LAKOTA Food Sovereignty Project
Spring Design Review
April 19th , 2019

EPICS

Three Universities Partner Together for One Vision

PURDUE
UNIVERSITY

SOUTH DAKOTA
SCHOOL OF MINES
& TECHNOLOGY

LAKOTA Food Sovereignty Project

This work is the combined effort by students from Purdue, SDSMT and OLC

EPICS

Project Partner ~ Oglala Lakota College

He Sapa

Pine Ridge Reservation

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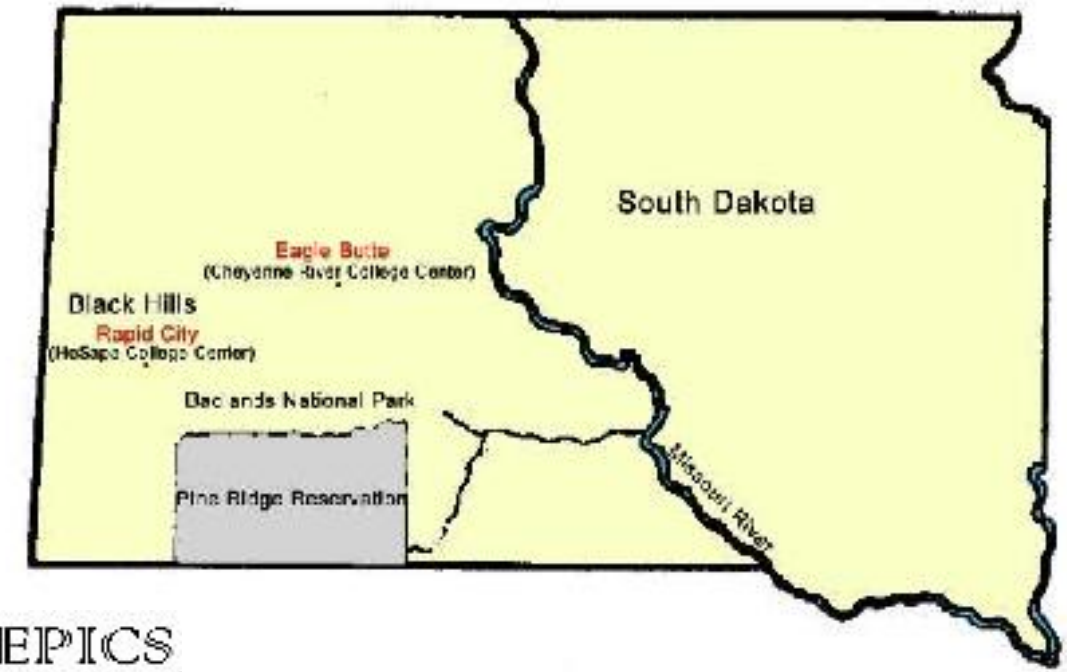
Community Partner Information

Food Desert: An area where either a substantial number or share of residents has low access to a supermarket or large grocery store (USDA)

- 80% limited access to grocery stores
- 95% of food from off-reservation sources
- Food cost 10% higher



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Funding Partners for our vision

Ford College Community Challenge

Ford

AIHEC

SOUTH DAKOTA COMMUNITY FOUNDATION

GROWING FOR GOOD FOR 30 YEARS

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Greenhouse

PURDUE GREENHOUSE TEAM MEMBERS

Marshall Beard
Webmaster
First Year Engineering

Bridget Fitzgerald
Design Lead
First Year Engineering

Katie Johnson
Aerospace Engineering

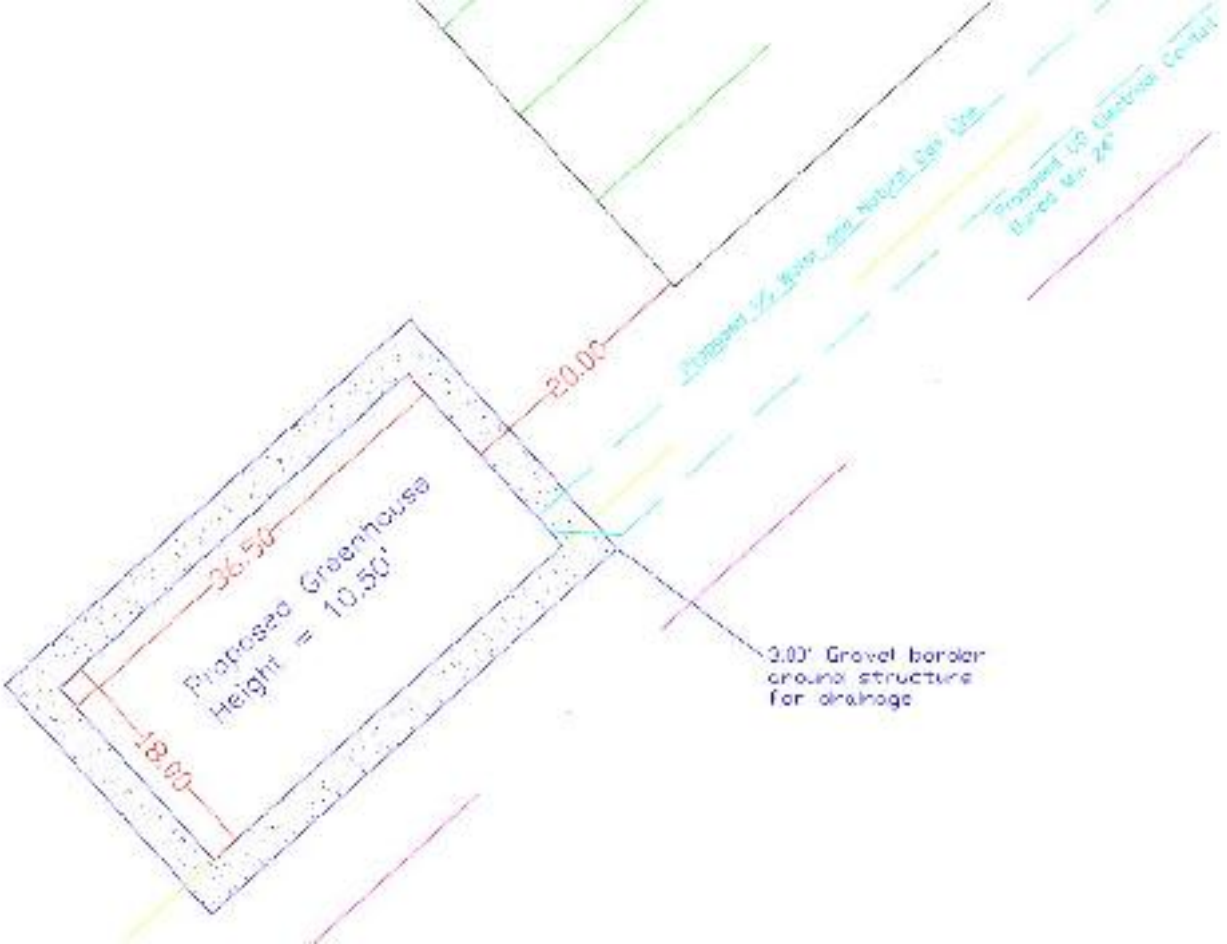
Thao Nguyen
Project Partner Liaison
Chemical Engineering

Overview of OLC Rapid City Campus Area

He Sapa College Campus (Southwest corner)

Proposed Greenhouse Site location

Proposed Site (Enlarged)



Greenhouse Structure

- **Pre-Engineered Kit from the Greenhouse Megastore**
- **Specs**
  - Model Name: Junior Teaching Greenhouse
  - 36’ x 18’ x 10’
  - Pre-selected gas heater, ventilation fans, and thermostat
- **Benefits**
  - Sized to fit the site
  - 30 lb load rating to resist extreme weather
  - 10 Year Warranty

Exterior View Example

Interior View Example

Construction Budget

Utility Breakdown*	
Line Item	**Cost**
Water*	$8,438.79
Electricity*	$5,217.15
Gas*	$3,229.00.
Total	$16,888.94

* Denotes Non-Finalized Pricing

Overall Budget	
Line Item	**Cost**
Greenhouse Kit	$15,394.50
Foundation	$17,400.00
Utilities*	$16,888.94
Interior Items*	$8,000.00
Misc*	$3,000.00
Total	$60,682.94
Available Funds	$75,000.00
Surplus	**$14,317.06**

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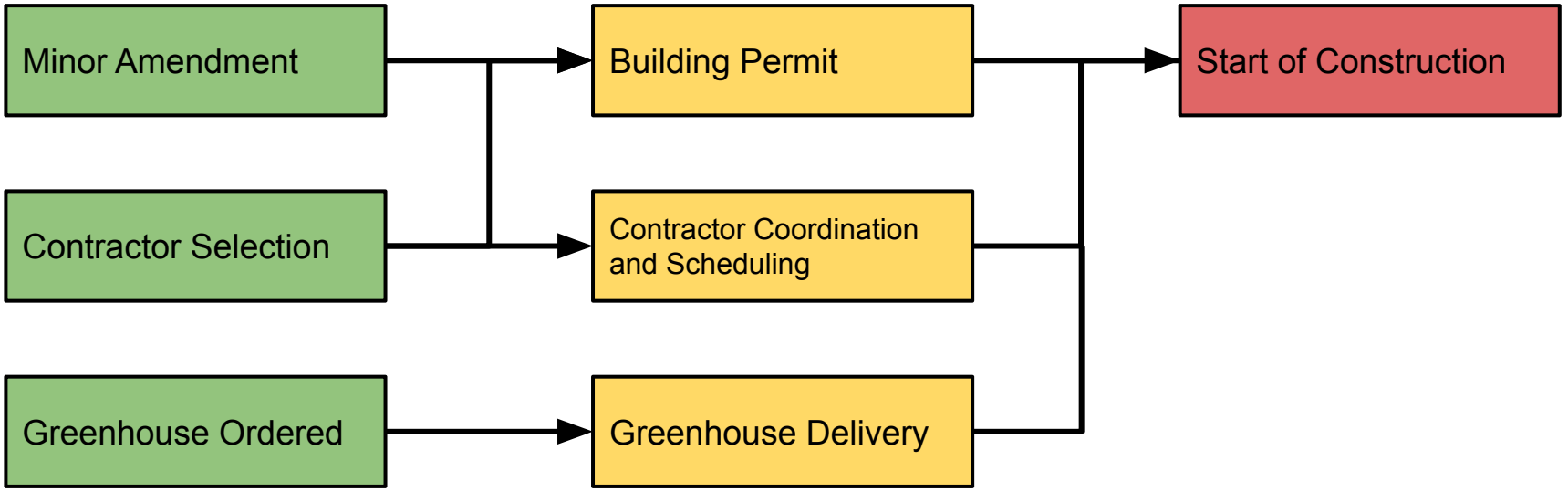
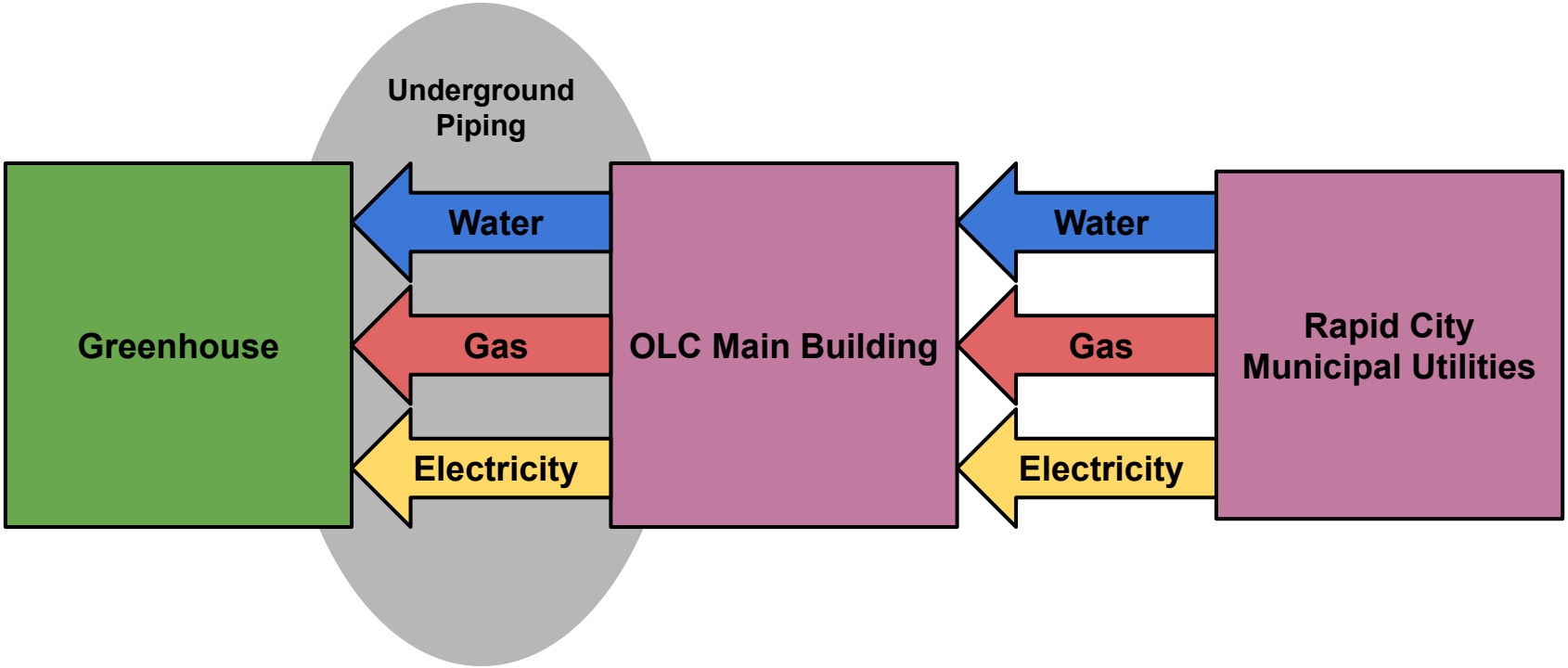
Project Flowchart



Utilities Overview



Utilities Breakdown

- **Natural Gas**
  - Underground line from OLC main building to the greenhouse to power the heater
  - To share a trench with the water line
- **Water**
  - Main source is a line from the OLC main building
  - Water and Gas installation to be performed by Loyal Plumbing
- **Electricity**
  - 100 Amp feeder from college's main panel to a new panel in Greenhouse
  - Electric installation to be performed by ACE electric

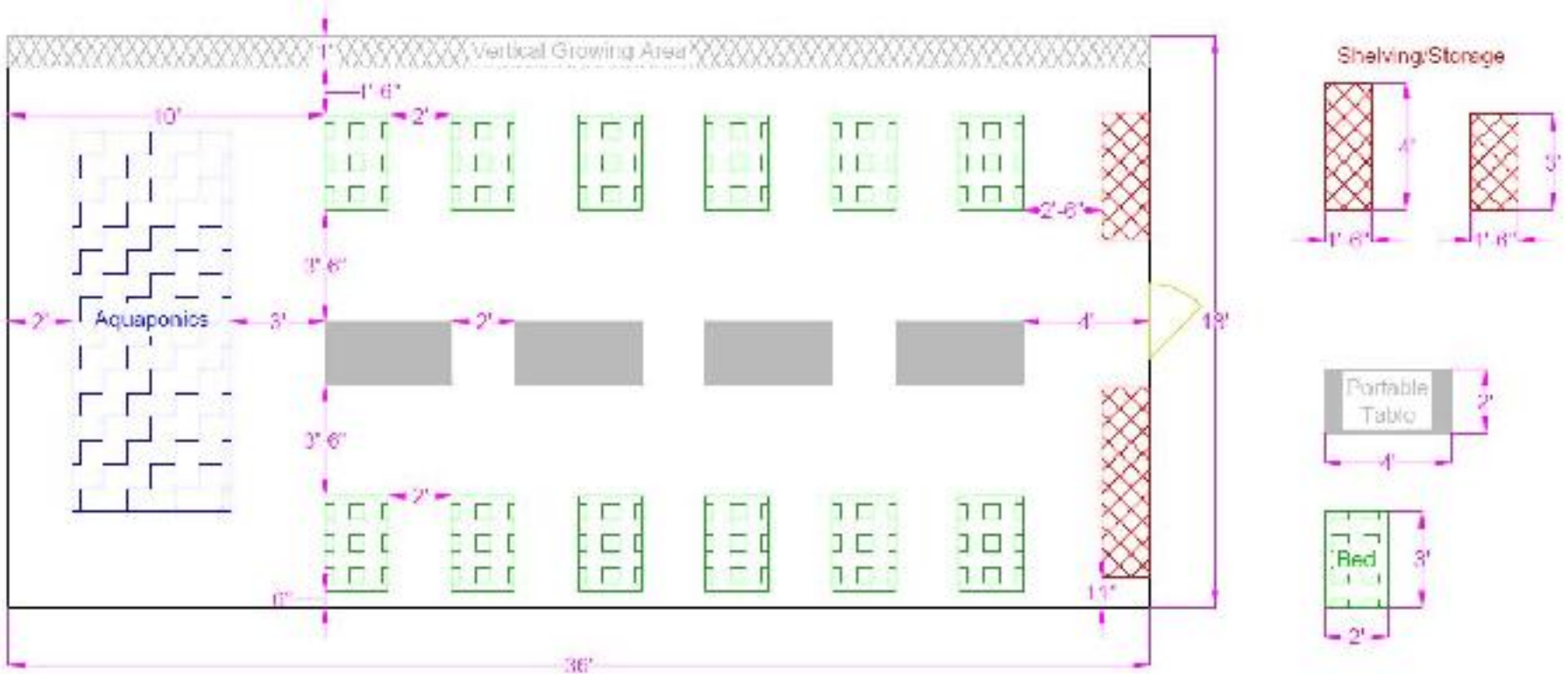
Interior Design Layout

- The interior of the greenhouse will be composed of several different sections
  - Growing Bed Layout
  - Interior Components Selection
  - Irrigation
  - Vertical Trellis for climber plant species

In Progress:

  - Aquaponics research

Bed Layout Finalized



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Interior Raised Beds Final Decision

Houzz Raised Planter Bed

Price: $143.99

Dimension: 36”x24”x36”

Materials: cypress wood, pressed

- Easy access
- Shelf underneath for storage
- Pest resistant

Portable Tables Final Decision

Walmart Fold-in-Half

Price: $47.99 ea

Dimension: 48”x24”x29”

Weight capacity: 300 lb

- Portable, easily cleaned, easily stored
- Fit for demonstration and touring

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Shelves Final Decision

Home Depot, Iron Horse 2300 series

Price: $82.98 ea

Dimension: 18”x36”x72”

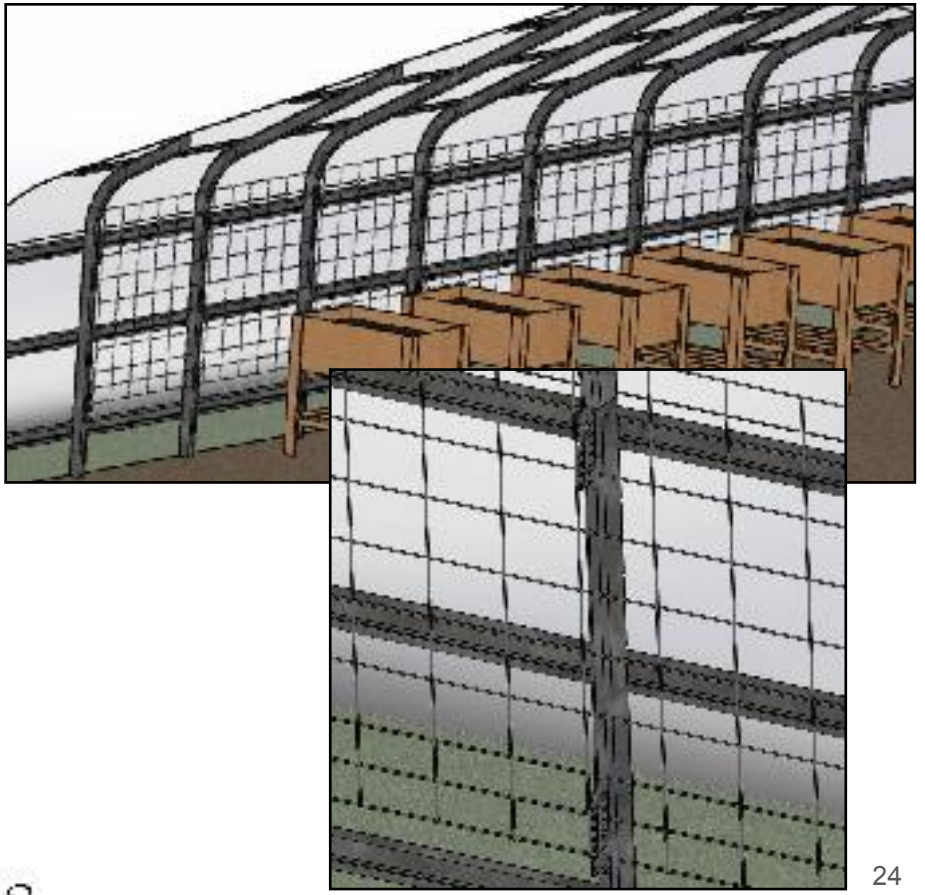
Weight capacity: 2300 lbs

Material: zinc plated

- Easy to clean
- Easy to assemble
- Adjustable shelf height

Vertical Trellis

- For growing climbing plants
- Located on North wall
- Trellis: cattle panel
- Mounting: Angle steel and wire



Vertical Trellis - Parts List and Price

Item Name	Store	Item Price	Quantity	Item Total
Cattle Panels (16 ft. 4-Gauge)	Runnings	$28.00	2	$56.00
Steel Perforated Angle (1-1/4" x 1-1/4" x 48")	Menards	$9.89	3	$29.67
Steel Galvanized Wire (14-Gauge 50')	Menards	$2.99	1	$2.99
Stainless Steel Sheet Metal Screws (#14 x 1" Hex)	Menards	$6.49	3	$19.47
Galvanized Flat Washer (1/4" Grade 2)	Menards	$2.99	1	$2.99
			Total:	**$111.12**

Irrigation Decision Matrix

	Weighting	Overhead Sprinklers	Drip Irrigation and Table Sprinklers	Overhead Misters	Hand Watering	Plug and Play
Safety	5	4	4	4	4	4
Running Cost	5	3	4	4	4	4
Cultural Impact	5	3	3	3	3	3
Flexability / Reconfigurability	4	4	3	1	5	5
Warranty	4	5	5	5	5	5
Labor (Higher # = Less Labor)	3	4	4	4	1	4
Water Consumption	3	2	5	4	4	4
Sustainability	3	3	4	4	4	5
Maintence (Higher # = Less Work)	3	4	3	4	5	4
Initial Cost (Higher # = Cheaper)	2	3	2	4	5	4
Expansion	1	2	3	2	5	5
Total:	100	133	142	137	152	157

Irrigation System Decision - Plug and Play

Pros

Maximum flexibility compared to other systems

Minimal water loss

Integration into other types of irrigation

Cost effective

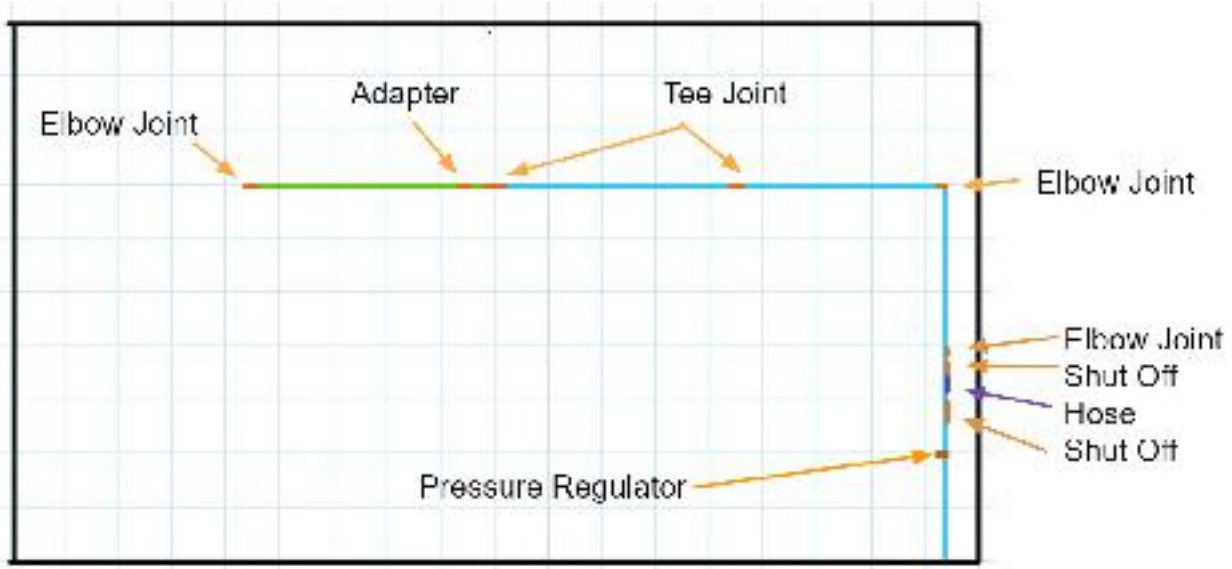
Cons

Higher level of initial work

Could be future cost to adapt to a different system (Ex. change from drip to sprinklers)

Irrigation Drawings

Front View/Door View



1 box = 1 sq ft
Green - ½" Pipe
Blue - ¾" Pipe
Orange - Joint or Shut Off Valve
Purple - Hose Attachment/Nozzle

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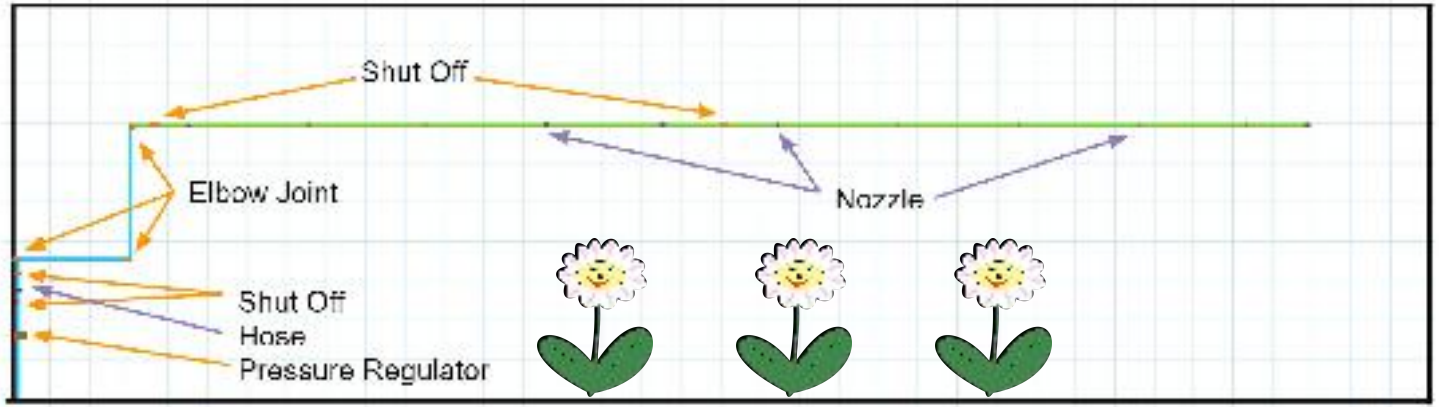
Irrigation Drawings

Side View



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Green - ½" Pipe
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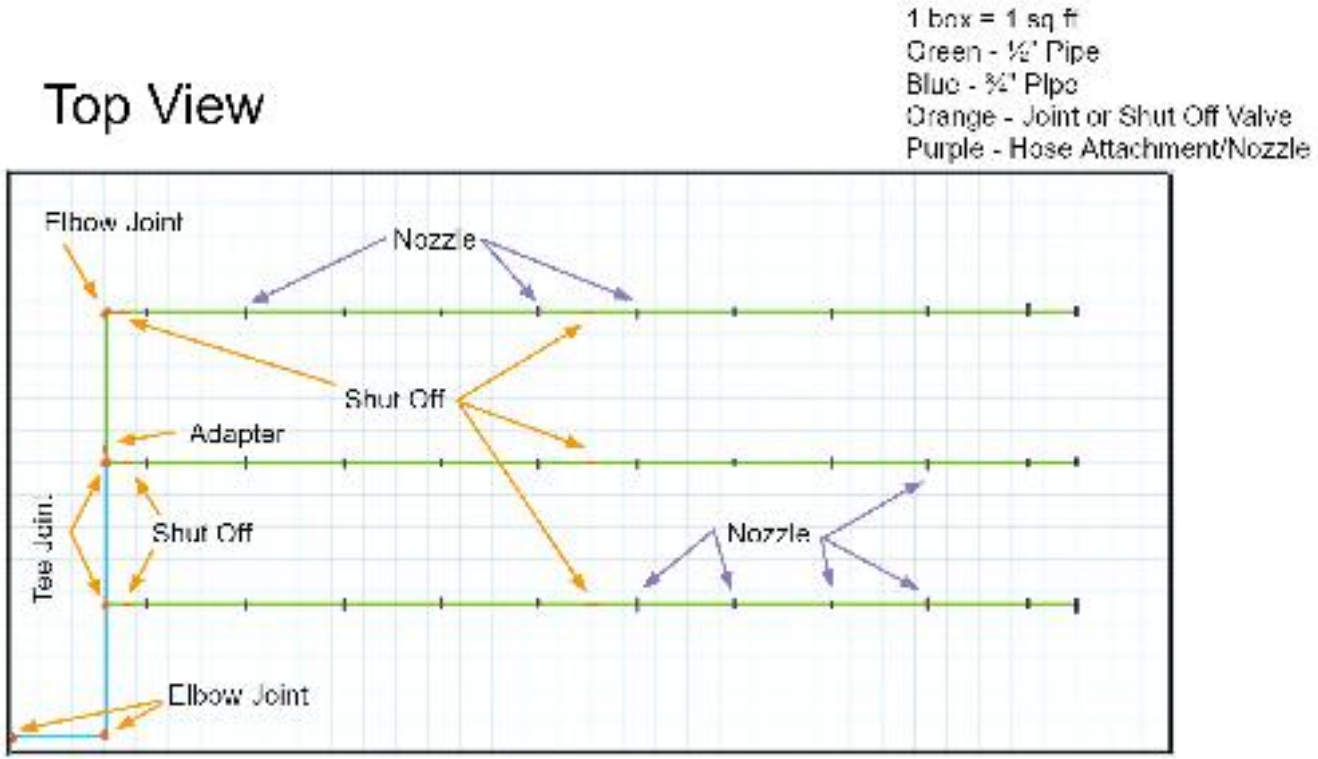
Orange - Joint or Shut Off Valve
Purple Hose Attachment/Nozzle

Irrigation Drawings



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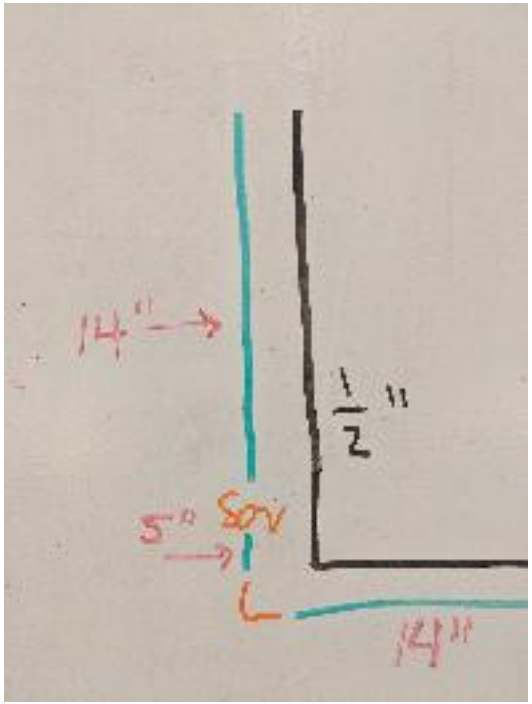
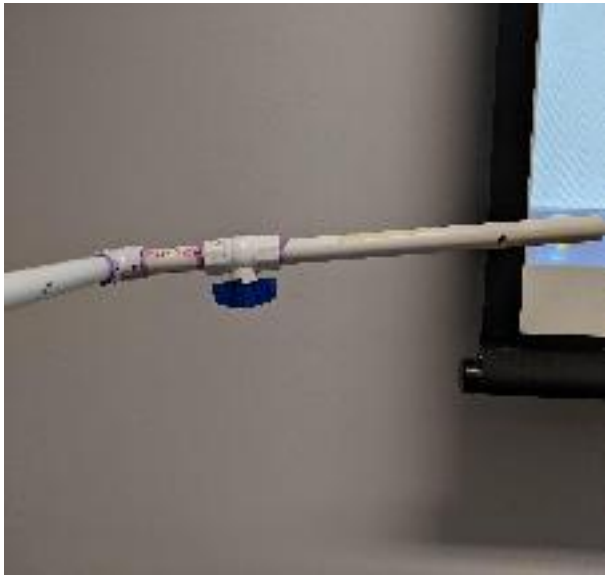
Irrigation Parts

- ½” and ¾” PVC Pipe
- ½” and ¾” Ball Valves
- ½” and ¾” T Joints
- ½” and ¾” Hose Attachments
- ¾” to ½” T Joint
- ½” and ¾” Elbow Joints
- Adapter Parts from ¾” to ½”
- Hose Cap and Control Valves
- UV Resistant Paint
- Hose
- Pressure Regulator
- PVC Joint Compound
- Ceiling Suspension

Irrigation Model





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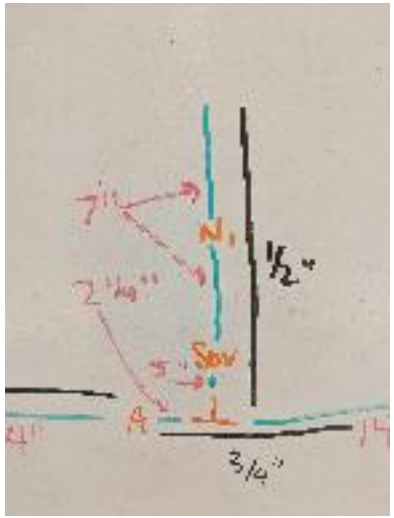

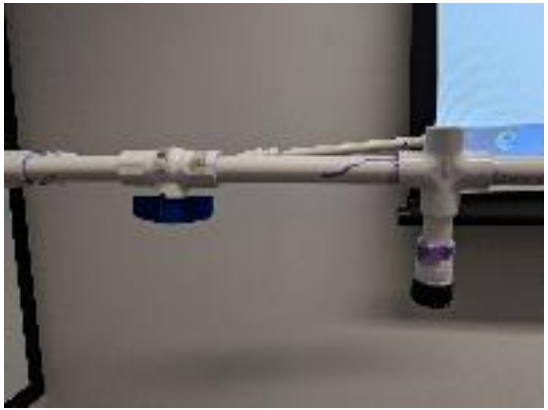

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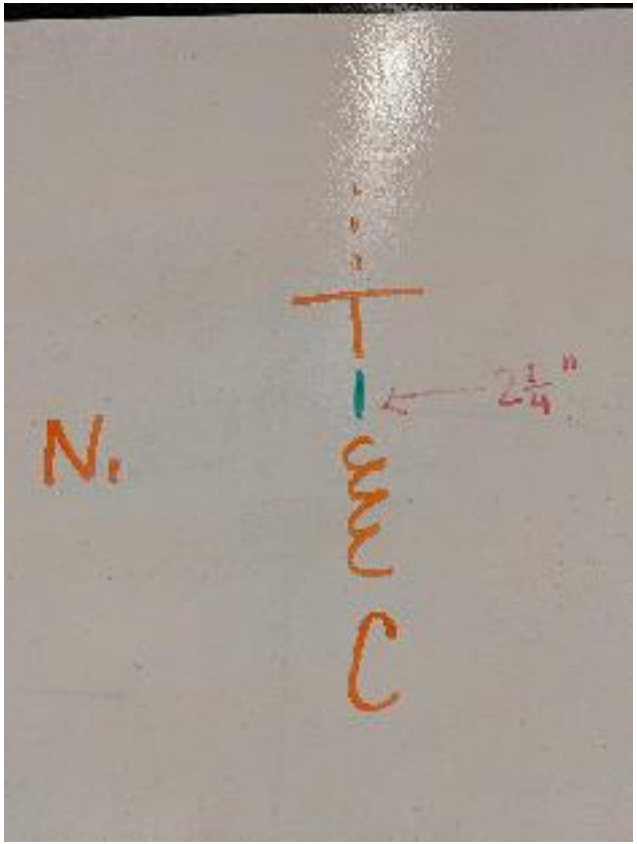
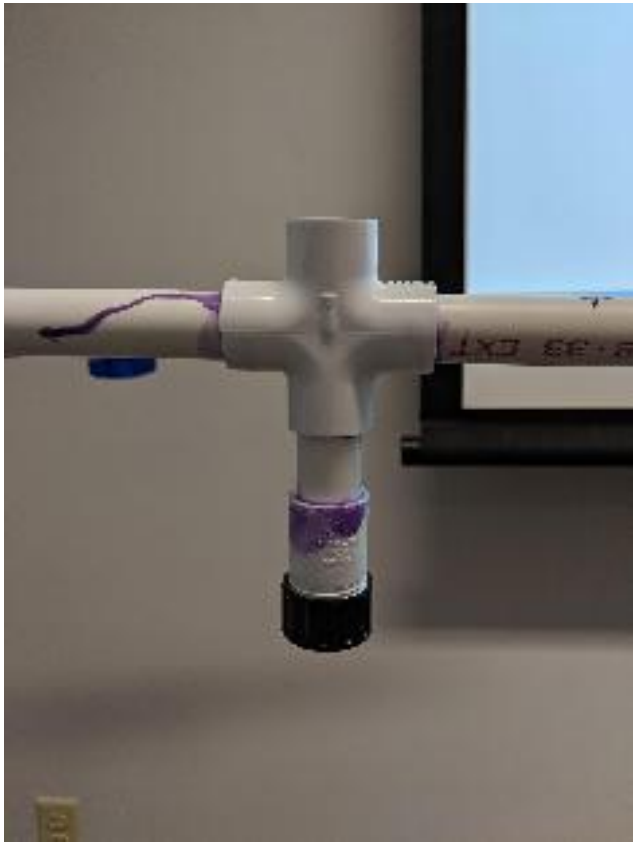
Irrigation Model





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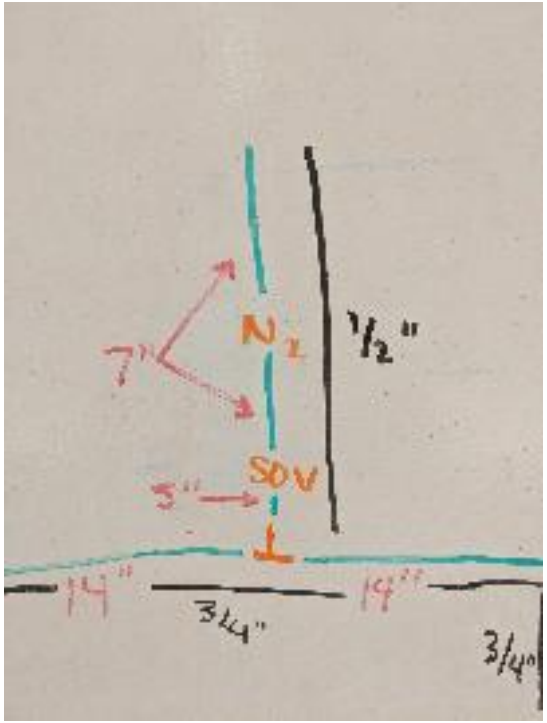

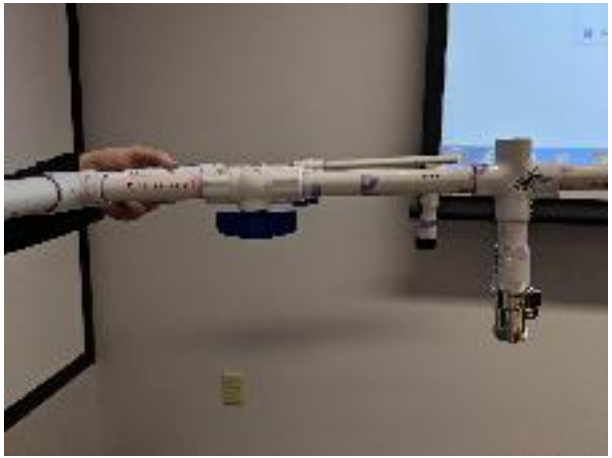

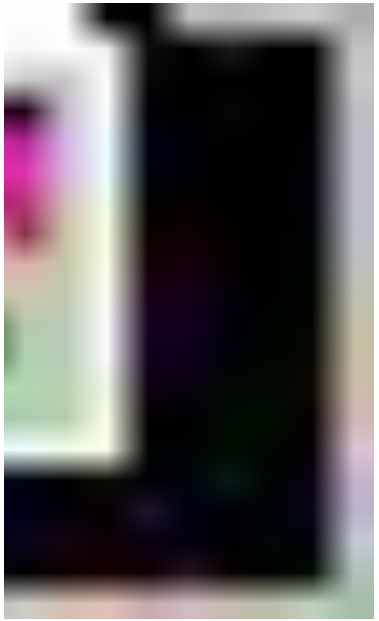

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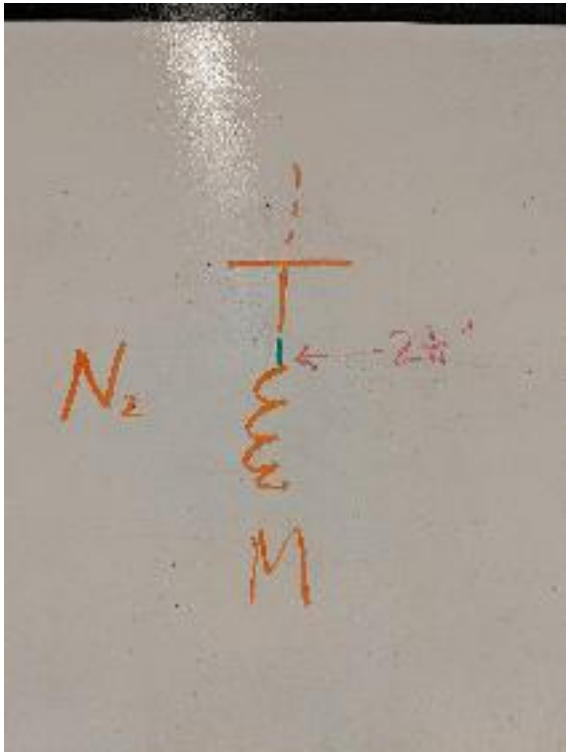

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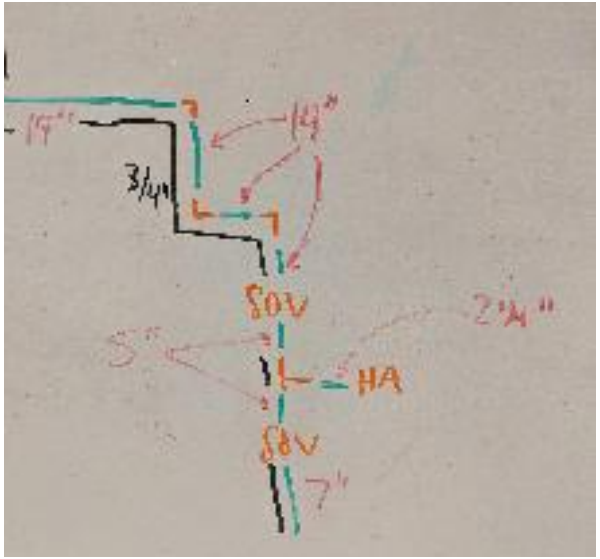

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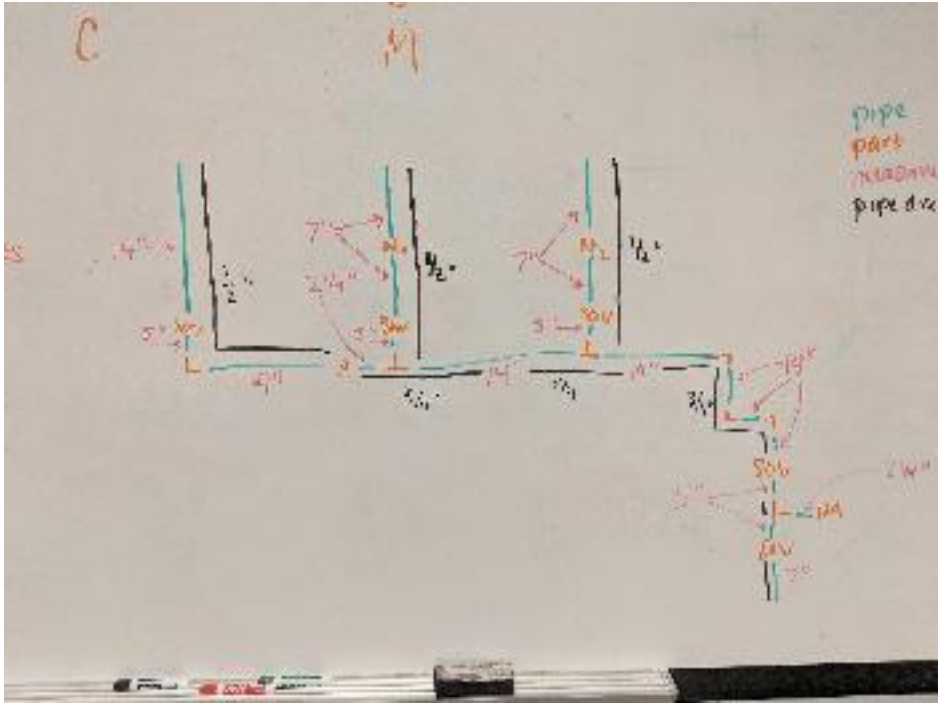
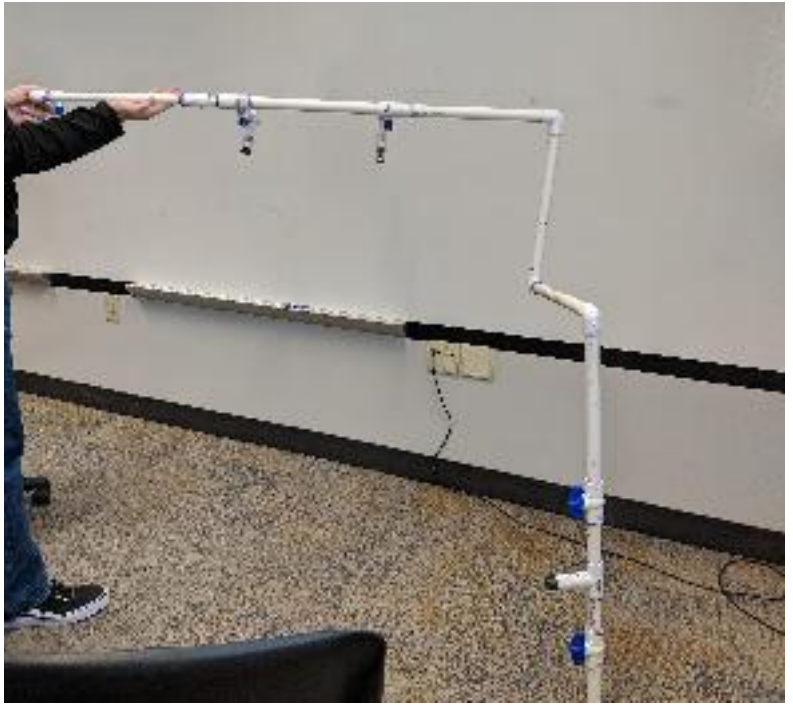




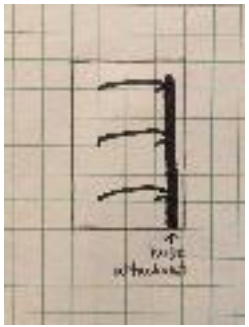
Irrigation for Each Bed

Emitters

¾ inch tube running the length of the bed

Emitters attached to the tube use 4mm tube

$630

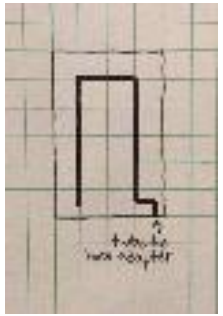


Dripper tube

¼ inch dripline laid out around the bed

Stakes to keep it in place

$480



Operating Budget

Water

Commercial 2019 pricing:

⅝ meter - $8.65

¾ meter - $11.13

1 unit of water - $3.83

1 unit is about 748 gallons of water

	⅝ meter	¾ meter
Monthly	$12	$15
Annually	$150	$180

Electric

Commercial rate for electricity is about 9.73 cents per kWh

$15 base charge

Estimate reflects what is included in the kit.

Annual	$518

Gas

$7.03 per dekatherm residential
$6.07 per dekatherm commercial

Gas heater would not be run year round

Used earlier heating calculations from our project partner for our cost estimate.

	Residential	Commercial
Annual	$132	$114

Operating Budget

Water		
Month	$, 5/8 meter	$, 3/4 meter
January	12	15
February	12	15
March	12	15
April	12	15
May	12	15
June	12	15
July	12	15
August	12	15
September	12	15
October	12	15
November	12	15
December	12	15
Annual	150	180

Electricity	
Month	$
January	44
February	40
March	44
April	43
May	44
June	43
July	44
August	44
September	43
October	44
November	43
December	44
Annual	518

	Gas	
Month	Price $, residential	Price $, commercial
January	49	42
February	23	19
March	-23	-20
April	-61	-52
May	106	91
June	-147	-127
July	-191	-165
August	-189	-163
September	-132	-114
October	72	62
November	6	5
December	55	47
Annual	132	114

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Additional Components

PURDUE GREENHOUSE TEAM MEMBERS

Jacob Lundgren
Civil Engineering

Abigail Thompson
First Year Engineering

Sami Bijonowski
Civil Engineering

Russell Kim
First Year Engineering

Overview

Seed Start

Aquaponics

Exterior Ideas

Rainwater Collection

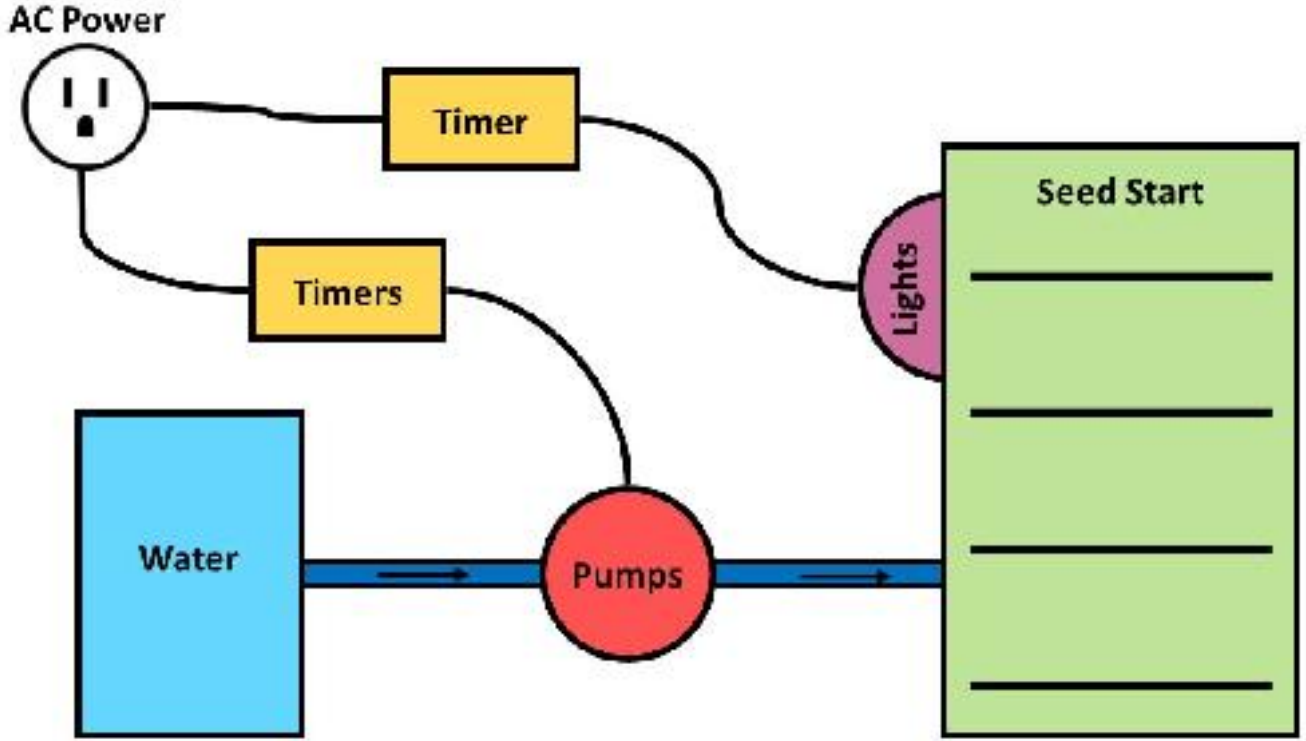
Compost

Heating Efficiency

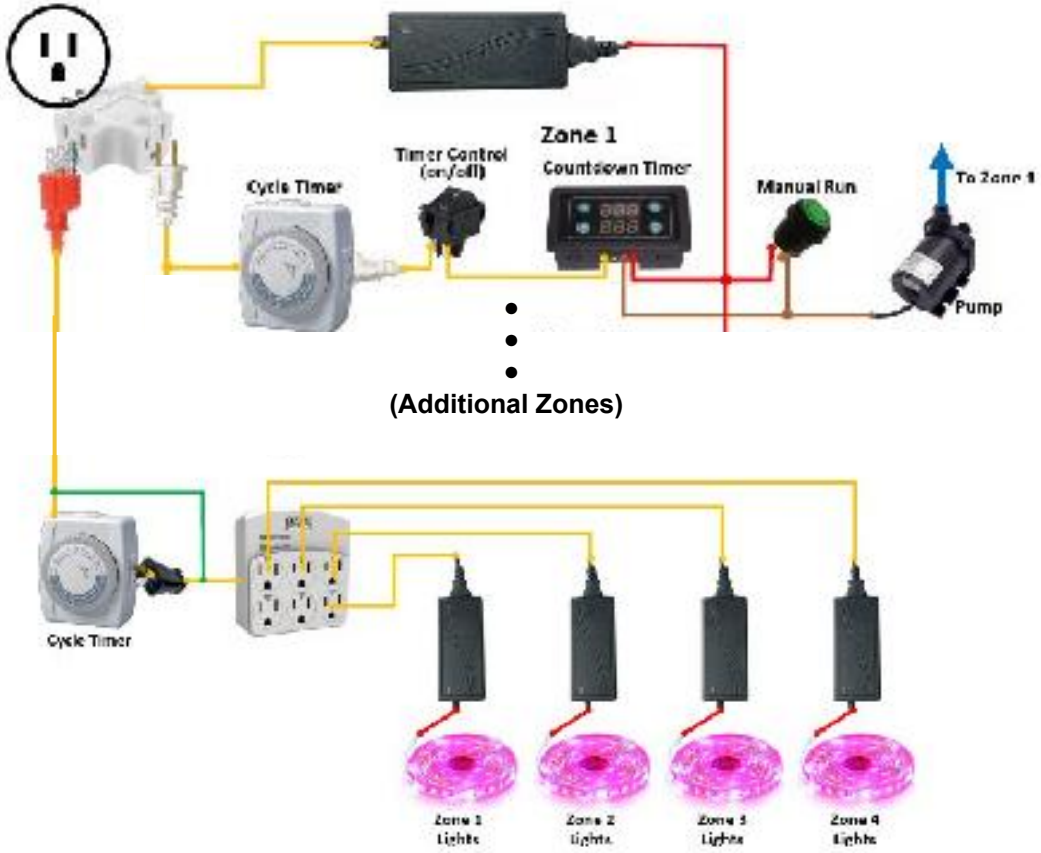
Seed Start

- Start seeds prior to growing season
- Automated lighting and watering
- Four independent zones
- Room for 1200 - 4500 pods
- Collaborating with another SDSM&T EPICS team

Seed Start - System Diagram



Seed Start - Control System



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Seed Start - Components and Prices

Lighting	Irrigation	Structural & Growing
• LED Strips • Timers	• DC Power Supply • Pumps • Timers • Water Storage	• Shelving Unit • Vinyl Sheeting • Growing Supplies
$103.64	**$268.01**	**$353.91**

Total:	$725.56

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Seed Start - Construction Progress

Assembled shelf

Added lighting

Cut vinyl covering

Began Sewing

Finished control board

Started wiring components

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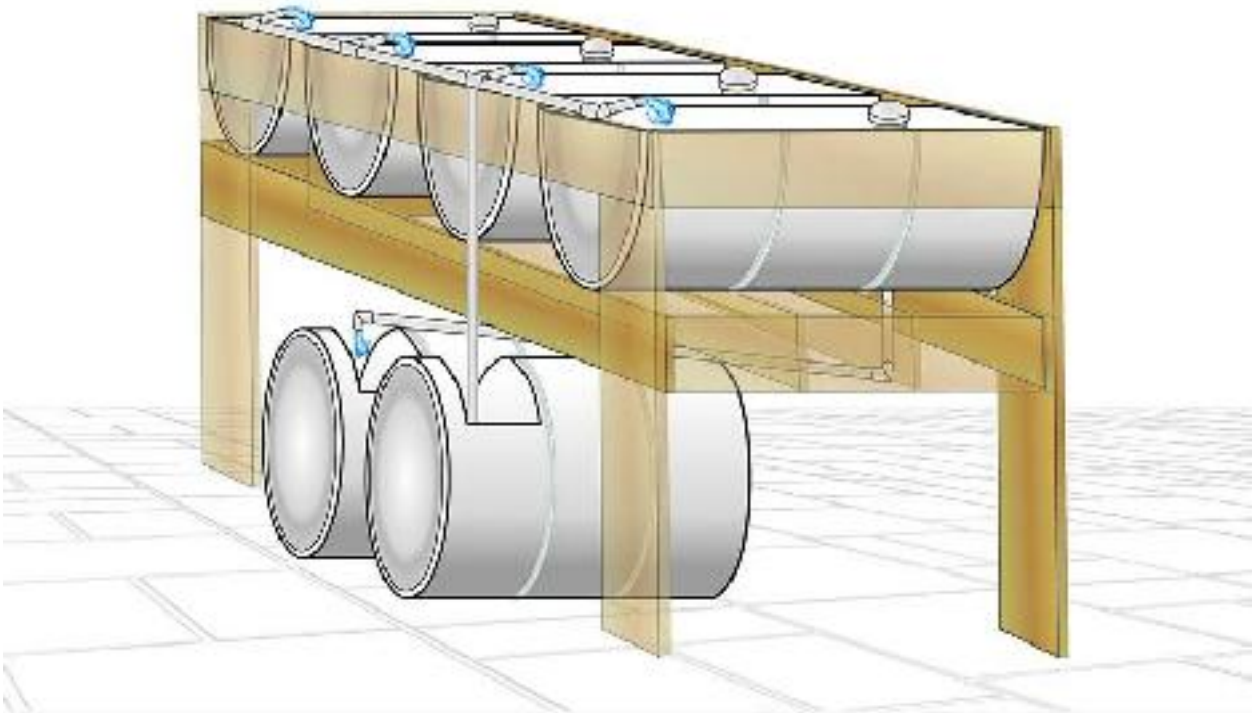
Aquaponics

Small system example:



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Aquaponics

Aquaponics Components

Waterbed material
- 55 gal barrels or larger gal barrel
- Fishtank

Growing media
- River rock
- Pea size gravel

Recommended plants
- Anything leafy (lettuce, kale, etc.)
- Basil
- Mint
- Chives

Recommended fish
- Tilapia
- Blue gill
- Sunfish
- Crappie
- Koi
- Goldfish

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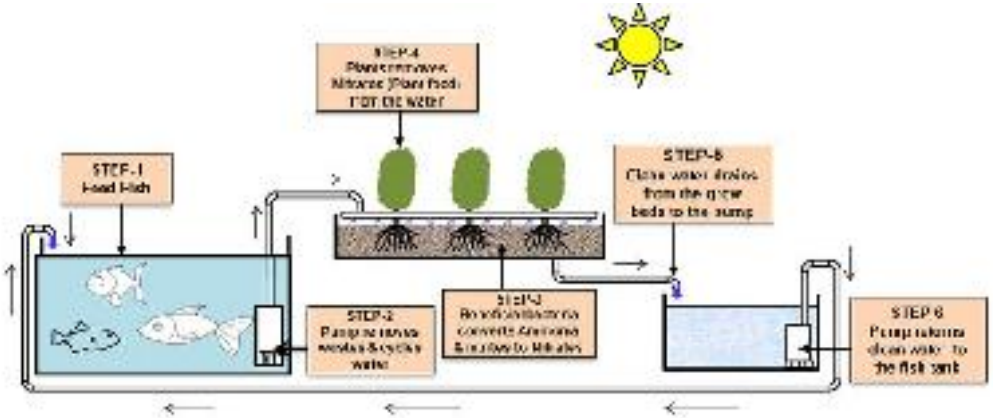
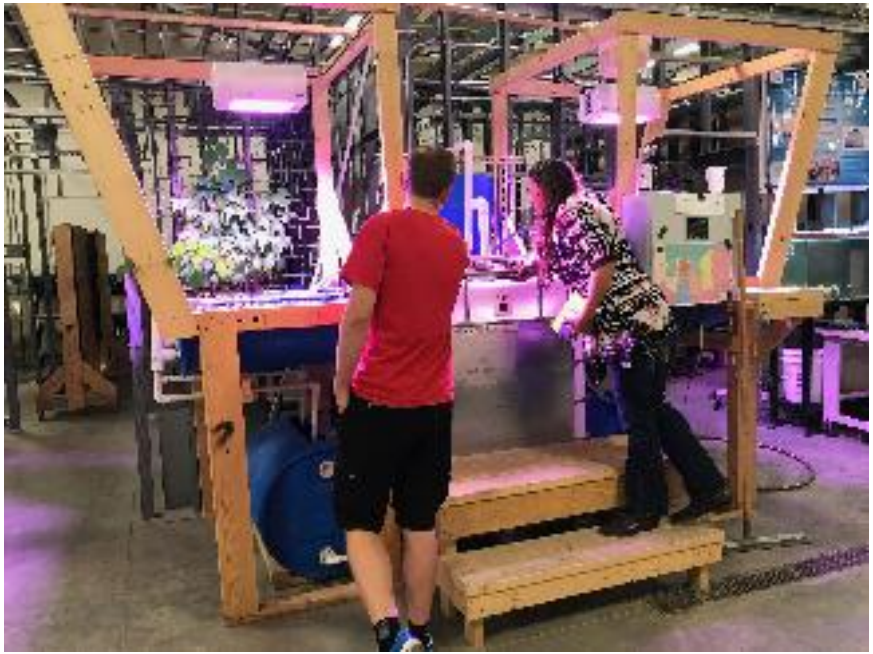
Aquaponics

Western Dakota Tech Aqua 2.0

Estimated cost ~ $3,450

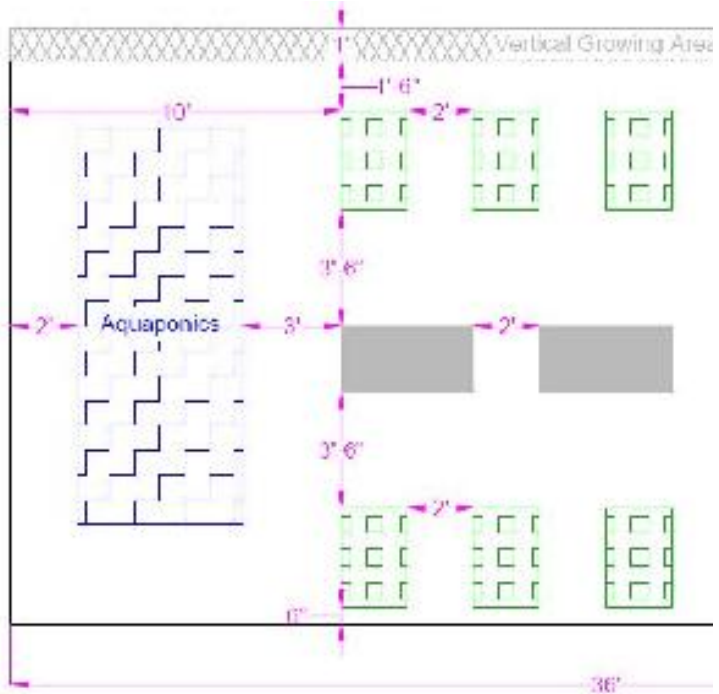




Aquaponics

Aquaponics Questions/Considerations

- Addition of chemicals to the water for pH control
- Ratio of water to plant
- Degree of automation
- Aeration
- Heating and living space for the fish
- Algae



Exterior Ideas

- Outdoor arbor
  - Firepit
  - Log seating
  - Trees - Circle of Ponderosa Pine Trees

Rainwater Collection Systems - Initial

Wet System - Very complicated to install, hard to maintain

Dry System - Has to be next to house

Rain Barrel - only holds 50 to 100 gal.

Rainwater Collection Systems

Gutter system voids warranty on Greenhouse

Compost

- Wooden
- Homemade
- Hard to rotate
- Hard to remove

- Light-weight
- Easy to use
- Produces the most compost

- Heavy - duty
- No smell
- Holds the most compost

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Compost

Compost Options	Durability x4	Smell x3	Efficiency x3	Size x2	Price x3	Ease of use x5	TOTAL
Option 1 - Wooden	**16**	**9**	**6**	**10** ~ Depends	**15** ~ $125	**10**	**66**
Option 2 - Tumblers Home Depot	**12**	**9**	**15**	**8** ~ 100 gallons	~ $250 **9**	**25**	**78**
Option 3 - Plastic Bin Gardeners Supply Company	**20**	**2**	**9**	**10** ~ 240 gallons (38 ft^3)	**12** ~ $200	**10**	**73**

Greenhouse Heating Efficiency

Thermal curtains are insulating blankets used for heat retention at night and on cold days. They can also be used for summer shading or light control.

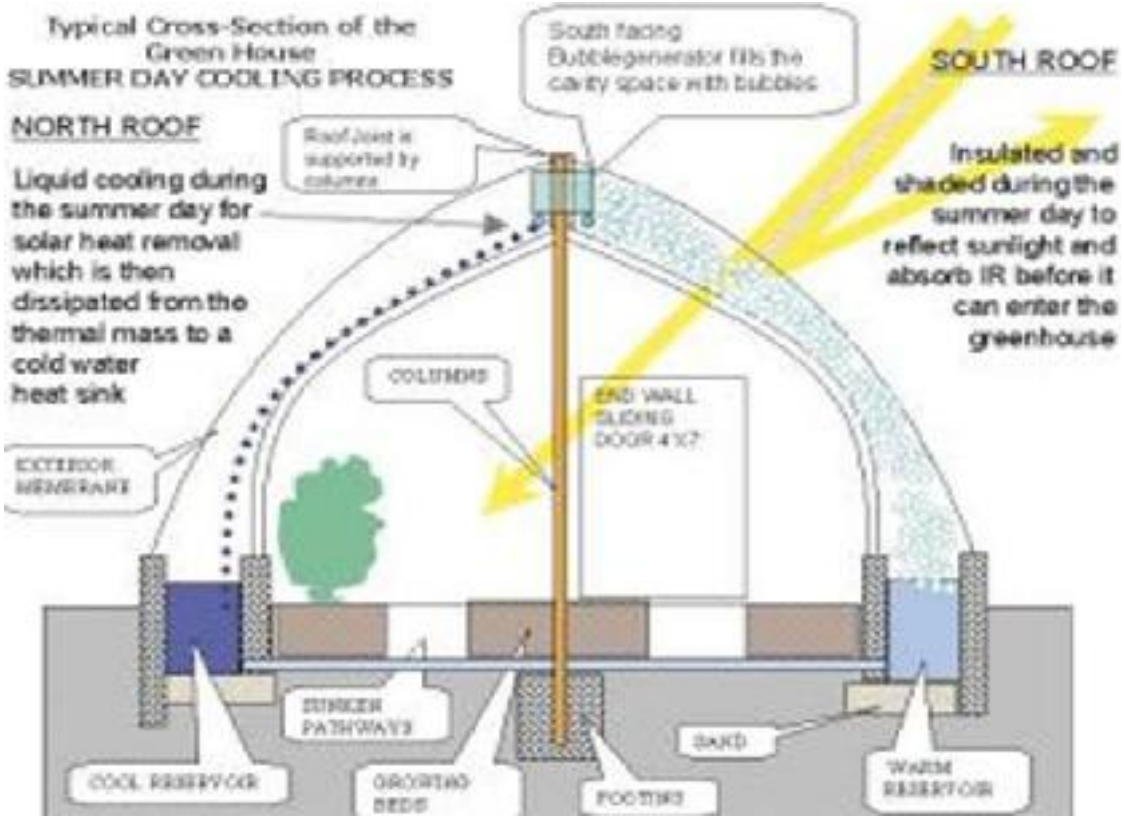
Cost of installation is about $2 per square foot

Estimated 52% percent savings on the energy cost with a fully equipped greenhouse

Alternatives

Inject foam between double poly films

50% energy savings



EPICS - Fall 2019

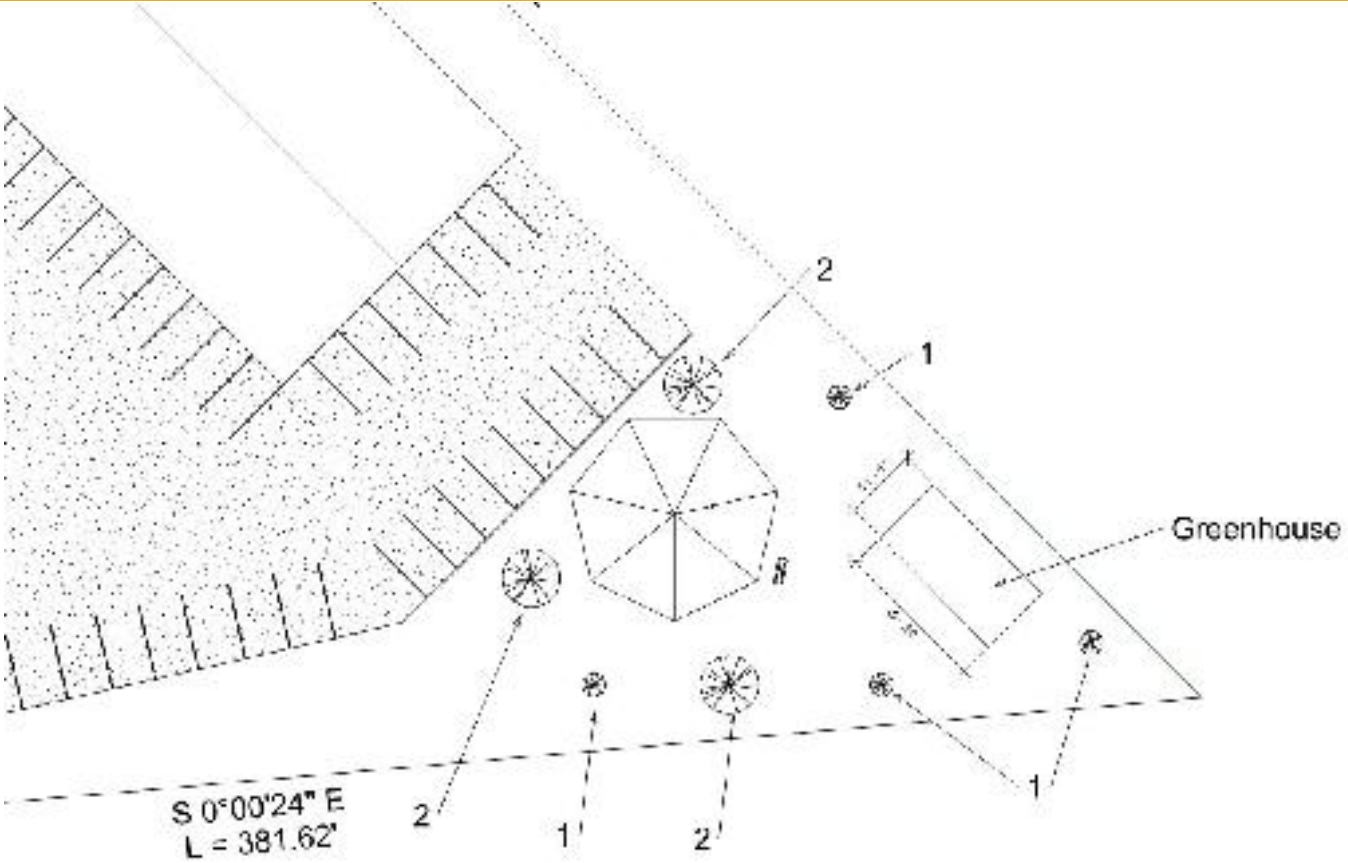
- South Dakota Trip
  - Possible Kyle Greenhouse
- Greenhouse Add-ons
- Aquaponics

Cultural Center

Purpose

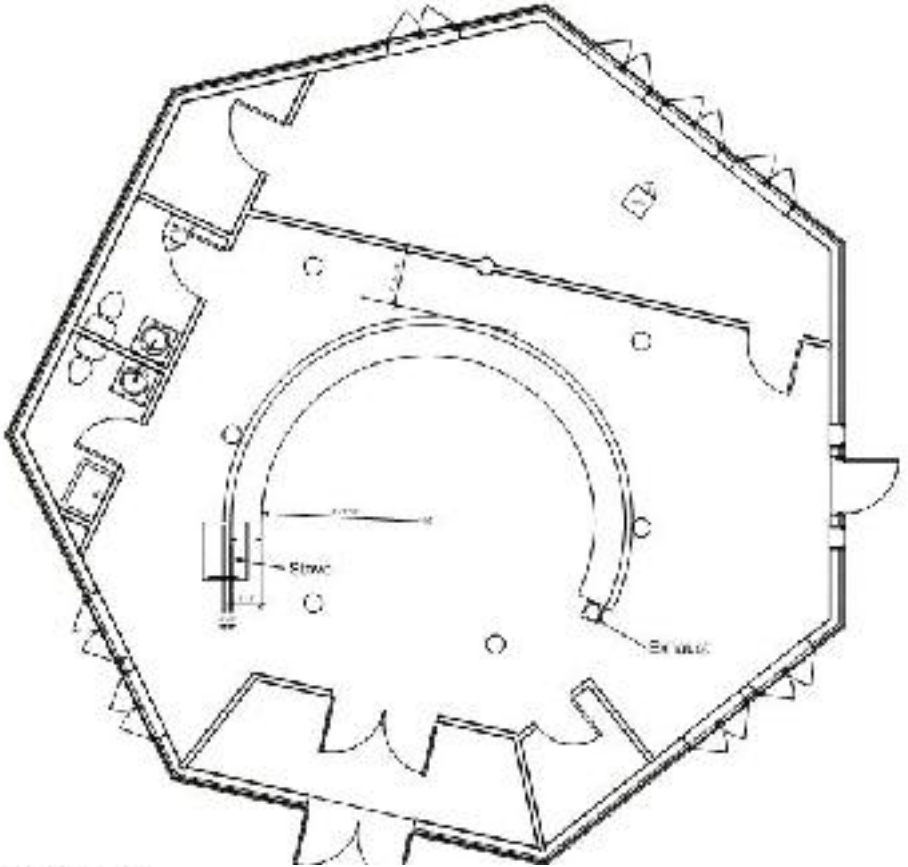
- Teaching
  - Augments learning opportunities provided by the greenhouse
  - Collaborative non traditional classroom environment
  - Additional meeting space for project-based learning teams
- Cultural Enrichment and Preservation
  - Display of cultural items
  - Community gathering area

Site



Design Overview

- 7 Sided Wood Framed Building
- Multi-Purpose Main Room
- Rocket Mass Heater
- Small Conference Room
- Low Maintenance
- Open Truss System
- Estimated Cost of $250k - $300k



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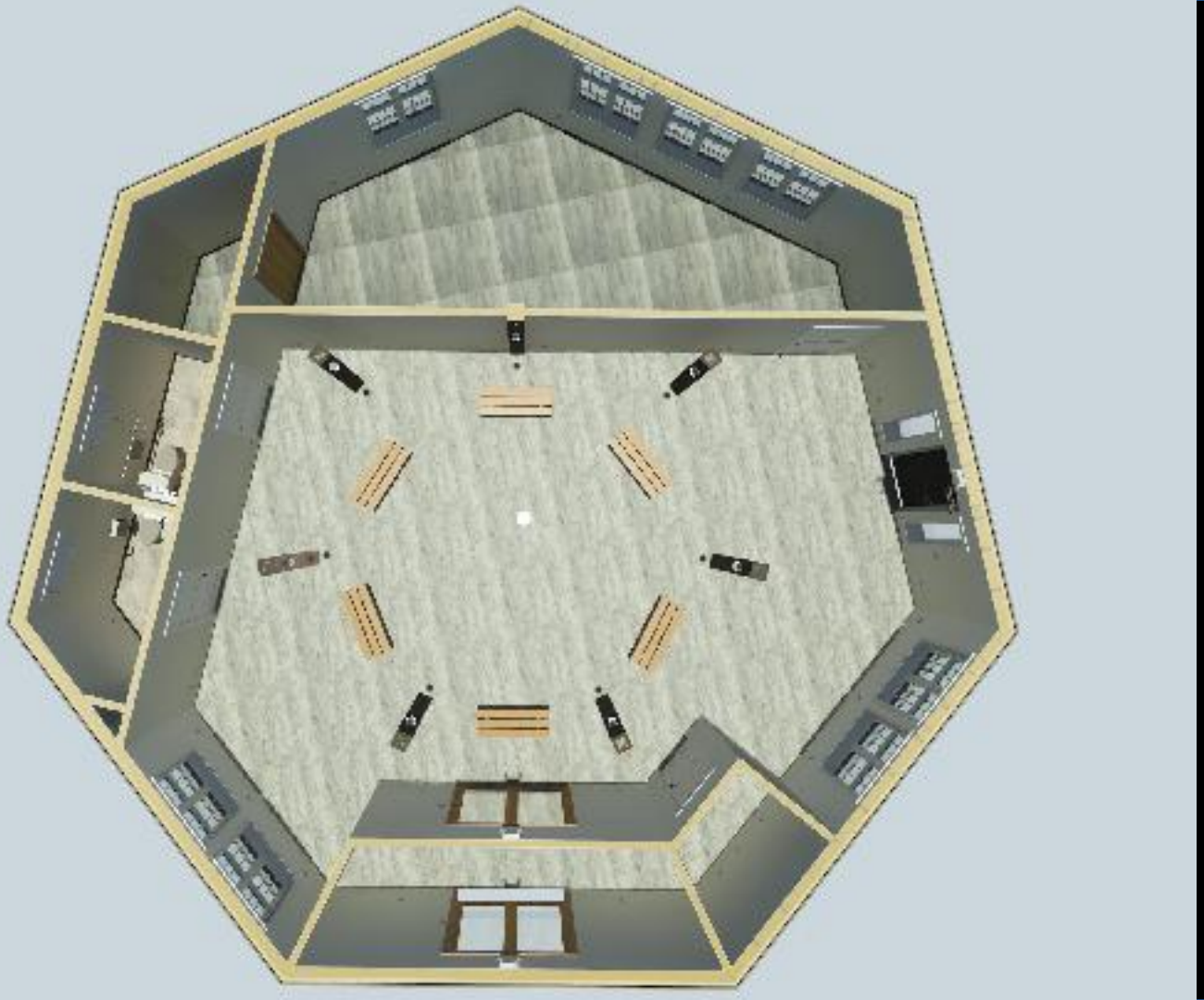
Design Overview (Elevation View)

Exterior



Interior Renderings 1

Interior Renderings 2

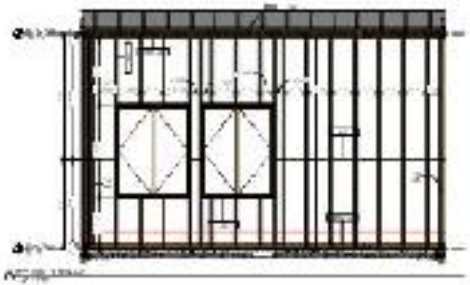
Interior Renderings 3

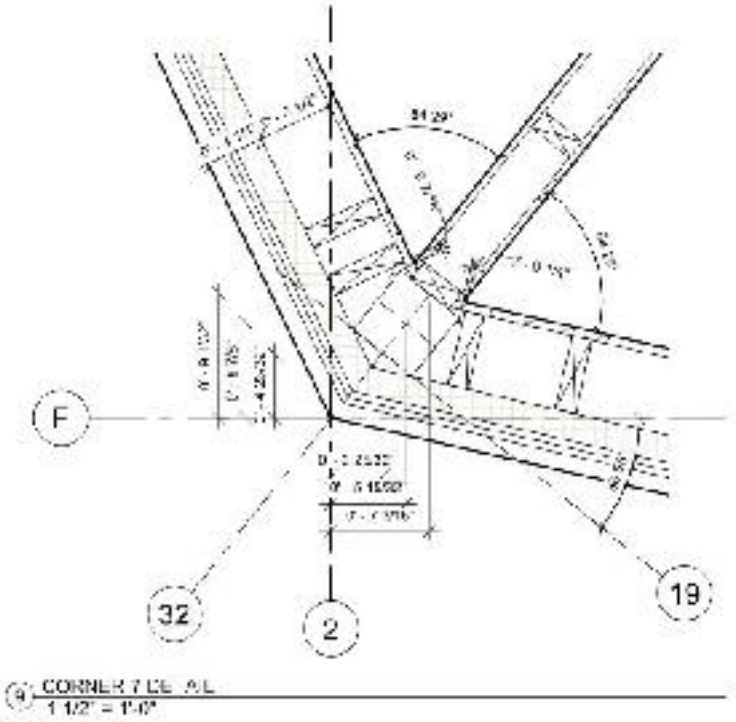
Cultural Center Semester Progress

- Cultural Center Wall Mock-Up
- Rocket Mass Heater Prototype
- Construction Documentation Development
  - Updated set of drawings
  - Complete material specifications
  - Engineer’s estimate (+/- 10%)

Cultural Center Wall Mock-up

- Two 8’ Sections
- Including Corner Assembly
- Partial to Full Construction
- Teaching Device





EPICS

Wall Pictures

Wall Pictures Cont.

What Did We Learn from the Wall?

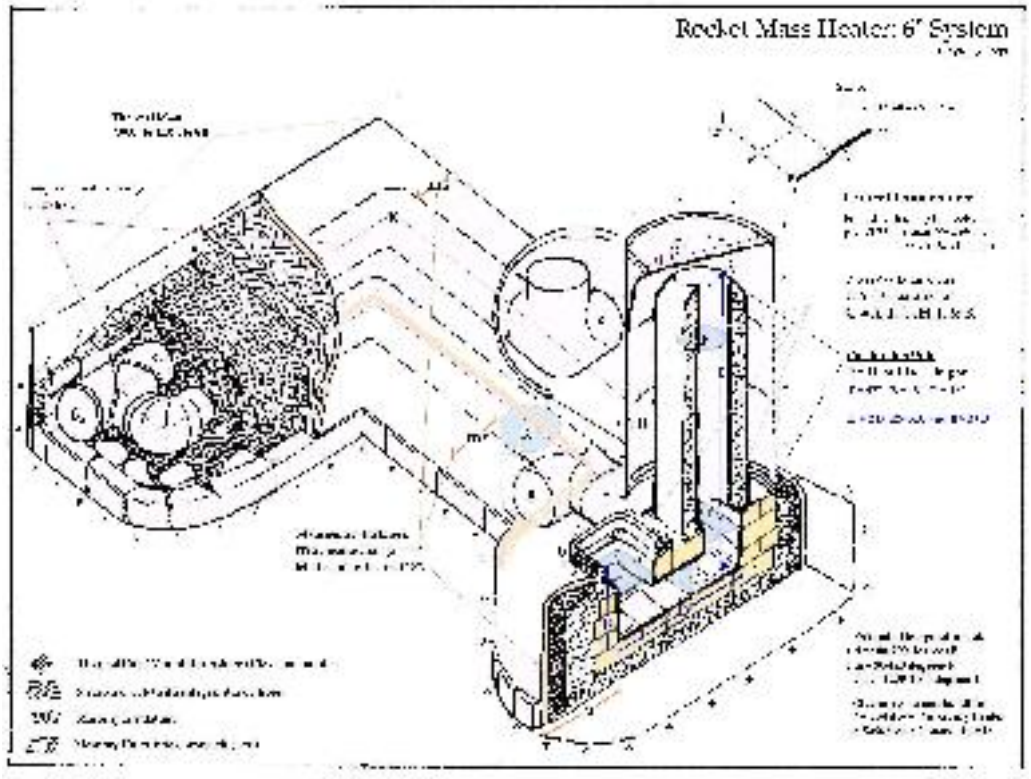
- The framed walls aren't that hard to construct
  - Important depending on the professional experience of our workforce (volunteers)
- A more practical way to build the wall joints
  - Original detail wasn't realistic
  - New detail involves lag bolts to hold the column and double studs in alignment
  - The odd angle of connection still presents a issue
- A 7-sided building will present numerous issues
  - Odd angles make wall joints at column locations difficult to construct
  - Construction costs significantly increased due to necessity of purchasing custom parts for things like siding, trim material, and truss connections

Rocket Mass Heater

- Type of wood burning furnace
- Heats self through conduction and then the air through radiation
- More efficient
- More environmentally friendly
- Can heat a large space quickly and easily
- Mass acts as a thermal reservoir to keep a space warm for an extended period of time

Purpose of Rocket Mass Heater Prototype

- Preplanned Design
- Testing materials and construction methods
- Testing heat output and ventilation concerns



EPICS

RMH Pictures 1

RMH Pictures 2

RMH Pictures 3

RMH Pictures 4

RMH Pictures 5

RMH Pictures 6

What Did We Learn from the RMH? 1

- Need for air circulation system
  - Small amounts of smoke leakage likely to occur
  - Temperature differential based on proximity to the heater
  - Ceiling fan at minimum, HVAC system likely
- Barrel Heat
  - Presents safety hazard to people and flammable materials
  - Need some system to limit access while preserving usability
  - Definitely adequate to use as cooking surface

What Did We Learn from the RMH? 2

- Heat Duct Size and Shape
  - Utilized a 6” exhaust duct in prototype. Team recommends increasing to 8”-10” duct to limit frictional losses and increase distance the heat can be transmitted through the bench
  - Bends reduce maximum travel distance of the exhaust by ~5 ft. Final design should limit their use.
- Cob
  - Works well at radiating heat
  - Difficult material

For Future Teams

- Cultural Center
  - PE Review of the Cultural Center
    - Review by local PE that can give detailed feedback and work with student groups
    - Make needed changes to bring structure up to code
    - Review by PE in SD to get plans / specs ready for constructions
  - Finalize location
  - Secure funding
  - Pre-construction Process
- Future Greenhouses
  - Assess local needs and resources
  - Identify viable locations
  - Secure Funding
  - Reference Greenhouse How-To Manual
  - Greenhouse additions and improvements