

Planning the 21st Century Urban Farm

IPRO 336

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Feeding A Person

Traditional Techniques of Farming

- On an average U.S. diet, it takes approximately 15,000 to 30,000 sq.ft. of land to feed one person per year.

- In acres, that is a total of 0.344 to 0.69 acres of land.



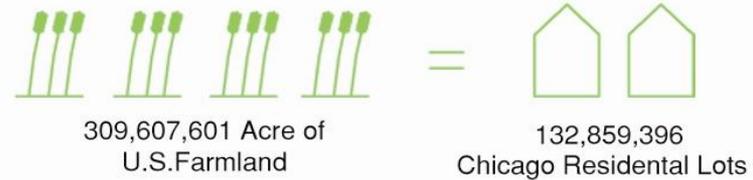
Amount of much farmland is used in the U.S.

- There's a total of 309,607,601 acre of land that were harvest in the year 2007.

- That amount of land can feed about 900,022,095 people per year.

- That's a total of 418,507,099,560 sq.ft. of land.

- Which is the equivalent of 132,859,396 Chicago city residential lots.



However

- It's not guaranteed that all the crops that are being grown or harvested will survive to feed a person.

- Various misfortunes may occur during the farming process ranging from...

- Poor Farming Maintenance
- Natural Disasters
- Pests
- Crops Spoiling

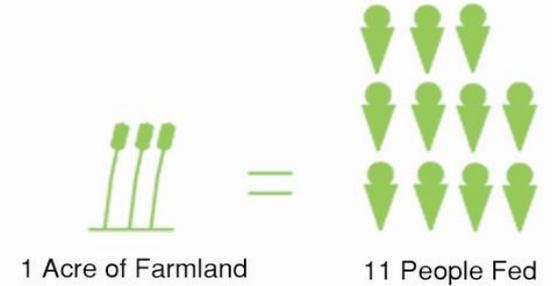


Feeding A Person

Vertical Farming

- Through new farming techniques and technology in the agriculture world, the amount of farmland required to feed a person for a year can be brought down to about 4000 sq.ft.

- That is approximately 0.09 acre of land to feed one person per year.



Project Farming Operations

- This project building footprint is 100,000 sq.ft. (2.29 acres)

- The amount of space that is planned to be used for farming operations is approximately 200,000 sq.ft. (4.59 acres)

- That can feed 50 people per year.



Comparing to Traditional Farming Methods

- For Traditional Farming Methods to feed 50 people per year, it would require 17.2 acres of land (749,232 sq.ft.).

- Our project is only occupying 2.29 acres of land (100,000 sq.ft.) to feed 50 people per year.

- We are saving a total of 14.91 acres of land (649,232 sq.ft.) compared to traditional farming methods.

- That is the equivalent of 207 Chicago Residential Lots.



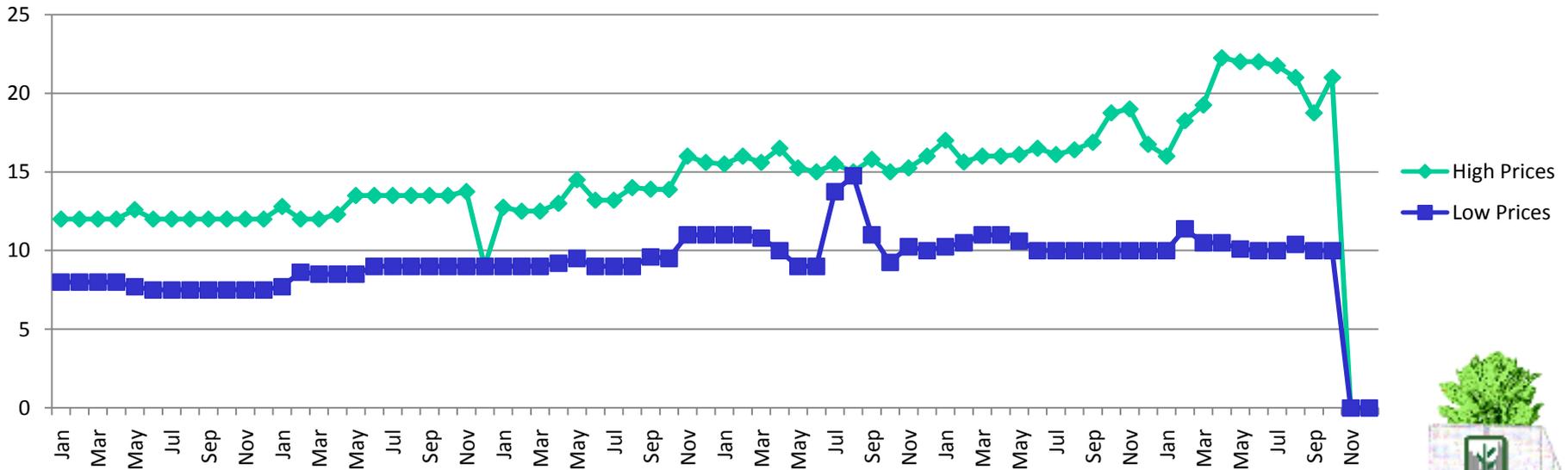
MARKETING



- Target final value of \$12.00 per square foot per year.
- Database of crops
 - Terminal Markets in Chicago
 - Expanded with additional information
 - Calculated prices per sqft/year
- Data used in analysis was standard farming techniques.
- Fish for aquaponics
 - Time to market size
 - Water temperatures



Commodity Name	City Name	Type	Package	Week Ending on	Low Price	High Price	Origin	Origin District	Item Size	Color	Environment	Unit of Sale	Quality	Condition	Appearance	Storage	Crop	Rep ack	Trans Mode
WATERCRESS	CHICAGO		cartons bunched	12/6/2008	10	10	CALIFORNIA		12s									N	
WATERCRESS	CHICAGO		cartons bunched	12/6/2008	18	19	CALIFORNIA		24s									N	
WATERCRESS	CHICAGO		cartons bunched	12/13/2008	10	10	CALIFORNIA		12s									N	
WATERCRESS	CHICAGO		cartons bunched	12/13/2008	15.5	16	CALIFORNIA		24s									N	
WATERCRESS	CHICAGO		cartons bunched	12/20/2008	10	10	CALIFORNIA		12s									N	
WATERCRESS	CHICAGO		cartons bunched	12/20/2008	15.5	16	CALIFORNIA		24s									N	
WATERCRESS	CHICAGO		cartons bunched	12/27/2008	10	10	CALIFORNIA		12s									N	
WATERCRESS	CHICAGO		cartons bunched	12/27/2008	15.5	16	CALIFORNIA		24s									N	



Crop	Growing Season	Max Height/Length (in)	Space Between Plants (in)	Yield (lbs) /sq. ft.	Time to Harvest (days)	Number of Plantings per Year	Value (\$)/sq. ft.	Avg Price Per lb	Price per year /sq. ft.
Chard	Early Spring	18	2 between seeds/18 between rows	0.67	57 - 64	6	\$3.13	\$4.67	\$18.87
Kale	Spring and Fall	36	1 between seeds/18 between rows	0.25	50 - 75	6	\$1.01	\$4.04	\$6.06
Shiitake Mushrooms	All Year	6	Grown on Logs	1.44	180	2	\$6.48	\$4.50	\$12.96
Watercress	Spring to Fall	24	6 to 8	0.47	40 - 70	5	\$4.70	\$10.00	\$23.50
Cucumbers	Summer	24	6 to 8	0.4	50 -60	1	\$1.20	\$3.00	\$1.20
Tomatoes	Summer	36 to 60	18 to 36	2.5	60 - 90	1	\$9.38	\$3.75	\$9.38
Arugula	Early Spring or Late Fall	18 to 24	6	0.47	30 - 40	5	\$4.70	\$10.00	\$23.50
Bell Peppers	Summer	6 to 36	12 to 36	0.53	56 - 95	1	\$1.99	\$3.75	\$1.99
Chives	Spring to Fall	20	12 to 18	0.11	60	4 initially/12 eventually	\$0.92	\$8.50	\$3.08/\$11.04
Button Mushrooms	All Year	6	N/A	1.9	50	12 to 15	\$2.28	\$1.20	\$27.36



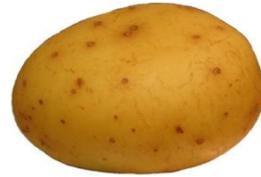
Species	Growing Season	Stocking Density (lbs/gallon)	Market Size (lbs)	Water Temperature (°F)	Value (\$)/lbs	Time to Harvest
Tilapia	All Year	0.25	.88 to 1.1 or 1.54 to 2.4	82 - 86 optimal 68 slow growth 50 death	\$1.50 - \$2.00 frozen fillet \$5.00 - \$6.00 fresh fillet \$8.00 - \$10.00 local whole fish	8 - 10 months or 11 - 14 months
Yellow Perch	All Year	1.5	0.33	70 - 75 optimal 50 - 40 slow growth 32 death	\$2.80 fresh fillet	20 months

•Yield per sqft/yr for fish in a 2ft deep pond is 14 fish/sqft. At \$2/fish, this equals \$28/sqft/yr.



AGRICULTURE / LIGHTING





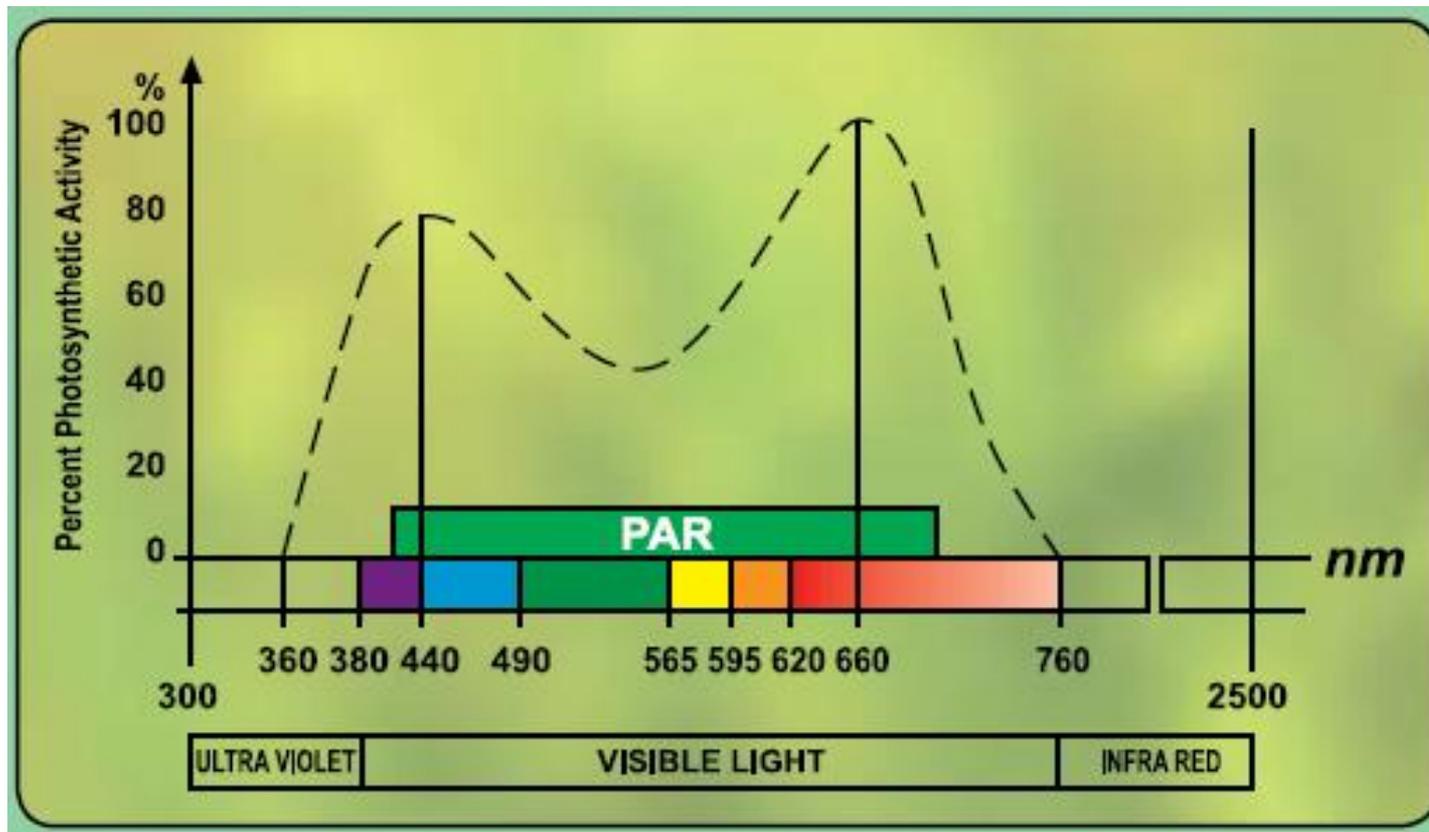
DIFFERENT SOIL FREE GROWING METHODS

- HYDROPONICS – Nutrient rich water flows through plant roots
- AEROPONICS – Nutrients are sprayed onto roots
- AQUACULTURE – Farming of water organisms
- AQUAPONICS – Combination of hydroponics and aquaculture

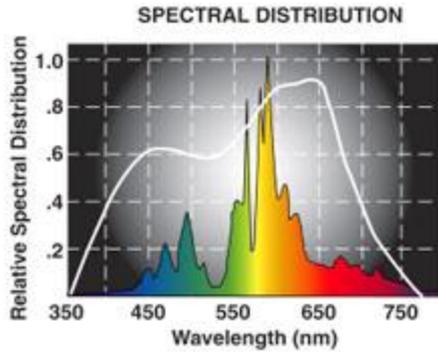
- Plants grow in controlled environment
- No pests or diseases, organic
- Regulate / optimize plant growth using artificial lighting
- Building systems to recycle waste energy



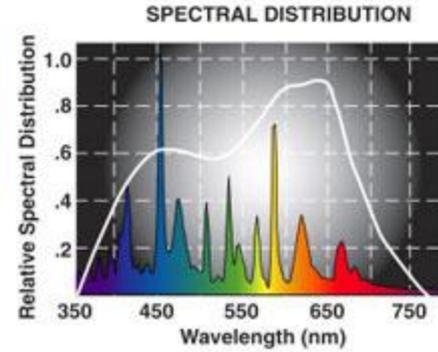
Photosynthesis



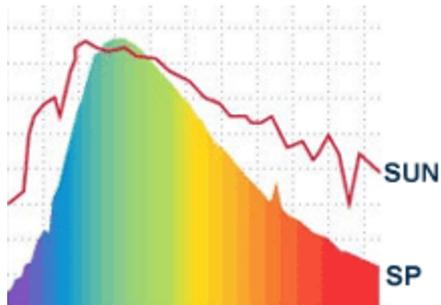
Type of Lighting



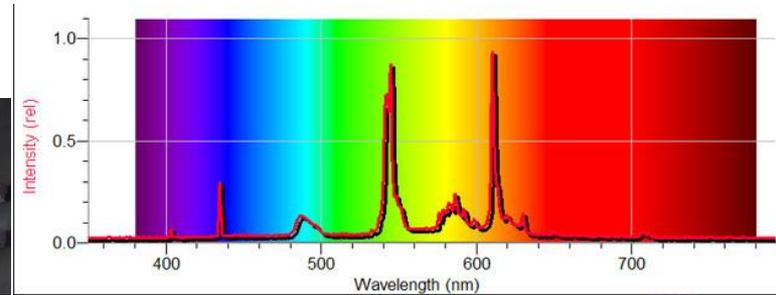
High Pressure Sodium



Metal Halide



Sulfur plasma



Flourescent lights



Fauna

- Animals such as honeybees and butterflies are natural pollinators.
- Can produce wastes that are processed into nitrogen and other nutrients for the plants.
- Have possible value in the market as food or pets.



Compost Heaps

- Compost heaps can be constructed out of waste materials.
- Require little maintenance and contain many of the nutrients plants need.
- Can contain worms to expedite the process.

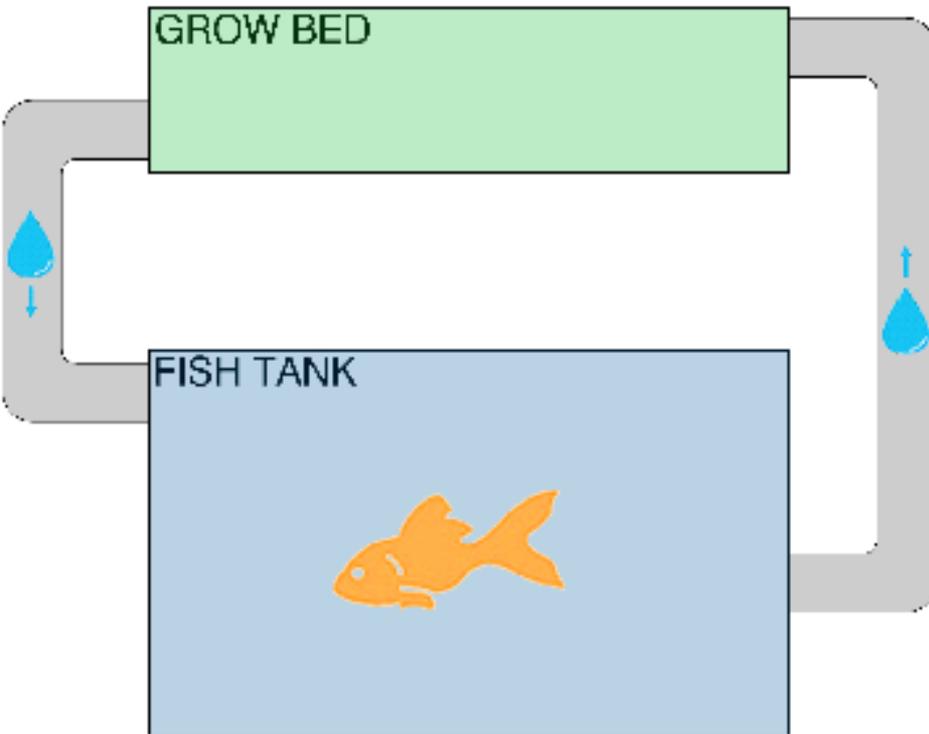


PROTOTYPE



HOW AQUAPONICS WORKS

LIGHT



Fish are fed food and produce Ammonia rich waste. Too much waste substance is toxic for the fish, but they can withstand high levels of Nitrates.



The bacteria, which is cultured in the grow beds as well as in the fish tank, breaks down this Ammonia into Nitrites and then Nitrates.



Plants take in the converted Nitrates as nutrients. The nutrients are a fertilizer, feeding the plants. Also, the plant roots help filter the water for the fish.



Water in the system is filtered by the plants roots and through the medium in the grow beds. It is heated to support fish growth.

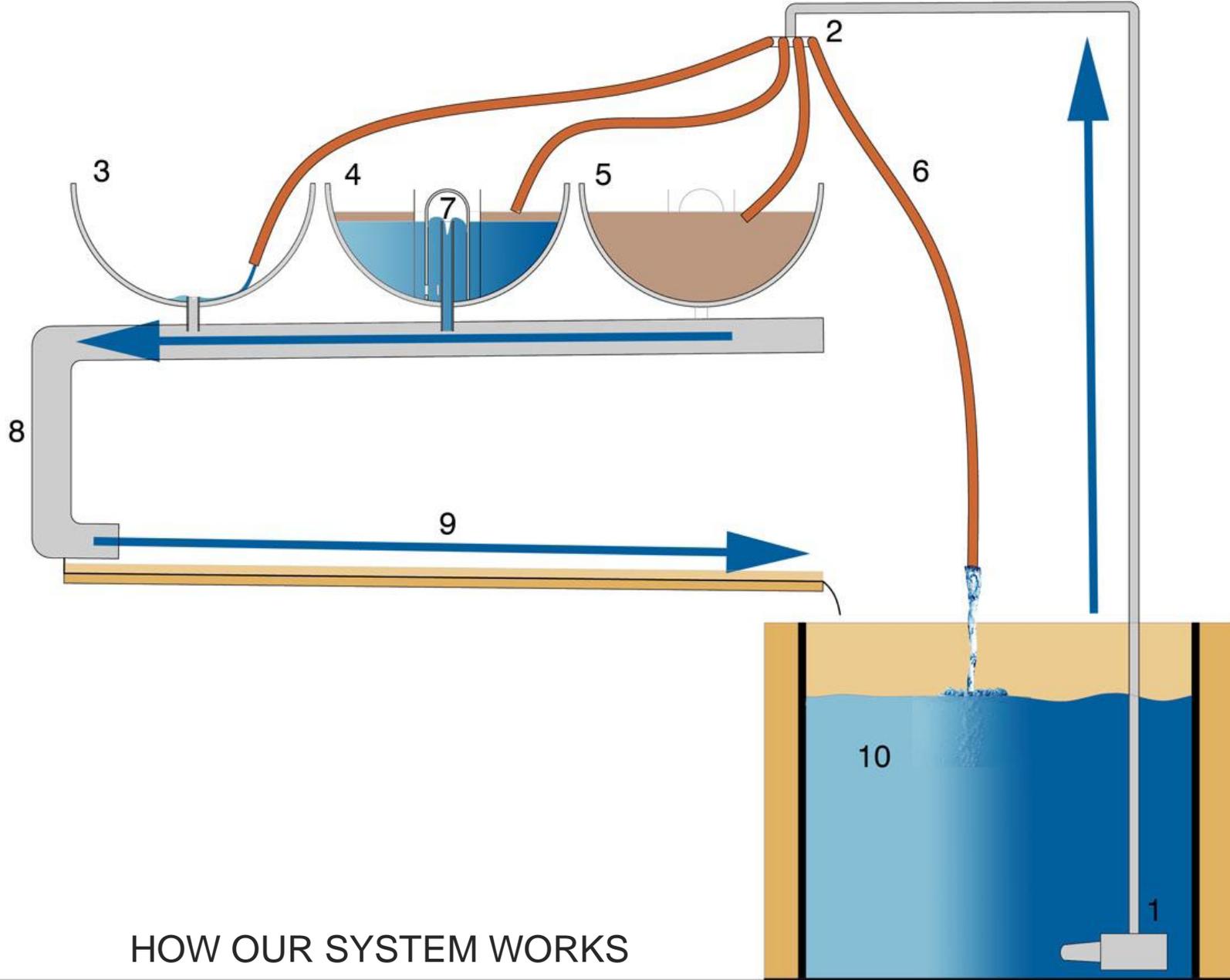


Oxygen enters the system to aid fish and plant growth through three operations:

- Air pump in fish tank
- Siphons in plant beds give roots time to breathe
- Water reentering fish tank create air bubbles



PLANT ARCHITECTURE



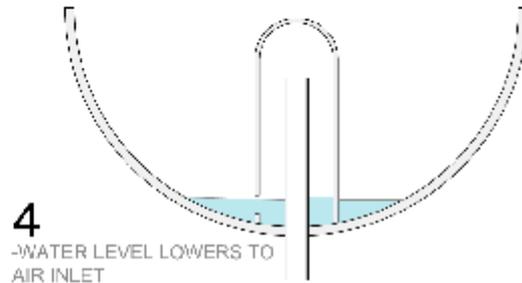
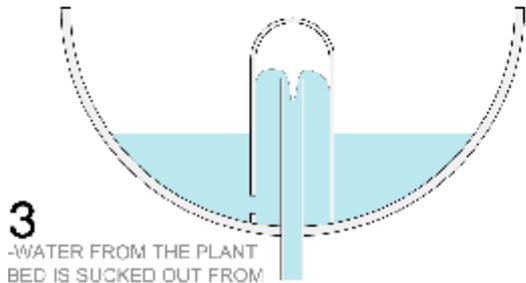
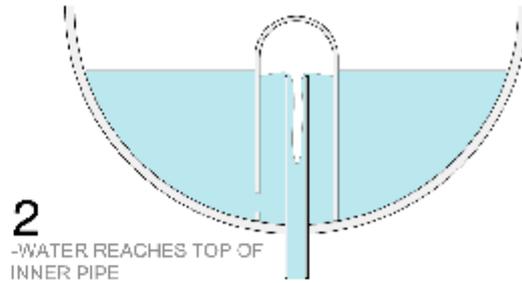
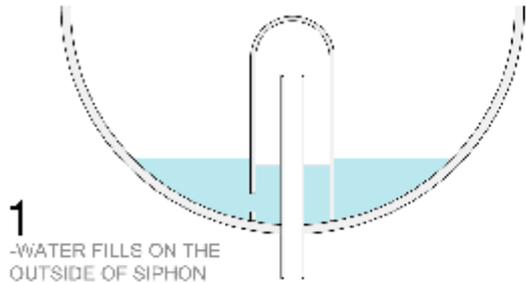
HOW OUR SYSTEM WORKS

PLANT ARCHITECTURE





HOW OUR SIPHON WORKS



Inner Pipe

Outer Pipe



Metal Halide





The Fish

We had to look at several different types of fish to find out which type of fish would be best for our project.

- For every 4 ounces of food eaten by the fish each day, we can supply one square meter of plants with the nutrients they need.
- We have much less space requirement for the plants, since we aren't relying on compost or dirt for the nutrients.
- X-X males, and also certain hybrids that bear mostly male offspring.

	Temperature	Food	Breeding	Market Size
Blue Tilapia	47 to 86 Can tolerate up to 106	Algae, duckweed, plant matter as adults	68-72 degrees	In 8 months
Perch	73-77 - optimum Max- 79	Algae, small fish, aquatic insects.	Must be chilled to 45	20 months

Challenges

- We encountered several challenges in coming up with a way to create and construct this system...
- First off, we have a height restriction
- Maintaining winter temperature control
- Monitoring water quality on several different parameters
- Balancing ratio of plants to fish
- Creating most everything from scratch
- Figuring out the BELL SIPHON!
- Finding cheap lighting



COMPUTER CONTROL SYSTEM



Control System

For this project we require develop a complex Control System to monitor and control the temperature of the building and other specific variables in Aquaponics and Hydroponics areas, such as oxygen levels, humidity levels, and light systems.

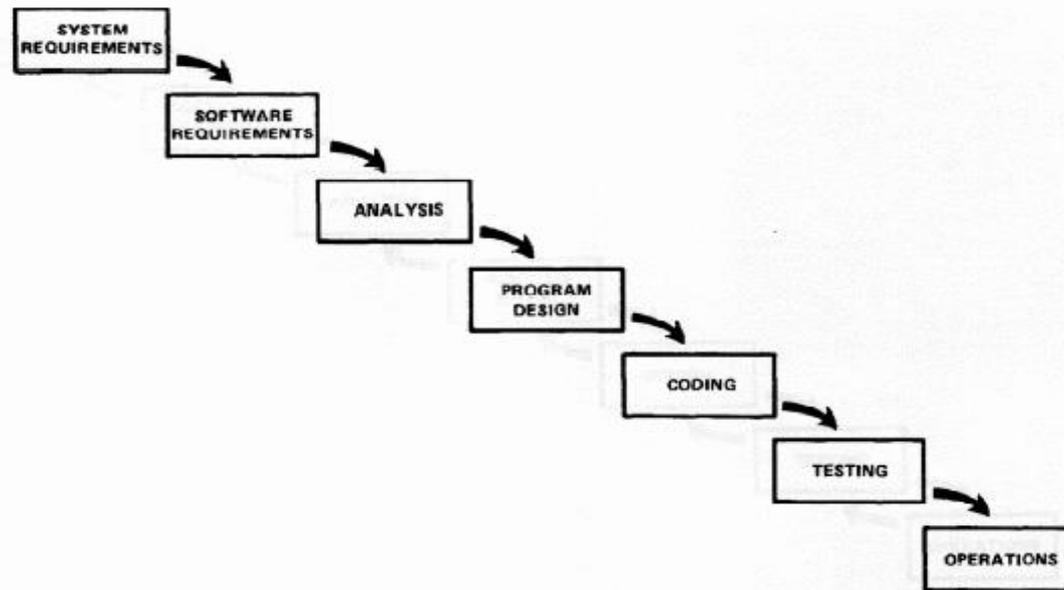
The temperature in each room and each farm area are independent between them, but all of them must be monitored and controlled from the software system.

To have a final an completely functional version of the control system we will require three semesters, of work, also we will need the participation of at least three students from computer science, one from electrical engineering and one from computer engineering.



Software development process

To develop a software system it is necessary follow some steps, those steps will allow us to control and monitor the quality of our software system, in the software engineering field those steps are know as the waterfall model phases. In this semester (fall 2009) we have covered the phases of system requirement, software requirement, analysis and design. It will be work of the next students in the next semester to go through the phases of coding and testing.



Software Development Project Plan

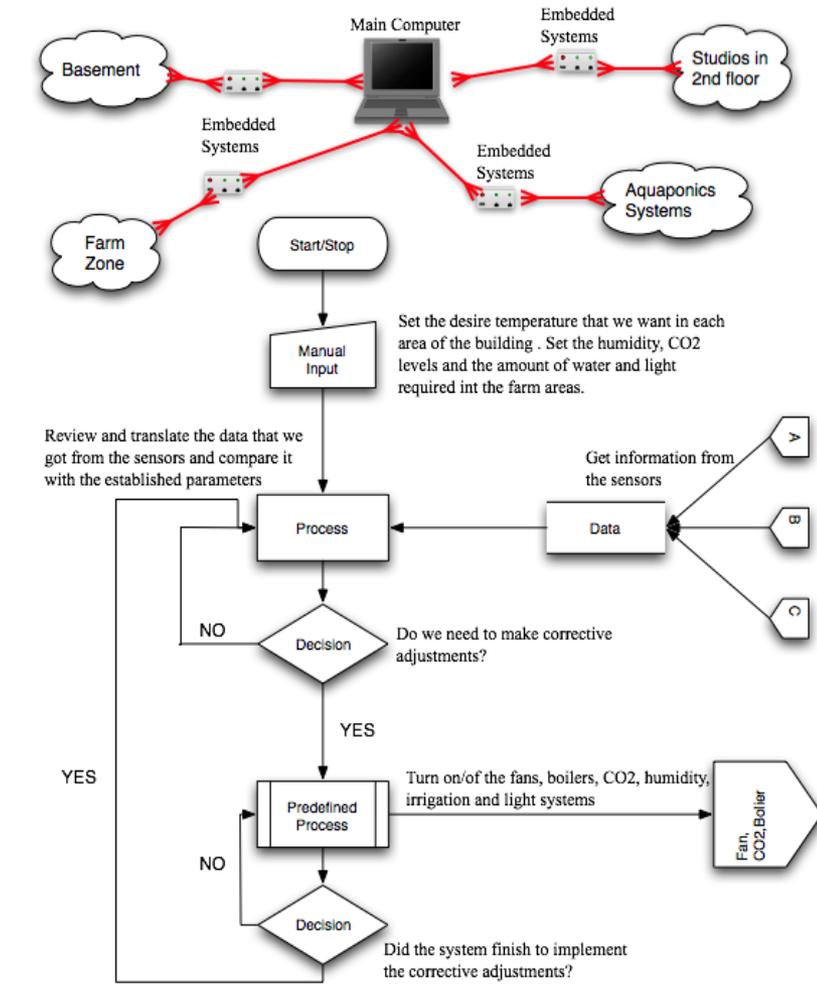
Following standards in software engineering, we will describe our system in an object oriented paradigm. We will use Class Diagram, Use Case Diagrams and Sequence Diagrams to describe the behavior and structure of our Control System.

The models that will be described in the analysis and design phases are independent of any coding language, this mean that we can use any coding language to develop our software and the models can be used to model the system. For instance we have decided use JAVA as our platform, because JAVA gives us the flexibility to create a software application that can be used in any operating system without necessity of any modification to the source code. If we used other language like C++ we would have to modify and recompile the source code if we moved from a computer with linux as operating system to a machine with Windows OS.



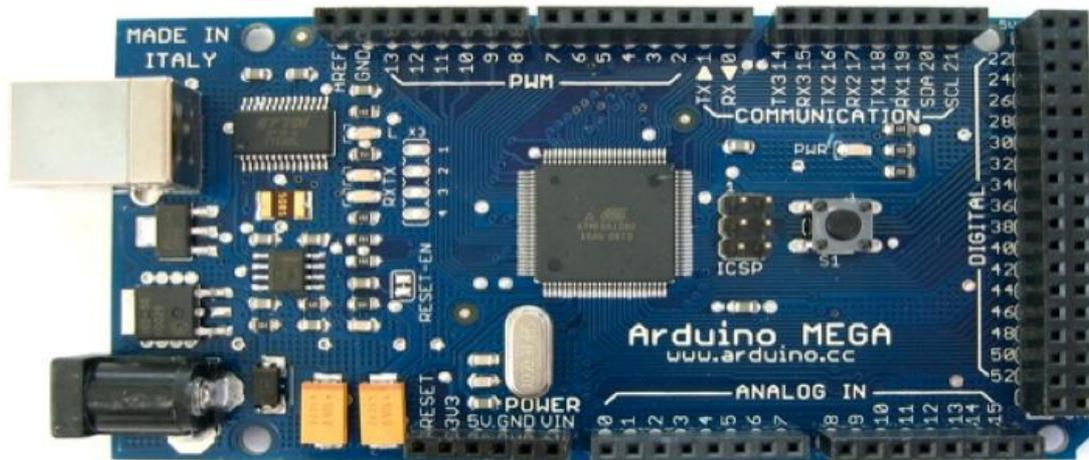
Control System Architecture

In our control system we will use a distributed computer system. We will have electronics boards (embedded systems) that will be directly connected to the sensors and to the water pumps, light system, oxygen system, etc. The embedded systems will be monitoring the environment of a small area and will keep the temperature levels of that space, the embedded system will send a report to the main computer, using the TCP/IP protocol. The main computer will monitor the environment of the full building and will take the decision of move hot air from one place to the other.



Control System Architecture

For the embedded systems we will use the Arduino's Ethernet Shield or the WiShield 1.0 for wireless transmission to communicate the embedded system with the main computer, also we will use an extender shield for each Arduino to allow to use two shields at once (say a WiFi shield and a stepper shield) and as the brain of the embedded system we will use the Arduino Mega board. In our main computer we will use Debian as our operating system. For the prototype we will require a computer with at least a pentium 3 1GHz, 512MB of memory Ram and 40Gb of hard drive space, a CD unit, a USB port. For the main project we will require a powerful workstation.



DESIGN



Building & Site



Location: Ashland & Pershing

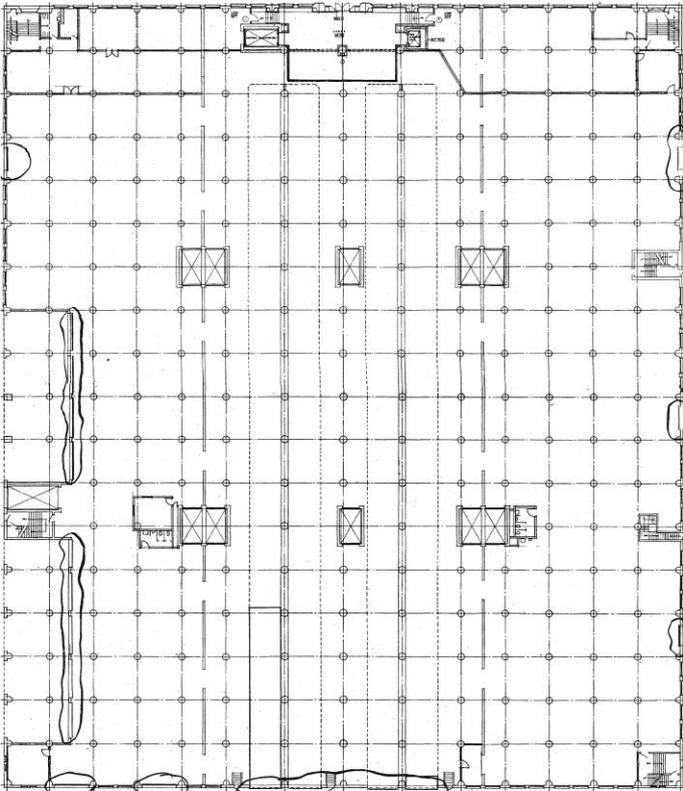
Old Armory Building

Building Stats:

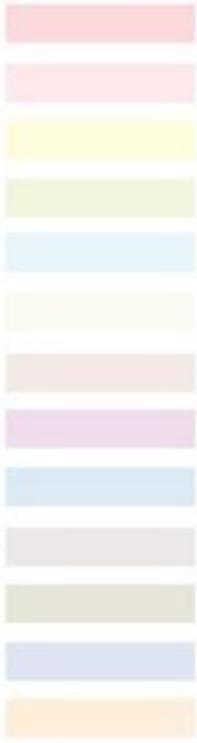
- * 18' bay size (typical)
- * 6 floors @ 80,000 sq. ft./floor
- * Total sq. ft. = 600,000 (+ roof)
- 200,000 sq. ft. for farming



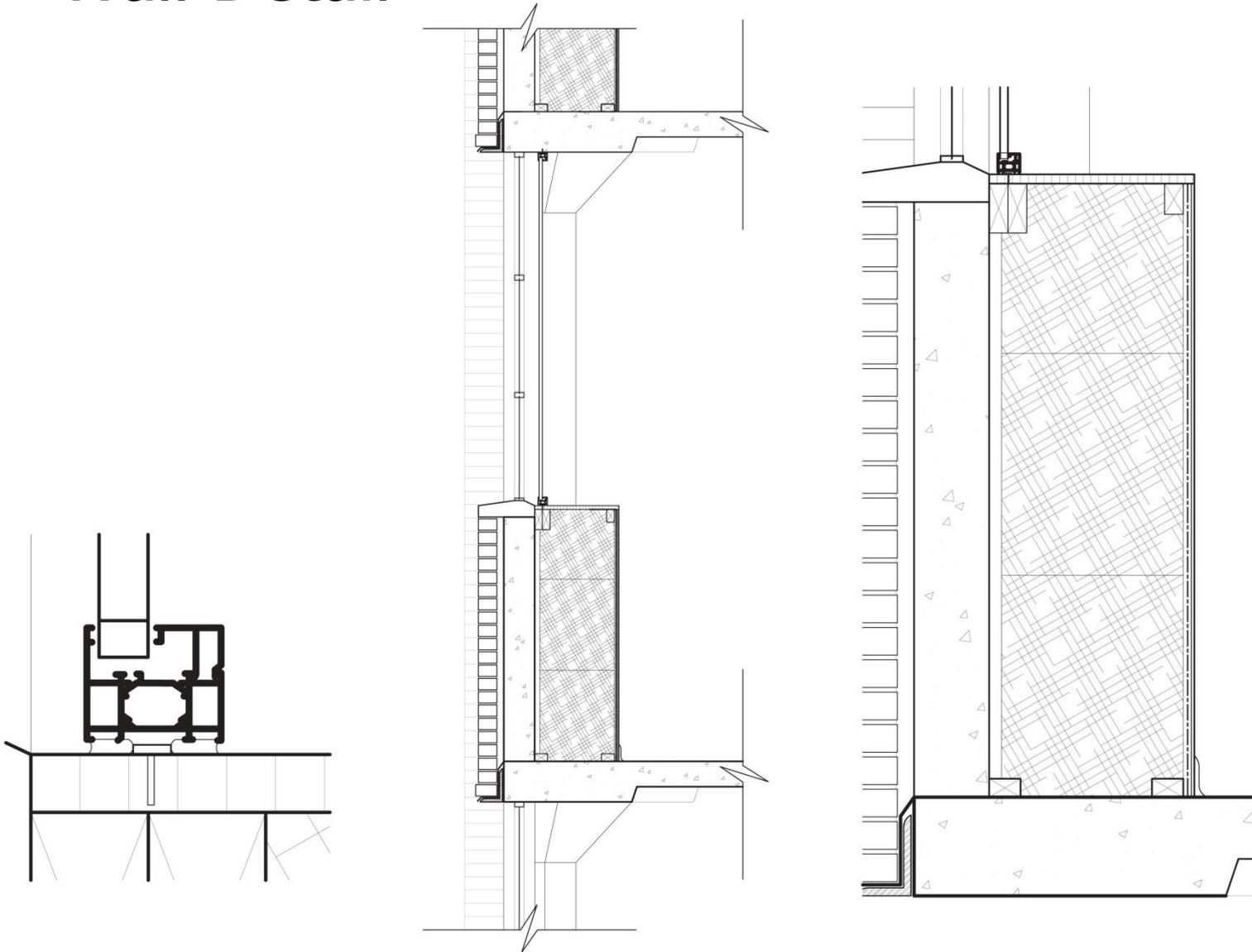
Program & Requests



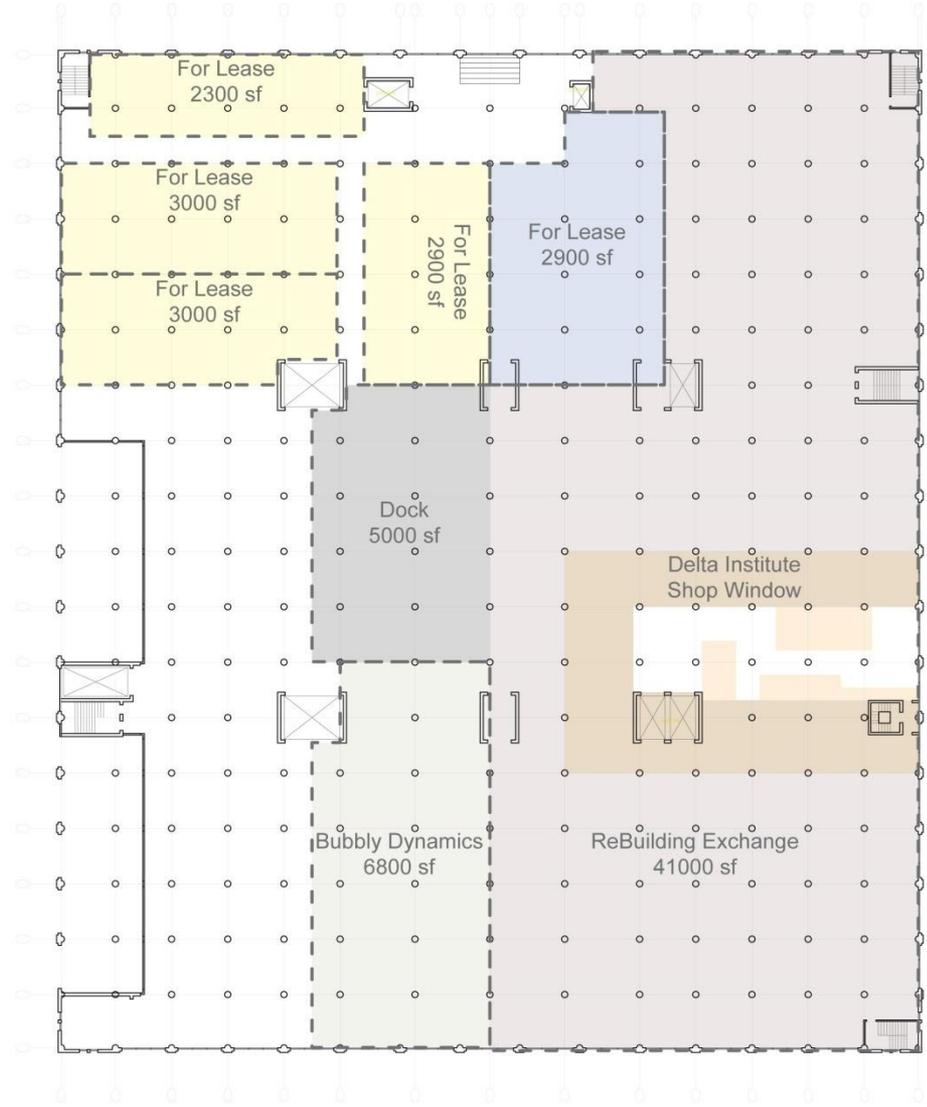
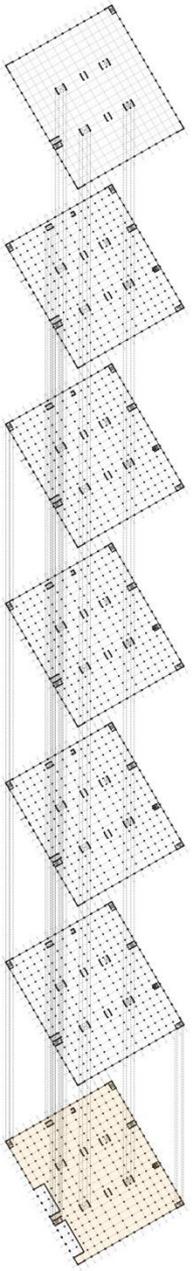
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- Auditorium
- For Lease / Studio&Manufacturing
- Farm
- Commercial Kitchen
- Commercial Space for Lease
- Restaurant
- Office Space for Lease
- Mechanical Equipment / Storage
- Delta Institute-Rebuilding Exchange
- Bubbly Dynamics
- Bike room
- Main Entrance



Wall Detail

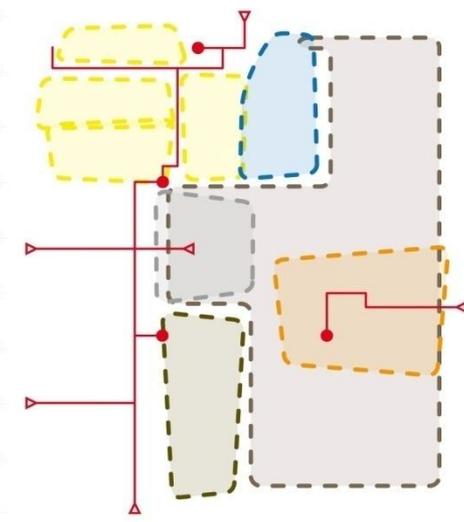


1st Floor

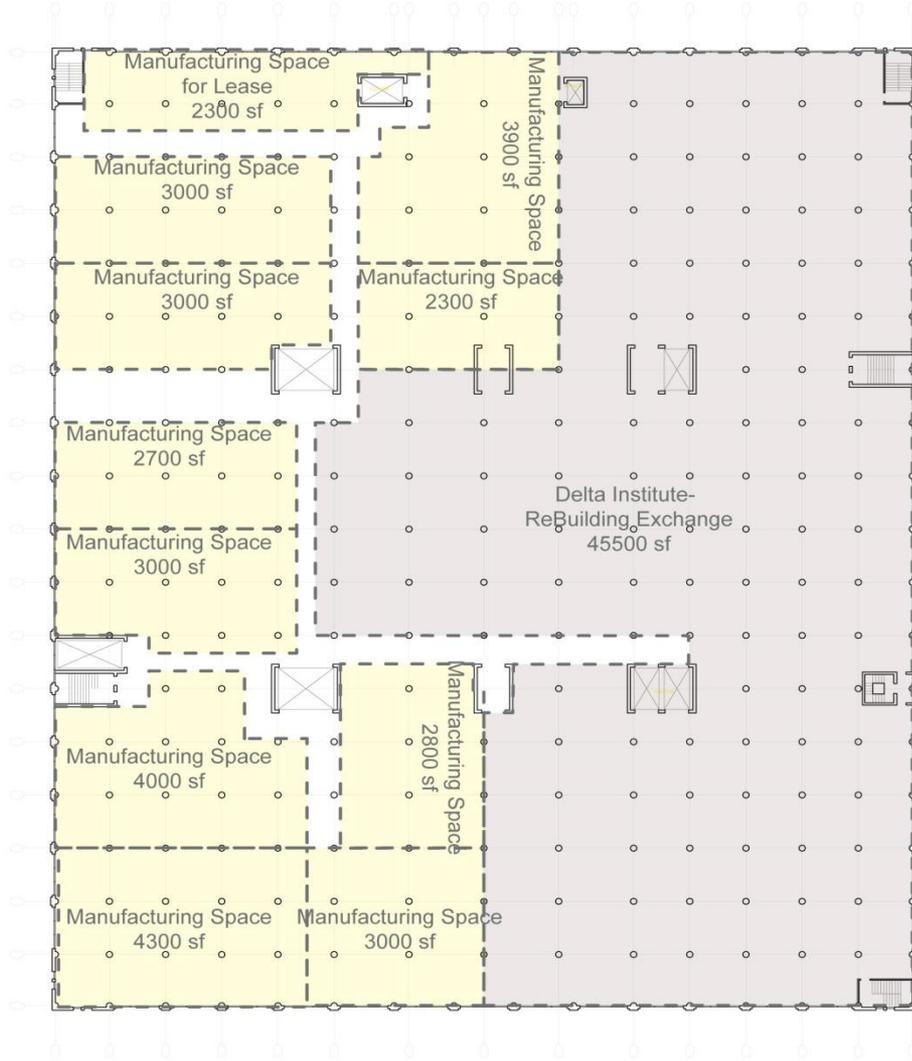
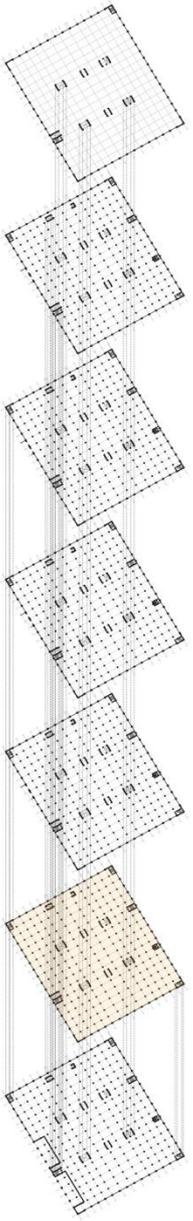


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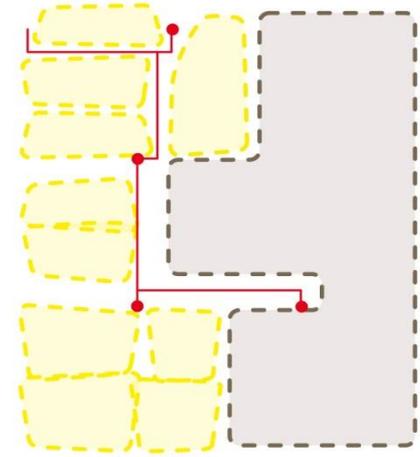


2nd Floor

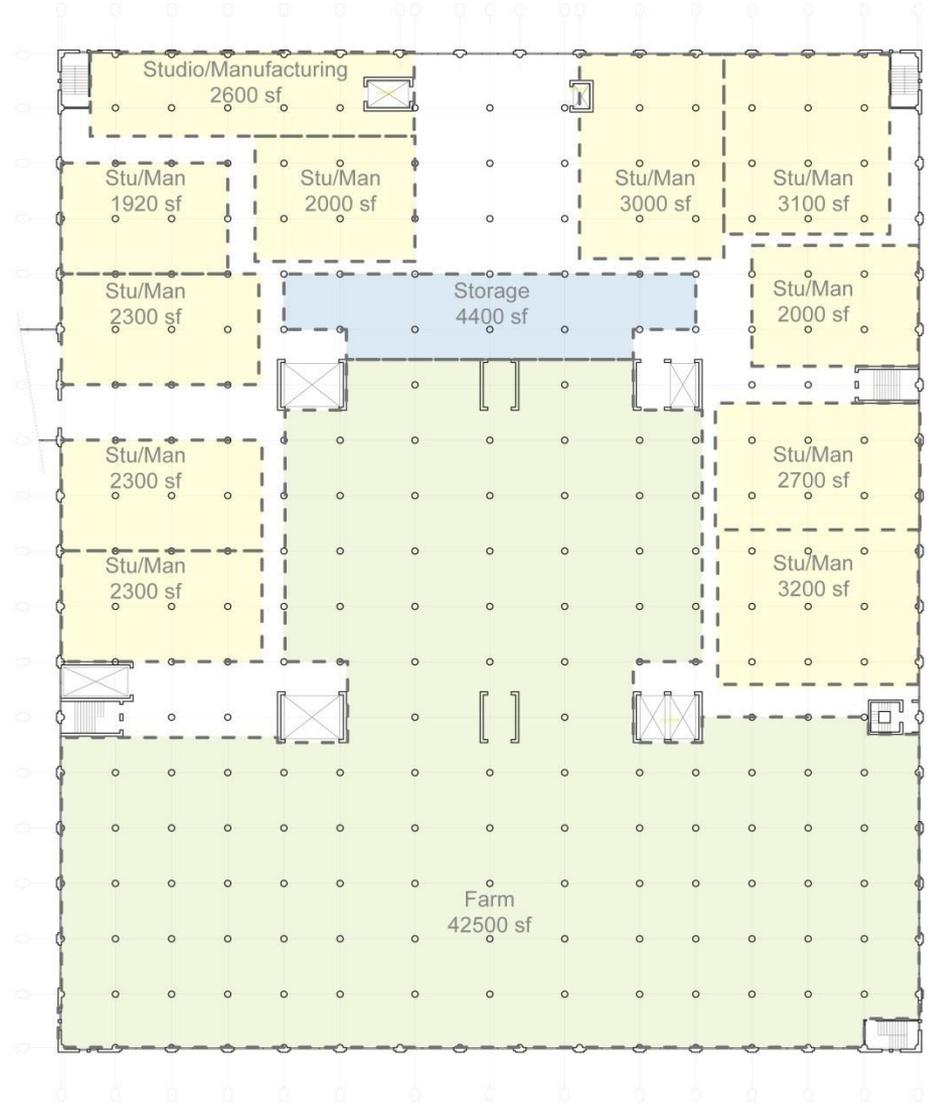
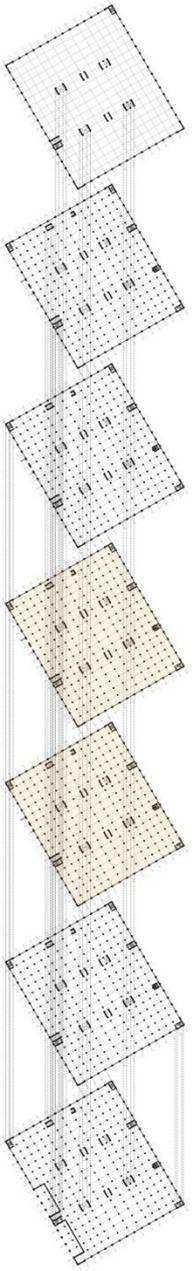


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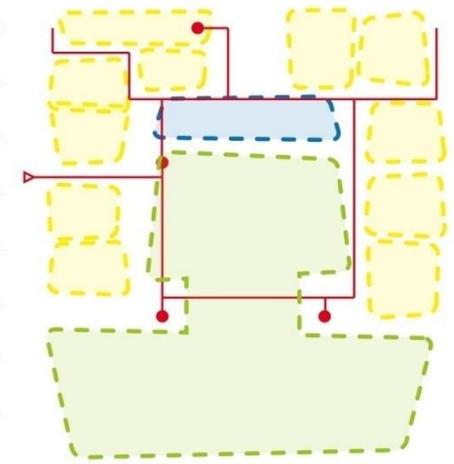


3rd&4th Floor

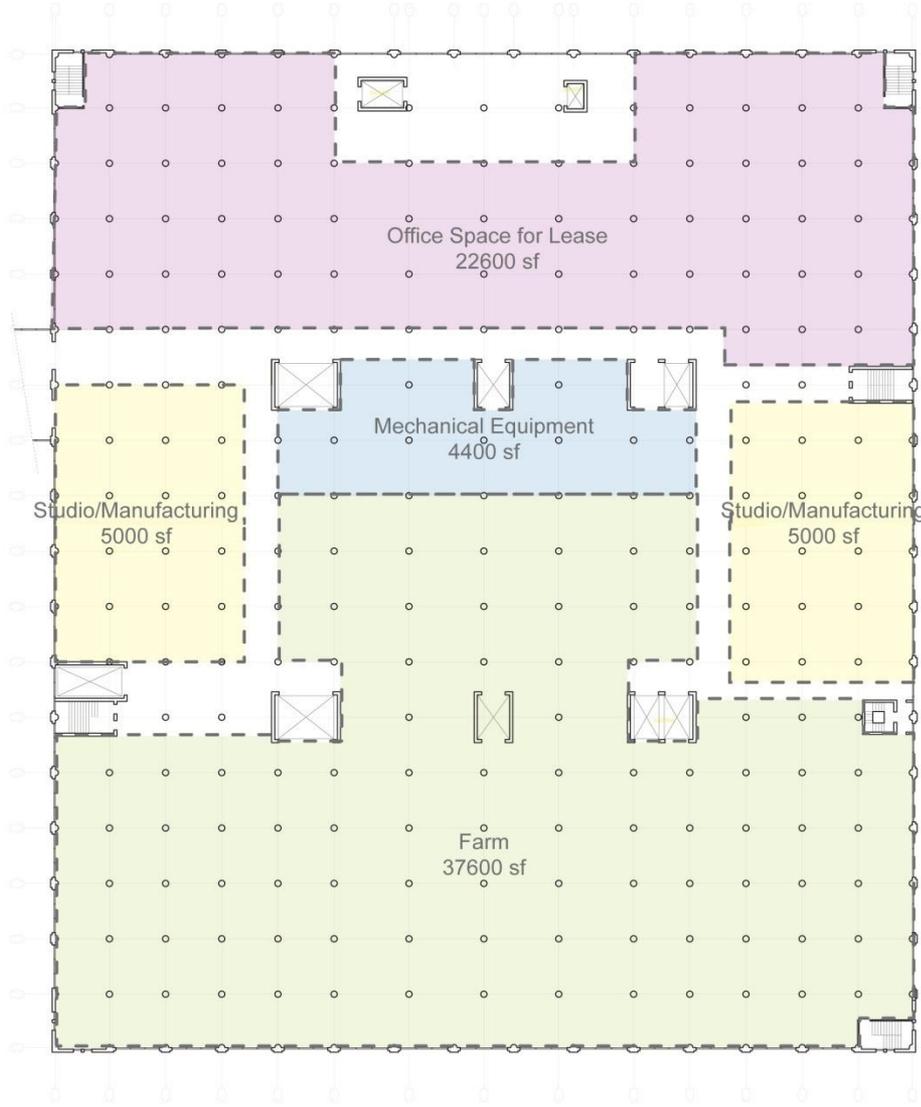
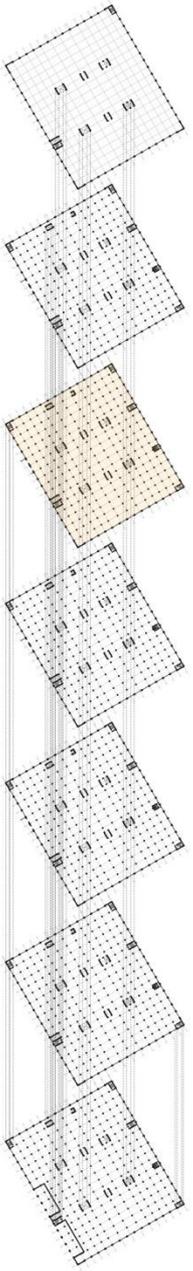


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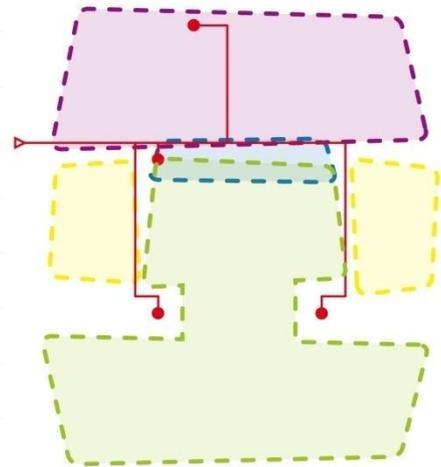


5th Floor

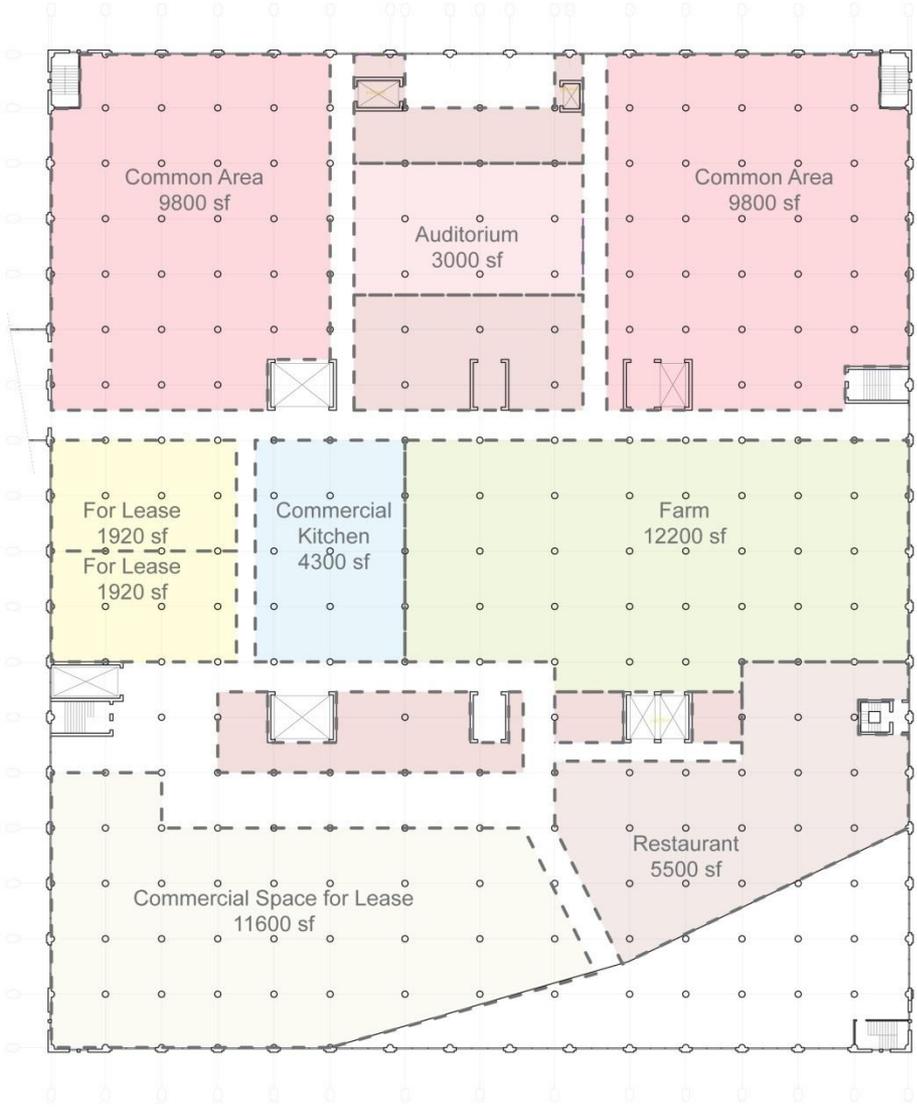
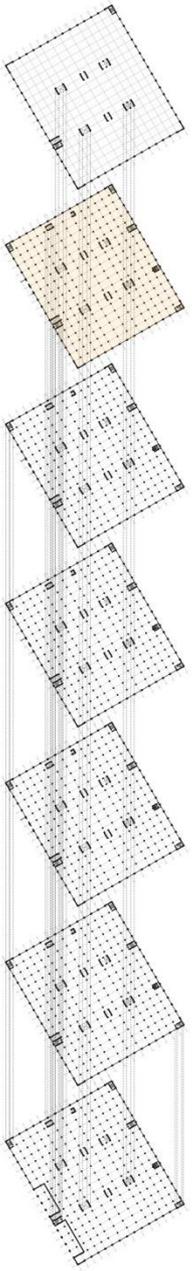


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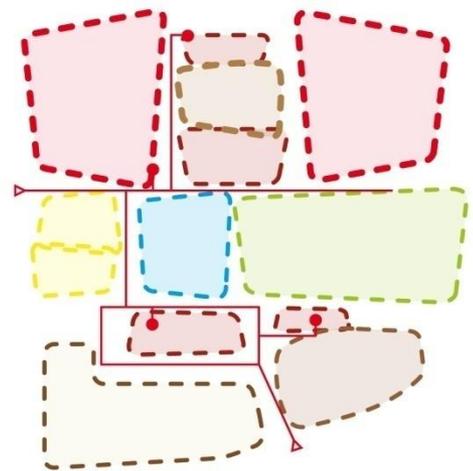


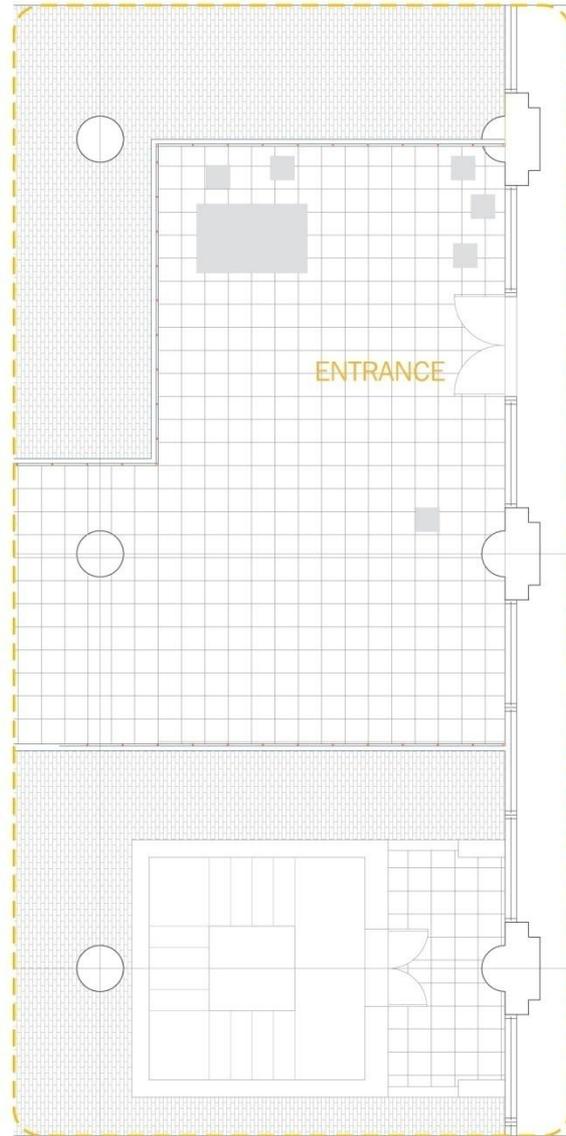
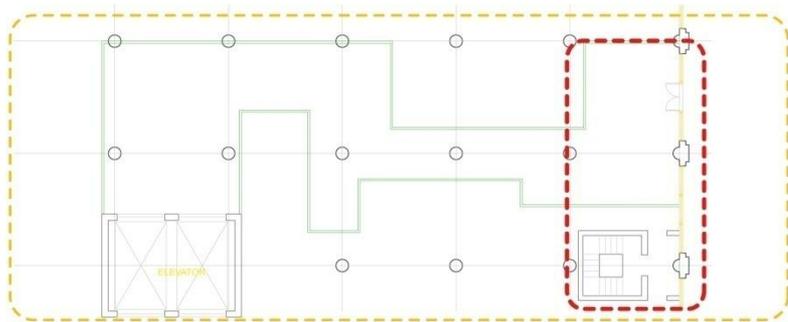
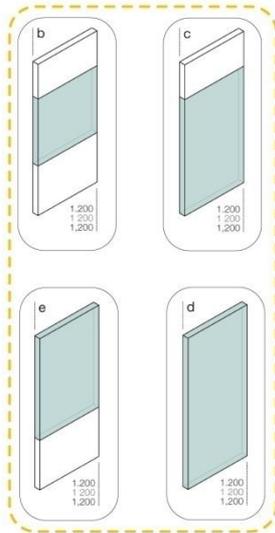
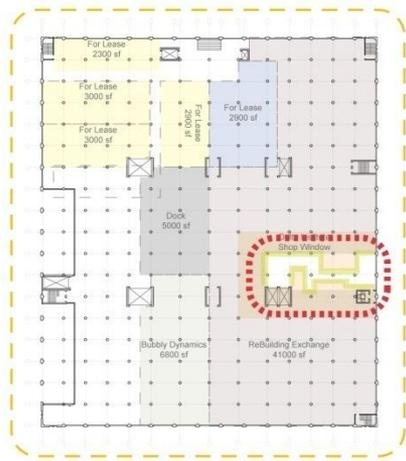
6th Floor

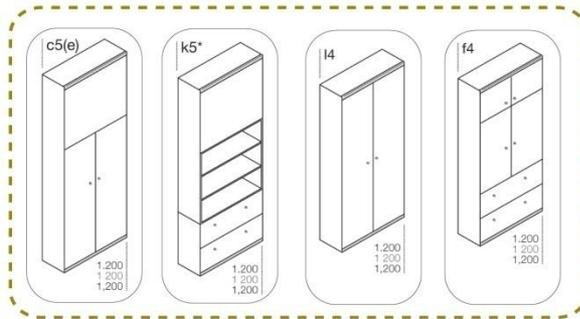
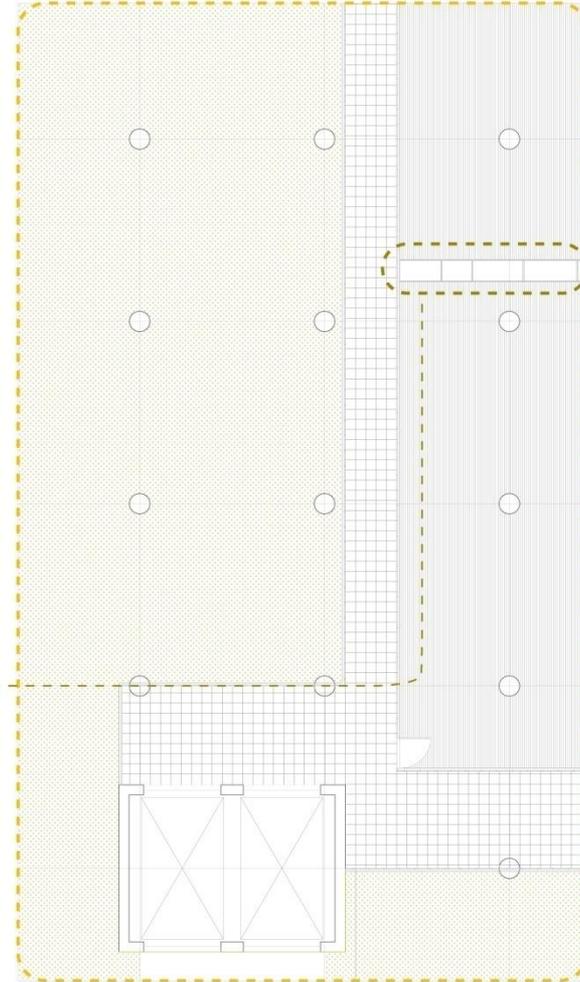
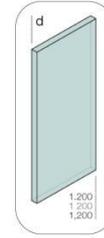
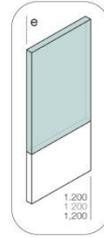
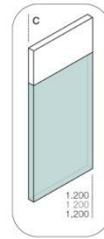
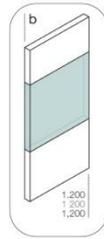
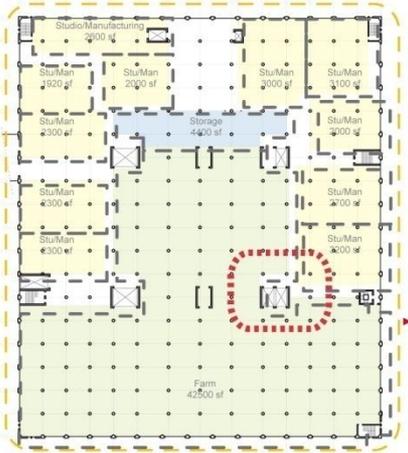


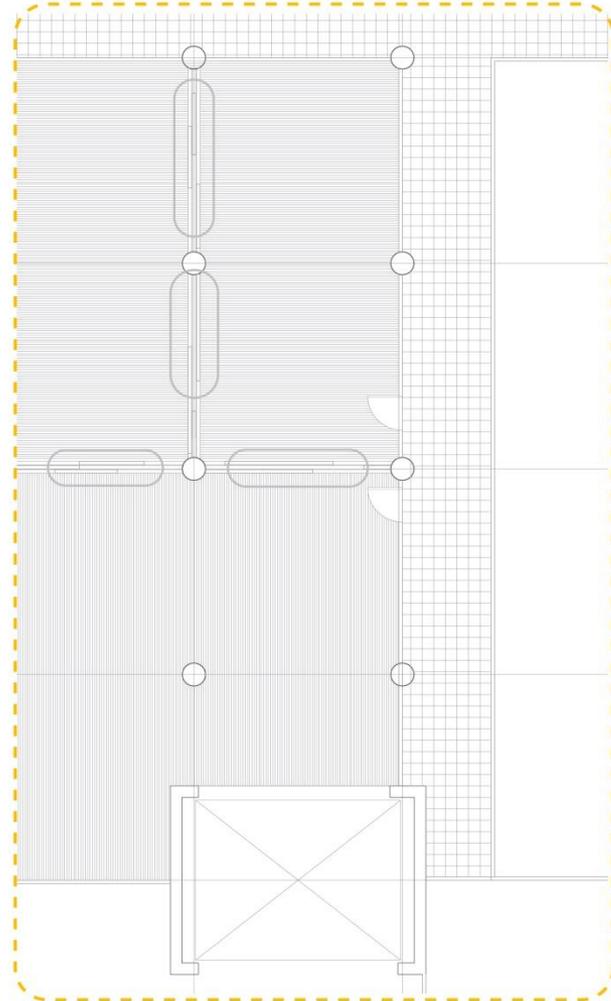
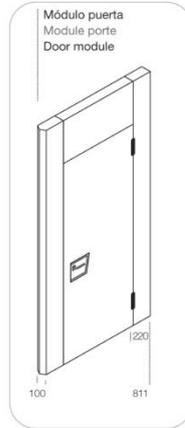
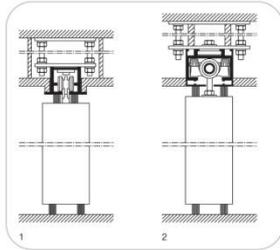
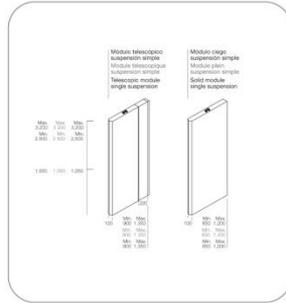
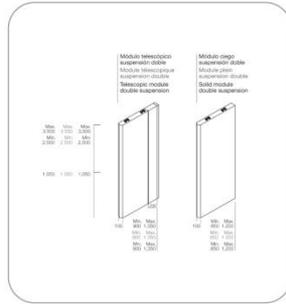
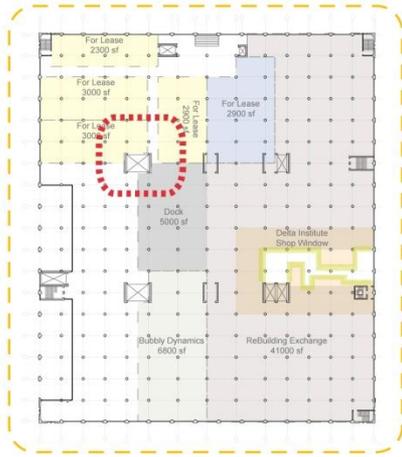
Key:

- Common Areas
- Auditorium
- For Lease / Studio&Manufacturing
- Farm
- Commercial Kitchen
- Commercial Space for Lease
- Restaurant
- Office Space for Lease
- Mechanical Equipment / Storage
- Delta Institute-Rebuilding Exchange
- Bubbly Dynamics
- Bike room
- Main Entrance









QUESTIONS?

