BUILDINGENERGY BOSTON

Commitment to Learning: A Case Study of Three Public Schools

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Curated by Aidan Mayer and Joy Yakie

Northeast Sustainable Energy Association (NESEA)
March 28, 2023

Building Energy Boston

Commitment to Learning | Case Study of 3 Public Schools

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HMFH ARCHITECTS

SPEAKERS

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Sustainability Leader
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Senior Associate
Sustainability Leader
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Break the ice...

SUSTAINABILITY VISIONING

ACTIVITY:

Consider your top priority related sustainability, or sustainable practices more generally and write it down.

Sustainability for All

Thoughtfully addressing overlapping systems requires effort and coordination between multiple design disciplines along with the project community.

Public school projects are a highly visible commitment from a community towards future generations, serving a wide range of students from diverse backgrounds and are a valuable resource to the surrounding community. Balancing strategies that fit within the goals and budget of a public institution and focused equally on energy, carbon, water, and waste can be difficult. Linking the strategies for each goal to impacts on the health and well-being of students provides a new framework for evaluating the impacts of design.

FRAME THE CONVERSATION

what is SUSTAINABILITY

SOCIAL SUSTAINABILITY
health & wellbeing
place
connectivity

ECONOMIC SUSTAINABILITY
prosperity
living infrastructure
resource regeneration

ENVIRONMENTAL SUSTAINABILITY
resource regeneration
living infrastructure
health & wellbeing

EDUCATIONAL SUSTAINABILITY
connectivity
living infrastructure
prosperity
health & wellbeing

FOCUS THE CONVERSATION

SET GOALS

MATERIALS + SOCIAL JUSTICE	HEALTH + WELL-BEING	WASTE + WATER	ENERGY + CARBON
Red list Free Materials for all Touch Surfaces	Access to Fresh Air in all Regularly Occupied Spaces	% Indoor Water Use Reduction	No On-Site Combustion
Inclusive and Equitable Design and Process	Access to Daylight and Views in all Regularly Occupied Spaces	Comprehensive Composting Program	Zero Energy Building
	Maximize Access to Educational Content through Enhanced Acoustic Performance	Potable Water Use Reduction	Maximize Incentives and Grants
		On-Site Stormwater Management	Measure Embodied Carbon at every project phase
			Reduce Embodied Carbon - LEED Standards

CASE STUDIES

Bristol-Plymouth Regional Technical High School

SIZE **420,000 SQFT**

GRADES **9-12**

ENROLLMENT **1434**

OPENS 2025

Annie E. Fales Elementary School

SIZE **72,000 SQFT**

GRADES **K-3**

ENROLLMENT **400**

OPENED 2021

Produces 11.6% More Energy than is consumed

24.9 EUI

40 Geothermal Wells @ 600'

1,354 PV Panels @ 375W / Panel

648,000 kw-hr PV Array

100% of the Learning Spaces have access to daylight and views

Bristol County Agricultural High School

SIZE **113,500 SQFT NEW 82,500 SQFT RENO**

GRADES **9-12**

ENROLLMENT **640**

OPENED 2020

39 pEUI for CSE

68% Water Use Reduction from code

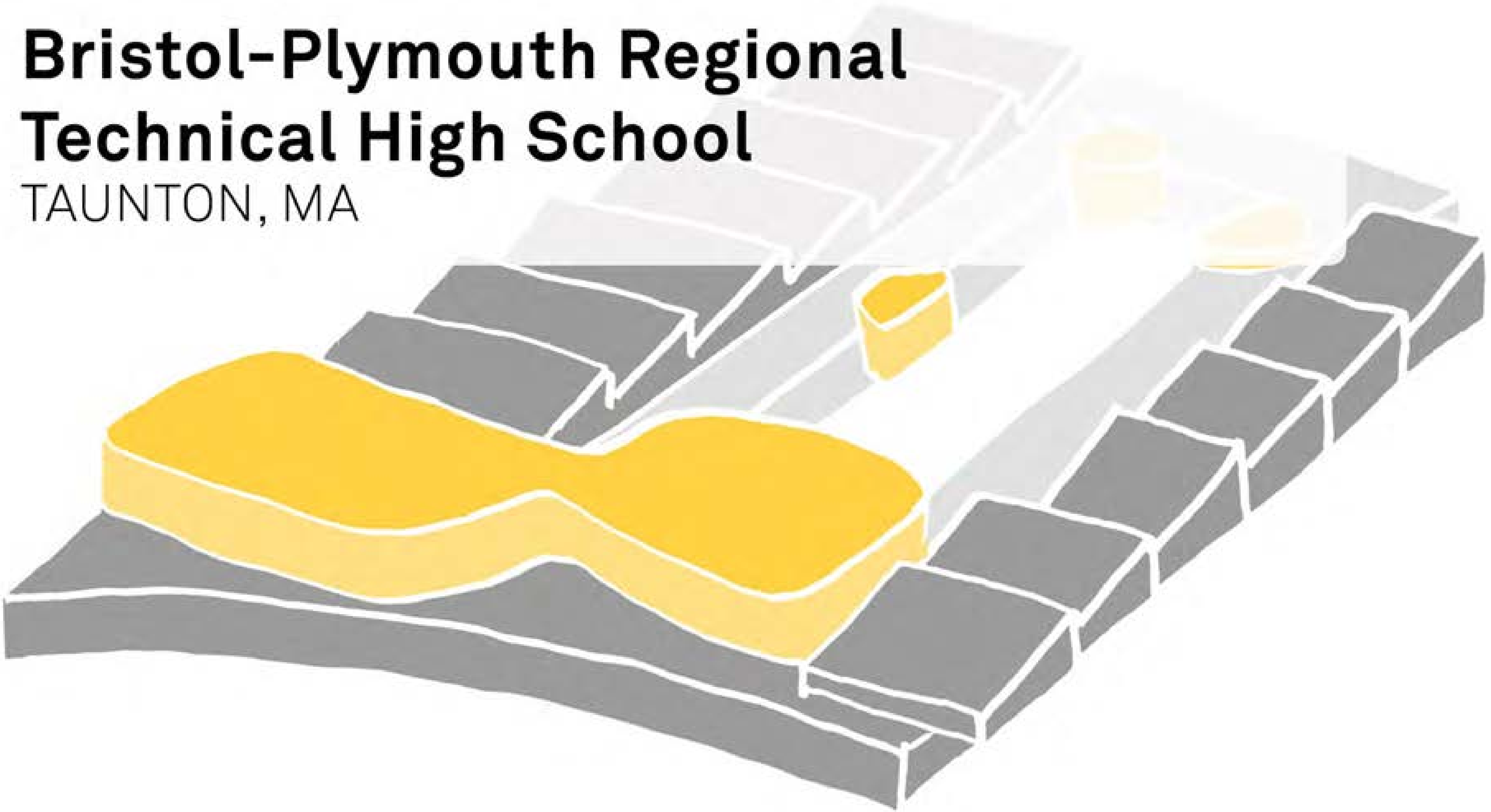
221 metric tons carbon avoided with (3) Timber buildings compared to steel

744 metric tons carbon avoided by reusing existing buildings

92% Regularly Occupied Bldgs have access to daylight and views

Bristol-Plymouth Regional Technical High School

TAUNTON, MA

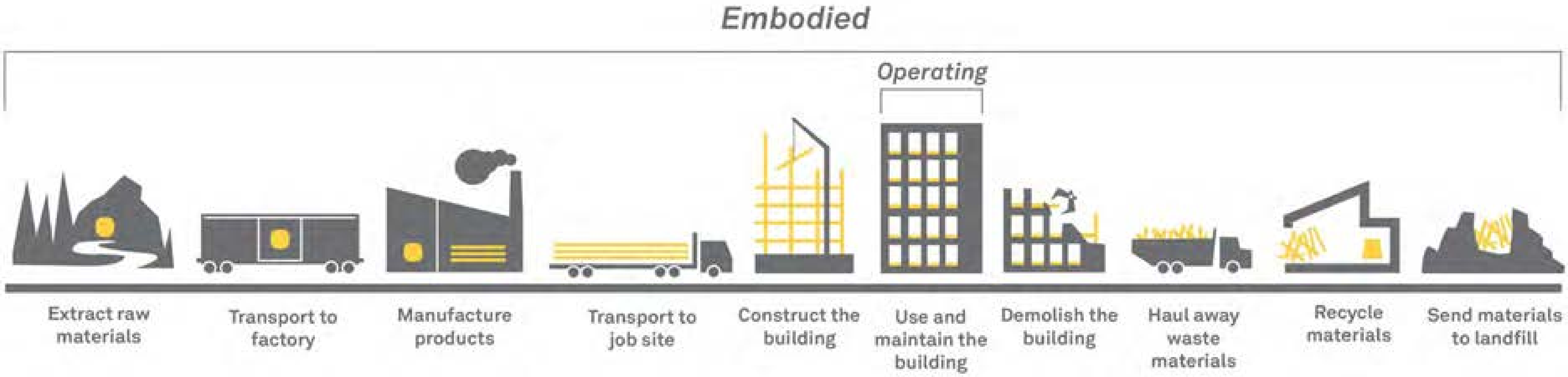



BRISTOL-PLYMOUTH REGIONAL TECHNICAL HS

Sustainability and Educational Design goals

THINKING BEYOND BUILDING OCCUPANTS

Circular Economy + Embodied Carbon



HMFH INITIATIVE

GOAL - RED List Free Materials

HMFH's design approach creates buildings with the best possible environmental quality. We focus on standards that optimize human health without compromising the health of the natural environment. This is done by specifying non-toxic materials based on the best available information and data. Our priority is the surfaces we touch but aim for all materials on any given project.

https://www.aia.org/pages/6351155-materials-pledge

HMFH PILOT PROGRAM

In the News - Coordination with MSBA

'The more you dig into it, you think, Oh, God.' A growing mission seeks to reduce toxic chemicals in schools

By Kay Lazar Globe Staff, Updated May 2, 2022, 7:15 a.m.

Boston Globe May 2, 2022

Jack McCarthy, executive director of the Massachusetts School Building Authority, aims to slash the number of toxic chemicals used in construction and renovation projects in the state's schools. JONATHAN WIGGS/GLOBE STAFF

The image is seared in Jack McCarthy's mind: a group of pre-kindergarteners gathered for story time, sitting in a circle on the carpet of a classroom, amid an invisible witches' brew of chemicals lurking in the dust on the floor.

Ever since he heard a talk a couple of years ago about health problems linked to flame retardants, stain repellents, and other potent building chemicals, McCarthy, executive director of the Massachusetts School Building Authority, has been on a mission to slash the number of such substances in the state's schools. His vision is taking hold in a $305 million construction project for a new Bristol-Plymouth Regional

HMFH PILOT PROGRAM - INTERNAL TRACKING

Material Sorting - Tier System

TIER 1 - LBC Declare Label with Red List Free Status

Products that disclose 100% of ingredients present at or above 100ppm (0.01%) in the final product and do not contain any Red List chemicals

TIER 2 - LBC Declare Label with Red List Approved Status

Products that disclose a minimum of 99% of ingredients present in the final product and meet the Red List Imperative requirements through one or more approved exceptions

TIER 3 - Cradle to Cradle Gold

TIER 4 - Cradle to Cradle Silver

TIER 5 - LBC Declare Transparency Label

Products disclose 100% of ingredients present in the final product, but contain one or more Red List chemicals that are not covered by an approved exception

Every product specified requires an HPD/EPD or letter stating they do not have an HPD/EPD

MATERIAL LABELS

Abiotic Depletion

Acidification Potential

Eutrophication Potential

Global Warming Potential

Ozone Layer Depletion Potential

Photochemical Ozone Creation Potential

Ecotoxicity

Human Toxicity

https://www.hpd-collaborative.org/

https://www.ul.com/resources/environmental-product-declarations-program

MATERIAL SELECTION CONSIDERATIONS

Transparency

Durability

Aesthetics

Cost

Warranty

Utility

Embodied Carbon

Material Transparency

Strategies for Implementation

EASY WINS
EFFICIENCY

EASY WINS

ACOUSTIC CEILING TILES

EASY WINS

ACOUSTIC ROOM COMPONENTS

EASY WINS

CARPET

EASY WINS

RESILIENT FLOORING

CHALLENGE

GYPSUM

CHALLENGE

PVC

CHALLENGE

INSULATION

CHALLENGE

LIGHTING

MISSING
MEP DATA

Public Schools

The Challenge of three equals

LIMITING THE PALETTE

PUBLIC SPACE

ACADEMIC CORRIDORS

TYPICAL CLASSROOMS

PILOT PROJECT - MATERIAL SUMMARY

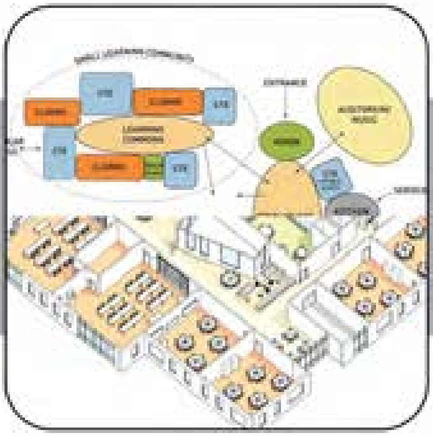
	MEETS GOALS	CHALLENGING	MORE INFO
ACT	●		
Acoustic Room Components	●		
Gypsum		●	
Intumescent Paint		●	
Lighting		●	
Linoleum	●		
Lockers		●	
Marker Boards		●	
MEP		●	●
Paint			●
Spray Fireproofing	●		
Ceramic Tile	●		

Healthy Materials

Strategies for Implementation

MAINTAINING MATERIAL TRANSPARENCY GOALS

PRE-DESIGN



DESIGN

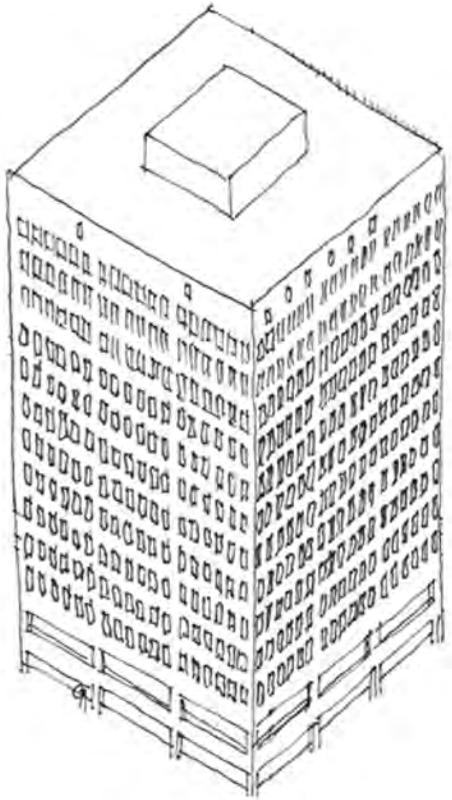
GOAL SETTING

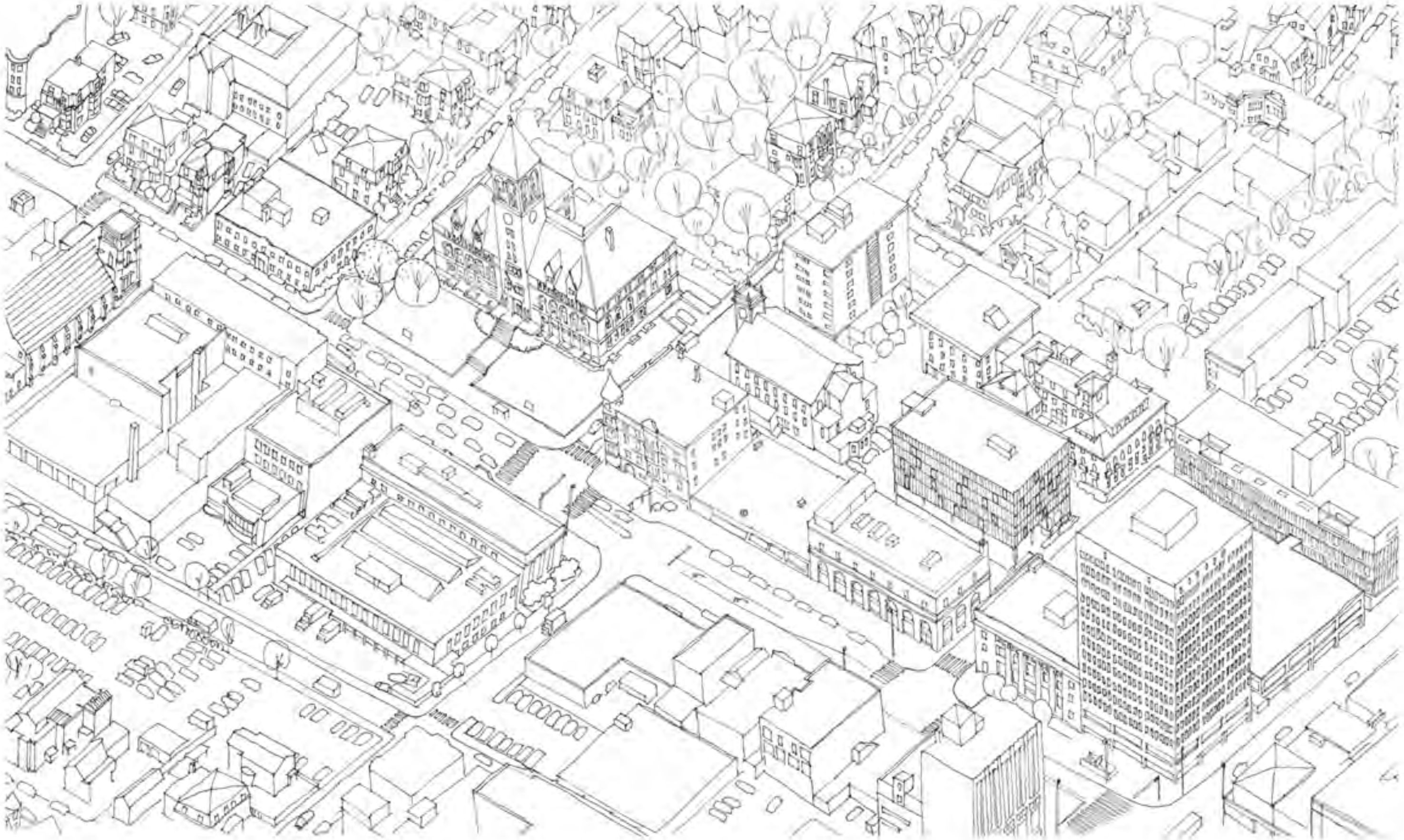
CONSTRUCTION

OCCUPANCY

CLOSING THE LOOP

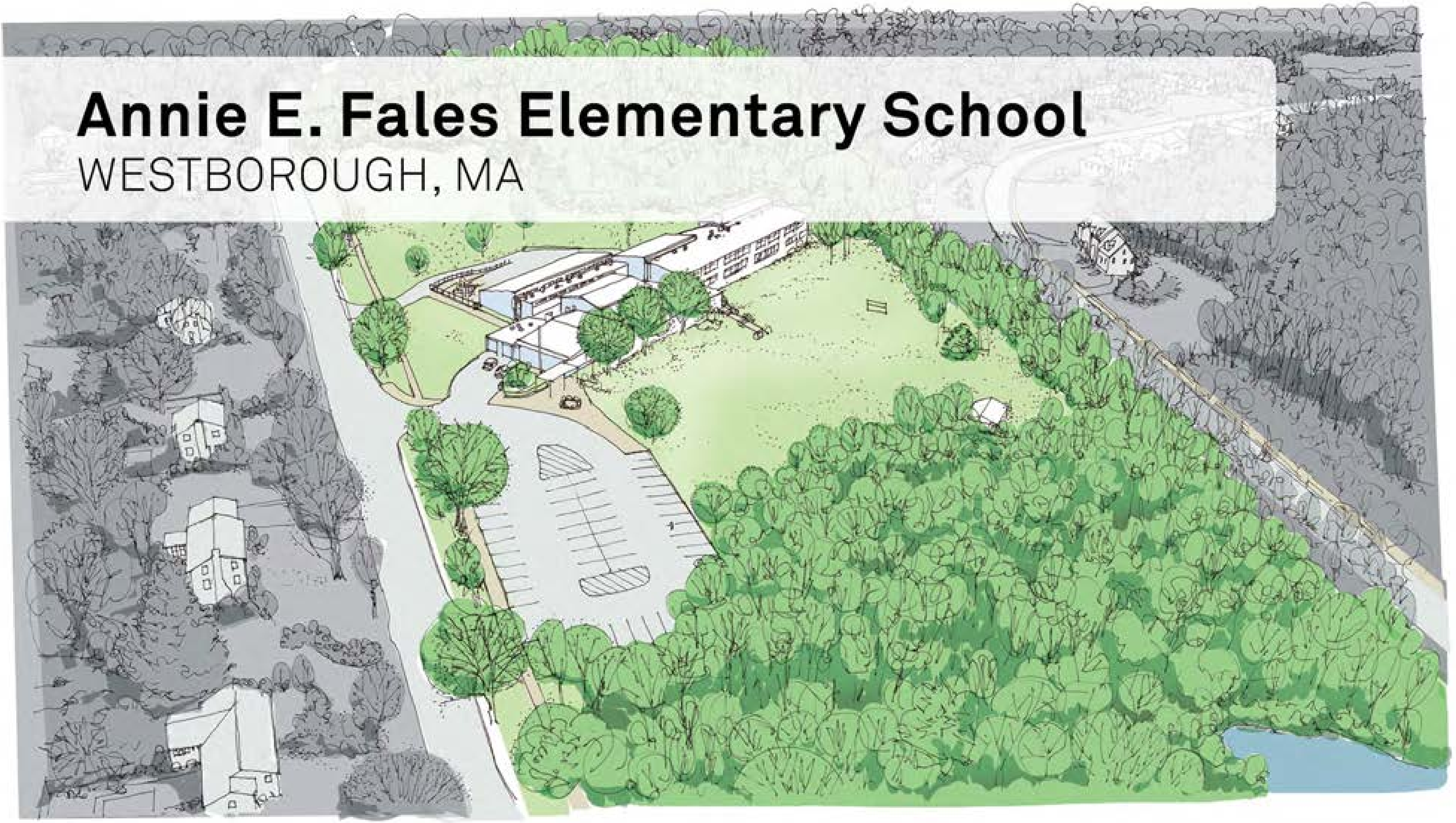
ADVOCACY





Annie E. Fales Elementary School

WESTBOROUGH, MA



ANNIE E. FALES ELEMENTARY SCHOOL

Sustainability and Educational Design Goals

- Connect to Nature
- Design for Young Children
- Maintain an Intimate, Neighborhood School
- Achieve Net Zero Energy

PLAN LAYOUT

- CIRCULATION
- SHARED
- ADMIN/TEACHER
- ART/MUSIC/TECH
- CLASSROOM
- SPECIAL ED
- ATHLETICS
- TOILET
- MECH/STORAGE

SECOND FLOOR

FIRST FLOOR

SITE LAYOUT

Connections to surrounding nature and fostering environmental stewardship

ENERGY GOAL

for this project Zero Net Energy is defined as:

producing on-site renewable energy equal to the energy used to operate the building annually

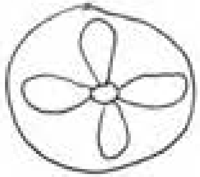
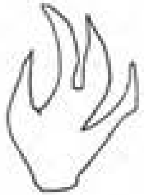
How did we get there?

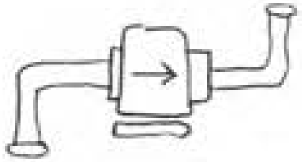
1. ***Reduce*** energy use as much as possible

2. ***Produce*** as much energy as possible

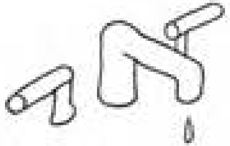
COMPONENTS OF ENERGY USE

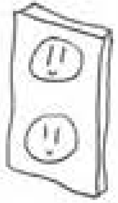
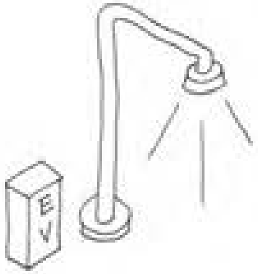
Fales Total Energy Use Intensity (EUI) = 24.9



Ventilation:	4.30	17%
Heating:	2.35	9%
Cooling:	1.97	8%
Pumps:	4.44	18%
HVAC:		52%



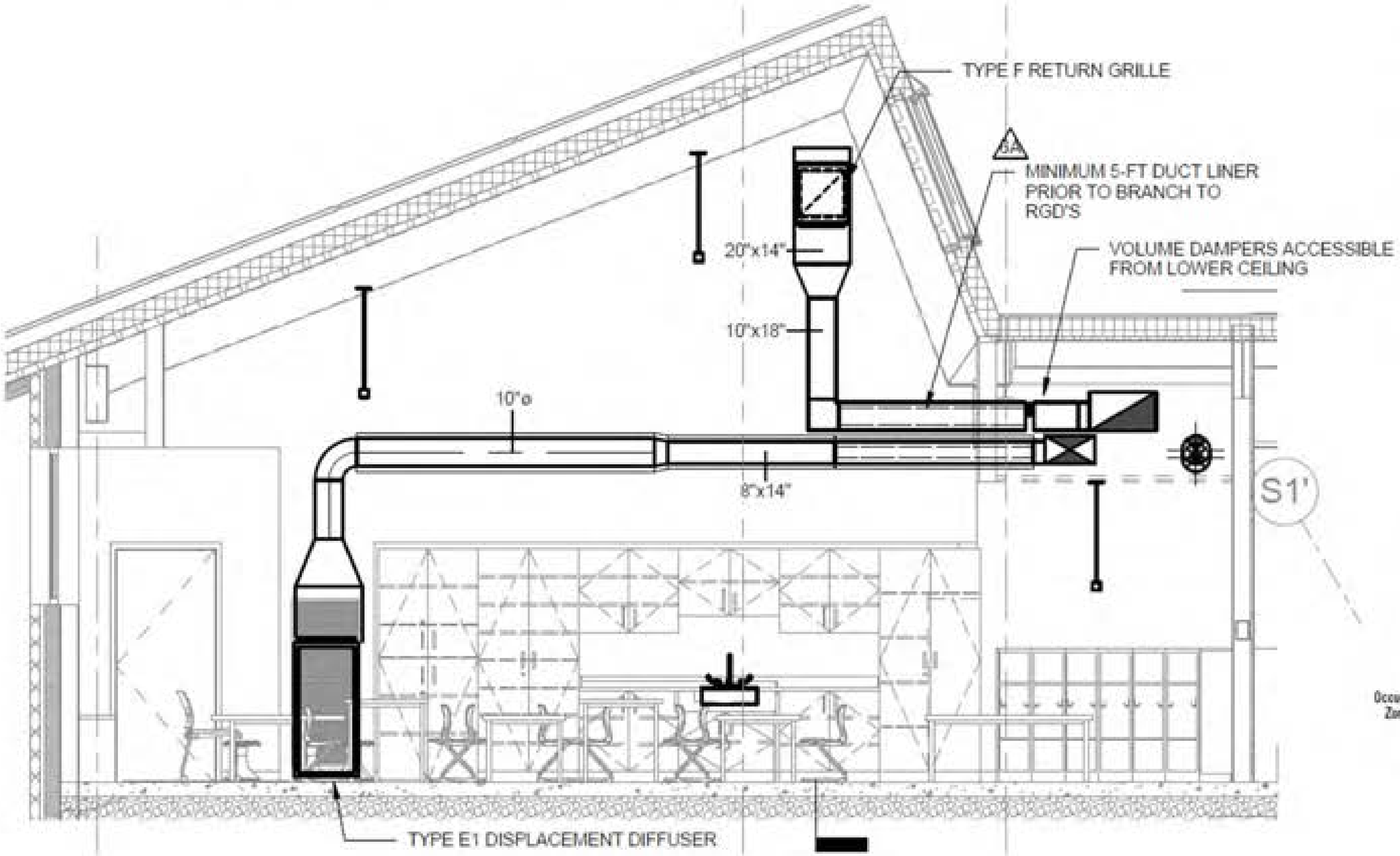



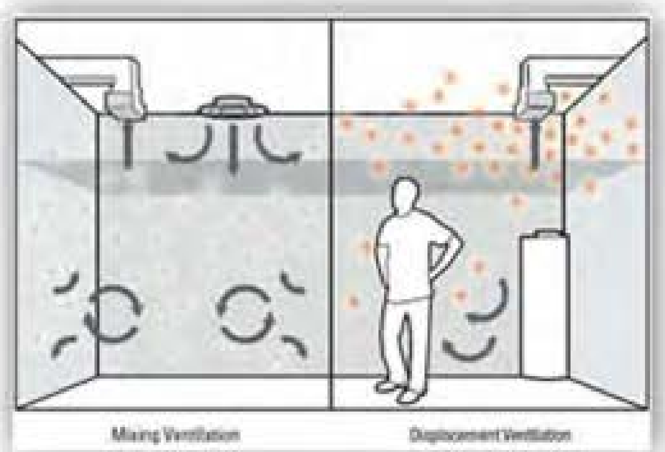
Hot Water:	0.28	1%
Lights:	3.13	13%
Plug Load: including kitchen equipment	7.95	32%
Exterior:	0.46	2%
Other:		48%

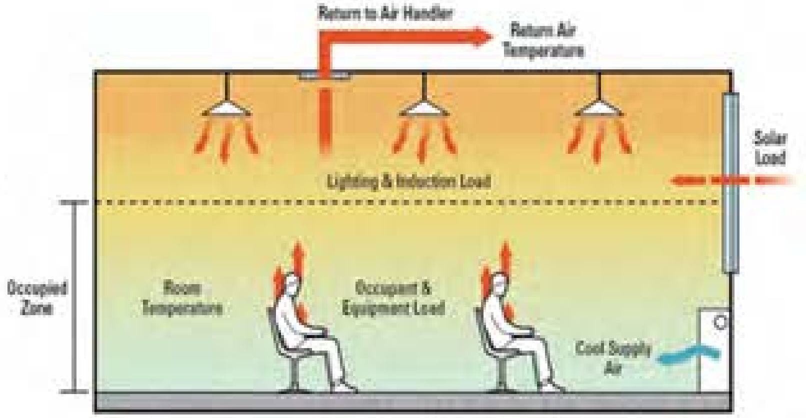
Balancing Energy Goals

Strategies for Implementation

AIR DISTRIBUTION

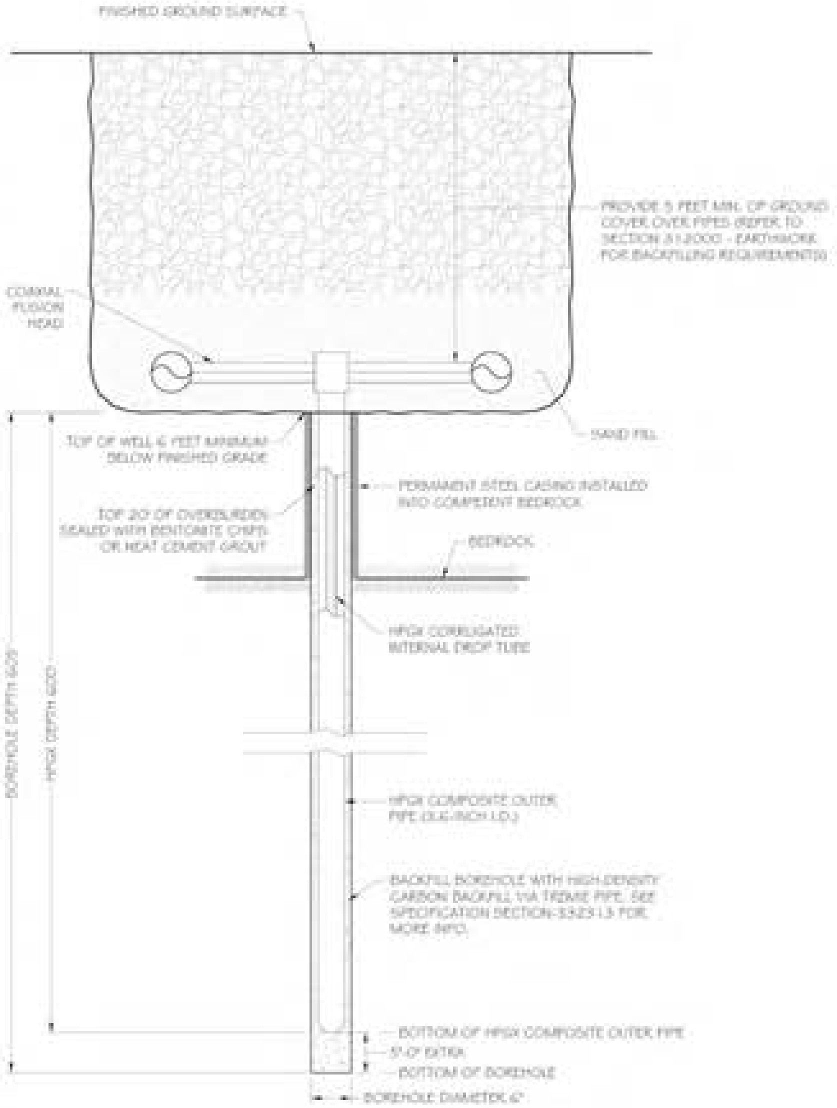






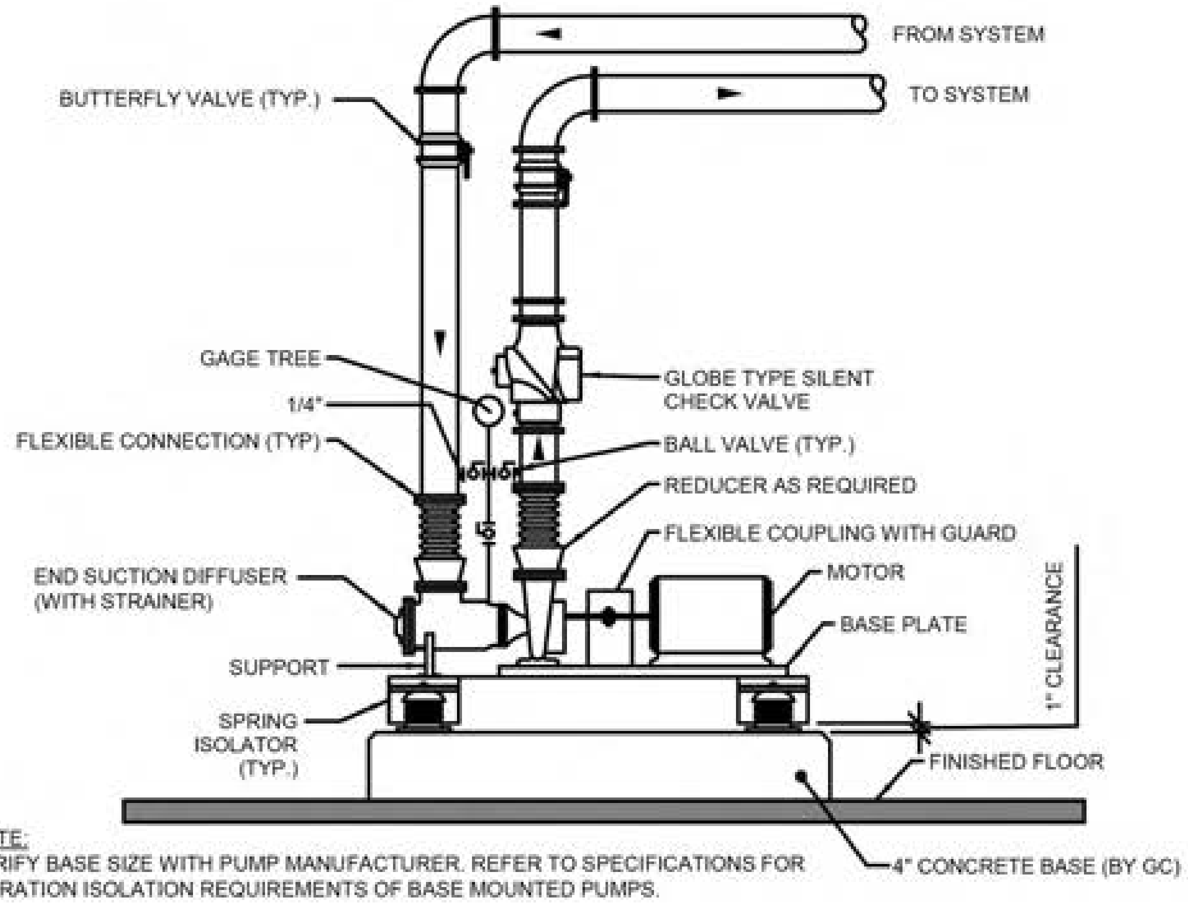
EASY WINS

GEOTHERMAL WELLS

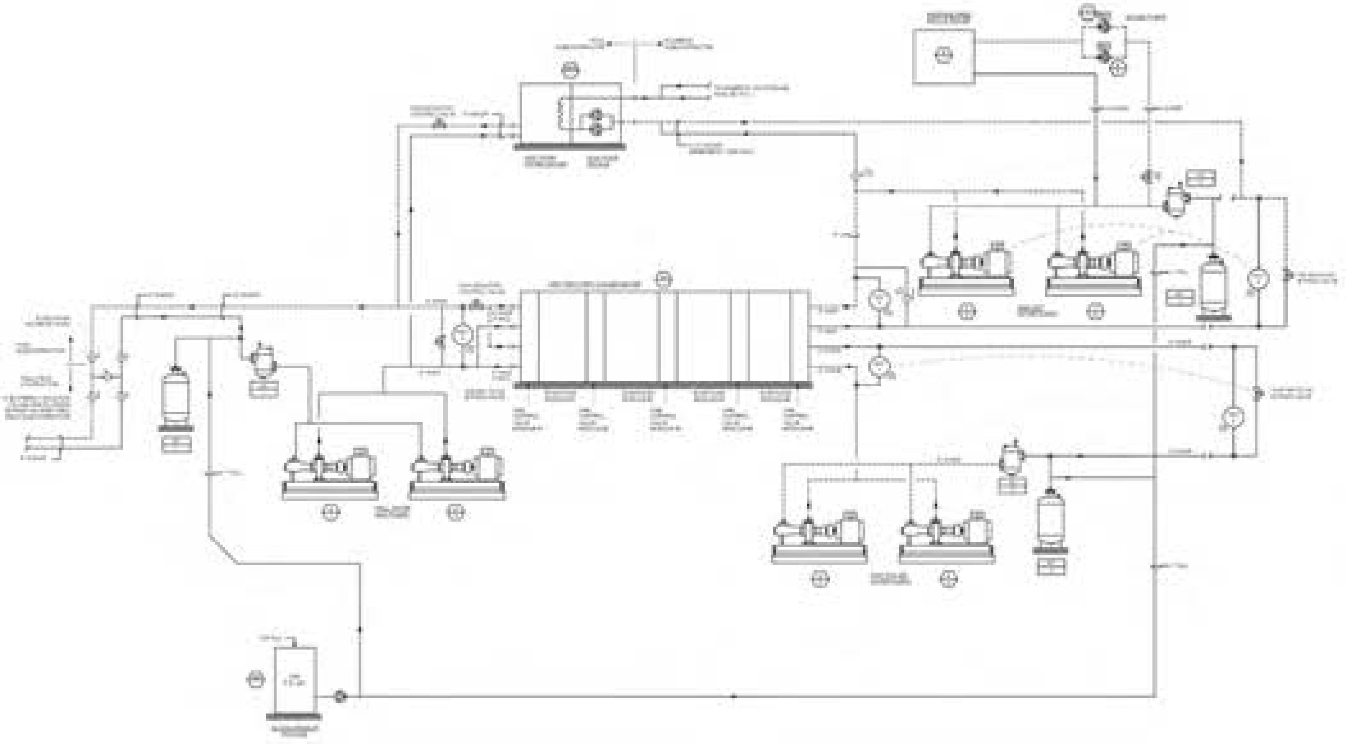


CHALLENGES

GEOTHERMAL PUMPS

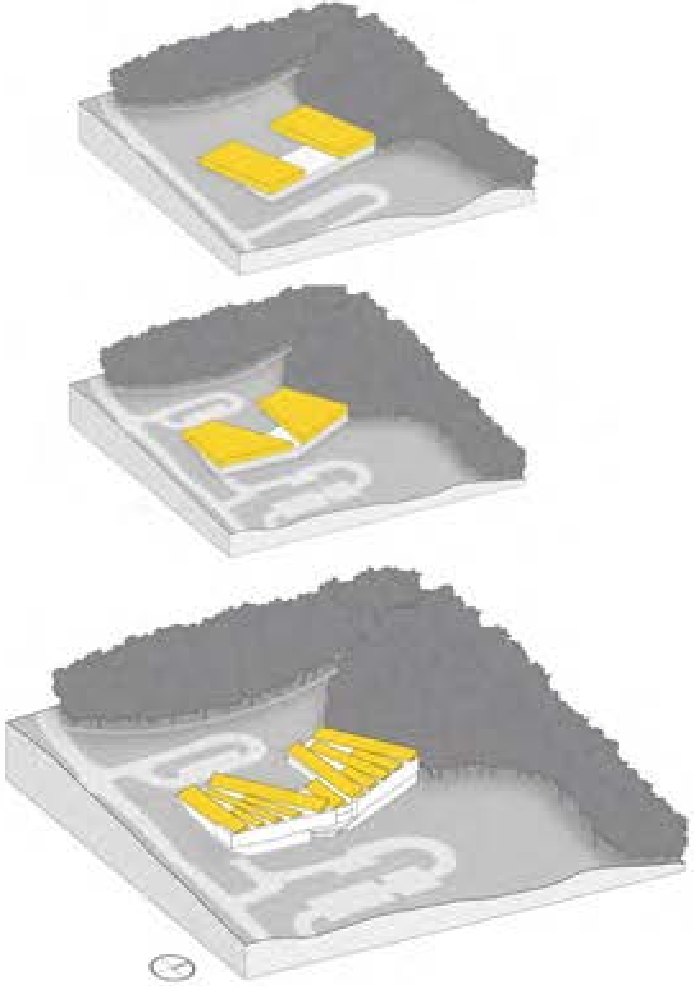


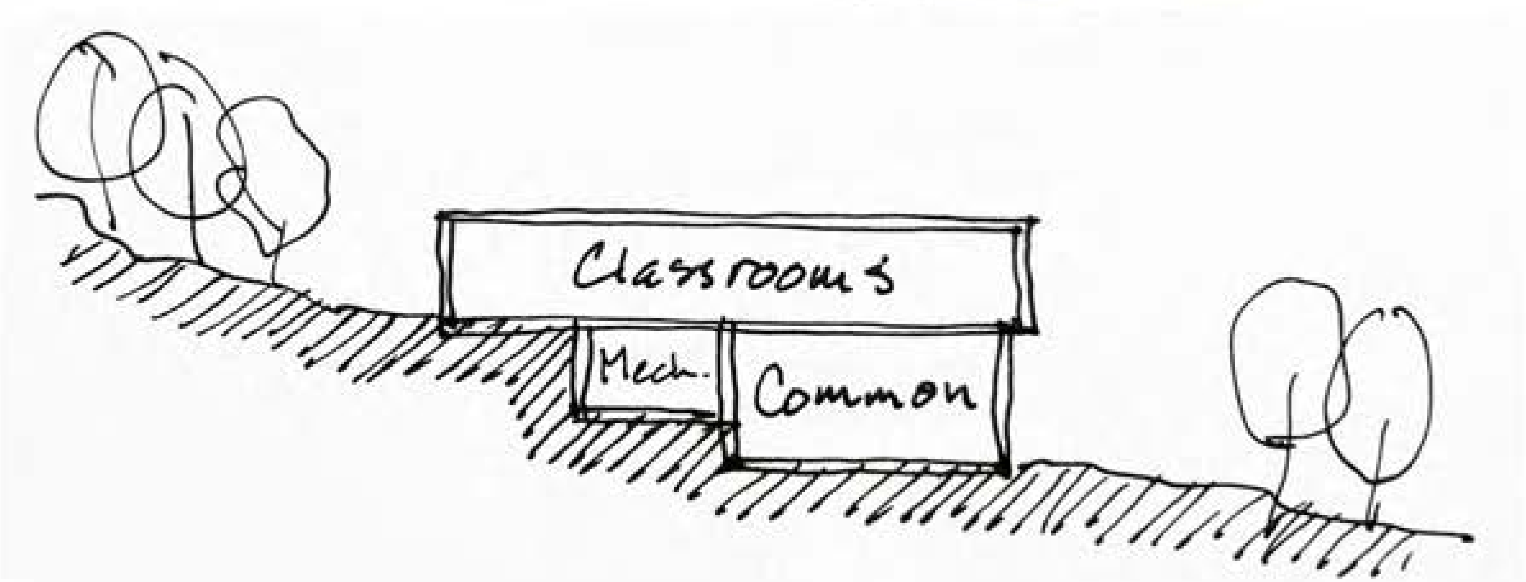
HIGH EFFICIENCY EQUIPMENT



EASY WINS

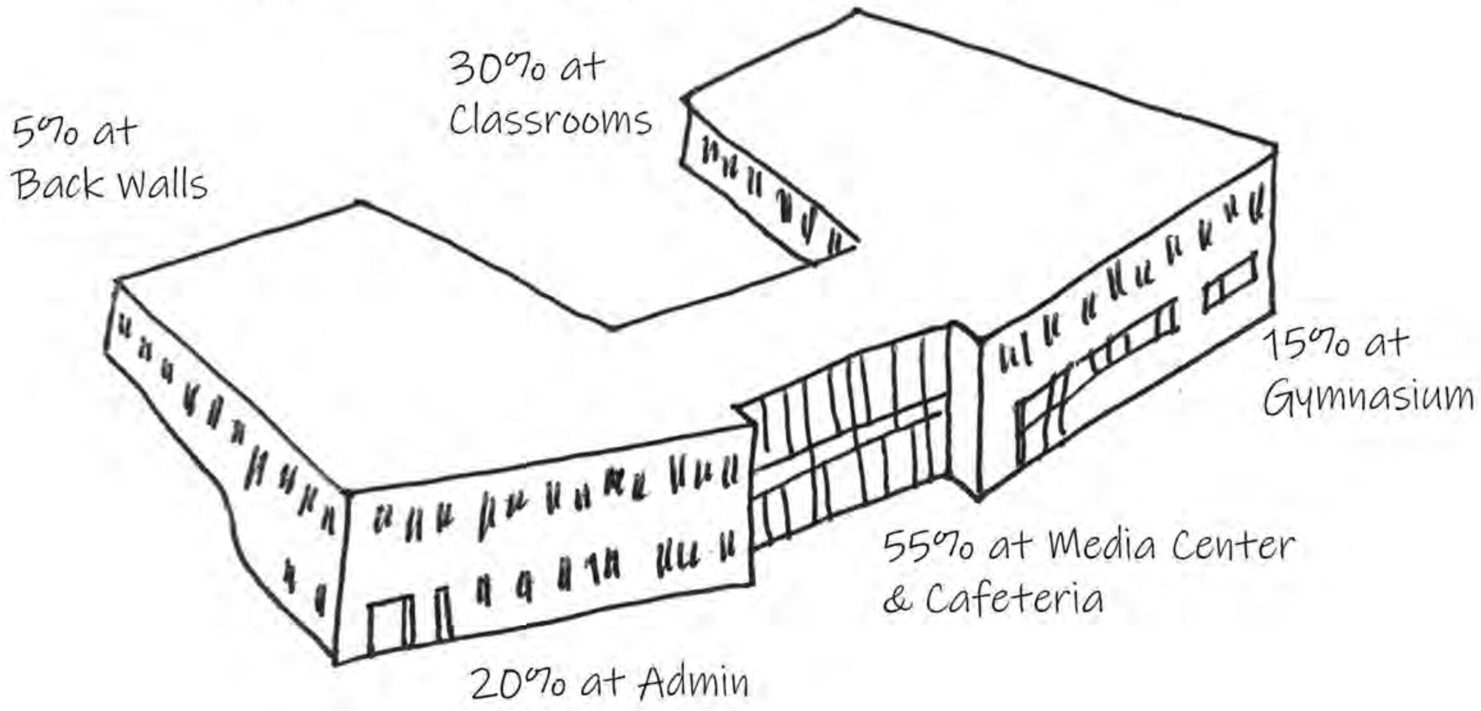
SITE STRATEGIES

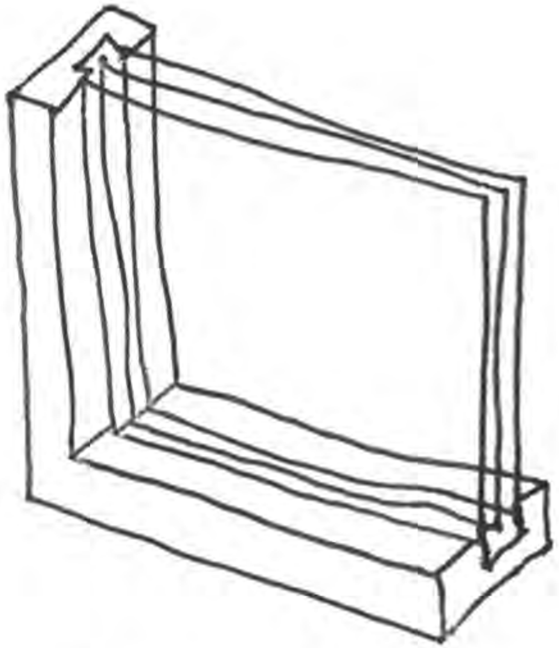




ENVELOPE STRATEGIES

- R30 for walls, R40 for roofs
- 25% window to wall ratio
- Triple glazed windows & skylights
- Balance solar heat gain & visible light





South, West, East Facades:
U-Value= 0.13
Solar Heat Gain = 0.23
Daylight Transmission = 54%
UV Transmission = 20%

North Facade:
U-Value= 0.13
Solar Heat Gain = 0.33
Daylight Transmission = 60%
UV Transmission = 28%

LIGHTING

Control and Analysis

Position glazing for Daylight Autonomy (DA)

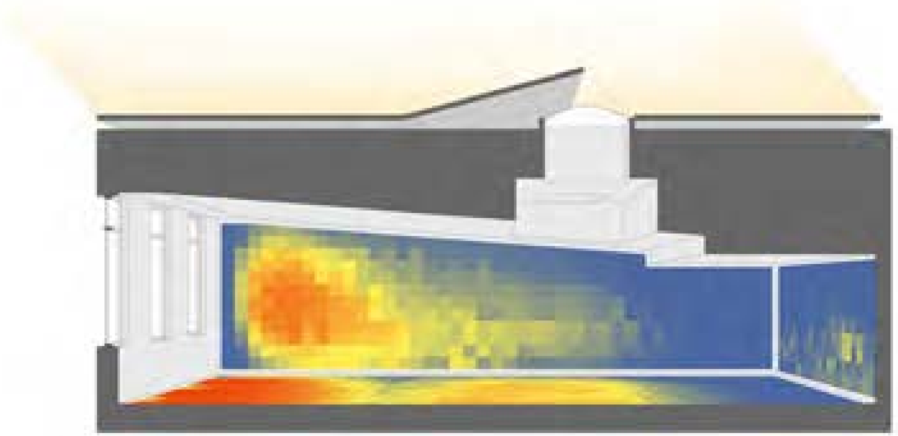
DA = percent of operating hours that an area can be lit exclusively with daylight

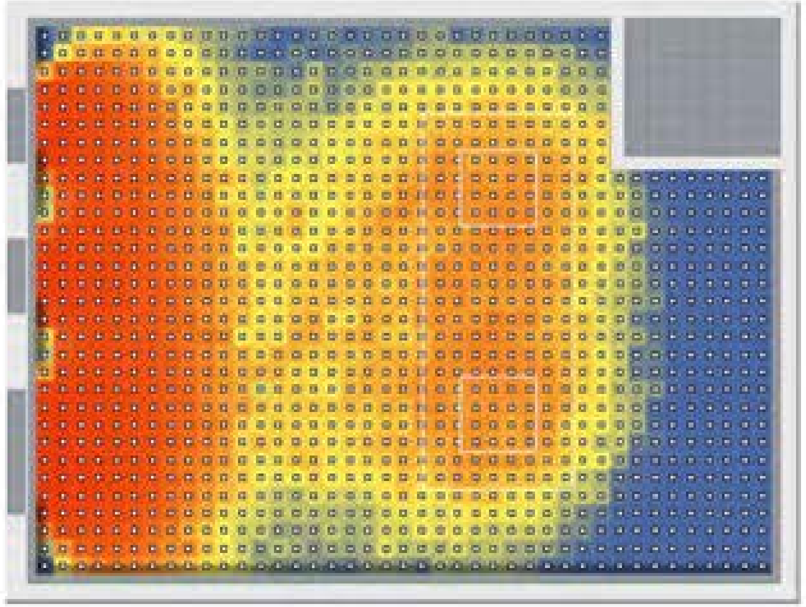
Control Artificial Lighting

- Daylight and occupancy sensors
- Fixtures zoned to balance daylight
- Master controls linked to BMS

Low Light Power Density (LPD)

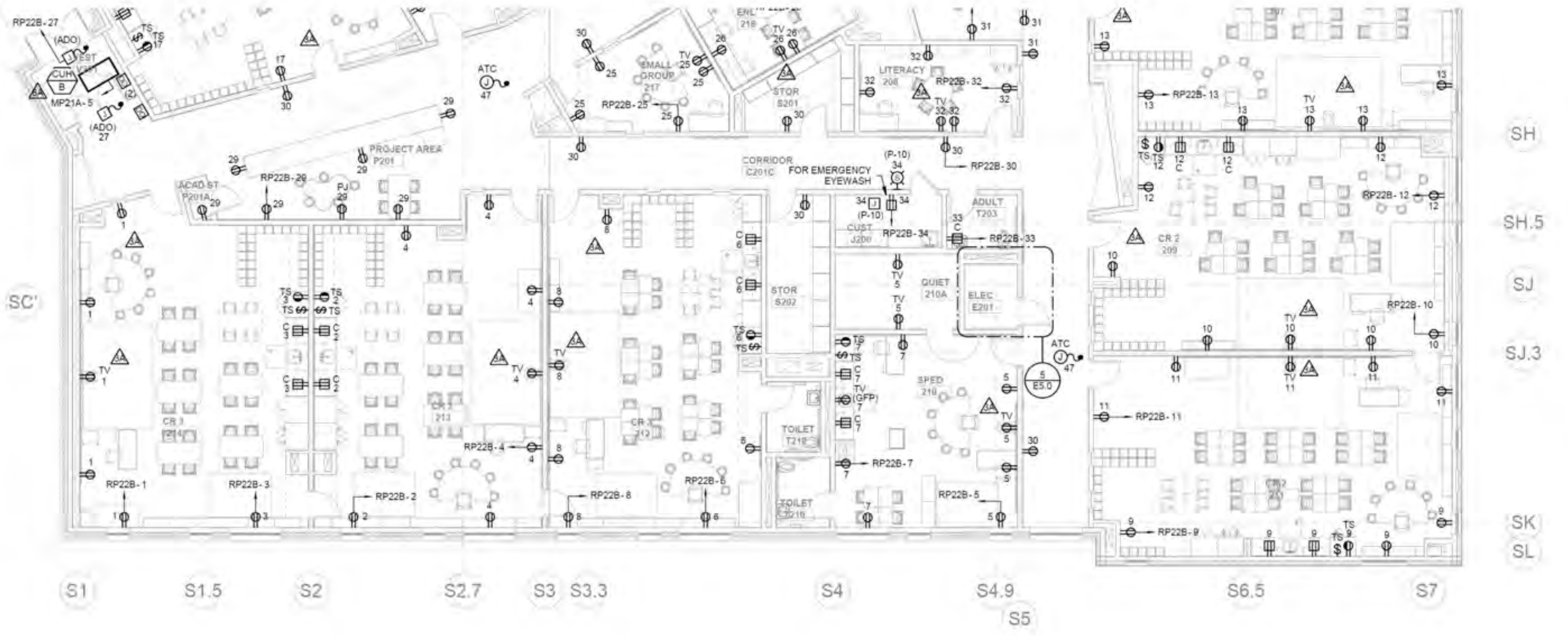
- Benchmark LPD is 1.2 watts per sf
- Target LPD is 0.43 watts per sf

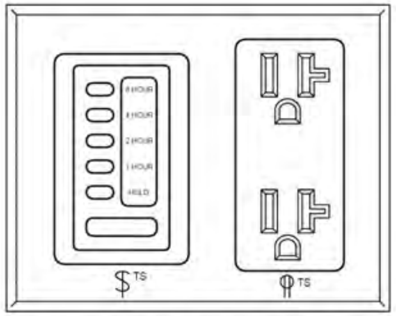




POWER

Plug Load

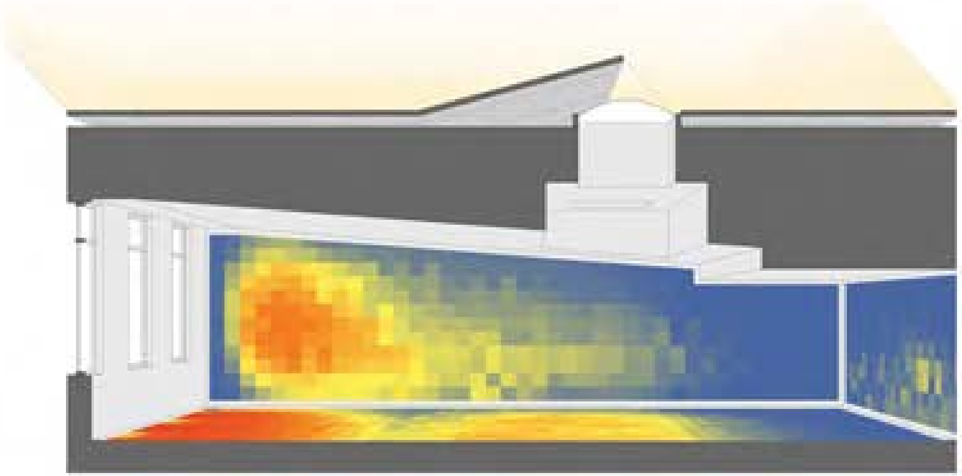


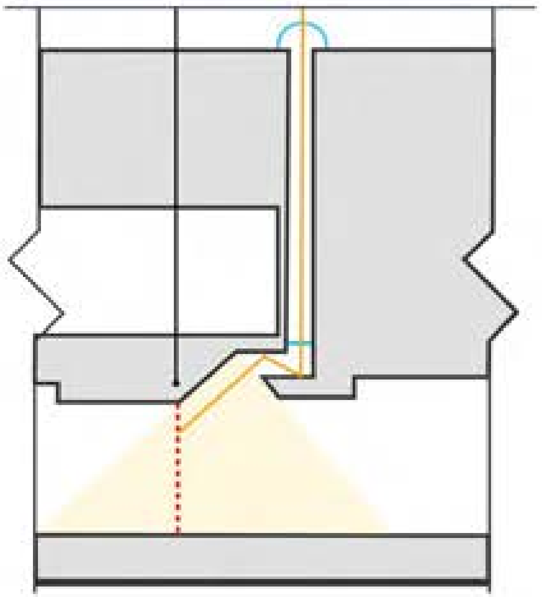


IN EACH CLASSROOM STORAGE CABINET WITH CHARGING STATIONS, PROVIDE INTERMATIC #EI220W ELECTRONIC COUNTDOWN TIMER SWITCH WIRED TO CONTROL DUPLEX RECEPTACLE. MOUNT IN 2-GANG BOX WITH SINGLE COVER PLATE. COORDINATE EXACT LOCATIONS WITH ARCHITECT AND DETAILS. INSTALL AT 40" ABOVE FINISHED FLOOR.

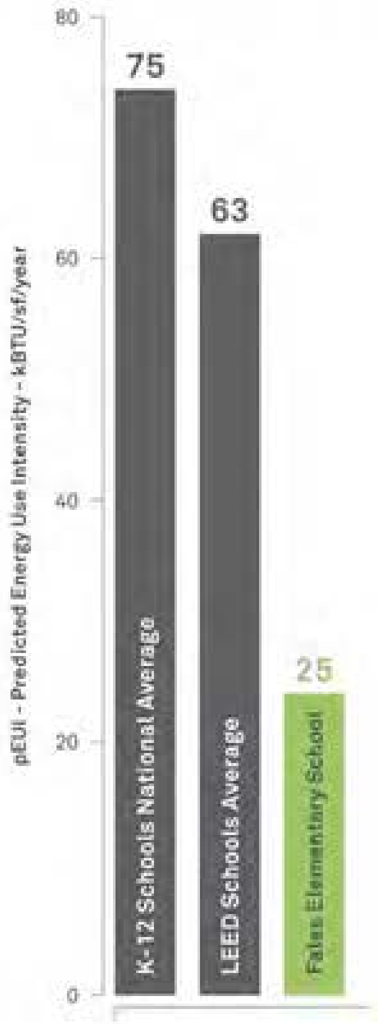
CLASSROOM CHARGING CABINET	NTS

DAYLIGHT STRATEGIES





ESTABLISHING TARGET ENERGY USE INTENSITY (EUI)



EUI = the amount of energy per square foot to operate the building over the course of a year

- benchmark for US K-12 schools = **75 EUI**
- typical for a net-zero school = **20-25 EUI**
- Fales target = **27.5 EUI**

Projected Annual Energy Use = 2,178,000 kBTU

RENEWABLE ENERGY

Solar PV

	Back-of-the-Envelope	**Final Design**
Energy Use Intensity:	*27.5 EUI*	**24.9 EUI**
Annual Energy Use:	*638,000 kW-hr*	**585,000 kW-hr**
Annual Energy Production:	*638,000 kW-hr*	**648,000 kw-hr**
Size of PV System:	*580 kW*	**508 kW**
Watts per Panel:	*320 W*	**375 W**
Size of Array	*32,000 sf*	**24,000 sf**

CHALLENGES
CONFLICTING GOALS

Energy Production and Energy Reduction

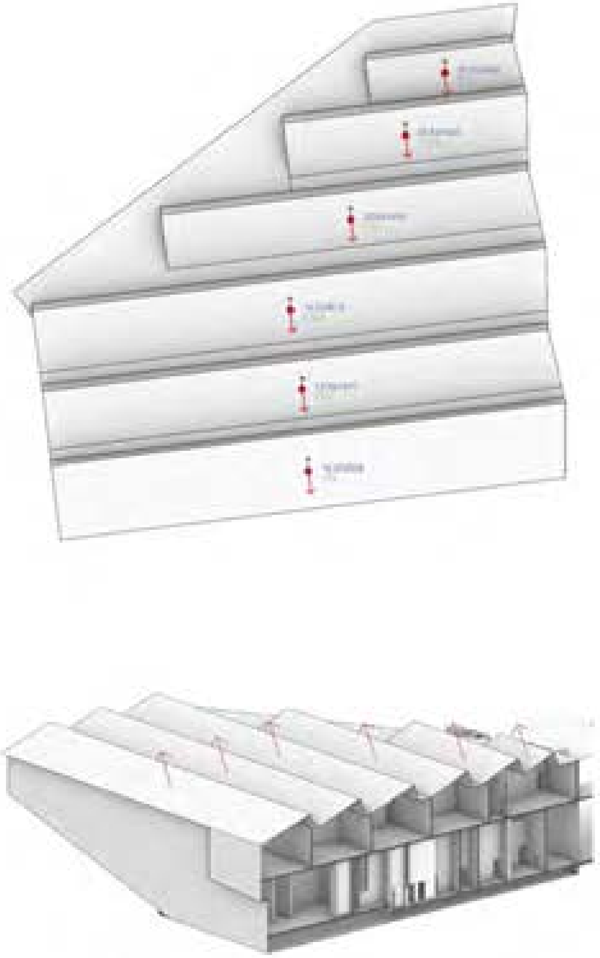
- Skylights and Solar PV Competing for roof area
- Traditional skylights have poor insulating values

Optimal for solar

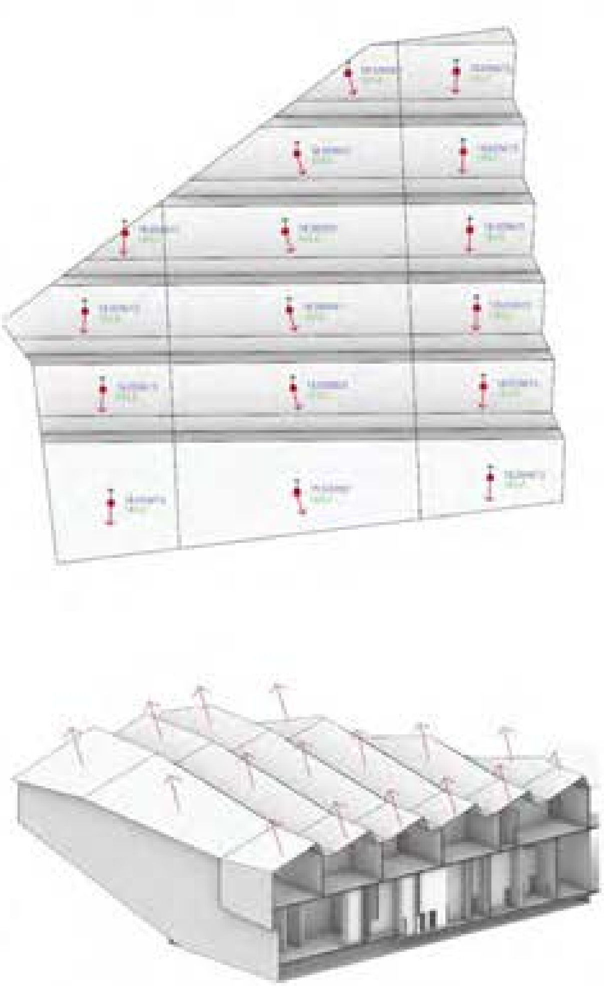
Optimal for daylight

Combined strategies

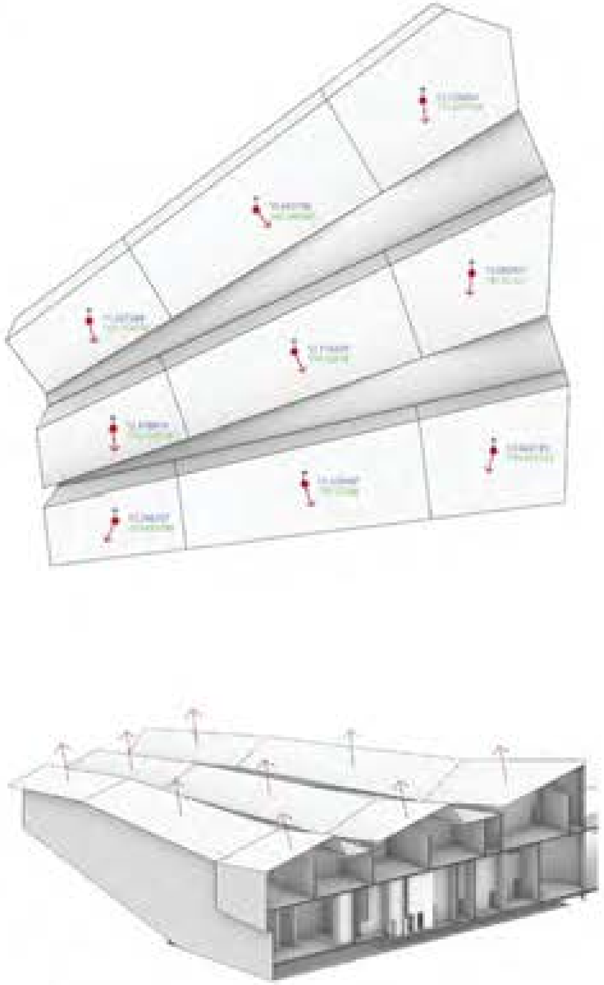
ROOF MASSING OPTIONS



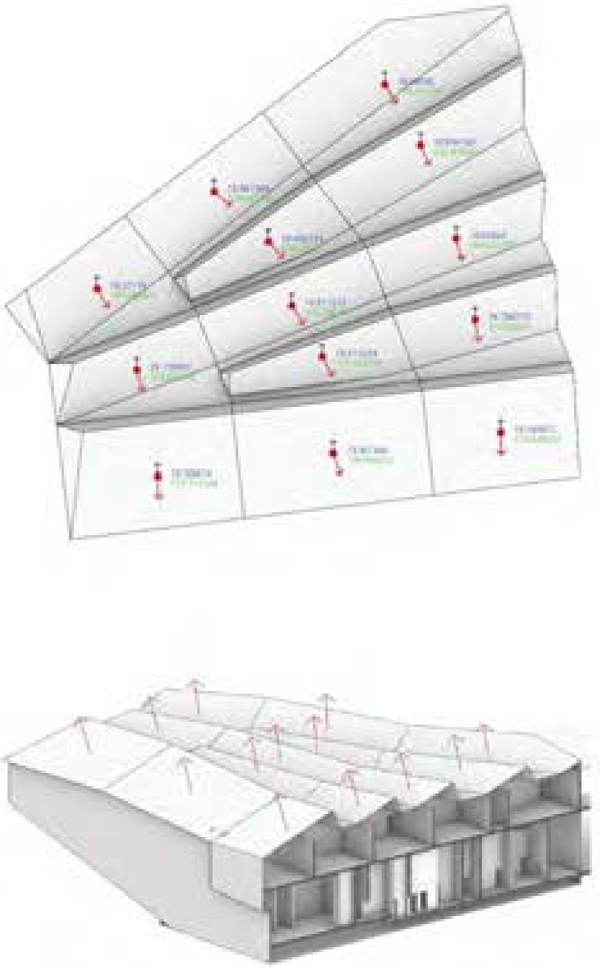
Parallel



Rotated Parallel



Triple - Pleat

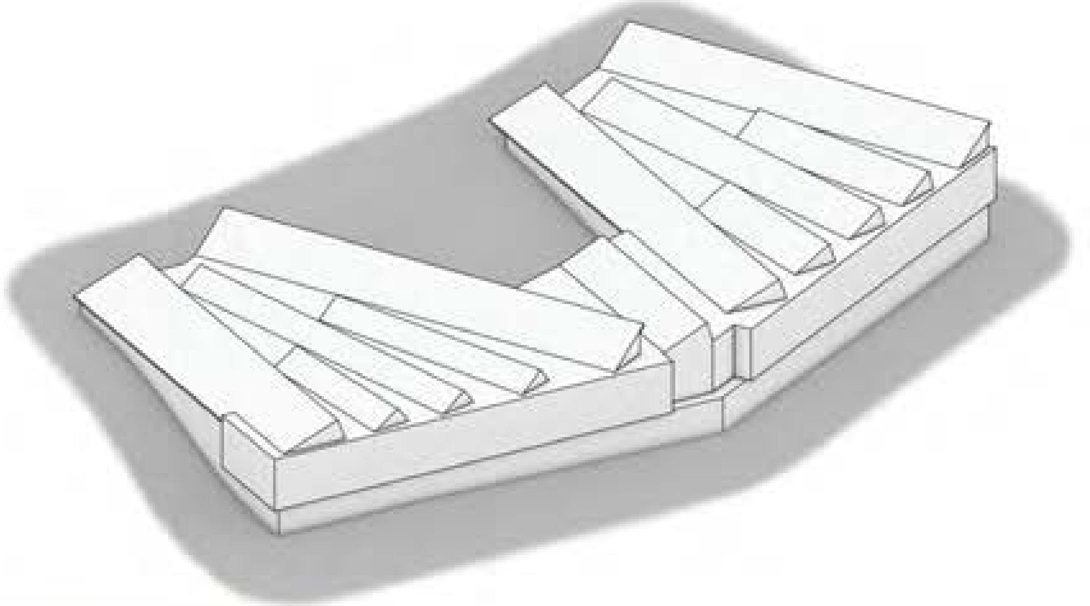


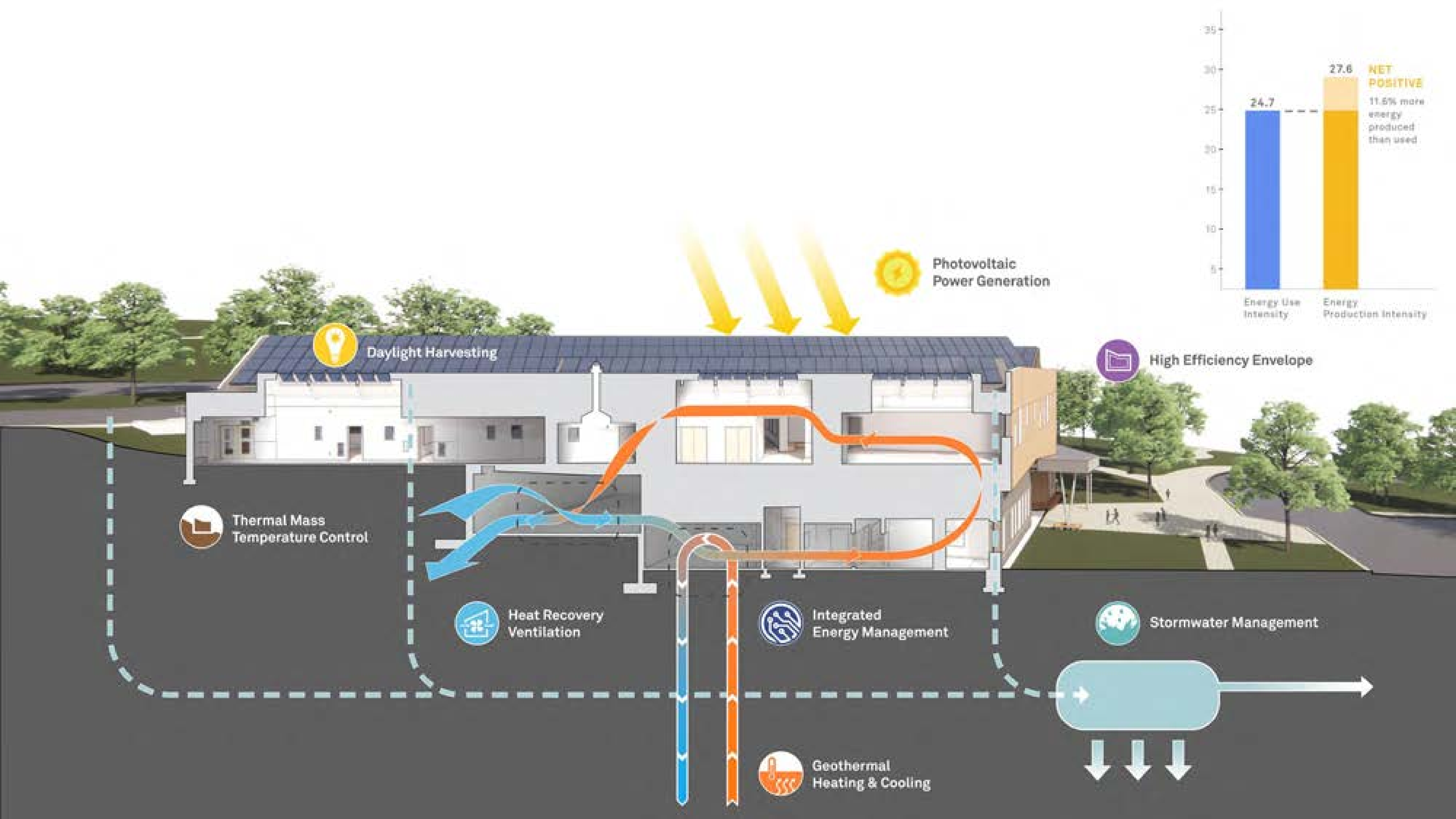
Quadruple - Pleat

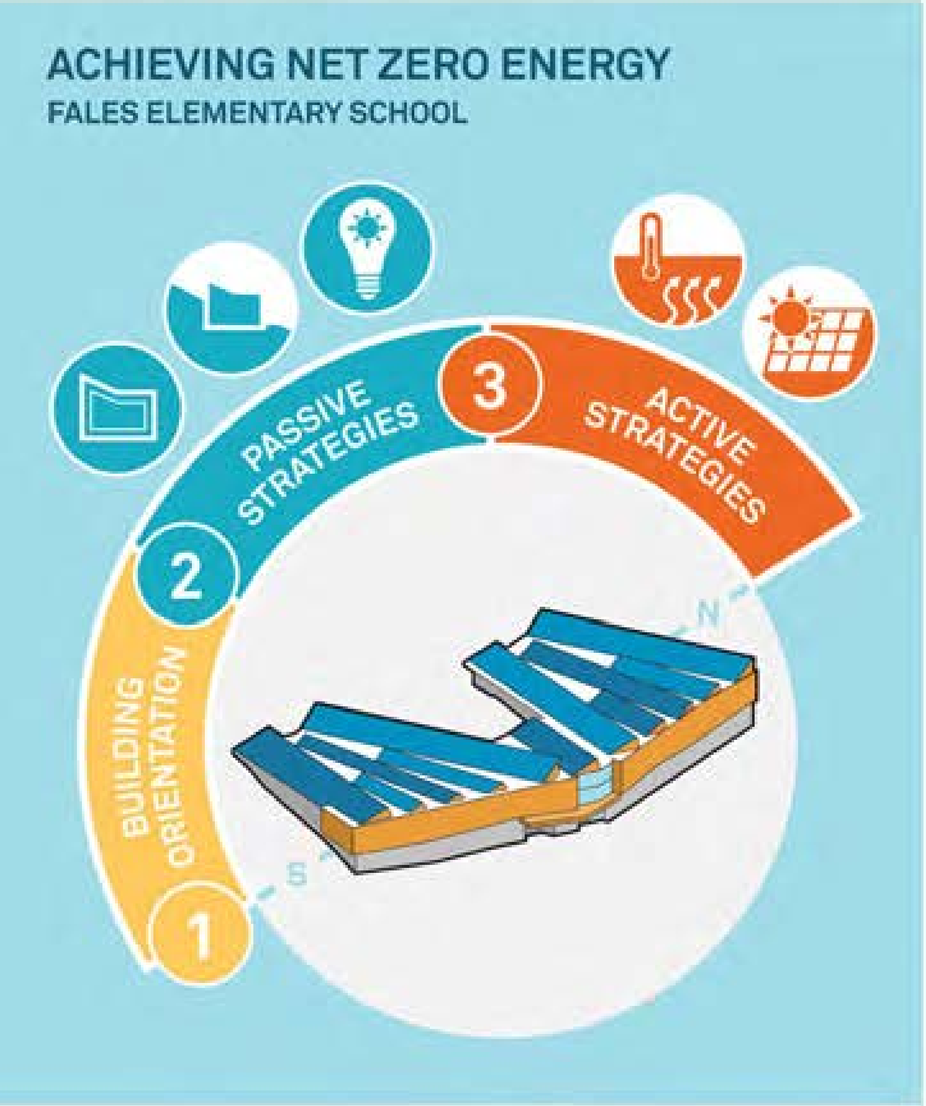
SAWTOOTH ROOF

Benefits

- Expands roof surface area by 18% over flat roof
- Brings more natural light into interior spaces
- Architectural expression of zero energy strategy




35
30
25
20
15
10
5
24.7
27.6
NET POSITIVE
11.6% more energy produced than used
Energy Use Intensity
Energy Production Intensity
Photovoltaic Power Generation
Daylight Harvesting
High Efficiency Envelope
Thermal Mass Temperature Control
Heat Recovery Ventilation
Integrated Energy Management
Stormwater Management
Geothermal Heating & Cooling



ENERGY STRATEGIES - SUMMARY

	EASY WIN	CHALLENGE
Low Flow Fixtures	●	
Limited Irrigation	●	●
Mechanical Crawlspace	●	●
All Electric, No Gas Cooking	●	●
No Gas Cooking	●	●
Geothermal HVAC System	●	●
Limiting Plug Load		●
Window - Wall Ratio of 20%		●
Sawtooth Roof	●	●
School as a teaching tool	●	

Bristol County Agricultural High School

DIGHTON, MA

First State Funded (MSBA) Building with Composting Toilets
BE+ Green Building of the Year 2022

BRISTOL COUNTY AGRICULTURAL HS

Thoughtfully addressing overlapping (water) systems requires effort and coordination between multiple design disciplines.

Architect **HMFH Architects**

Stormwater Management

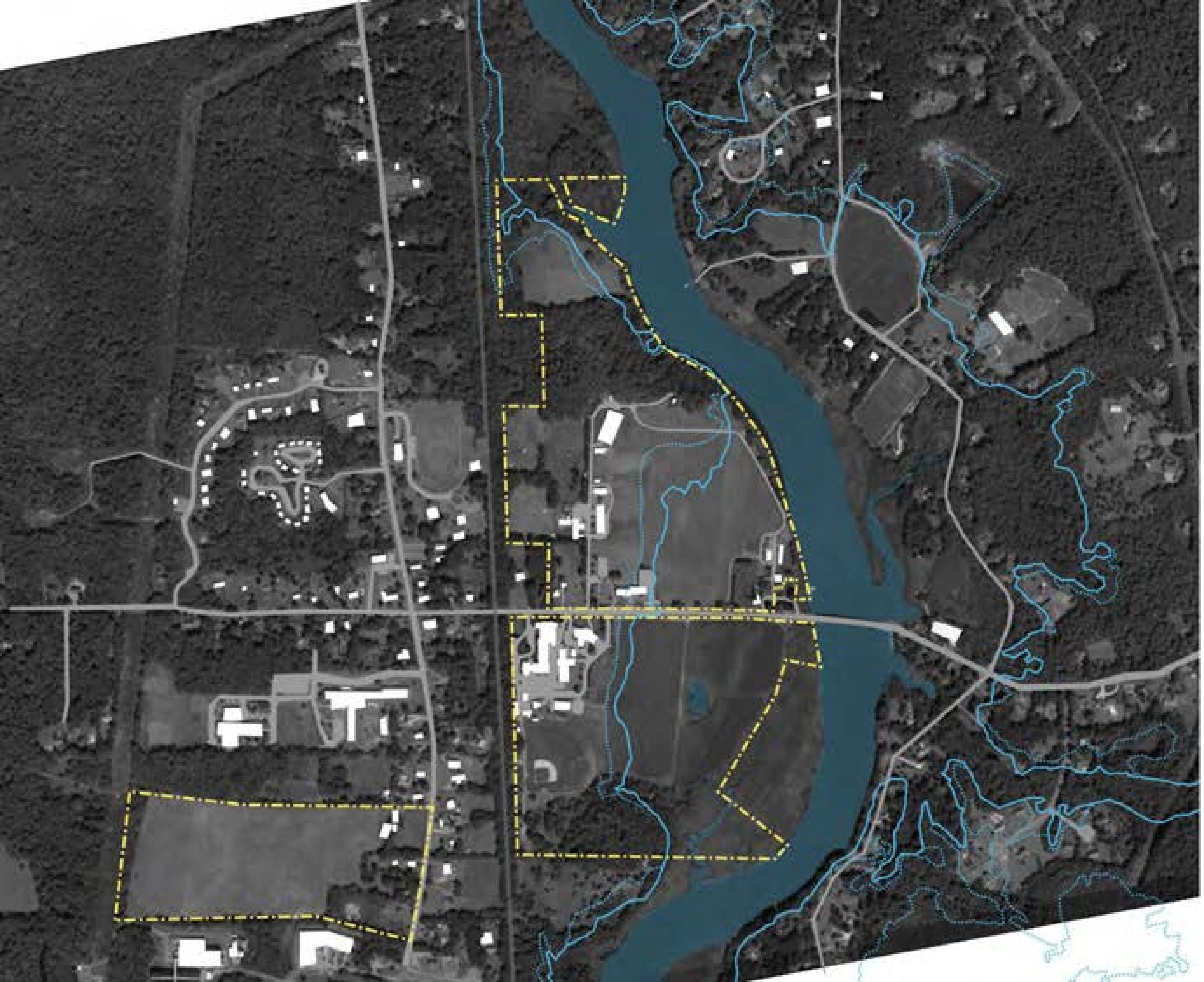
Civil Engineer **Samiotes**

Landscape Architect **Halvorson, Tigh & Bond**

Potable Water Use Reductions and Storm Water Reuse

Plumbing Engineer **Garcia Galuska DeSousa**

Landscape Architect with Irrigation Consultant **Irrigation Consulting, Inc.**



EXISTING CAMPUS

220 acre working farm along the Taunton River

Public career technical vocational high school

Agricultural and science based curriculum

22 Sending communities

Combined educational and sustainability goals

CAMPUS ANALYSIS

BRISTOL COUNTY AGRICULTURAL HIGH SCHOOL

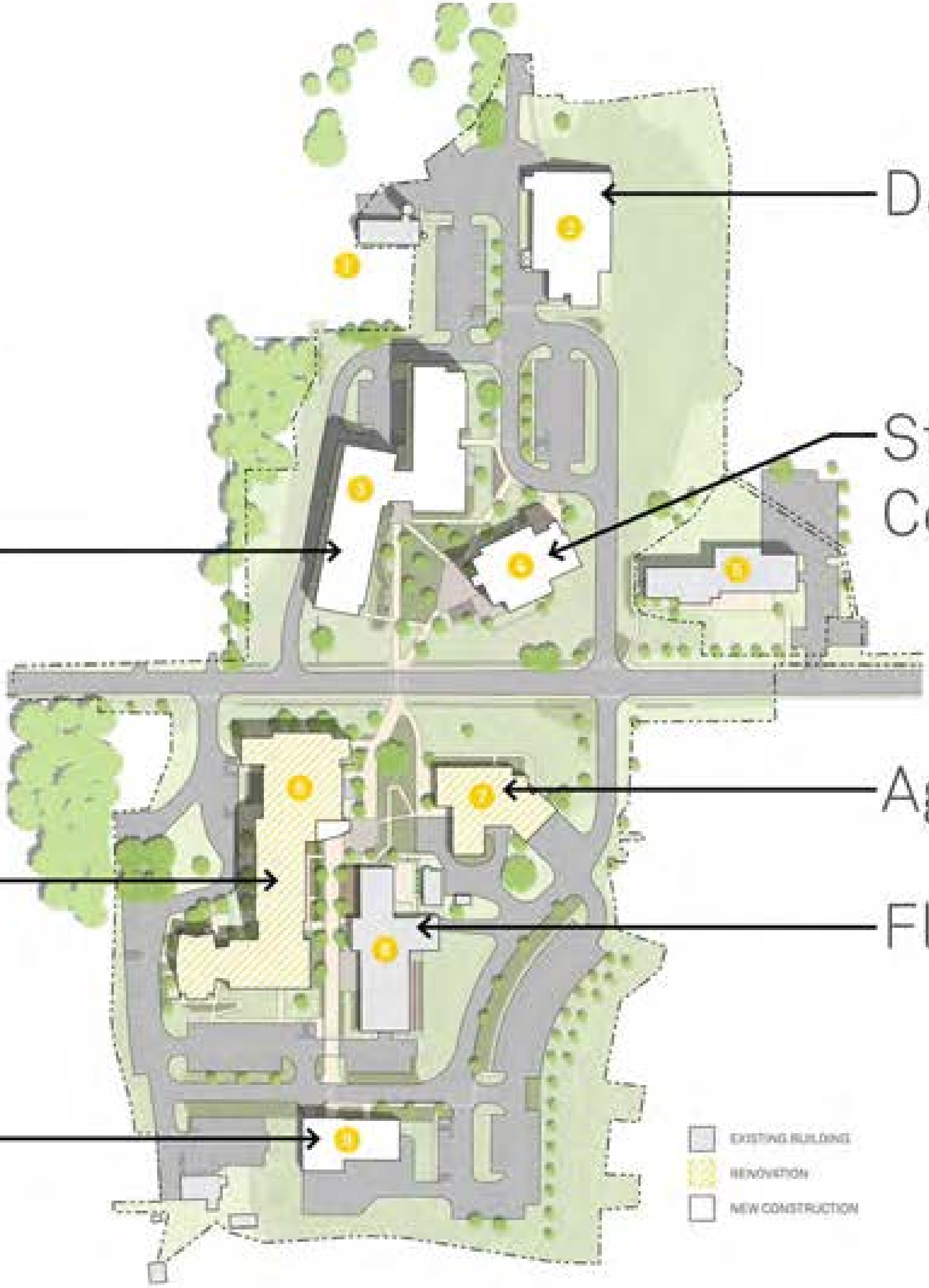
Sustainability and Educational Design goals

- All new facilities should be highly energy efficient, set net zero as a goal!
- Promote sustainable agricultural practices and sustainability curriculum
- Grow more food for students

- Achieve 10% better than code
- Make each building /structure a champion for specific sustainability measures
- Center for science and the environment will be a ‘living lab’ for the students and the community
- Design the dairy barn to be NZE
- No impact on the taunton river watershed

NEW SITE PLAN

Project includes 6 buildings; 4 NC and 2 Renovations. Of the NC, 3 were timber (2 Mass Timber).



Dairy Barn **(DB)**

Center for Science and the Environment **(CSE)**

Student Commons **(SC)**

Ag Mech **(AG)**

Gilbert Hall **(GH)**

Floriculture

Landscape/Arbor **(LA)**

WATER GOAL

Do no harm to the Taunton River

The Taunton River is a federally designated Wild and Scenic River (NPS)

Bristol Aggie is situated along the river where it is brackish - a sensitive ecotone and major contributor to the students educational journey

TAUNTON WATERSHED

Dighton's water supply comes from 5 groundwater wells

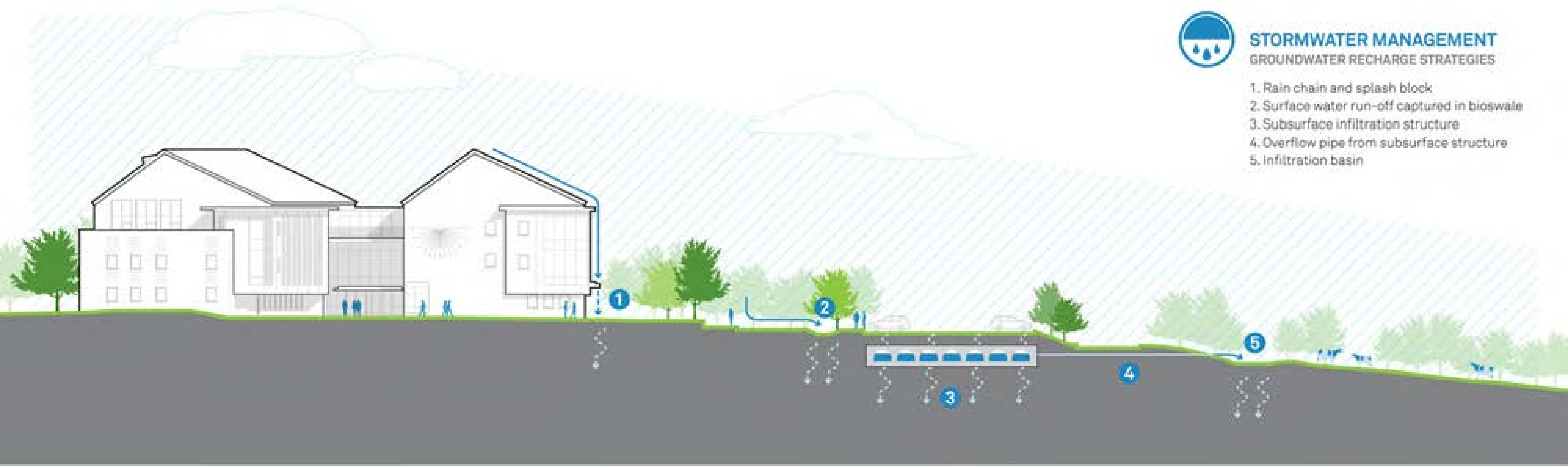
In recent years the well water levels have dropped significantly due to lack of recharge

The town had to issue a complete watering ban in 2020

Water Conservation

Strategies for Implementation

SITE WATER STRATEGIES



STORMWATER MANAGEMENT

GROUNDWATER RECHARGE STRATEGIES

1. Rain chain and splash block
2. Surface water run-off captured in bioswale
3. Subsurface infiltration structure
4. Overflow pipe from subsurface structure
5. Infiltration basin

EASY WIN SITE WATER

Use Reduction

Green Roofs

Rainwater harvesting:
- 40,000 gal. cistern.
- 20,100 roof captured
- 22,000 sf irrigated landscape

Limited irrigation area

Water efficient planting

EASY WIN SITE WATER

Groundwater Recharge

Rain Chain and Basin

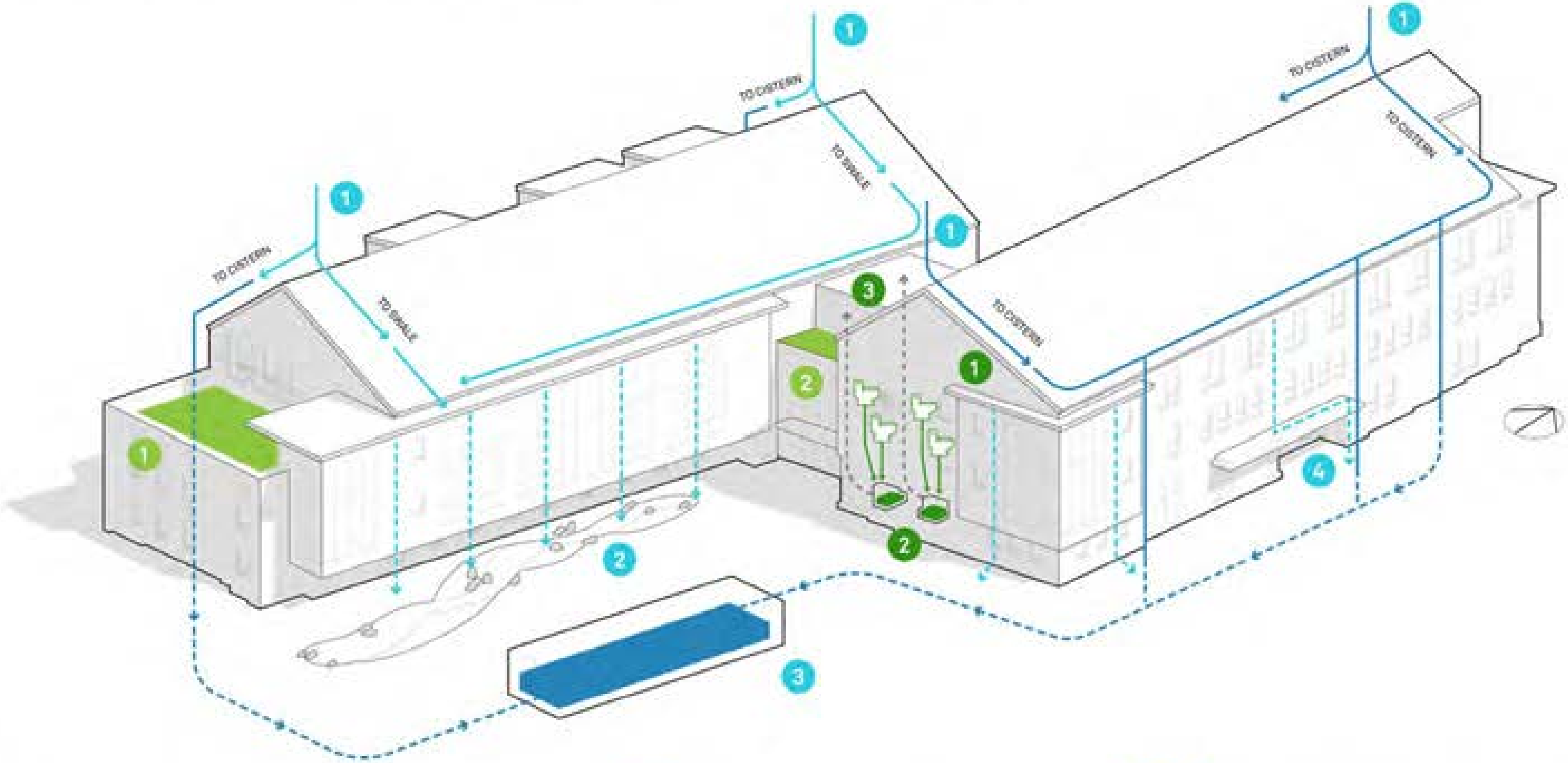
Bioswale

Subsurface infiltration Structure

Infiltration Basin


INTENSIVE GREEN ROOF
VISUAL CONNECTION TO WATER SYSTEMS
COMPOSTING TLTS
EXTENSIVE GREEN ROOF
UNDERGROUND CISTERN

BUILDING WATER STRATEGIES



STORMWATER MANAGEMENT

1. Incoming rain
2. Dry swale
3. Underground irrigation cistern
4. Rain chain

GREEN ROOFS

1. Intensive green roof
2. Extensive green roof

COMPOSTING TOILET SYSTEM

1. Composting toilets
2. Composters
3. Exhaust vents

EASY WIN GREEN ROOFS

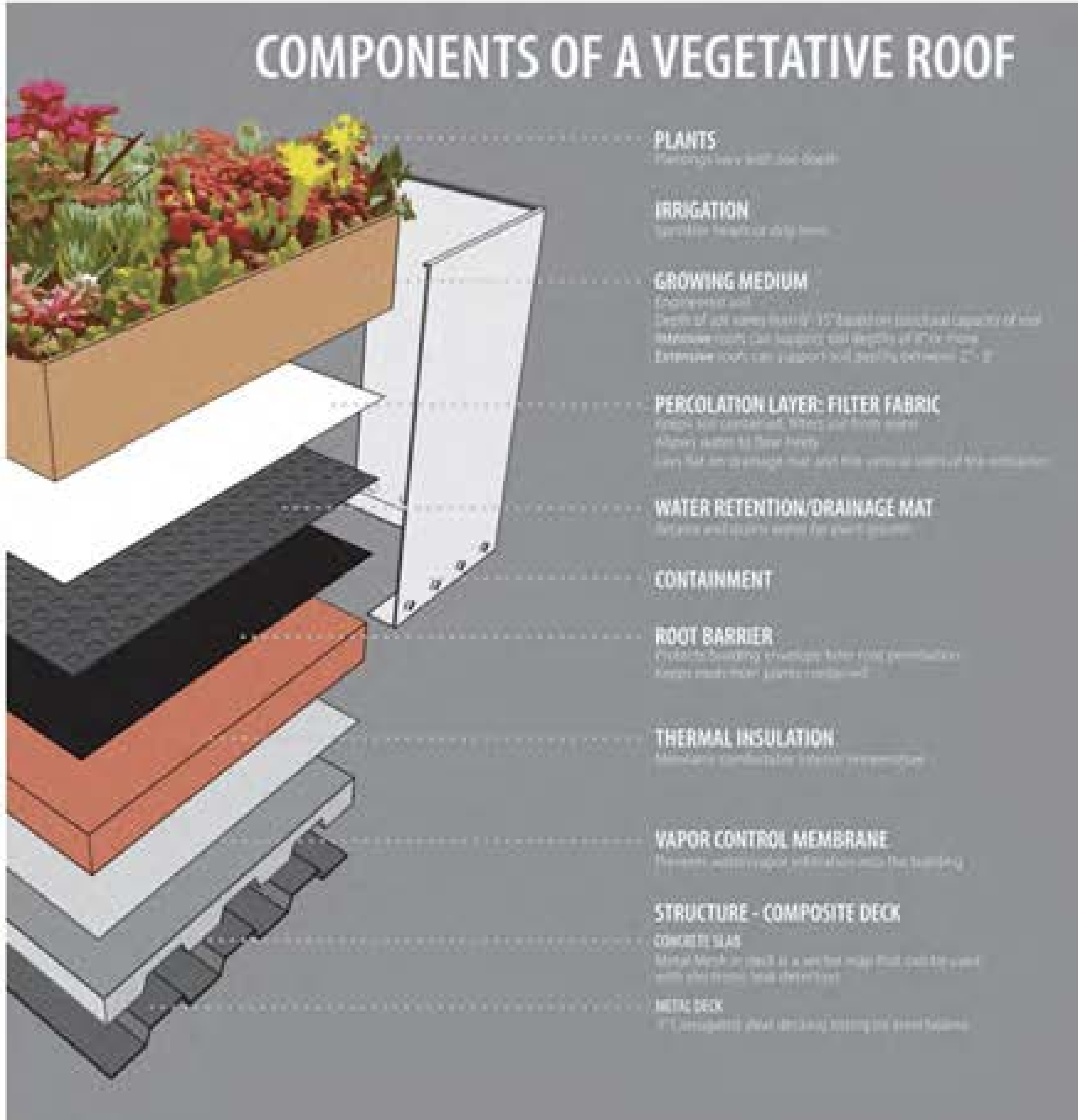


Table 6 – R1 Pre-development Fixture Flow Rates Versus Post-development Ultra-Water Saver Fixture Flow Rates			
Fixture Type	Average Flow Before 1994	Minimum Standard After 1994	% Reduction
Toilet	3.5 gal/flush	1.28 gal/flush	63
Urinal	1.5 gal/flush	0.125 gal/flush	92
Lav Sinks	3 gal/min	0.35 gal/min	88
Hand Sprays (lever triggered)	1.75 gal/min	1 gal/min	43
Clevis Multrum	3.5 gal/flush	.023 gal/flush (not tributary to Bristol Aggie Pump Station)	99
Classroom Sinks	3.5 gal/min	0.5 gal/min	
Laboratory Sinks	3.5 gal/min	.74 gal/min	
Showers	3 to 4 gal/min	1.5 gal/min	
Kitchen Dishwasher	5.4 gal/min	1.8 gal/min	
Wash sink (trough) 4 head – manually operated	7 to 8 gal/min	Eliminated in post-development program	N/A

EASY WIN

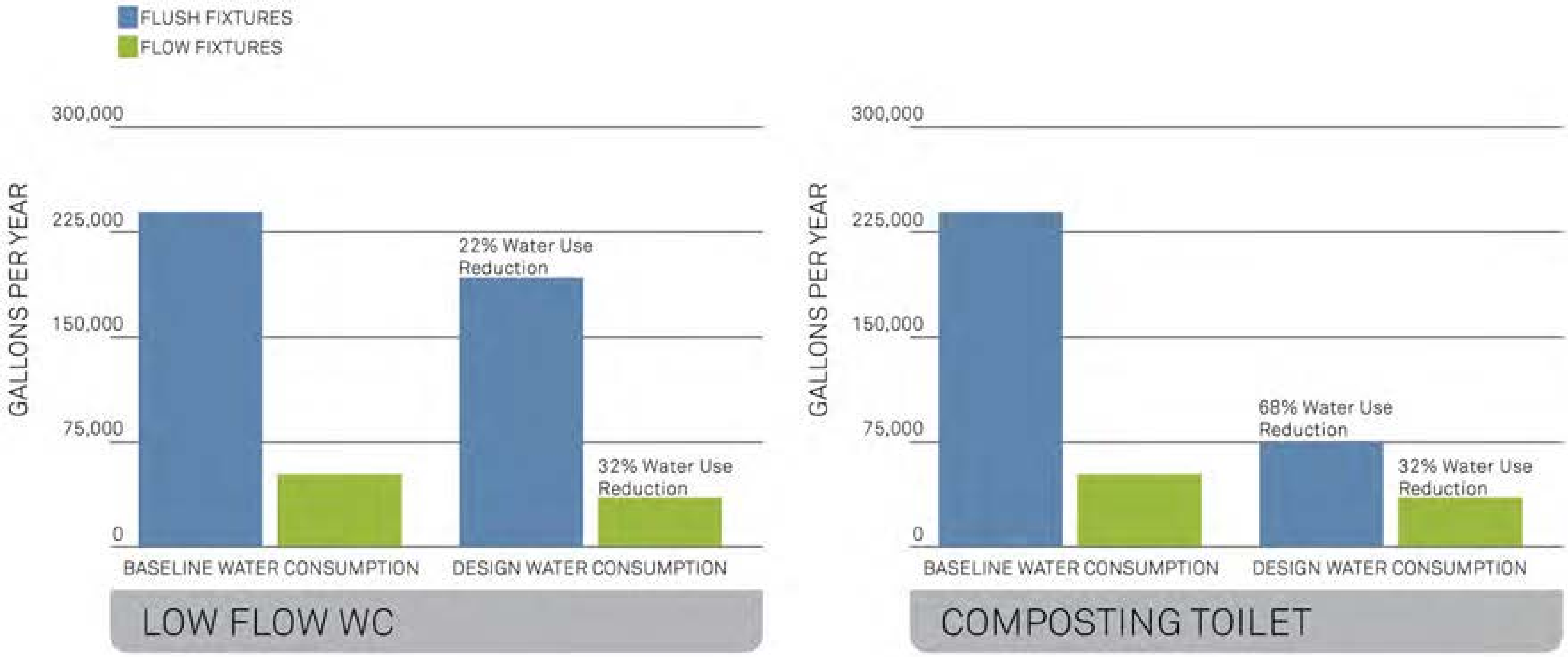
LOW FLOW FIXTURES

Except for 7 toilets, Bristol Aggie water fixtures pre-date 1992 and are not compliant with the U.S. Energy Policy Act of 1992.

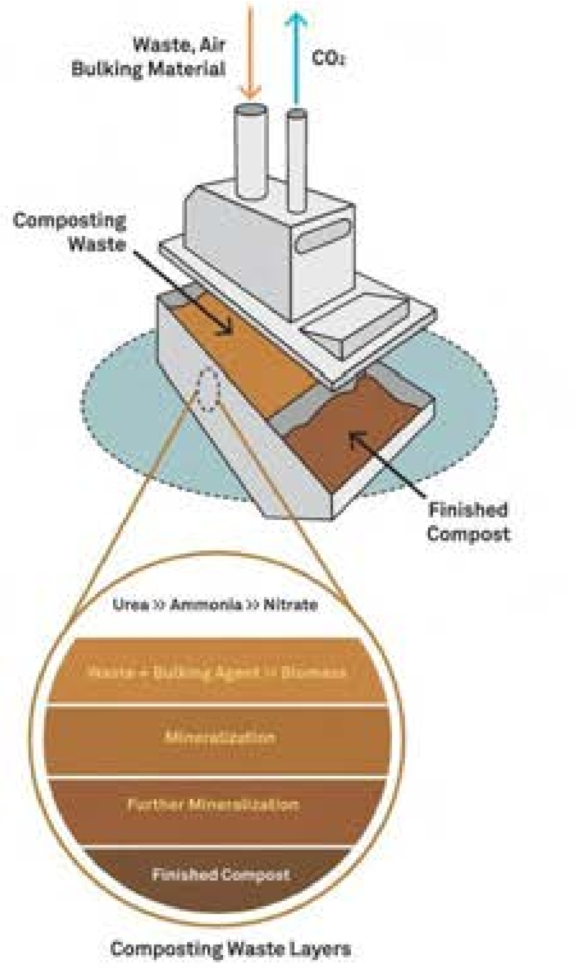
There are some fixtures that are so archaic that they most likely exceed the range of pre-1992 published (or anticipated) flow rates.

BRISTOL AGGIE WATER USAGE

Code Baseline Comparison



COMPOSTING TOILETS



WATER STRATEGIES - SUMMARY

	EASY WIN	CHALLENGE
Low Flow Fixtures	●	
Limited Irrigation	●	
Drought Tolerant Planting	●	
Green Roofs	●	●
Rainwater harvesting - Irrigation	●	●
Rainwater harvesting - Tlts	●	●
Rain Gardens	●	●
Infiltration Structures	●	●
Composting Toilets	●	●
School as a teaching tool	●	

*With minor additional coordination all strategies above could easily be achieved. The challenge often lies in the additional cost water strategies require, whether infrastructure or energy costs.

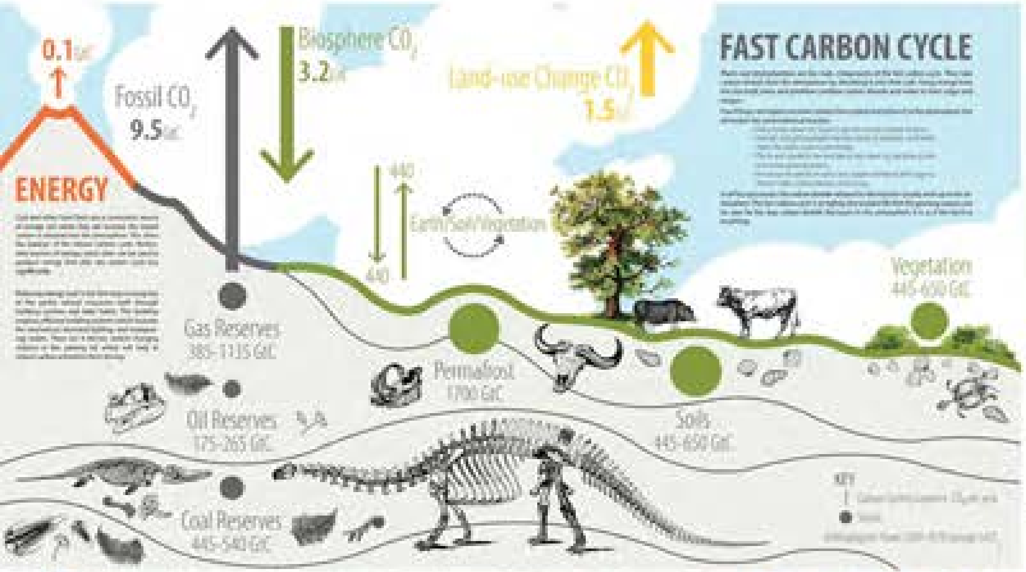
Holistic Design

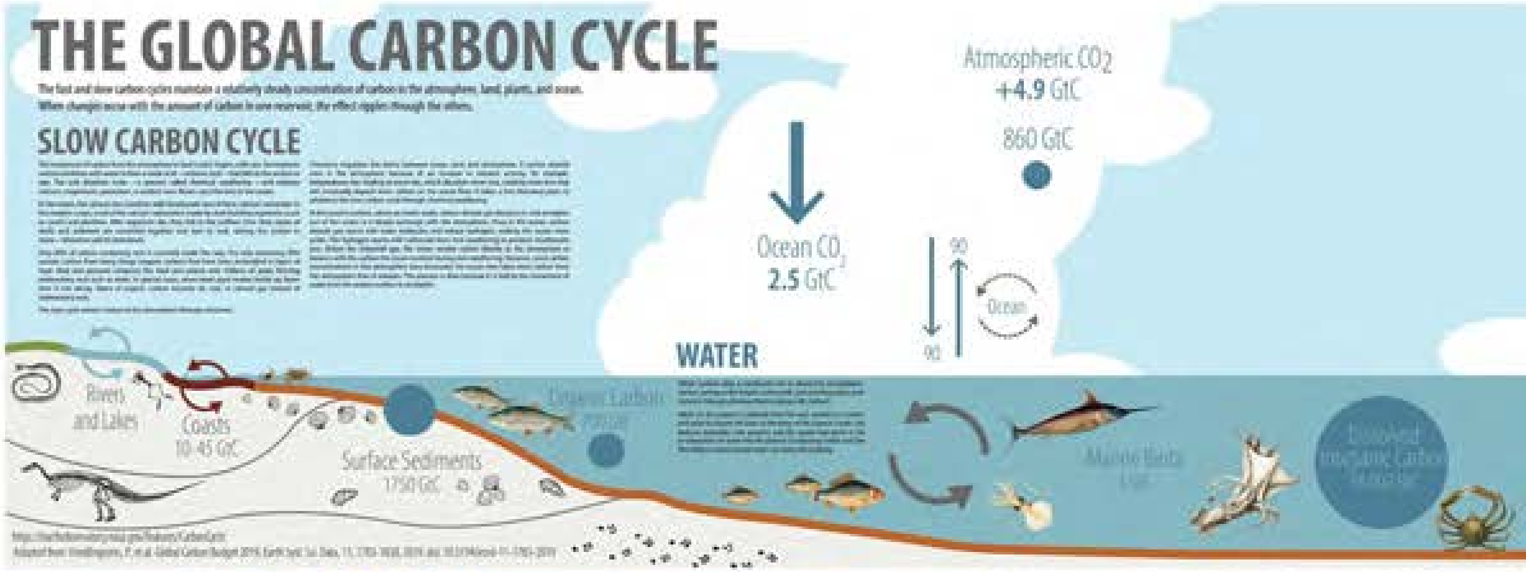
Connecting Strategies

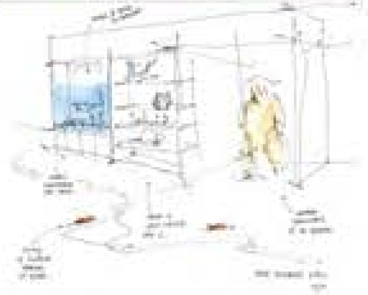
OVERLAPPING STRATEGIES

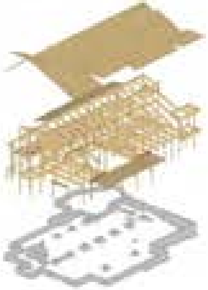
MATERIALS + SOCIAL JUSTICE | **HEALTH + WELL-BEING** | **WASTE + WATER** | **ENERGY + CARBON**

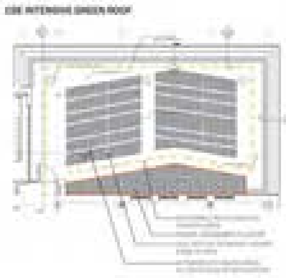
MATERIALS + SOCIAL JUSTICE	HEALTH + WELL-BEING	WASTE + WATER	ENERGY + CARBON
Red list Free Materials for all Touch Surfaces	Access to Fresh Air in all Regularly Occupied Spaces	% Indoor Water Use Reduction	No On-Site Combustion
Inclusive and Equitable Design and Process	Access to Daylight and Views in all Regularly Occupied Spaces	Comprehensive Composting Program	Zero Energy Building
	Maximize Access to Educational Content through Enhanced Acoustic Performance	Potable Water Use Reduction	Maximize Incentives and Grants
		On-Site Stormwater Management	Measure Embodied Carbon at every project phase
			Reduce Embodied Carbon - LEED Standards


0.1GtC
Fossil CO2
9.5GtC
Biosphere CO2
3.2GtC
Land-use Change CO2
1.5GtC
FAST CARBON CYCLE
ENERGY
440
440
Earth/Soil/Vegetation
Gas Reserves
385-1135 GtC
Permafrost
1700 GtC
Oil Reserves
175-265 GtC
Soils
445-650 GtC
Vegetation
445-650 GtC
Coal Reserves
445-540 GtC
KEY

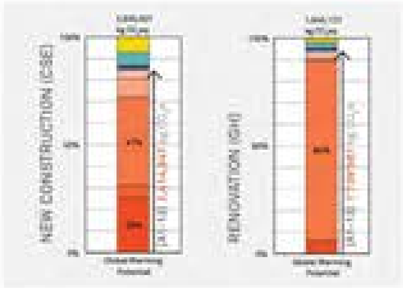

THE GLOBAL CARBON CYCLE
The fast and slow carbon cycles maintain a relatively steady concentration of carbon in the atmosphere, land, plants, and ocean.
When changes occur with the amount of carbon in one reservoir, the effect ripples through the others.
SLOW CARBON CYCLE
Atmospheric CO2
+4.9 GtC
860 GtC
Ocean CO2
2.5 GtC
90
90
Ocean
WATER
Rivers
and Lakes
Coasts
10-45 GtC
Surface Sediments
1750 GtC
Organic Carbon
Marine Biota
Dissolved
Inorganic Carbon






CSE INTENSIVE GREEN ROOF


ANIMAL CELL
PLANT CELL


NEW CONSTRUCTION (CSE)
RENOVATION (GH)
Global Warming Potential


CENTER FOR SCIENCE & ENVIRONMENT
DAYLIGHT AUTONOMY

Q&A

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