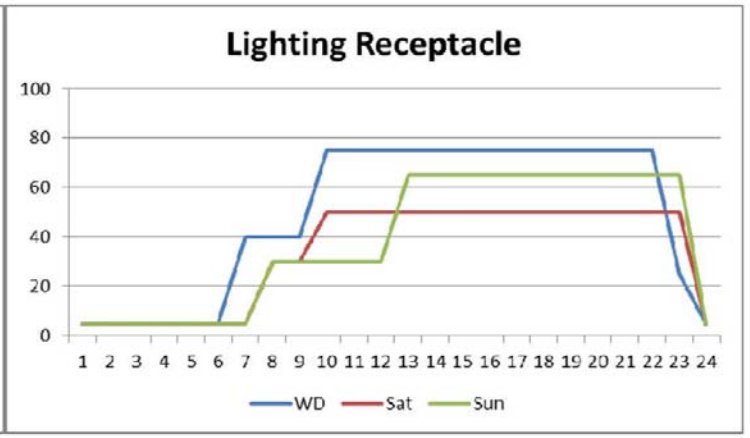
Office:





Assembly:





Results:

Probable Energy Use and Utility Costs:

	Building with All Envelope and HVAC Systems Minimally Compliant with the Vermont Commercial Energy Code		Base Building with VRV HVAC system and Propane Supplemental Heat		Base Building with Geothermal HVAC system		Insulated Building Envelope with VRV System and Propane Supplemental Heat		Insulated Building Envelope with Geothermal HVAC System		Building with All Envelope and HVAC Systems Minimally Compliant with the Vermont Commercial Energy Code - VT Code Lighting		Base Building with VRV HVAC system and Propane Supplemental Heat - VT Code Lighting		Base Building with Geothermal HVAC system - VT Code Lighting		Insulated Building Envelope with VRV System and Propane Supplemental Heat - VT Code Lighting		Insulated Building Envelope with Geothermal HVAC System - VT Code Lighting	
	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm	Electricity (kWh)	Combustion Therm
Heating	-	6,795	44,807	1,055	27,901	-	16,258	106	7,607	-	-	5,834	37,572	991	23,179	-	11,393	88	4,922	-
Cooling	9,713	-	11,997	-	6,495	-	11,579	-	6,938	-	14,088	-	16,586	-	9,859	-	18,285	-	11,879	-
Interior Lighting	26,271	-	26,271	-	26,271	-	26,271	-	26,271	-	68,574	-	68,574	-	68,574	-	68,574	-	68,574	-
Exterior Lighting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interior Equipment	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-	30,826	-
Exterior Equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fans	24,739	-	11,422	-	11,958	-	10,845	-	10,890	-	24,774	-	11,707	-	12,019	-	11,486	-	11,263	-
Pumps	-	-	68	-	2,347	-	5	-	1,006	-	-	-	65	-	2,258	-	4	-	1,158	-
Heat Rejection	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Humidification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Recovery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Generators	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total End Uses	91,549	6,795	125,391	1,055	105,798	-	95,784	106	83,537	-	138,262	5,834	165,330	991	146,715	-	140,568	88	128,622	-
Total End Uses Minus Lighting	65,278	6,795	99,120	1,055	79,527	-	69,513	106	57,266	-	69,687	5,834	96,756	991	78,141	-	71,994	88	60,048	-
Utility Cost	$ 13,203	$ 29,567	$ 17,999	$ 4,592	$ 15,222	$ -	$ 13,803	$ 459	$ 12,068	$ -	$ 19,823	$ 25,387	$ 23,659	$ 4,313	$ 21,021	$ -	$ 20,150	$ 381	$ 18,457	$ -
Total		$ 42,770		$ 22,591		$ 15,222		$ 14,263		$ 12,068		$ 45,210		$ 27,972		$ 21,021		$ 20,531		$ 18,457
Utility Cost Minus Lighting	$ 9,480	$ 29,567	$ 14,276	$ 4,592	$ 11,499	$ -	$ 10,080	$ 459	$ 8,345	$ -	$ 10,105	$ 25,387	$ 13,941	$ 4,313	$ 11,303	$ -	$ 10,432	$ 381	$ 8,739	$ -
Total		$ 39,047		$ 18,868		$ 11,499		$ 10,540		$ 8,345		$ 35,492		$ 18,254		$ 11,303		$ 10,813		$ 8,739

Probable Peak Energy Demand:

	Building with All Envelope and HVAC Systems Minimally Compliant with the Vermont Commercial Energy Code			Base Building with VRV HVAC system and Propane Supplemental Heat			Base Building with Geothermal HVAC system			Insulated Building Envelope with VRV System and Propane Supplemental Heat			Insulated Building Envelope with Geothermal HVAC System			Building with All Envelope and HVAC Systems Minimally Compliant with the Vermont Commercial Energy Code - VT Code Lighting			Base Building with VRV HVAC system and Propane Supplemental Heat - VT Code Lighting			Base Building with Geothermal HVAC system - VT Code Lighting			Insulated Building Envelope with VRV System and Propane Supplemental Heat - VT Code Lighting			Insulated Building Envelope with Geothermal HVAC System - VT Code Lighting		
	Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel		Electricity	Combustion Fuel	
	kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr		kW	kbtu/hr	
Time of Peak	20-JUL-15:0	06-FEB-06:0	-	05-FEB-13:0	03-FEB-05:15	-	06-FEB-09:15		-	06-FEB-10:45	06-FEB-05:15	-	20-JUL-15:00		-	20-JUL-15:00	06-FEB-06:00	-	05-FEB-13:0	03-FEB-05:15	-	06-FEB-09:15		-	20-JUL-15:00	06-FEB-05:15	-	20-JUL-15:00		-
Heating	-	545,720	-	42,772	315,598	-	17,263		-	21,432	134,190	-	9		-	-	532,161	-	39,223	315,598	-	14,711		-	-	134,190	-	8		-
Cooling	21,216		-	33		-	98		-	72		-	7,109		-	24,377		-	66		-	101		-	12,308		-	9,688		-
Interior Lighting	6,270		-	2,820		-	6,270		-	6,270		-	6,270		-	16,384		-	7,337		-	16,384		-	16,384		-	16,384		-
Exterior Lighting	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Interior Equipment	6,679		-	3,257		-	6,679		-	6,679		-	6,679		-	6,679		-	3,257		-	6,679		-	6,679		-	6,679		-
Exterior Equipment	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Fans	3,987		-	1,863		-	2,448		-	1,480		-	1,746		-	4,090		-	1,796		-	2,251		-	1,940		-	1,891		-
Pumps	-		-	33		-	1,211		-	95		-	469		-	-		-	33		-	1,020		-	-		-	599		-
Heat Rejection	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Humidification	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Heat Recovery	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Water Systems	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Refrigeration	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Generators	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Total End Uses	38,152	545,720		50,779	315,598		33,970		-	36,029	134,190		22,282		-	51,530	532,161		51,712	315,598		41,148		-	37,311	134,190		35,250		-
Total End Uses Minus Lighting	31,882	545,720		47,958	315,598		27,700		-	29,759	134,190		16,013		-	35,146	532,161		44,375	315,598		24,764		-	20,927	134,190		18,866		-

VERMONT INTEGRATED ARCHITECTURE, PC

COMMISSIONING

Waterbury Municipal Complex

Zero by Degrees LLC
Energy Independence in Affordable Steps

Envelope Kick Off Meeting Minutes
Waterbury Municipal Complex
Aug 5, 2015
Jon Haehnel, Mike LaCrosse - Zero by Degrees, LLC

1. Introduction to Envelope Testing:
   a. Why do it?

2. Quality Assurance
   a. Documentation of field installations (photos)
   b. Visual inspections
   c. Field Testing
      i. 1st Instance Testing (infrared and fog)
      ii. Compliance testing (blower door)
      iii. Goal: to make the repairs/corrections while it is easy

3. First Instance Test locations:
   a. Wall to ceiling (4 locations Janes house)
   b. Wall to ceiling (4 locations new const)
   c. Wall to roof at low slope (2 directions -Janes house)
   d. Roof to Wall at flat roof (2 locations new const)
   e. Wall inside and outside corners (Janes house)
   f. Wall inside and outside corners (new const)
   g. At installed punched window and storefront (new const)
   h. At installed window and refurbished window (Janes house)
   i. At wall to slab at typical framed wall (2 locations)
   j. At refurb wall to floor (1st and 2nd floor- Janes house)

4. Possible test outcomes and follow up actions

5. Compliance Testing
   a. What is a blower door test and how do we prepare for one?
   b. The air barrier recommended target: whole building leakage rate of 0.1 CFM/sf at a pressure differential of 50 Pascals (or 1.57 psf).

AIR SEALING:

NEW BUILDING TARGET: .10 CFM50/SF SHELL

NEW BUILDING TEST 1: .34 CFM50/SF SHELL

NEW BUILDING TEST 2: .23 CFM50/SF SHELL

JANES HOUSE: .95 CFM50/SF SHELL

of 3 of these wide open to the attic.	
	
Directly on the other side in room 211, we see that same wall bay again, and going just off picture is a leaking outlet/switch. Also notice the cold air pouring in around the duct penetrations. The wall and ceiling Intello across the top of this partition is not working. There is a disconnect. The Intello should have been sealed to either side of this partitions top plate or	Visible Light Image

VERMONT INTEGRATED ARCHITECTURE, PC

Waterbury Municipal Complex
Schematic Total Project Budget
January 13, 2014 *Revised January 27, 2014*

Revised January 2, 2015

		Scheme B 12 - Attached New Build 2 Story Library/2 Story Municipal		Scheme B 12 - Attached New Build 2 Story Library/2 Story Municipal		
PROGRAM AREAS:						
Municipal Offices		4,659 sqft.		4,659 sqft.		
Library		7,656 sqft.		7,656 sqft.		
Historical Society		1,070 sqft.		1,070 sqft.		
Shared		2,565 sqft.		2,565 sqft.		
TOTAL PROGRAM AREA		**15,950 sqft.**		**15,950 sqft.**		
BUILDING AREAS:						
Existing Basement (Jane's House)		sqft.		sqft.		
Main Level Renovation (Jane's House)		2,025 sqft.		2,025 sqft.		NO CHANGE
Upper Level Renovation (Jane's House)		1,630 sqft.		1,630 sqft.		NO CHANGE
Total Renovation Area		3,655 sqft		3,655 sqft		
Main Level New		8,615 sqft.		8,483 sqft.		NET REDUCTION
Upper Level New		3,680 sqft.		4,566 sqft.		919 SF MECH ROOM INCREASE AND STAIR INCREASE
Total New Construction Area		12,295		13,049		
TOTAL BUILDING AREA		**15,950 sqft.**		**16,704 sqft.**		4.7% GROWTH
CONSTRUCTION COST:						
Site Development		$516,948		included below		
Renovation of Jane's House		$535,028	146.38 / SF	included below	0.00 / SF	
Floodproofing (Jane's House) - Allowance		$75,000		included below		
Basic Building Construction:		$2,829,137	230.10 / SF	$4,193,010	0.00 / SF	
Total Construction Cost Without Contingency		$3,956,113		$4,193,010		
Construction Contingency	10 %	$395,611		$314,476	7.50%	
Performance and Payment Bond				$38,314		was in Owners Cost
TOTAL CONSTRUCTION COST WITH CONTINGENCY		**$4,351,724**		**$4,545,800**		4.5% GROWTH
DESIGN PROFESSIONAL FEES						
Predevelopment - Phase 1		$23,225		$ 38,945		CO #1, #2
Predevelopment - Phase 2		$7,790		$ 18,790		CO #3
DD through CA		$254,640		$ 254,640		
Design Contingency - 10 %		$28,566		$ 7,500		
TOTAL DESIGN PROFESSIONAL FEES		**$314,221**		**$319,875**		1.8% GROWTH
OTHER/ OWNER COSTS						
Land Acquisition		$0		$0		
Geotechnical Engineering		$2,500		$0		w/ER belt
Professional Consulting (Archae./Hist Pres./environmental/Archi		$75,000		$90,393		BRD $31,956
Boundary/Topographic Survey		$0		$1,417		WL $21,186
Financing (Bond Counsel)		$1,000		$1,000		Prichett $960
Legal		$10,000		$14,978		Hartgen $9,412
Clerk of The Works		$25,000		$0		Weston&Samp $2,486
Independent Testing Inspection (Concrete+ Compaction)		$2,500		$8,000		compactn KAS $24,404
Hazardous Material Assessment and Abatement		$6,000		$31,190		$90,393
Public Notices Printing Cost		$4,000		$11,458		
Payment and Performance Bond & Builder's Risk Insurance		$28,286		$0	in insur. cost	
Permit Fees:		$45,693		$25,700		Hazard: Radon $3,478
Utility Charges & Fees:		$2,500		$2,500		Asbestos $22,000
Security and CCTV System		$0		$0	estimate	Soil $5,712
Telephone System (Handsets and Hardware)		$3,000		$0		Lead ?
Data System - Cabling		$4,500		$0		$31,190
Audio - Visual Equipment		$5,000		$0		
Moving, Storage & Miscellaneous Expenses		$20,000		$10,000		
Emergency Generator		$0		$0		
Furniture, Fixtures and Equipment		$25,000		$0		
Vault Fit-Up		$19,500		$19,500		
Window Treatment		$7,500		$7,500		
Signage		$2,500		$2,500		stand alone exterior
Water Flow and Pressure for Fire Protection System		$0		$0		
Sub-total Owner's Costs:		**$289,479**		**$226,136**		
Owner Contingency 10% of Owner's Costs	10 %	$28,948		$16,960	7.50%	
TOTAL OWNER COSTS		**$318,427**		**$243,096**		-23.7% GROWTH
TOTAL PROJECT BUDGET		**$4,984,372**		**$5,108,771**		2.5% GROWTH

VERMONT INTEGRATED ARCHITECTURE, PC

FORM FACTOR

Waterbury Municipal Complex

VERMONT INTEGRATED ARCHITECTURE, PC

FORM FACTOR

Waterbury Municipal Complex

VERMONT INTEGRATED ARCHITECTURE, PC

FUTURE
Waterbury Municipal Complex

gbA ARCHITECTURE & PLANNING

BreadLoaf Architects Planners Builders

VIA VERMONT INTEGRATED ARCHITECTURE

Wiemann Lamphere ARCHITECTS

MaclayArchitects CHOICES IN SUSTAINABILITY

PAUSE FOR BREAK

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Efficiency Vermont

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Northfield Savings Bank

Jeff Stetter, Gossens Bachman Architects

Middlebury Town Office

Chris Huston, Bread Loaf Corporation

Waterbury Municipal Complex

Ashar Nelson, Vermont Integrated Architecture

Vermont Public Radio

David Roy, Wiemann Lamphere Architects

Waitsfield Town Offices

Bill Maclay, Maclay Architects

Vermont Public Radio - Design Team

Wiemann Lamphere Architects

Krebs and Lansing

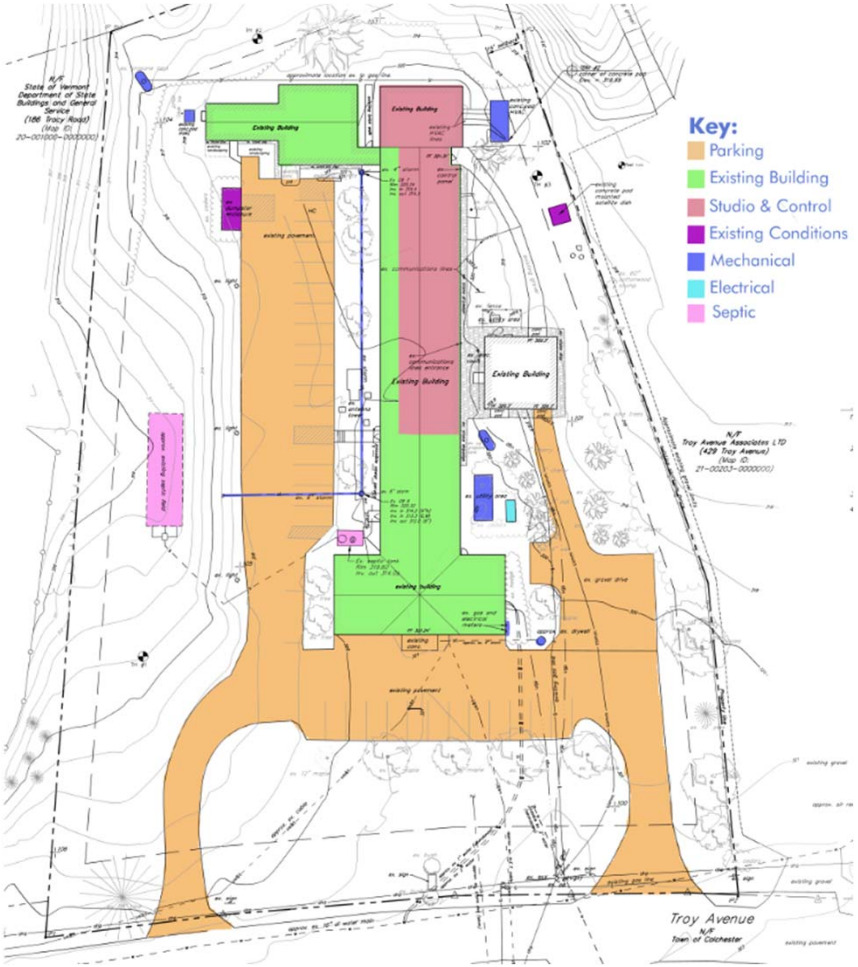
Hardy Structural

Engineering Services of Vermont

GWR Engineering – Modeling & Commissioning

Zero by Degrees – Testing & Inspection

Pre-Construction Conditions



Existing 1906 Masonry Building 8,312 S.F.
1995 Addition (wood frame) 1,215 S.F.

Designed for 27 employees
Current Staffing / Occupancy: 47 persons

Site: Parking: 41 poorly defined parking spaces

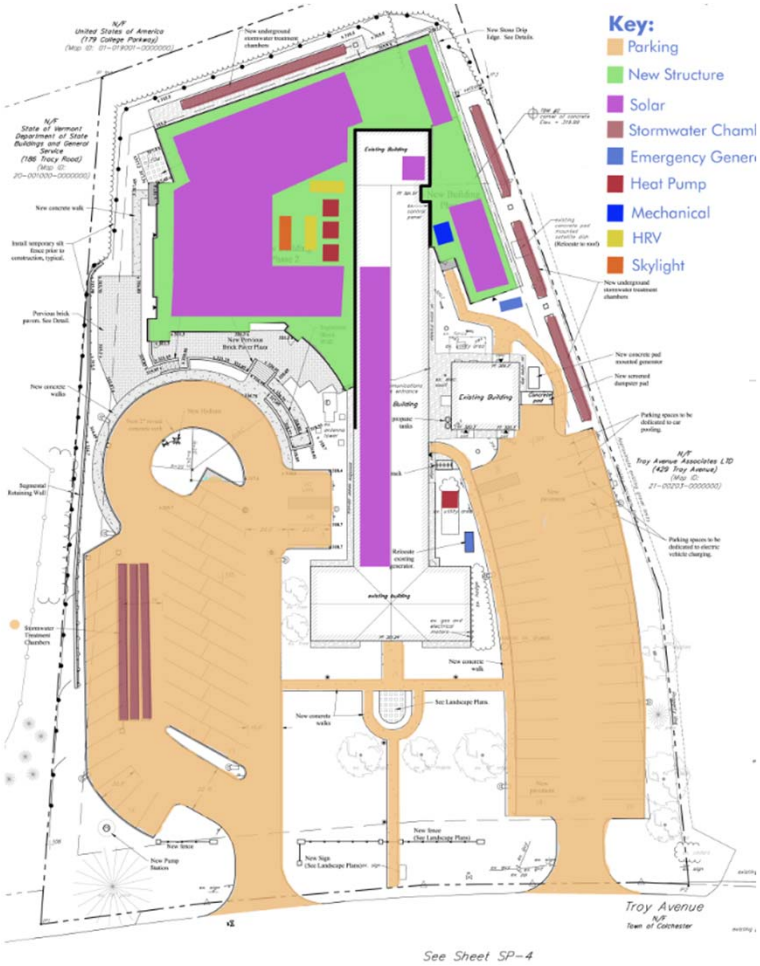
Hours of Operation:
6:00 a.m. to 5:00 p.m.
Performances & Meetings:
Evenings and Weekends.

Studio's and Control Rooms:
2 "Talk" studio's
1 Performance Studio
3 Control Rooms
1 "Termination" Rooms (server)

Challenges:
Limited building site / available coverage.
Scattered M/E infrastructure.
Existing Building is very leaky:

1.09 CFM/SF @ 50 Pa

Architectural Parameters



Proposed Addition:	14,223 S.F.
Projected Staffing:	63 Planned 87 Employees (future) (Some employees off-site)
Parking:	81 spaces
Utilities:	New municipal water and sewer. New & existing emer. generator
Storm-water:	Underground chambers.
Building Envelope:	Multi-Wythe wall to be Internalized where possible
	Existing attic air-sealed
	Replace existing windows
Solar Orientation:	Glass primarily SE with exterior sun-shade

Mechanical systems

HVAC: City-Multi A.S.H.P.
Operating temp. -18 F to 115 F
I.E.E.R. 17.9
C.O.P. 3.41

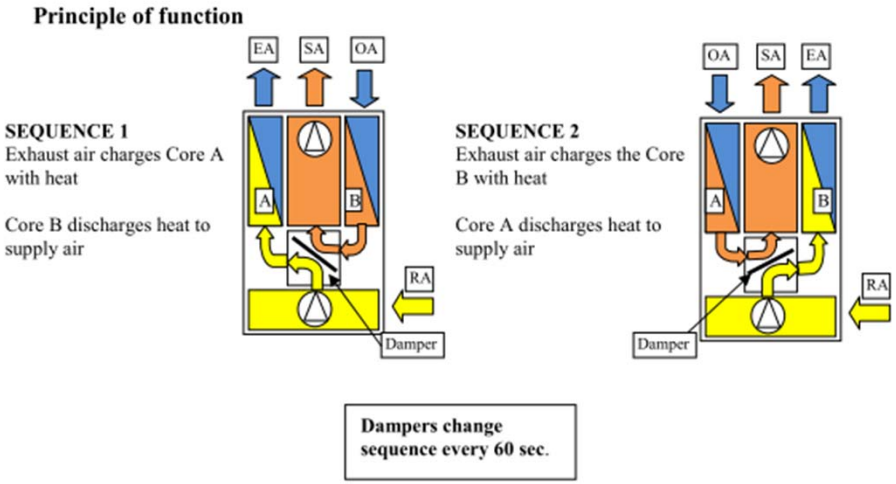
Server Room:

City- Multi used in summer to reject heat

Ventilation:

Tempeff Dual Core Heat Exchanger
90% Thermal Efficiency (+/-5%)
No heating coils required.

Cool Air Recovery in summer
(by damper cycling).



Electrical Systems & Natural Lighting

Full DDC control system

Lighting Power Density - .47 watt/SF

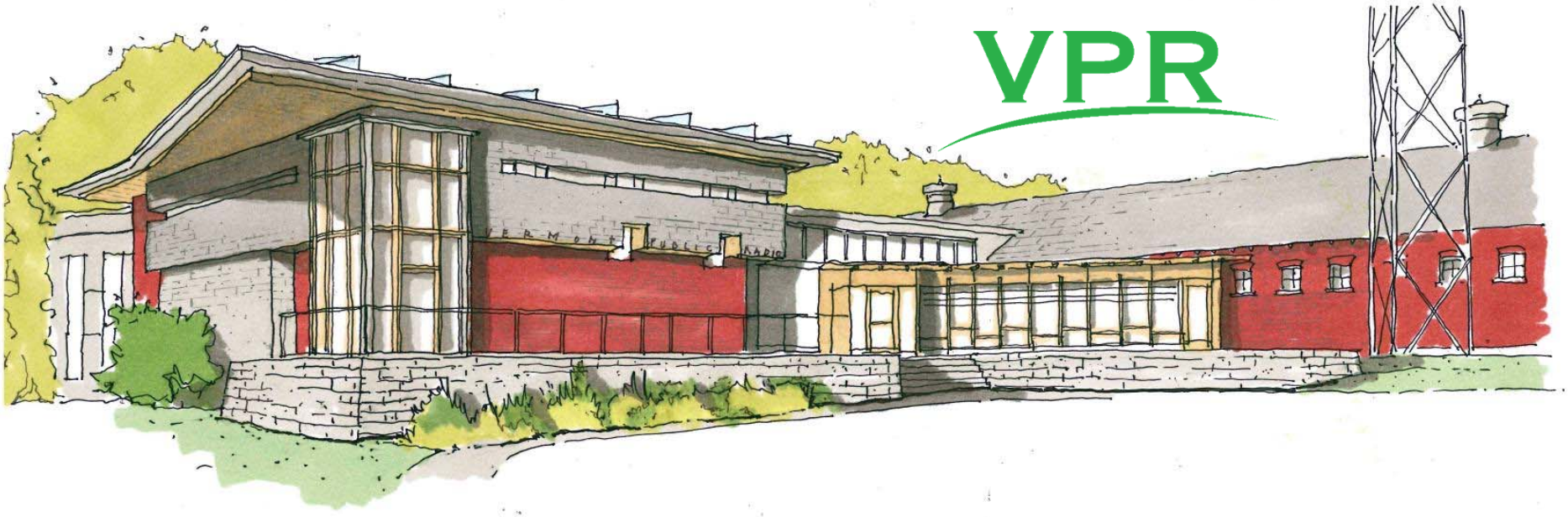
LPD is 54% below allowed by Energy Code

Occupancy / Photo-Stats Throughout

(2011 C.B.E.S.)

Lighting Control System:

Crestron “Green Light” system.



Owner Project Goals

- Develop a transformational facility that is part of the Efficiency VT Net–Zero Pilot Program;
- Become the most relevant media institution in Vermont;
- Enhance & expand public service while engaging community in new and innovative ways;
- Host a wide range of events, performances and meetings for live and recorded broadcasts.

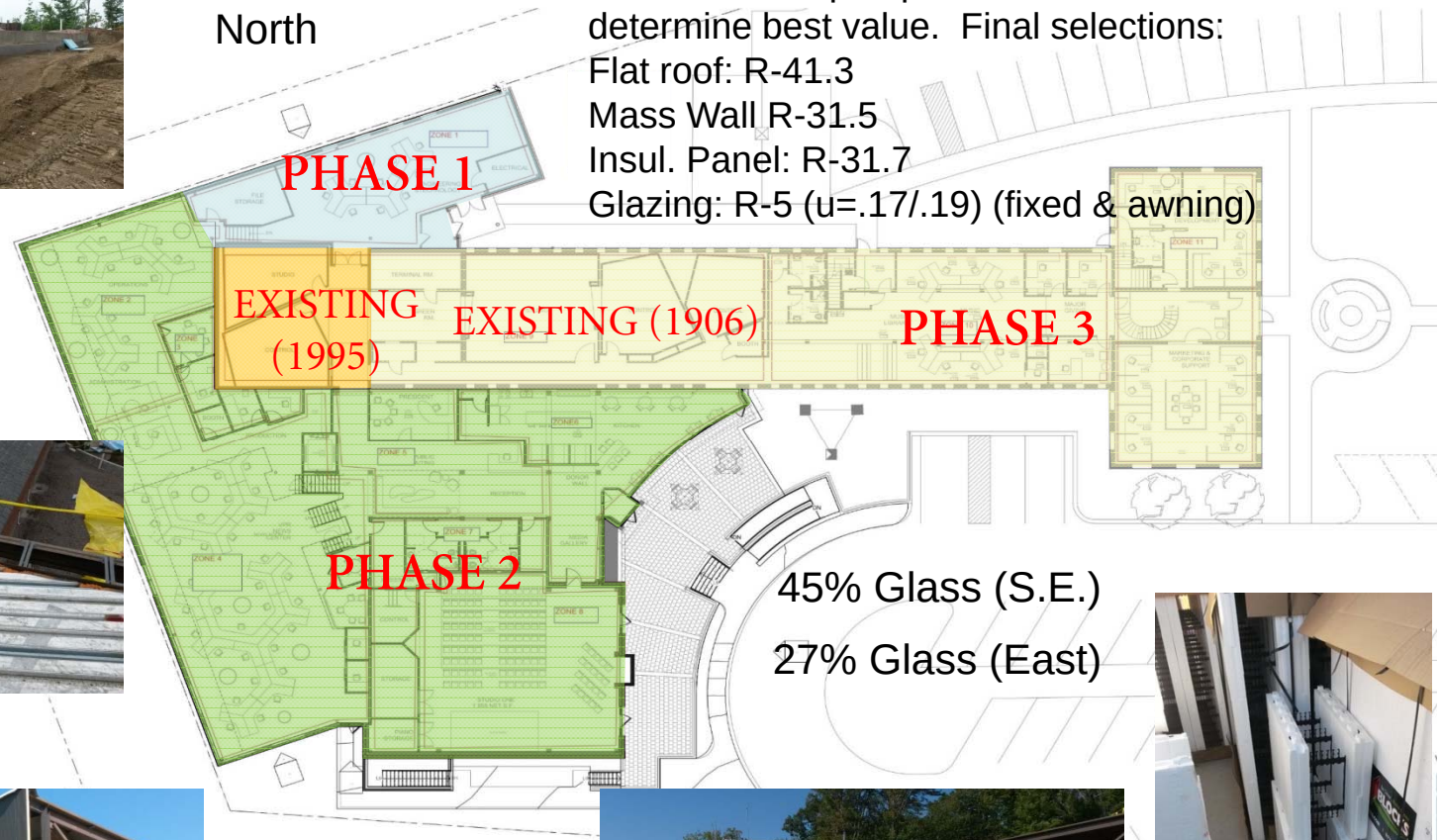
Challenges (or opportunities)

- Heavy electrical equipment energy use
- Requirement to remain operational throughout construction
- Mitigating effects of construction vibration and sound.

Building Envelope

7.4% Glass
North

Various envelope options were modeled to determine best value. Final selections:
Flat roof: R-41.3
Mass Wall R-31.5
Insul. Panel: R-31.7
Glazing: R-5 (u=.17/.19) (fixed & awning)



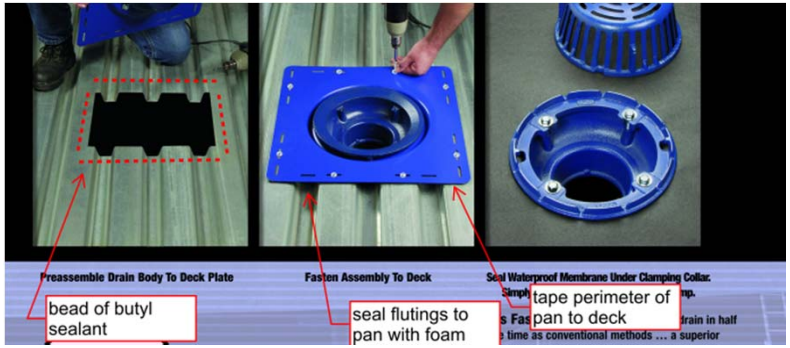
16% Glass
(West)

45% Glass (S.E.)

27% Glass (East)

13% Glass
(South)

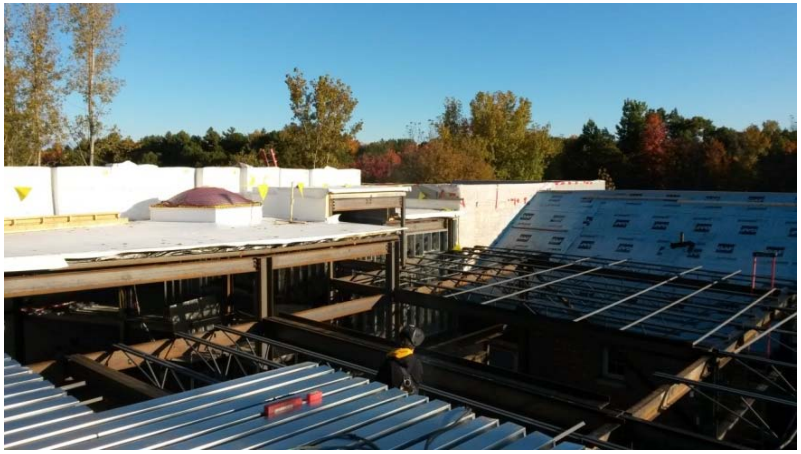
Air-sealing - Conditions

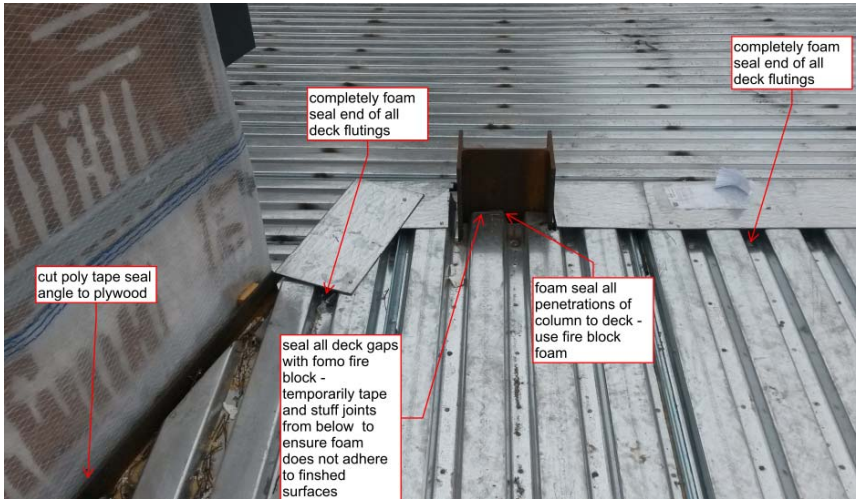


Air Sealing of Roof Drain

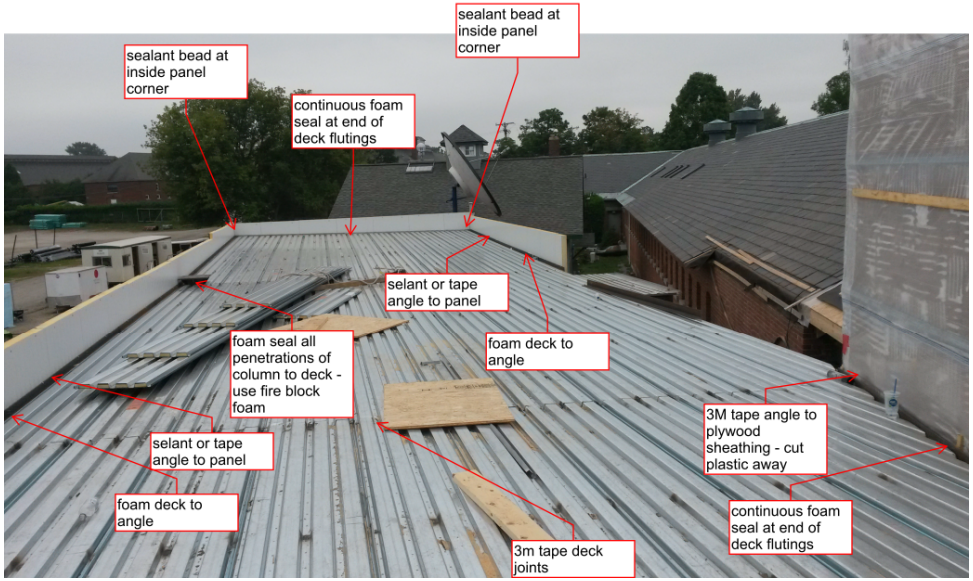
Existing to new transitions

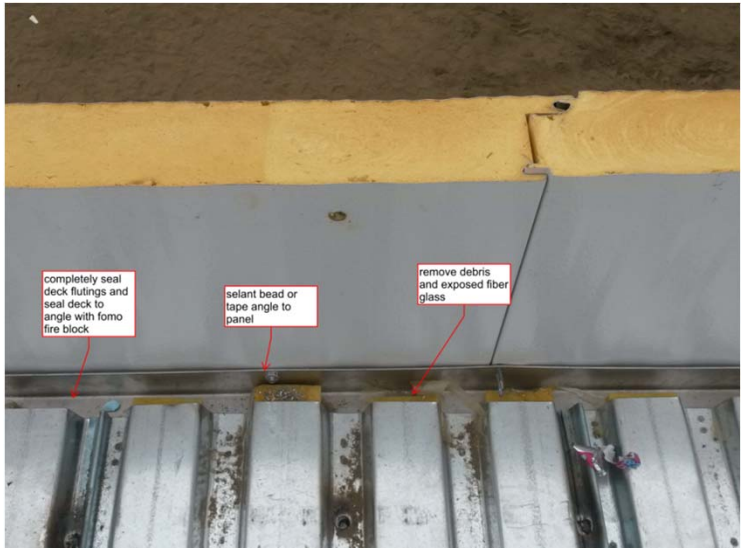
Transitions require attention





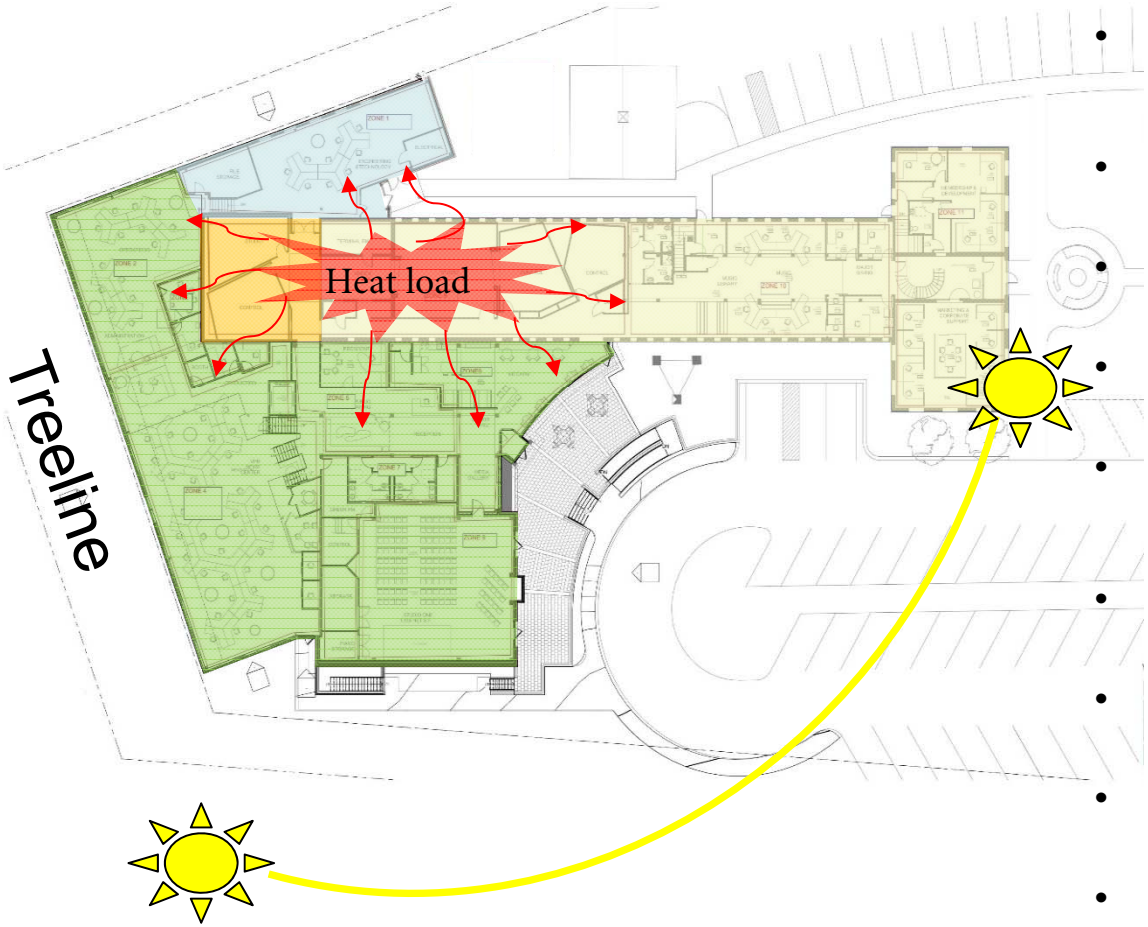
Air Sealing - Strategies





ompatible mastic or caulk.

Energy Charrette - Strategies:



- Build around existing to maximize lot use & minimize exposure of existing envelope
- Prioritize glazing to south/entry exposure
- Western façade primarily shaded by trees
- Envelope options to be modeled & chosen
- Take advantage of existing heat load from electrical broadcast equipment
- Very limited hot water demand
- LED lighting to minimize LPD
- Photovoltaics on roof surfaces (limited site)
- Existing envelope leaky and uninsulated
- Avoid use of fossil fuels – all electric
- Air Sealing modeled at 0.2 cfm/sf@ 50 Pa

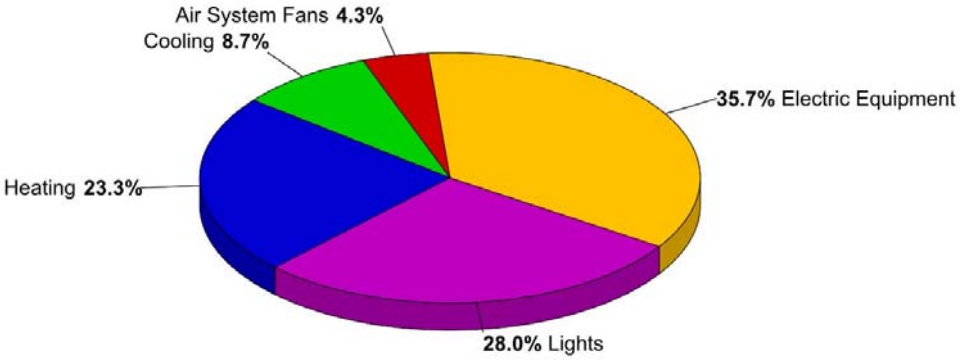
Energy Efficiency & Renewables

Aerial view of solar PV being installed on Phase 1 +2 roof

- Energy Unit Intensity
  EUI Phases 1+2: 19.9 kbtu/sf/yr
  EUI Phase 3 only: 35.6 kbtu/sf/yr
- Light Power Density: 0.47 watts/sf
- Air Sealing modeled at 0.2 cfm/sf@ 50 Pa
- Heat pump system with Hyper Heat designed to operate down to -18
- Tempeff 90% thermal efficiency heat recovery system w/ ability to dump excess heat in cooling system
- Demand Controlled Ventilation (throughout)
- Full DDC system with energy metering. HVAC / lighting / Process / Water heating
- Net Metered 90 kW AC Solar PV system
  94,970 DC Watts anticipated generation

Energy Modeling

Phase 1 & 2 - 14,223 SF Addition



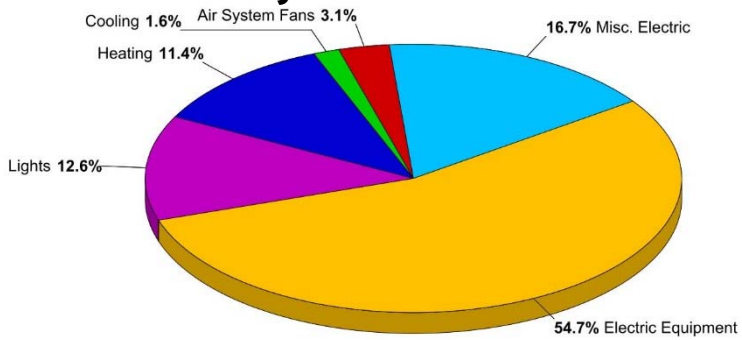
2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)
Air System Fans	13,160	0.857
Cooling	27,607	1.797
Heating	68,747	4.476
Pumps	0	0.000
Heat Rejection Fans	0	0.000
HVAC Sub-Total	**109,514**	**7.129**
Lights	86,485	5.630
Electric Equipment	110,087	7.167
Misc. Electric	0	0.000
Misc. Fuel Use	0	0.000
Non-HVAC Sub-Total	**196,572**	**12.797**
Grand Total	**306,085**	**19.926**

EUI Phases 1+2: 19.9 kbtu/sf
Non-HVAC: 12.79 kbtu/sf

EUI Phase 3: 35.6 kbtu/sf
Non-HVAC: 29.94 kbtu/sf

Phase 3 - Existing Building



2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)
Air System Fans	11,450	1.109
Cooling	5,742	0.556
Heating	41,334	4.004
Pumps	0	0.000
Heat Rejection Fans	0	0.000
HVAC Sub-Total	**58,525**	**5.669**
Lights	46,516	4.506
Electric Equipment	201,246	19.495
Misc. Electric	61,358	5.944
Misc. Fuel Use	0	0.000
Non-HVAC Sub-Total	**309,120**	**29.945**
Grand Total	**367,646**	**35.614**

Energy Monitoring & Commissioning

Segregated Electrical Loads for all three phases (metering is expensive!)

- Lighting Loads
- Mechanical / HVAC
- Plug Load
- Solar Renewable Generation

Commissioning:

- Owner involvement is critical to success;
- Focus on performance verification as a long-term activity;
- Controls Integration Meeting is valuable to determine the operational goals;
- Collaboration amongst team members is imperative.

Construction Cost

Building Only Construction Cost

Phases 1, 2 & 3 Total: $277/S.F.
(new $340/S.F. / Existing $97/S.F.)

Commercial Net Zero

Design and Construction Lessons Learned through Efficiency Vermont's Commercial Net Zero Pilot Program

Northfield Savings Bank

Jeff Stetter, Gossens Bachman Architects

Middlebury Town Office

Chris Huston, Bread Loaf Corporation

Waterbury Municipal Complex

Ashar Nelson, Vermont Integrated Architecture

Vermont Public Radio

David Roy, Wiemann Lamphere Architects

Waitsfield Town Offices

Bill Maclay, Maclay Architects

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

DESIGN TEAM:

Architect - Maclay Architects

Civil - Wilcox and Barton

Mech/Plumbing -Kohler and Lewis

Structural - DeWolfe Engineering Assoc.

Elec/Fire -William Bissell

Cost Estimator - Erickson Consulting

Landscape - SE Group

BUILDER:

Millbrook Building & Remodeling, Inc.

COMMISSIONING:

Mech - Thomas Engineering Association

Envelope - Common Sense Energy

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- SIZE: 4,700 sf
- USE: Town offices, vault, community meeting room
- LOCATION: Waitsfield, VT
- EUI: Modeled 16 kBtu/sf-yr

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Architectural –R40 walls, R60 roof, R20 below slab, R4.9 windows, 0.1cfm50/sf of above grade surface area
- Mechanical –ASHP and ERV
- Electrical – LED lighting with controls
- Unique Aspects –Daylighting, healthy building, building science

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

PROJECT GOALS:

- Efficient and functional town office, vault and meeting space
- Resilient
- Durable and prudent long term investment
- Architectural compatibility
- Net Zero

MaclayArchitects
CHOICES IN SUSTAINABILITY

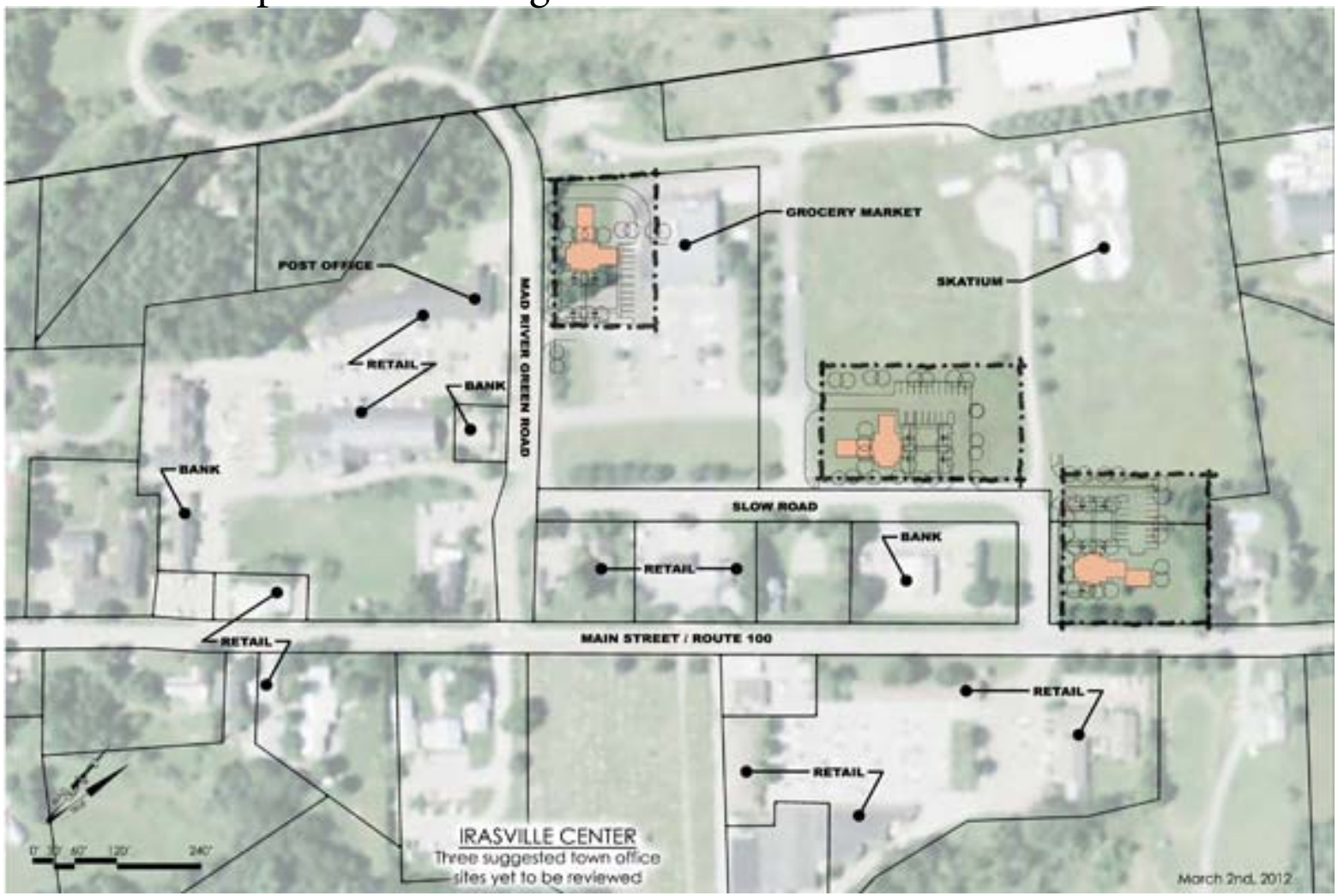
Waitsfield Town Offices – Feasibility Study 2012

- Historic Waitsfield infill

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – Feasibility Study 2012

- Irasville Center –possible smart growth area



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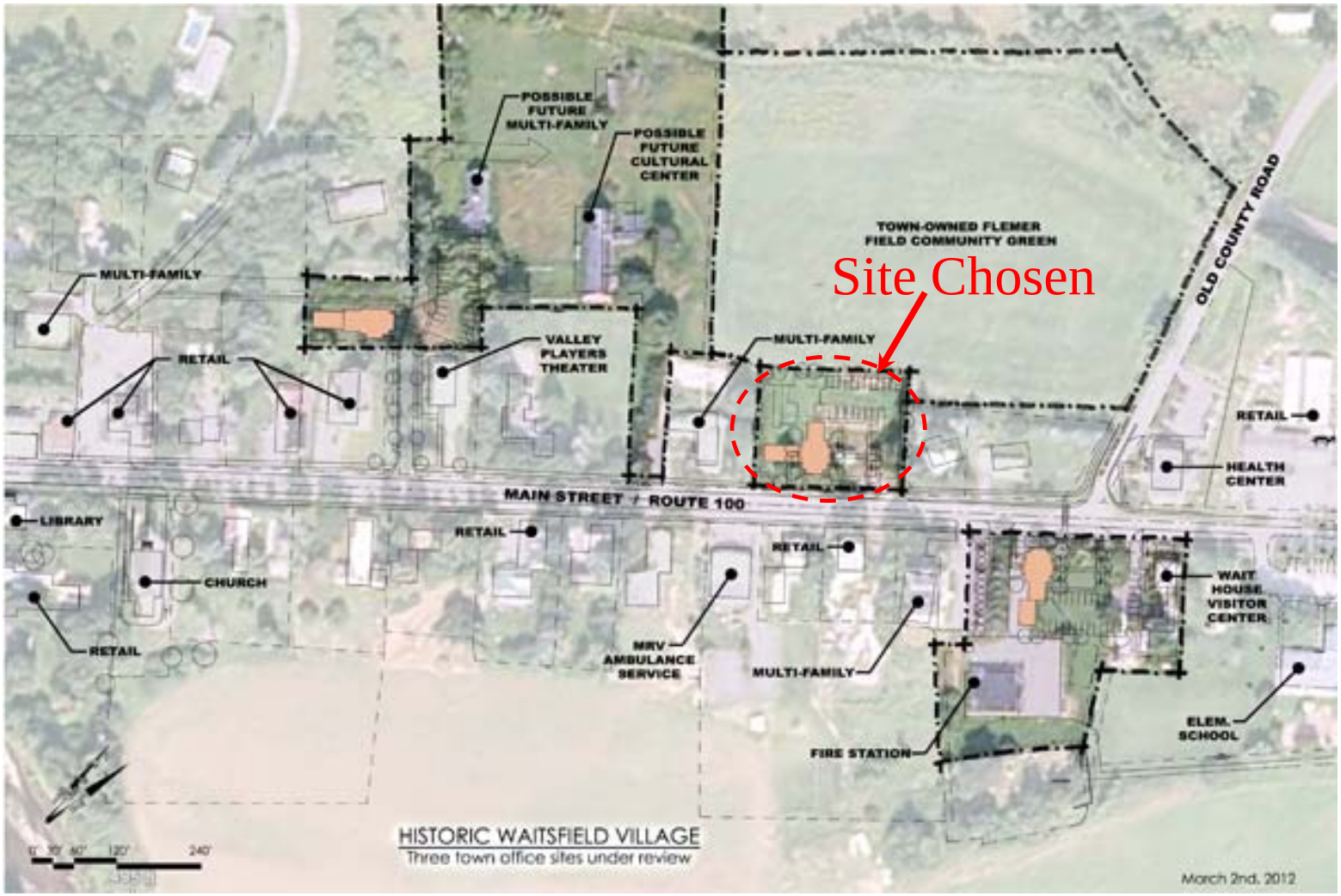
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – Feasibility Study 2012

- Historic Waitsfield infill



MaclayArchitects
CHOICES IN SUSTAINABILITY

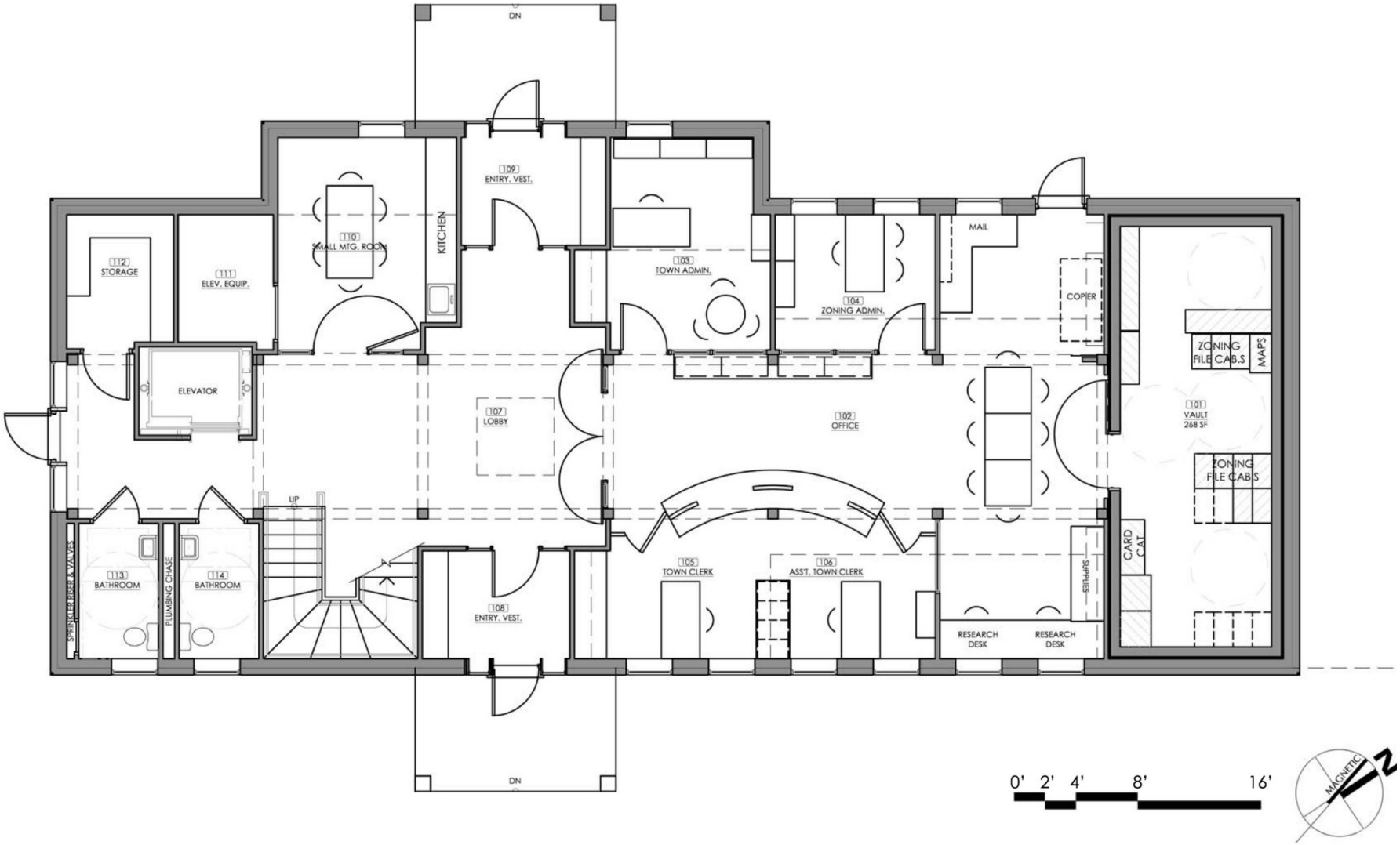
Waitsfield Town Offices – Site Plan

SE GROUP

- Historic Waitsfield infill
  - Flat site with rain gardens
  - Street trees to integrate with town streetscape
  - Site lighting control to minimize impact to neighbors

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – 1st floor



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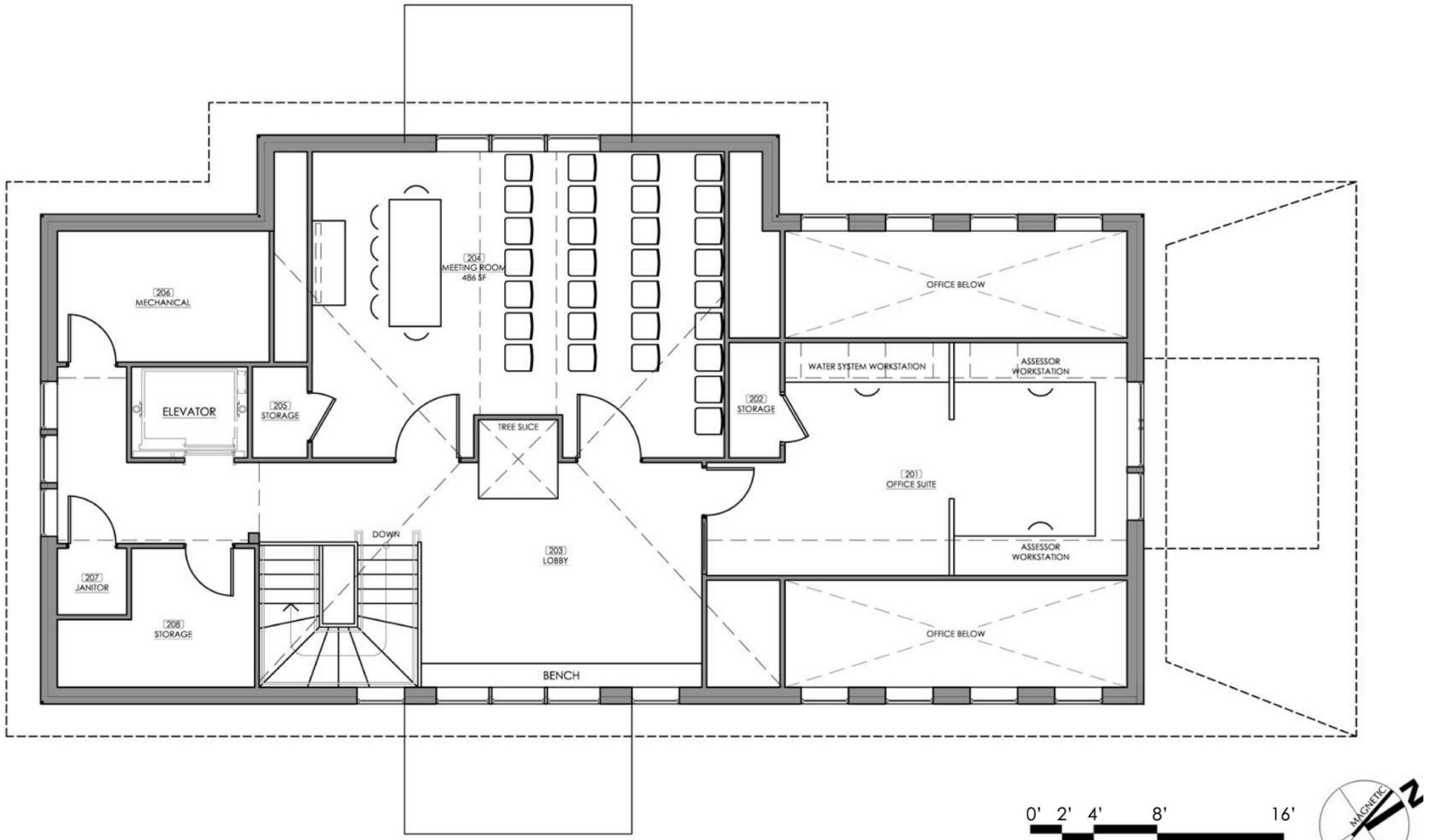
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – 2nd floor



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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – Elevations

- Main Street elevation

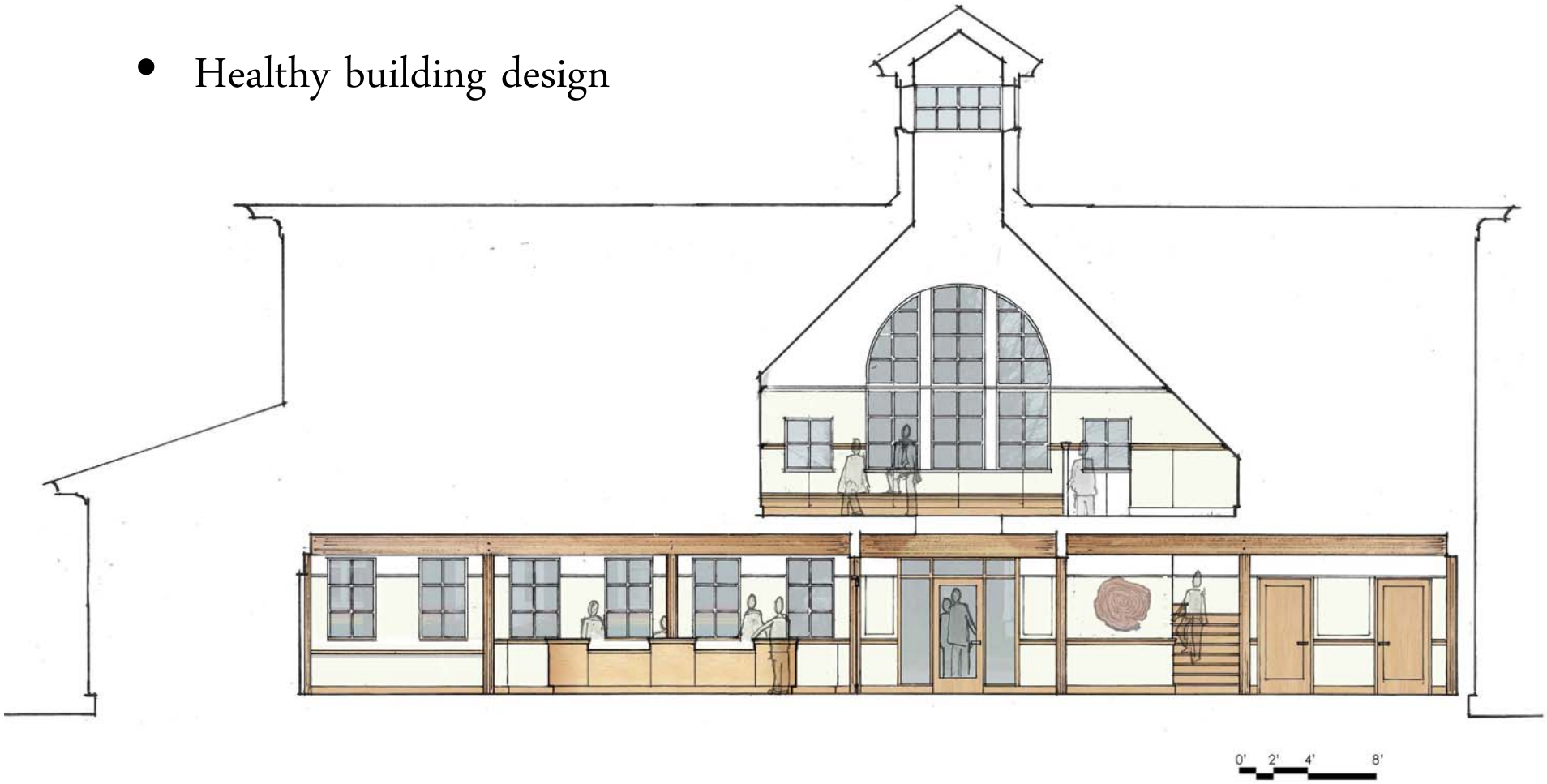
- Field elevation

- South elevation

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – Interiors

- Exposed wood
- Daylighting with high windows, cupola, and glass floor
- Healthy building design



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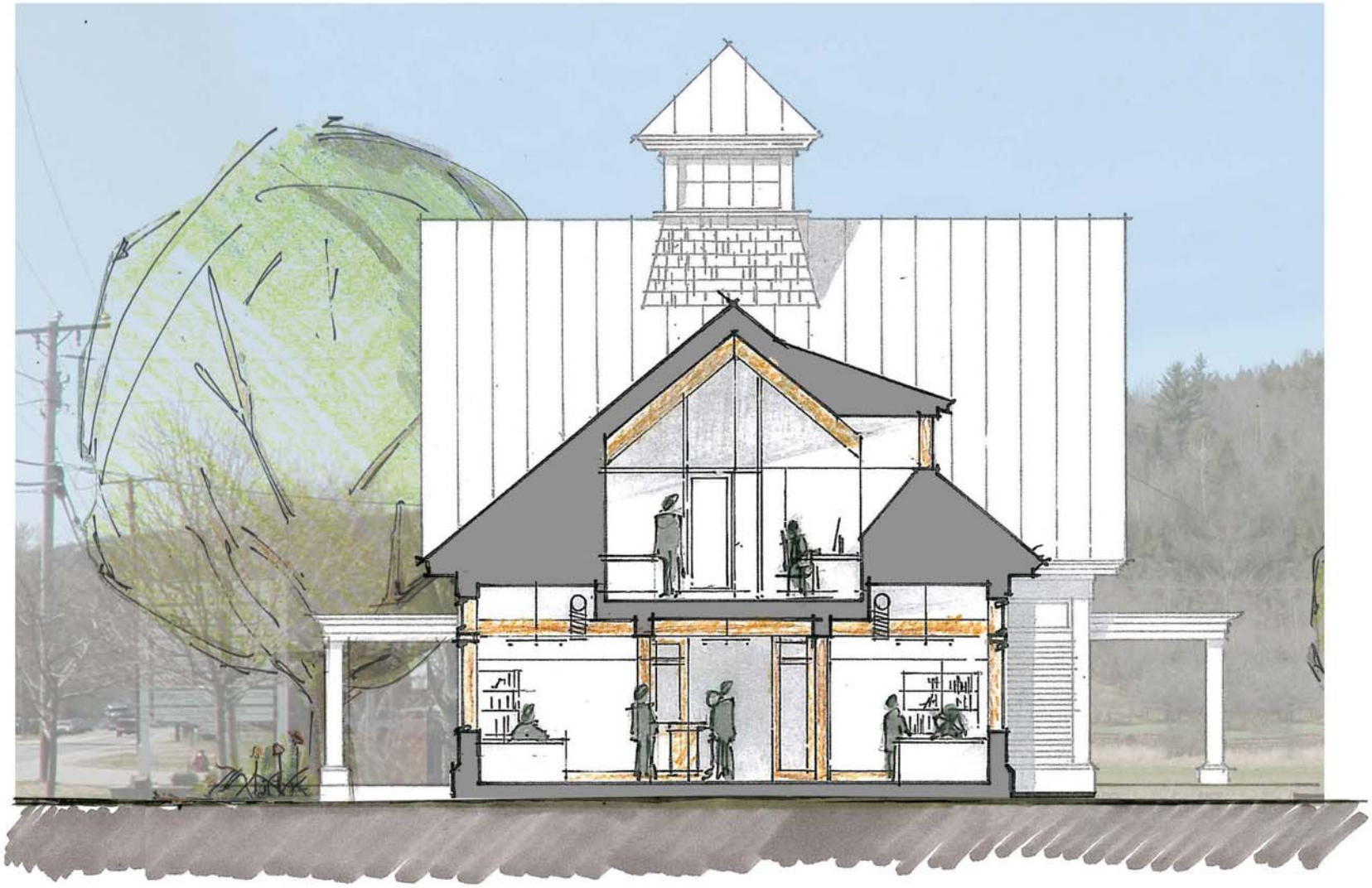
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – Interiors



OFFICE SECTION

0' 2' 4' 8' 16'

MaclayArchitects
CHOICES IN SUSTAINABILITY

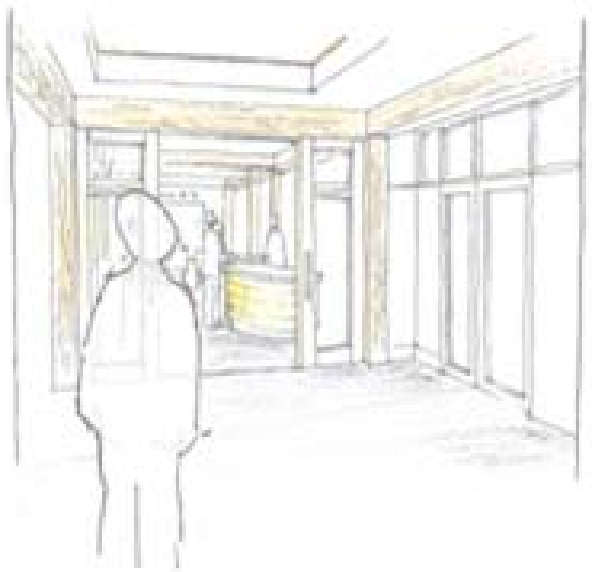
Waitsfield Town Offices - Interiors

- Entry
- Open stairs
- Glass floor opening

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices - Interiors

- Open offices with transom windows



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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices - Interiors

- Meeting room lobby
- 2nd floor

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette – Internal design team energy charrette occurred before pilot program participation with later input/review from Efficiency Vermont

- Energy Efficiency
- Renewable Energy Generation
- Energy Modeling
- Commissioning
- Construction Costs
- Client Interactions

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency – Architectural, Mechanical, Electric, Unique Features
- Renewable Energy Generation
- Energy Modeling
- Commissioning
- Construction Costs
- Client Interactions

MaclayArchitects
CHOICES IN SUSTAINABILITY

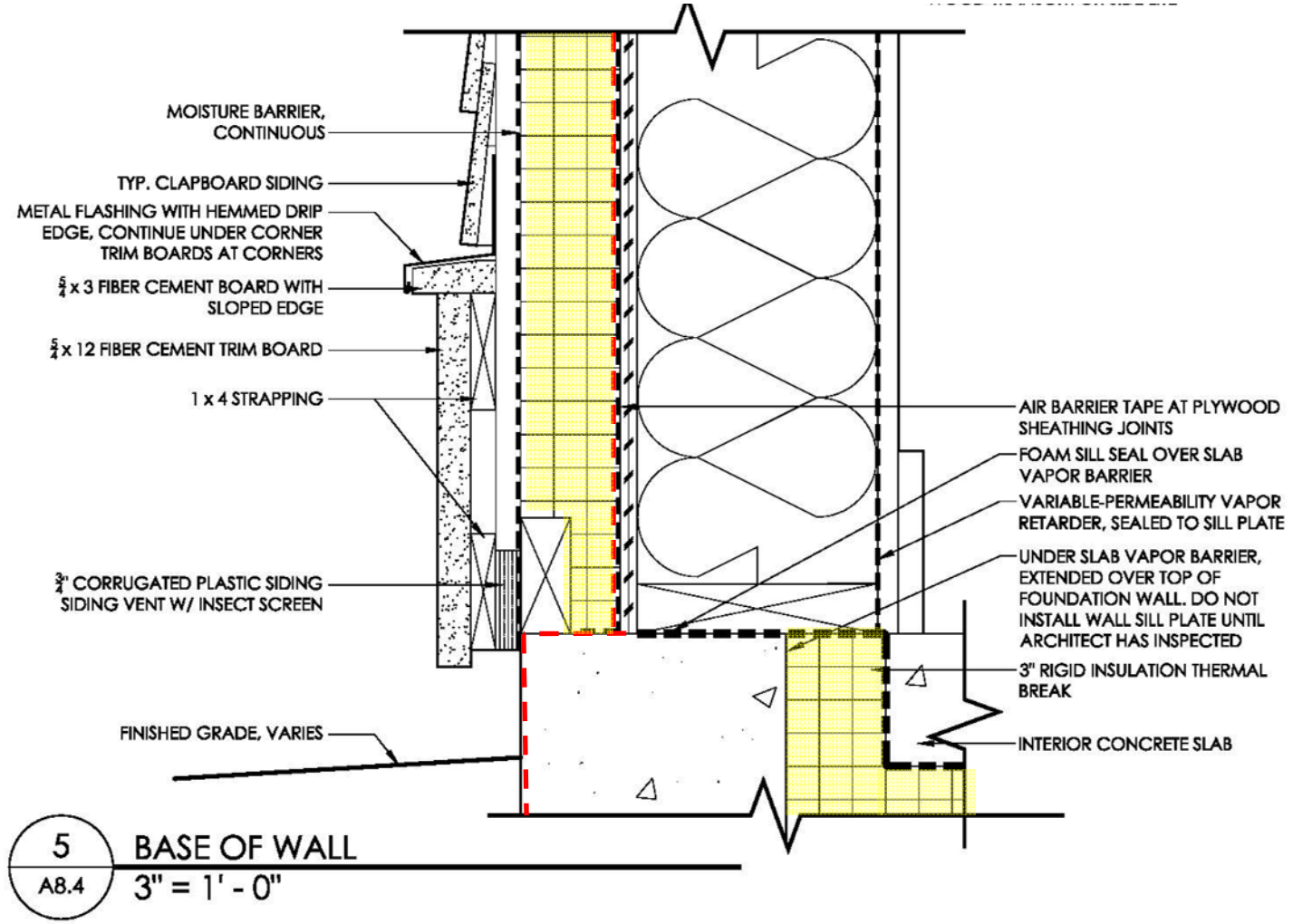
Waitsfield Town Offices

- Architectural –R40 walls: 3" exterior polyiso, 2x8 dense pack cellulose, R60 roof: 5" closed cell spray foam, 11" dense pack cellulose, R20 below slab: 5" XPS, urethane isolation blocks, continuous air, moisture and vapor barrier systems, 0.10 cfm50/sf of above grade surface area (target), R5 windows, 20% glazing
- Mechanical – Ducted and wall mounted ASHP (15.7 IEER, 3.37 COP), ERV (87%), all instantaneous electric DHW (98% eff), less duct work with open floor plan and ceiling fan
- Electrical – LED lighting, lighting controls: occ sensors and daylight photosensors, exterior lighting controls with sharp cutoffs, to provide minimal disturbance in mixed neighborhood
- Unique Aspects –Daylight windows and cupola with glass floor to first floor

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Typical Building Details – Wall Foundation



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CHOICES IN SUSTAINABILITY

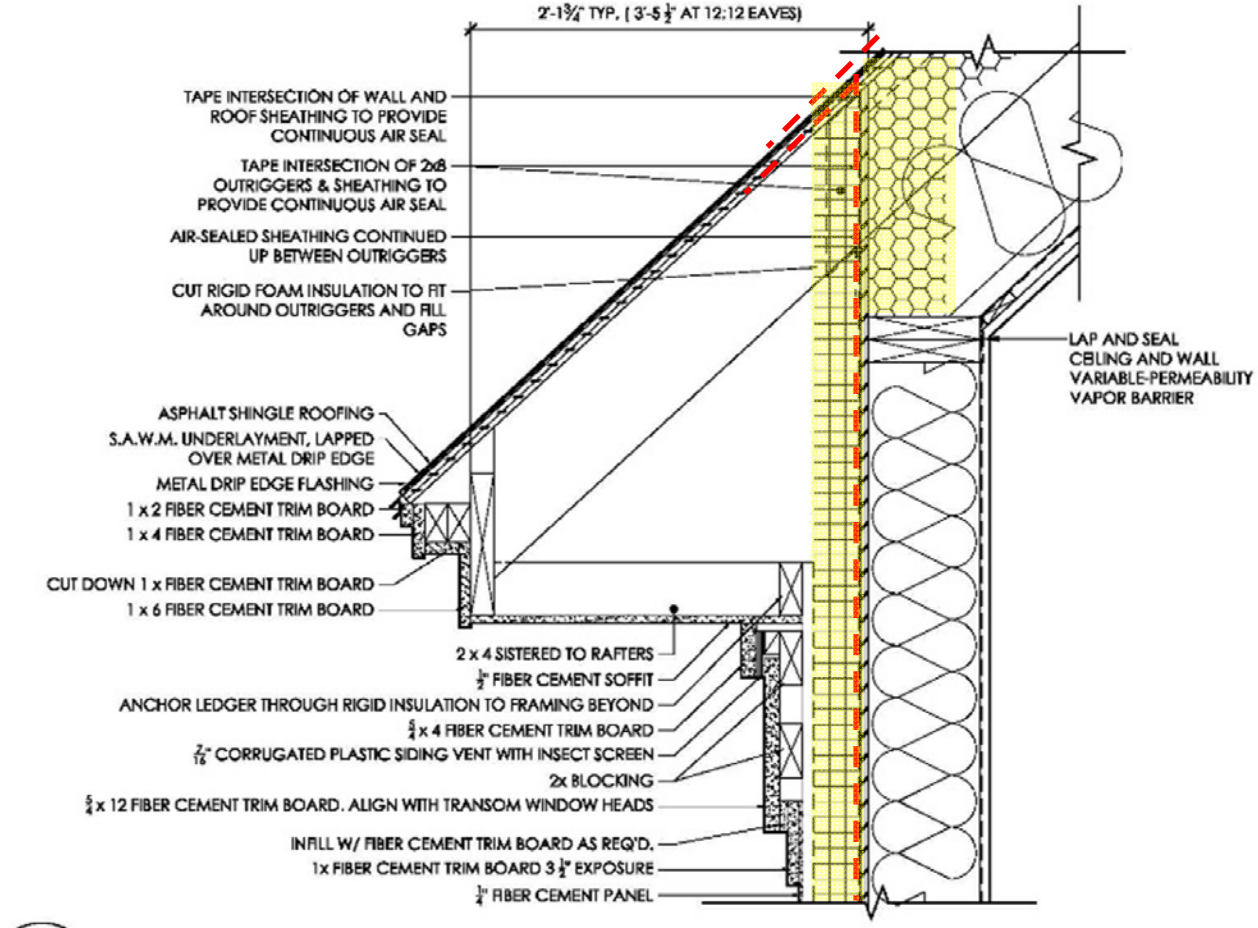
Waitsfield Town Offices

- Typical Building Details – Wall Foundation

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Typical roof details



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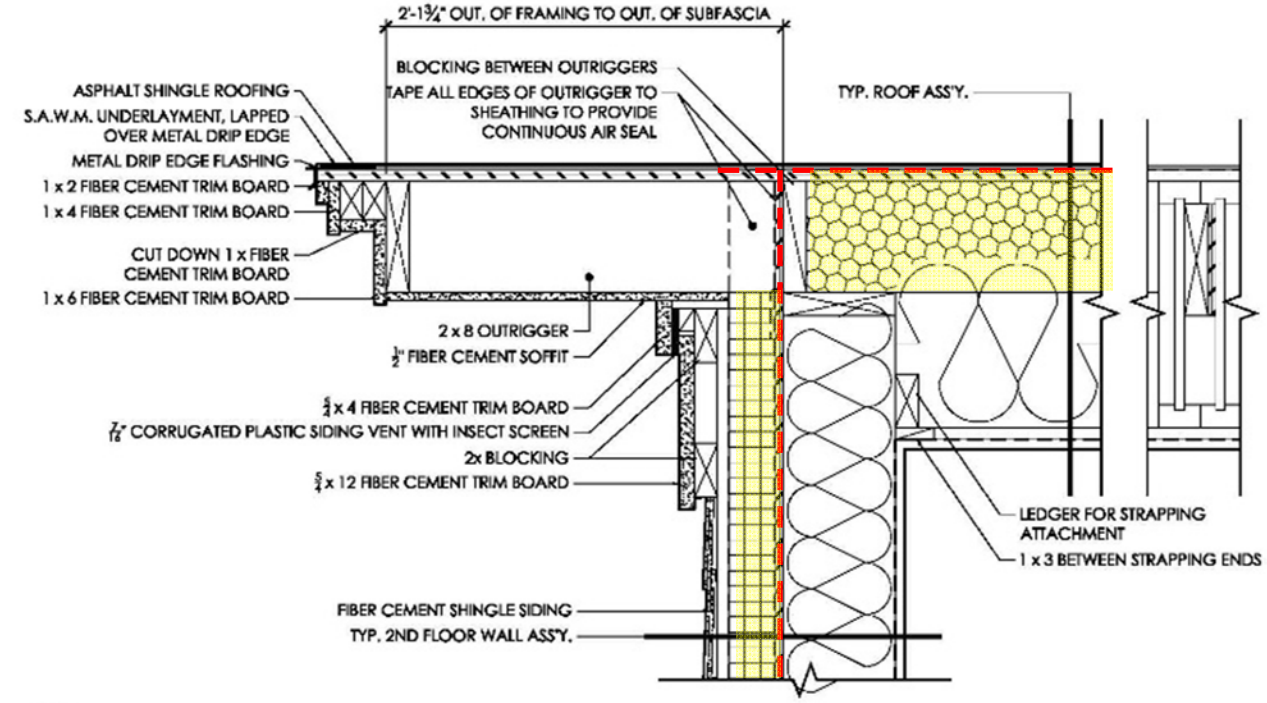
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Typical roof details



2 / A8.1 TYP. RAKE
1 1/2" = 1' - 0"

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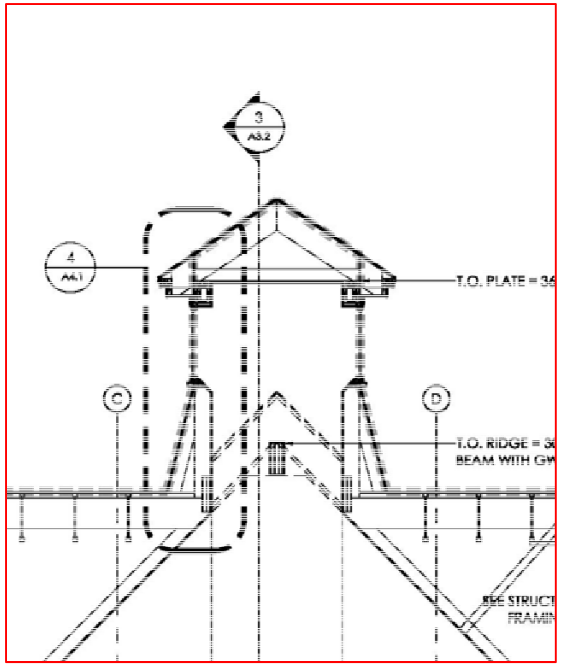
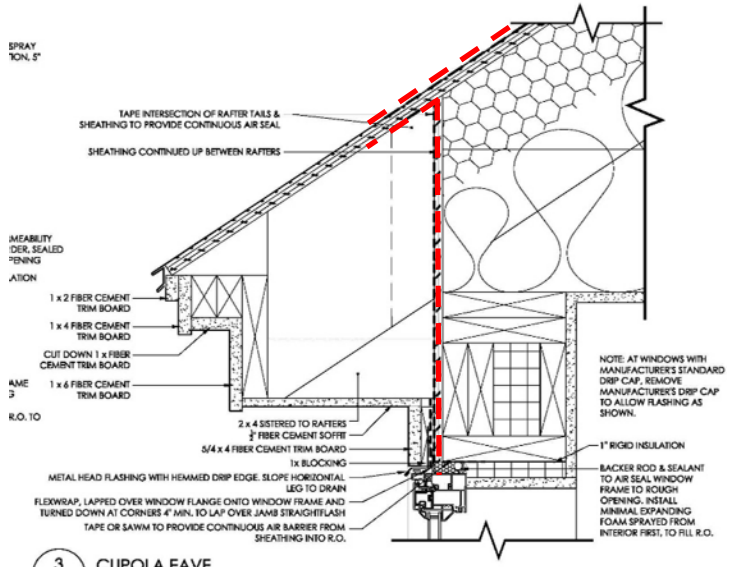
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

Waitsfield Town Offices

- Building Details – Cupola





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CHOICES IN SUSTAINABILITY

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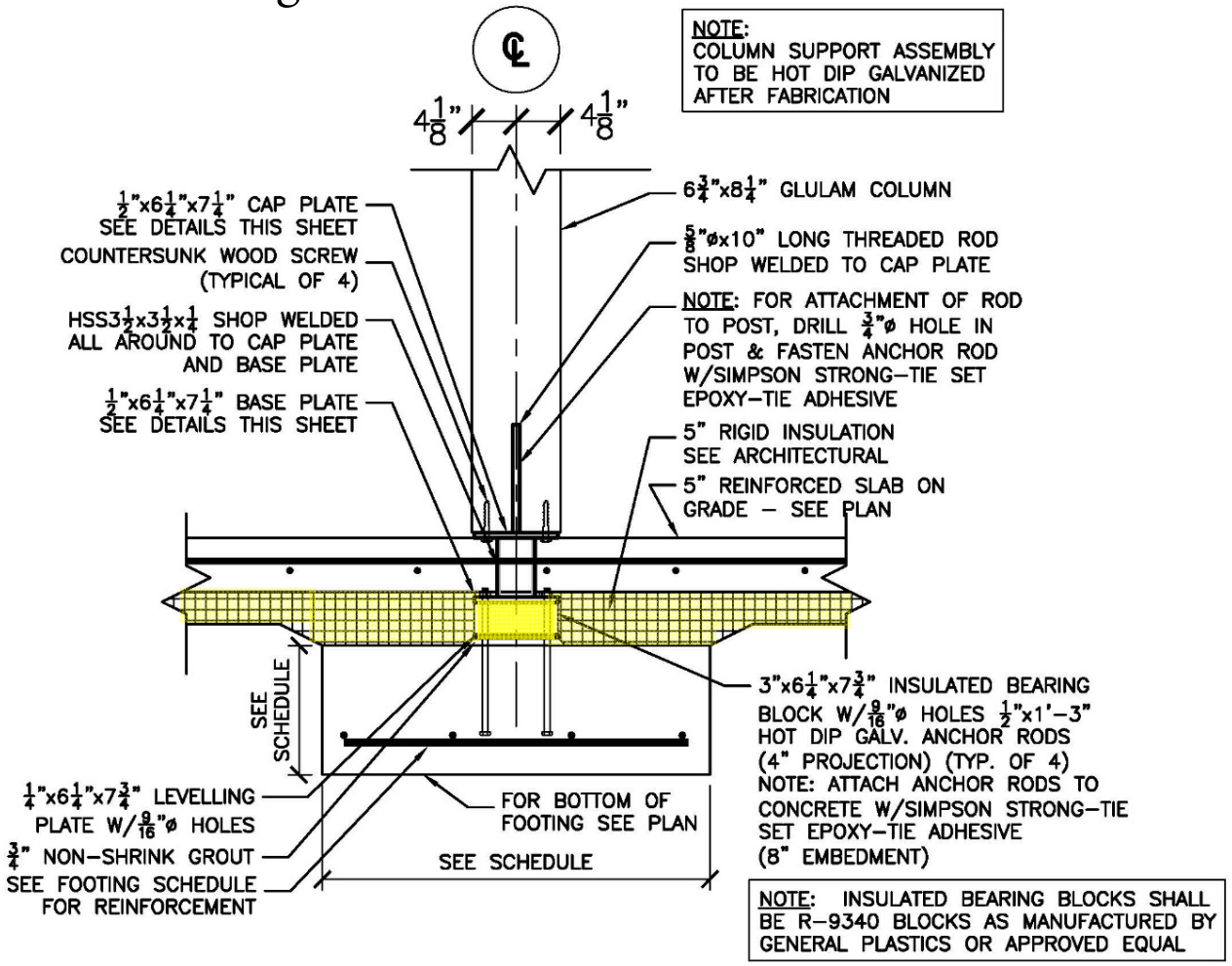
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

Civil & Structural Engineers
DeWolfe
ENGINEERING ASSOCIATES

- Building Details – Thermal isolation block



TYP. INTERIOR COLUMN & FOOTING DETAIL

SCALE: 3/4"=1'-0"

4
S2.1

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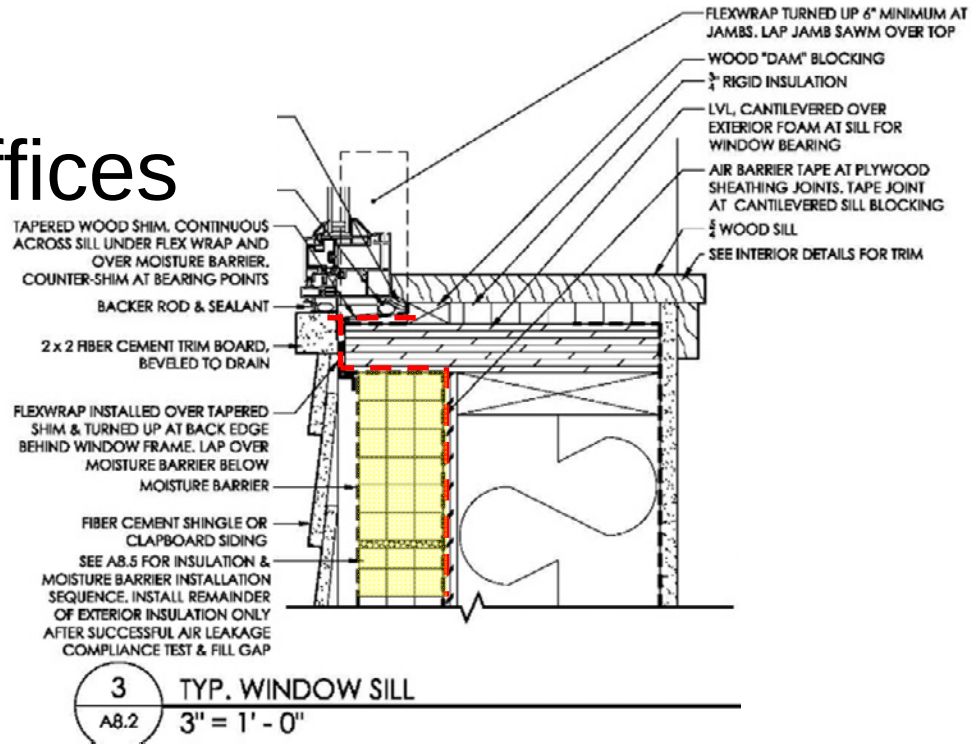
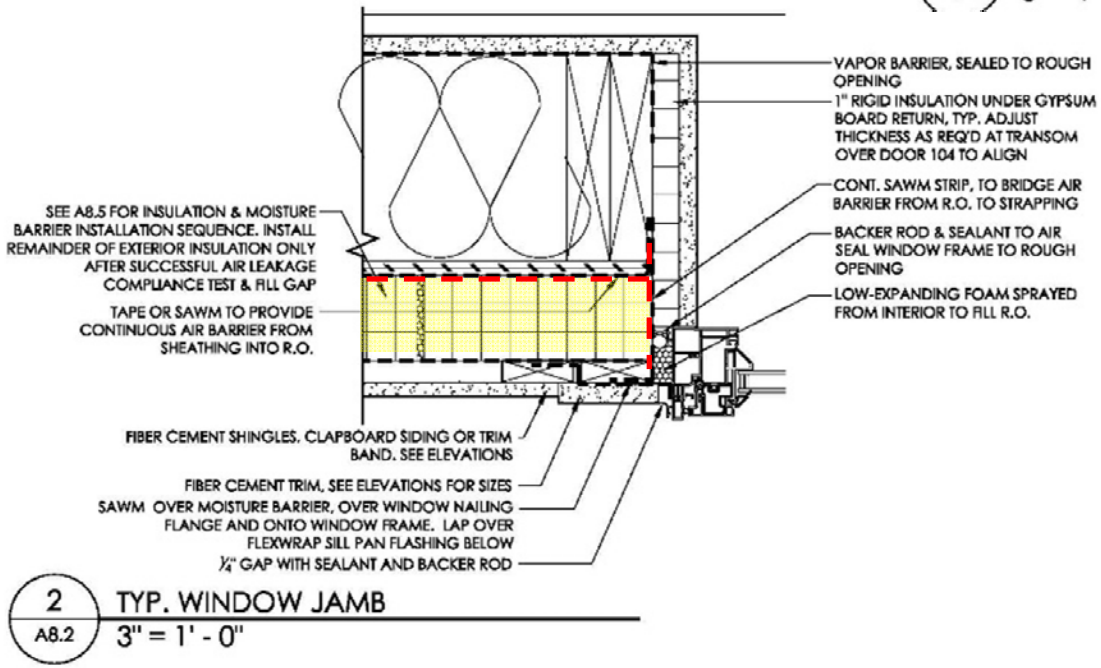
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices -Construction

Waitsfield Town Offices

- Building Details – windows





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CHOICES IN SUSTAINABILITY

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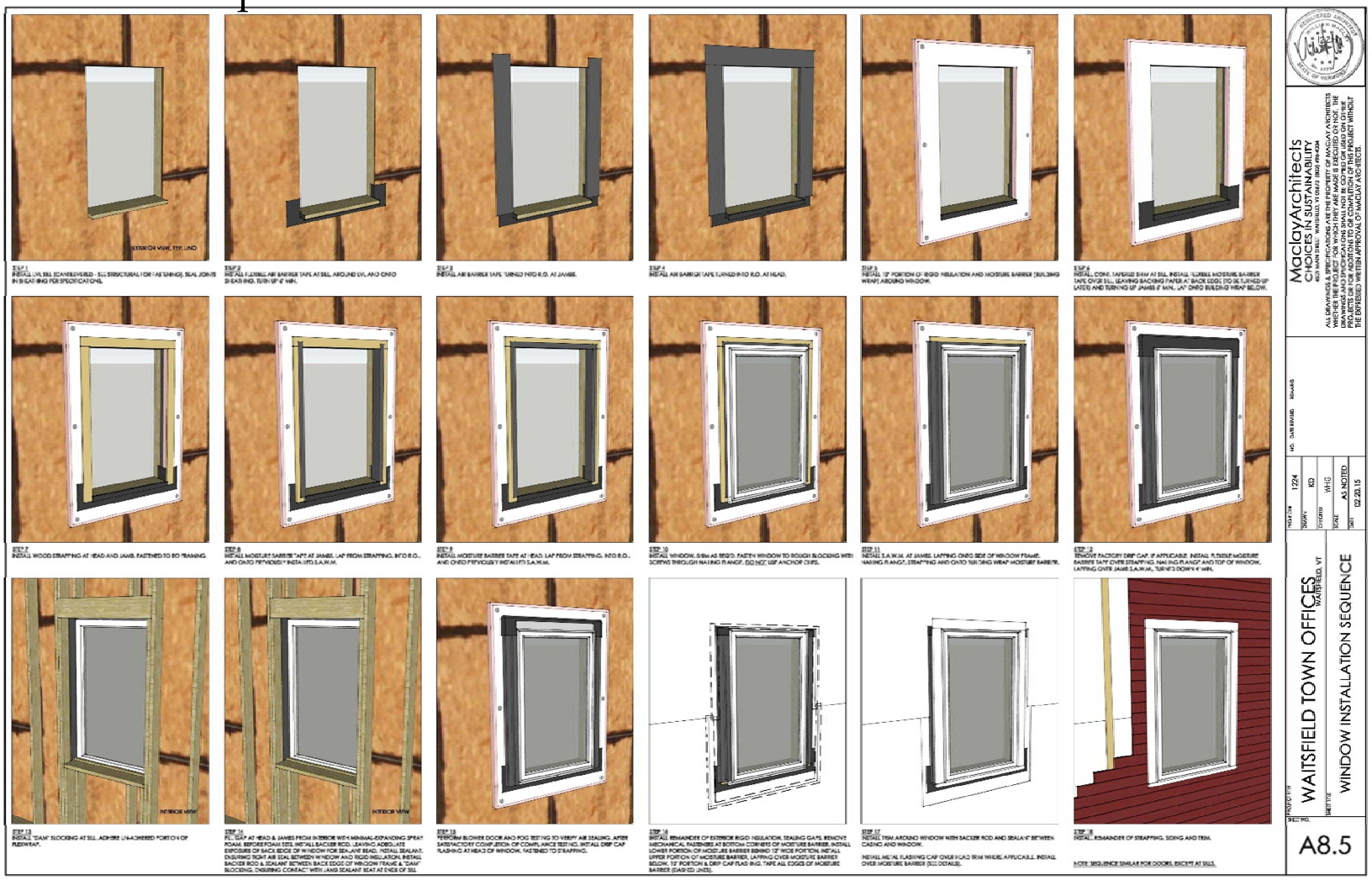
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Window Sequence



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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices -Construction

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices -Construction

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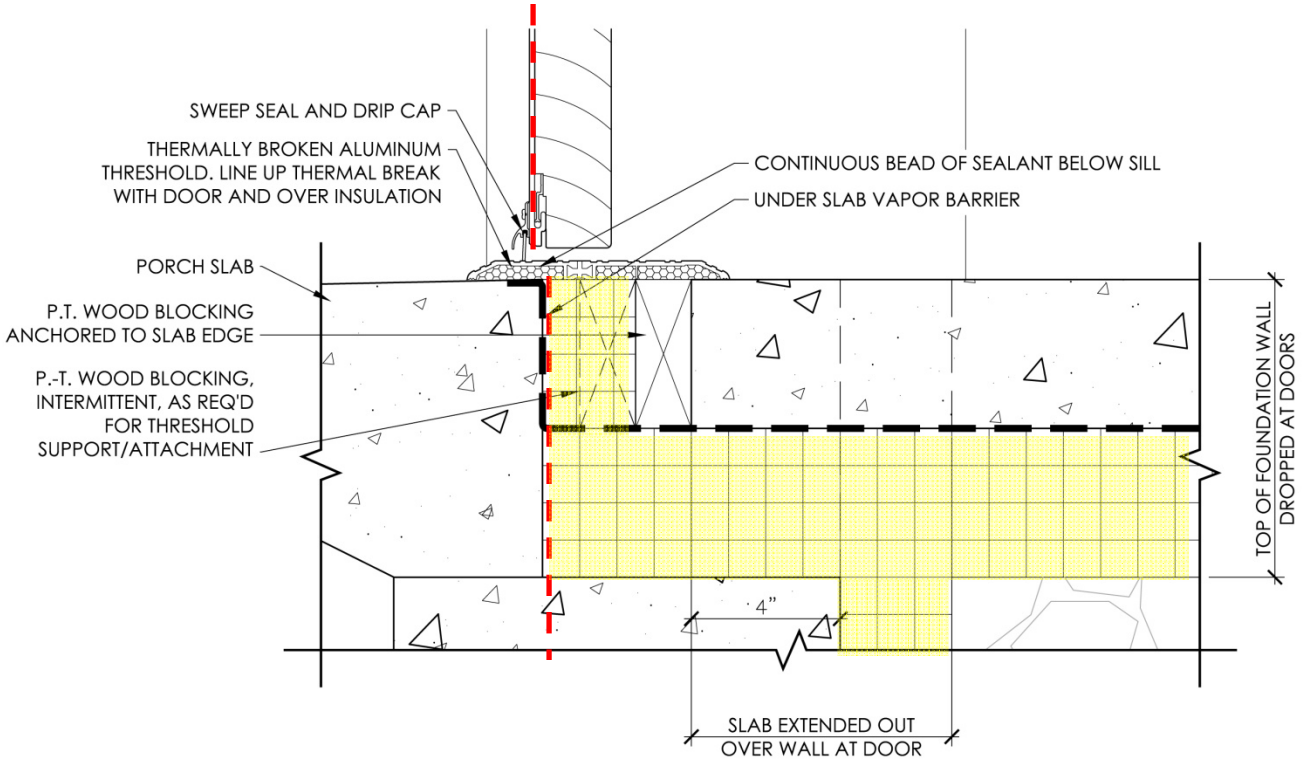
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Building Details – Door sill – thermal break



4 / A8.3 DOOR SILL @ PORCH
3" = 1' - 0"

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Building Details – Door sill – thermal break

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices -Construction

MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices -Construction

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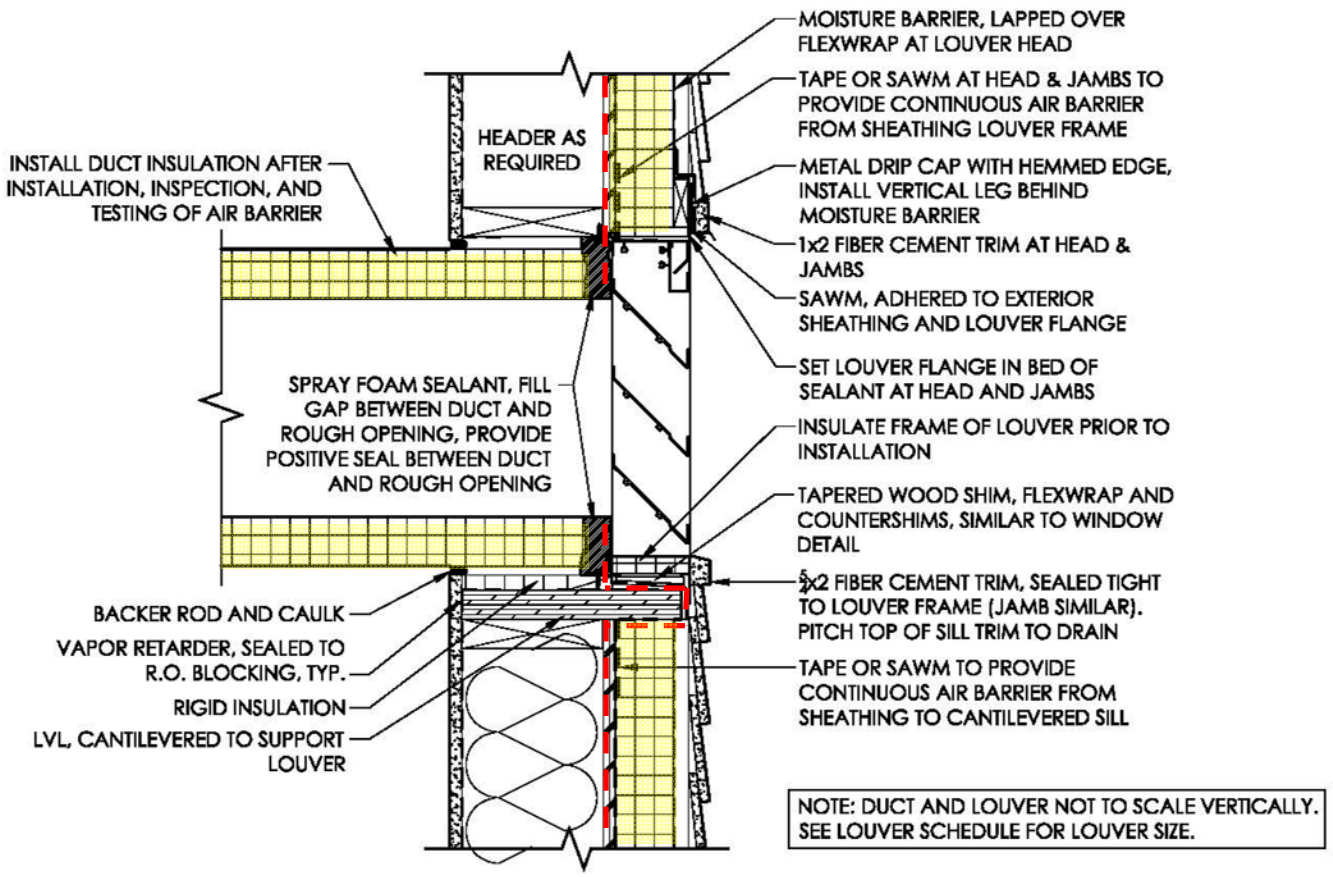
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

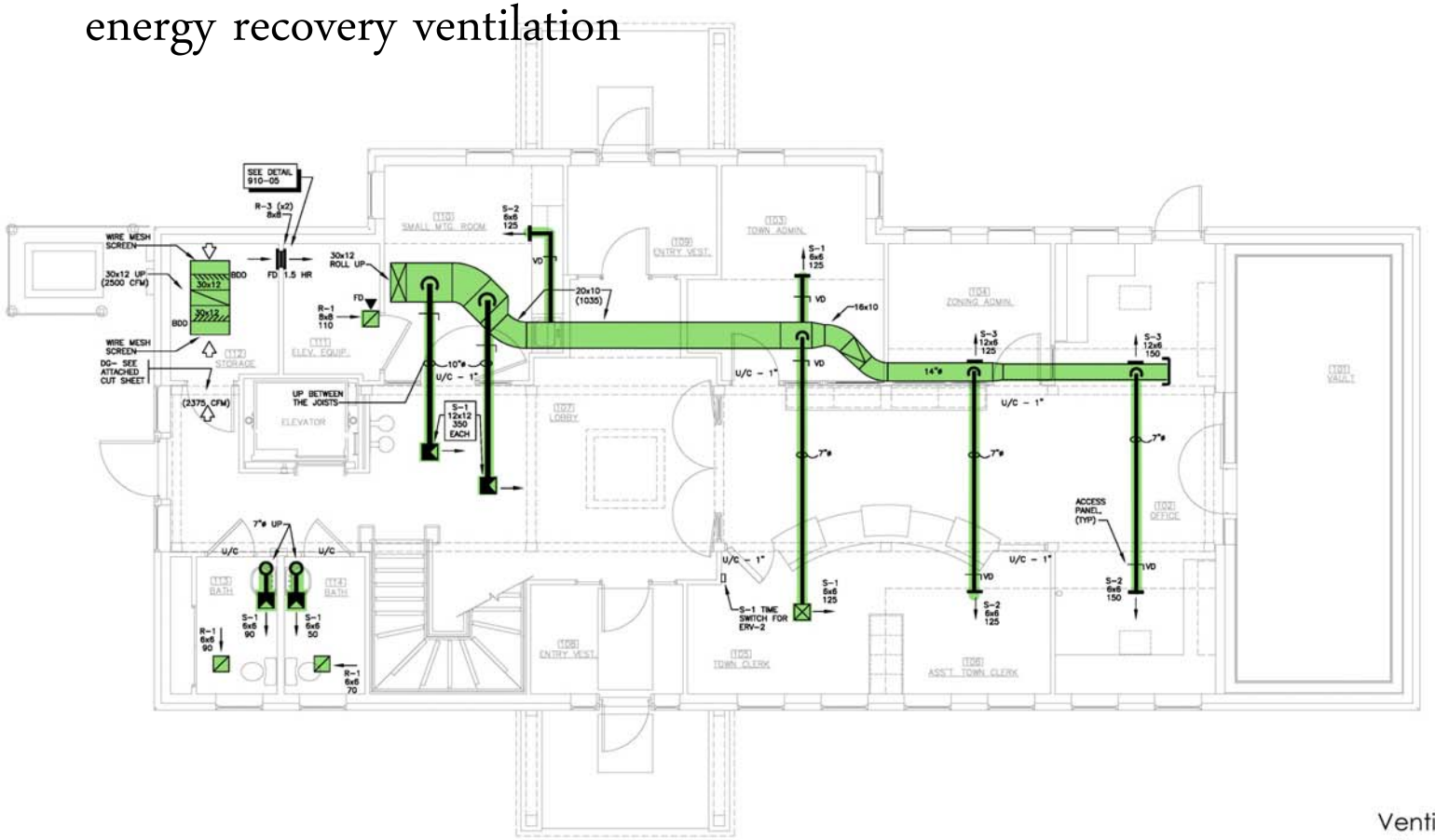
- Building Details – Louver



10 / A8.1 TYP. LOUVER
1 1/2" = 1' - 0"

Waitsfield Town Offices

Combined: Ducted air source heat pump heading and cooling with energy recovery ventilation



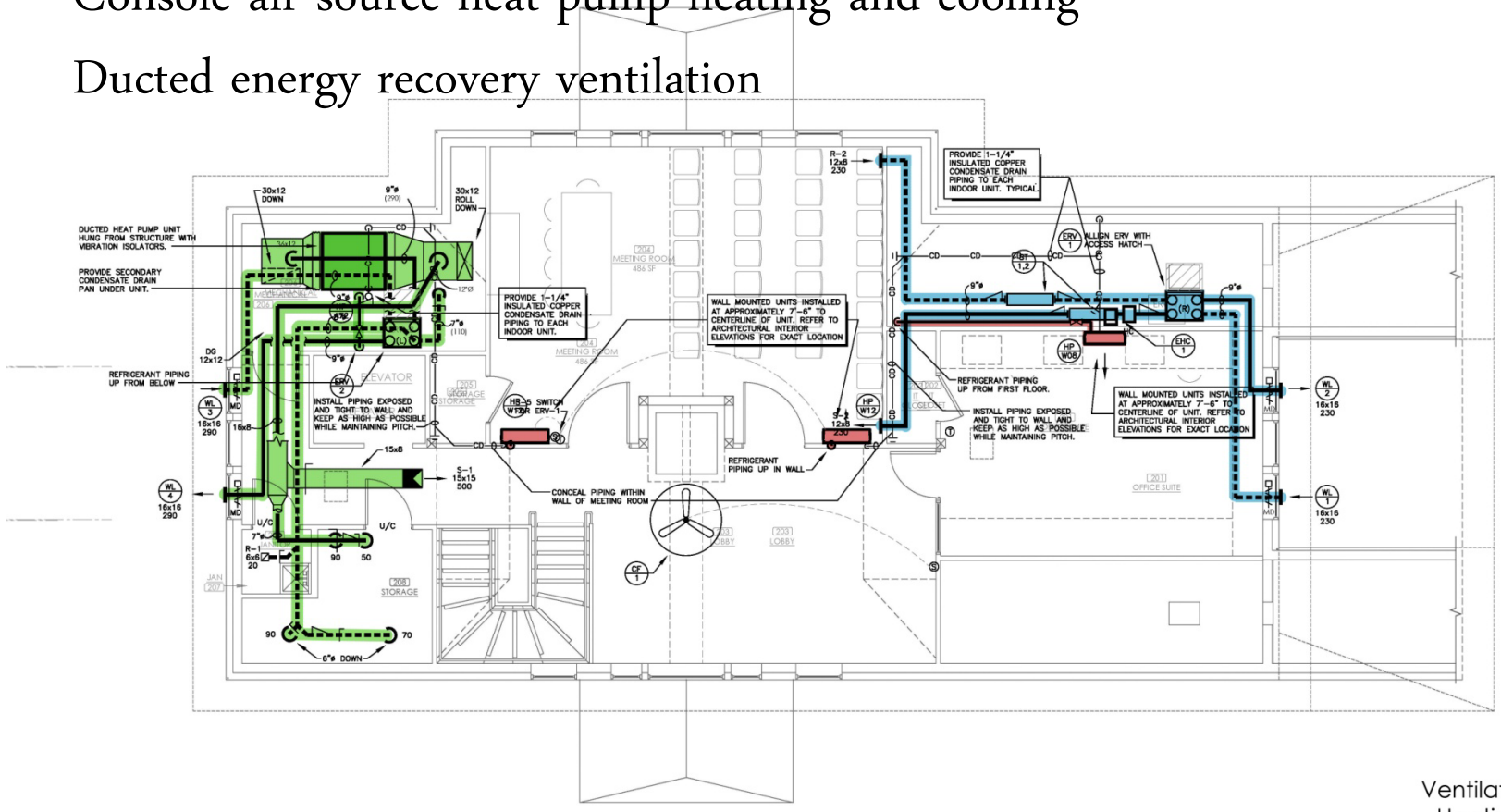
Ventilation - ERV
Heating - ASHP
Combined

Waitsfield Town Offices

Separate:

Console air source heat pump heating and cooling

Ducted energy recovery ventilation



Ventilation - ERV
Heating - ASHP
Combined

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency
- Renewable Energy Generation – Town installation net metered offsite, ground mounted fixed array at Town Garage
- Energy Modeling
- Commissioning
- Construction Costs
- Client Interactions

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – offsite PV

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices – offsite PV

100 kW Town owned system ~ 17 kW needed for Town Offices

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency
- Renewable Energy Generation
- Energy Modeling – First - internal modeling and financial analysis, Later -Kohler and Lewis modeled in order to participate in the pilot program
- Commissioning
- Construction Costs
- Client Interactions

MaclayArchitects
CHOICES IN SUSTAINABILITY

ERICKSON CONSULTING LLC

Waitsfield Town Offices

- Additional Construction Costs for Net Zero Ready

	Building Component	Code	Net Zero Ready	Notes	Category Added Cost
Envelope	Windows	double glazed argon filled Marvin Clad Windows	triple glazed argon filled Paradigm windows	No additional cost	$35,000
	Air/Vapor Barrier	Infiltration is 0.5 CFM50/sf	Infiltration is 0.1 CFM50/sf		
	Insulation	Walls: R-20 cavity insulation with 1" exterior rigid	Walls: R-40 - added 3" rigid exterior to code building		
		Roof: R-49	Roof: R-60		
		R10 to 48"	Underslab insluation R 20		
Mechanical	HVAC	Water Source Heat Pump with propane boiler and cooling tower	Ground Source Heat Pump (GSHP)		$40,000
				Total Added Cost	**$75,000**
				Added Envelope Cost Per Square Foot	$8.75
				Added Mechanical Cost Per Square Foot	$10.00
				Total Added Cost Per Square Foot	**$18.75**

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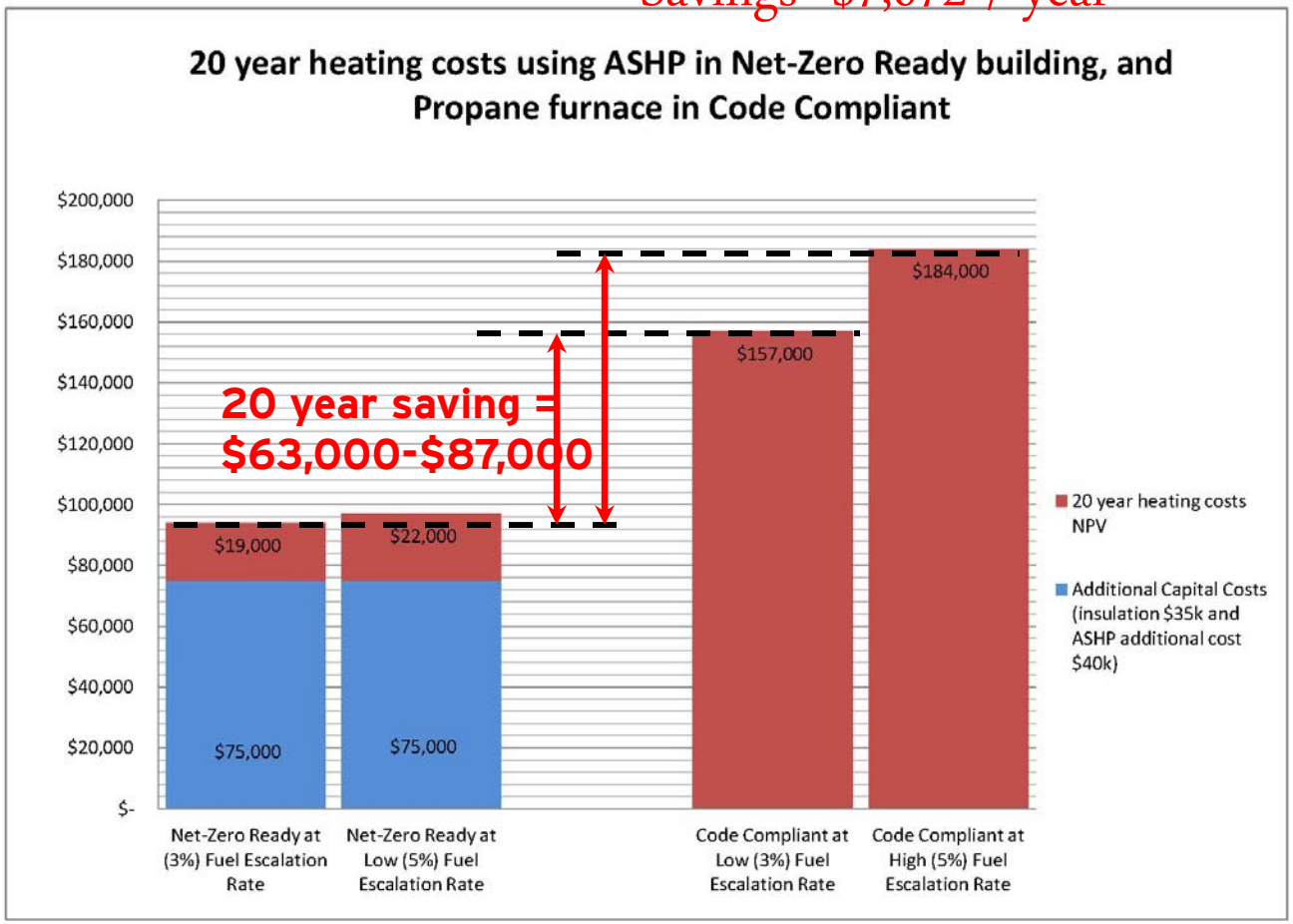
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Heating Costs –
  - First-year Heating Cost Net Zero Ready $990
  - First-year Heating Cost Code $8,062

Savings $7,072 / year



Waitsfield Town Offices

Kohler and Lewis Energy Model to participate in Net Zero Pilot Program

	Percent Savings		Energy Use Intensity	
	Energy	Cost	Proposed Design (kBTU/ft²)	Baseline Design (kBTU/ft²)
Summary Data	**61.1 %**	**52.1 %**	**15.53**	**39.89**

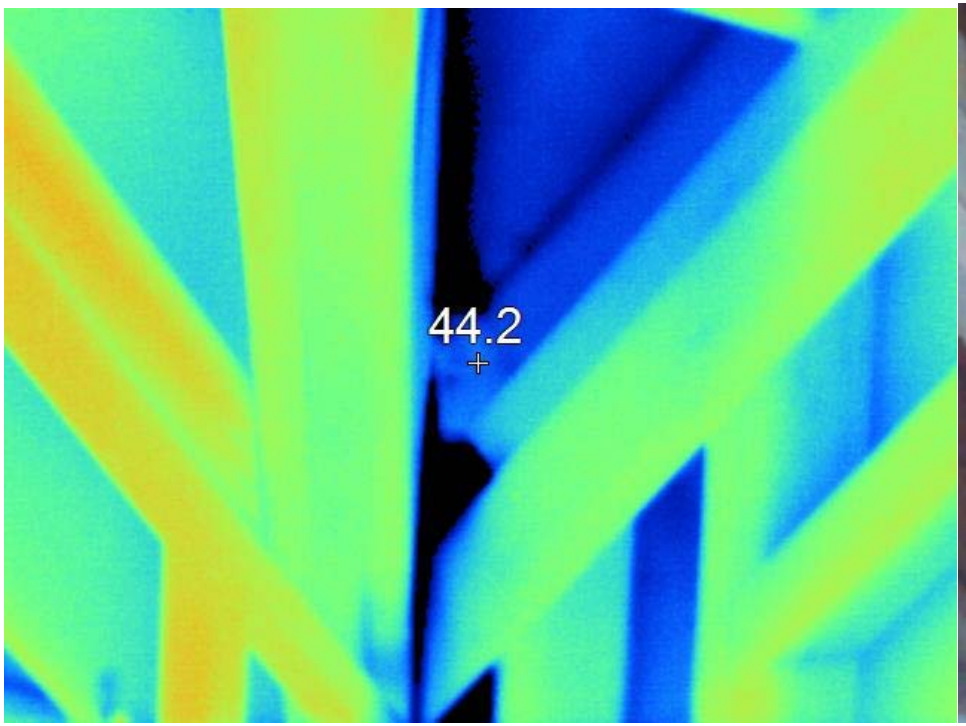
Performance Rating Table - Performance Rating Method Compliance

End Use	Process ?	Baseline Building Units	Baseline Building Results	Proposed Design Energy Type	Proposed Design Units	Proposed Building Results	Percent Savings
Interior Lighting	No	Energy kWh	8,603	Electric	Energy kWh	8,603	0 %
		Demand kW	3.1		Demand kW	3.1	0 %
Space Heating	No	Energy kWh	0	Electric	Energy kWh	2,367	n/a
		Demand kW	0.0		Demand kW	2.9	n/a
Space Heating	No	Energy Gal	987	Propane	Energy Gal	0	100 %
		Demand MBH	99.9		Demand MBH	0.0	100 %
Space Cooling	No	Energy kWh	1,434	Electric	Energy kWh	1,370	4 %
		Demand kW	3.5		Demand kW	2.0	42 %
Pumps	No	Energy kWh	0	Electric	Energy kWh	0	n/a
		Demand kW	0.0		Demand kW	0.0	n/a
Heat Rejection	No	Energy kWh	0	Electric	Energy kWh	0	n/a
		Demand kW	0.0		Demand kW	0.0	n/a
Fans - Interior	No	Energy kWh	7,026	Electric	Energy kWh	2,834	60 %
		Demand kW	2.5		Demand kW	1.6	35 %
Receptacle Equipment	Yes	Energy kWh	2,424	Electric	Energy kWh	2,424	0 %
		Demand kW	0.9		Demand kW	0.9	0 %
Domestic Hot Water	Yes	Energy kWh	569	Electric	Energy kWh	569	0 %
		Demand kW	0.1		Demand kW	0.1	0 %
Energy Totals	Baseline Total Energy Use (kBTU)		159,211	Proposed Total Energy Use (kBTU)		61,986	61 %
	Baseline Annual Process Energy (kBTU)		10,212	Proposed Annual Process Energy (kBTU)		10,212	0 %

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency
- Renewable Energy Generation
- Energy Modeling
- Commissioning
  - Common Sense Energy - Envelope Blower door 1.Air sealing plan/meeting 2. Progress Testing 3. Compliance Testing 4. Record Test upon completion
  - Mechanical - Thomas Engineering Associates – added to comply with Pilot Program
- Construction Costs
- Client Interactions

Waitsfield Town Office – Progress Testing



MaclayArchitects
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency
- Renewable Energy Generation
- Energy Modeling
- Commissioning
- **Construction Costs – Analysis during design**
- Client Interactions

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

- Energy Charrette
- Energy Efficiency
- Renewable Energy Generation
- Energy Modeling
- Commissioning
- Construction Costs
- Client Interactions
  - Needed to prove no net cost to participate in pilot program
    (The Town was already committed to a Net Zero building)

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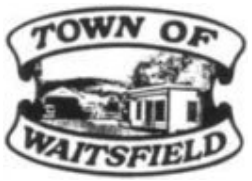
CHOICES IN SUSTAINABILITY

Waitsfield Town Offices



- Benefits from participation in pilot program
  - Energy model to compare actual energy performance
  - eGauge Monitoring
  - Mechanical Commissioning
  - Marketing opportunity
- Opportunities for the future
  - Small project modeling flexibility
  - Possible financial support for incremental net zero capital costs

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CHOICES IN SUSTAINABILITY

Waitsfield Town Offices

Summary

- Net Zero Definition
- Energy Efficiency
- Renewable Energy
- Commissioning
- Energy Modeling
- Cost-Effectiveness
- Plug Loads

Summary

Equipment Approach

5-10%*

energy savings

Minimum Assistance | Above-Code Equipment

Yankee Farm Credit

Efficiency Vermont provided financial support for efficient equipment, enabling above-code energy performance.

Equipment Approach

High Performance

10-20%*

energy savings

Moderate Assistance | Above-Code Performance

Norwich University

Supporting a comprehensive approach to energy efficiency, Efficiency Vermont helped this customer attain a high performance goal.

Whole Building Approach

Net Zero

30-45%*

energy savings

Extensive Assistance | Best Building Performance

Northfield Savings Bank

Efficiency Vermont worked closely with the project team to set a path to achieve their net zero goal.

Whole Building Approach

*Versus 2015 VT CBES

Photos: Leslie O'Halloran & Gary Hall Photography

QUESTIONS AND DISCUSSION

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Efficiency Vermont