Water Resource Management Design Review

Dec 9, 2016

Armstrong Hall, 1098C

EPICS PURDUE

Team Comments/Design Review Headings

- Introduction of Reviewers- Name, Organization/Department

- Handouts- red page numbers

  Plants Used Spring 2016 (Page 2-3)

Finances

- Budget:
  - Started Semester with $9,997.
- Thank you to the following organizations:
  - CIE: Service Learning: Service Learning Sustainability Grant- $3000 (Happy Hollow)
  - Office of Engagement: Service Learning Grants- $3000 (1500 Happy Hollow, 1500 Hydroponics)

Happy Hollow Park

Taken at Happy Hollow Park, January 2015

Agenda

- Overview of team
- Community partner introduction
- Project background
- Semester progress
- Open discussion

Introduction

- Monica Moran, Design Lead
  - *Sophomore, Environmental and Ecological Engineering*
- Matt Springer, Financial Officer
  - *Freshman, First Year Engineering*
- Nolan Miller, Project Partner Liaison
  - *Freshman, First Year Engineering*
- Blaire Coleman, Archivist
  - *Sophomore, Industrial Engineering*
- Stephanie Verhoff
  - *Senior, Natural Resources and Environmental Science*
- Jacob Mickey
  - *Freshman, First Year Engineering*

West Lafayette Parks and Recreation

- Serves to:
  - Enhance quality of life
  - Designate trails
  - Maintain the grounds of West Lafayette parks

Taken from: www.westlafayette.in.gov

Purpose of Happy Hollow Park Team

- Aids the West Lafayette Parks and Recreation Department in remediating potential problems in Happy Hollow Park.
  - Mitigate hill slope soil erosion
- Work with Dan Dunten
  - Director of the Lilly Nature Center

Happy Hollow Park

- Approximately 81 acres
  - Playground
  - Hiking/exercising trail
  - Shelters and other areas for entertaining
  - History of erosion
    - Progressively worsening for 30+ years

Taken at Happy Hollow Park, September 4, 2015
Information from: www.westlafayette.in.gov

Stakeholders

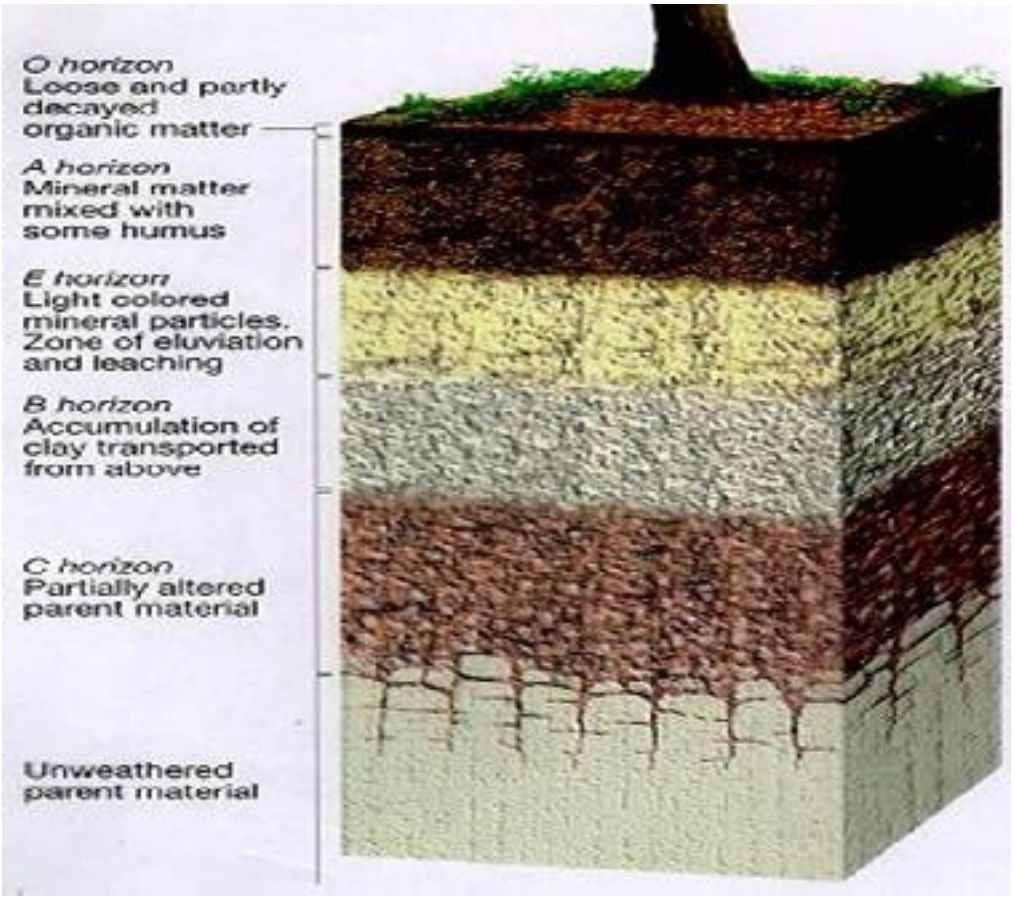
- West Lafayette Parks and Recreation Department
  - Utilizes solution
- Park Goers
  - Residents
  - Hikers
  - Bikers
  - Students
- Wildlife
  - Animals affected by possible solution

Main Problem: Erosion

- Erosion is:
  - "The process whereby materials of the earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another" –United States Geological Survey

Taken at Happy Hollow Park, January 2014

Severity Level of Erosion



Taken from: http://www.ctahr.hawaii.edu/mauisoil/images/a_profile_clip_image002_0000.jpg

Project Background

- Reason for project:
- Severe erosion throughout Happy Hollow Park
  - Types of erosion
    - Gullies
    - Stream bank erosion
    - **Hill-slope erosion**
  - Contributing sediment to the Wabash River
  - Largely natural, exacerbated due to manmade development
  - Affecting use of park (aesthetics and purpose)

Taken at Happy Hollow Park, September 2013

Vision for Project

- To create a long-term mitigation method for hill slope erosion in Happy Hollow Park
  - Mitigate erosion on hill slopes
  - Allow reestablishment of topsoil and vegetation on the park's hill sides to trap sediment

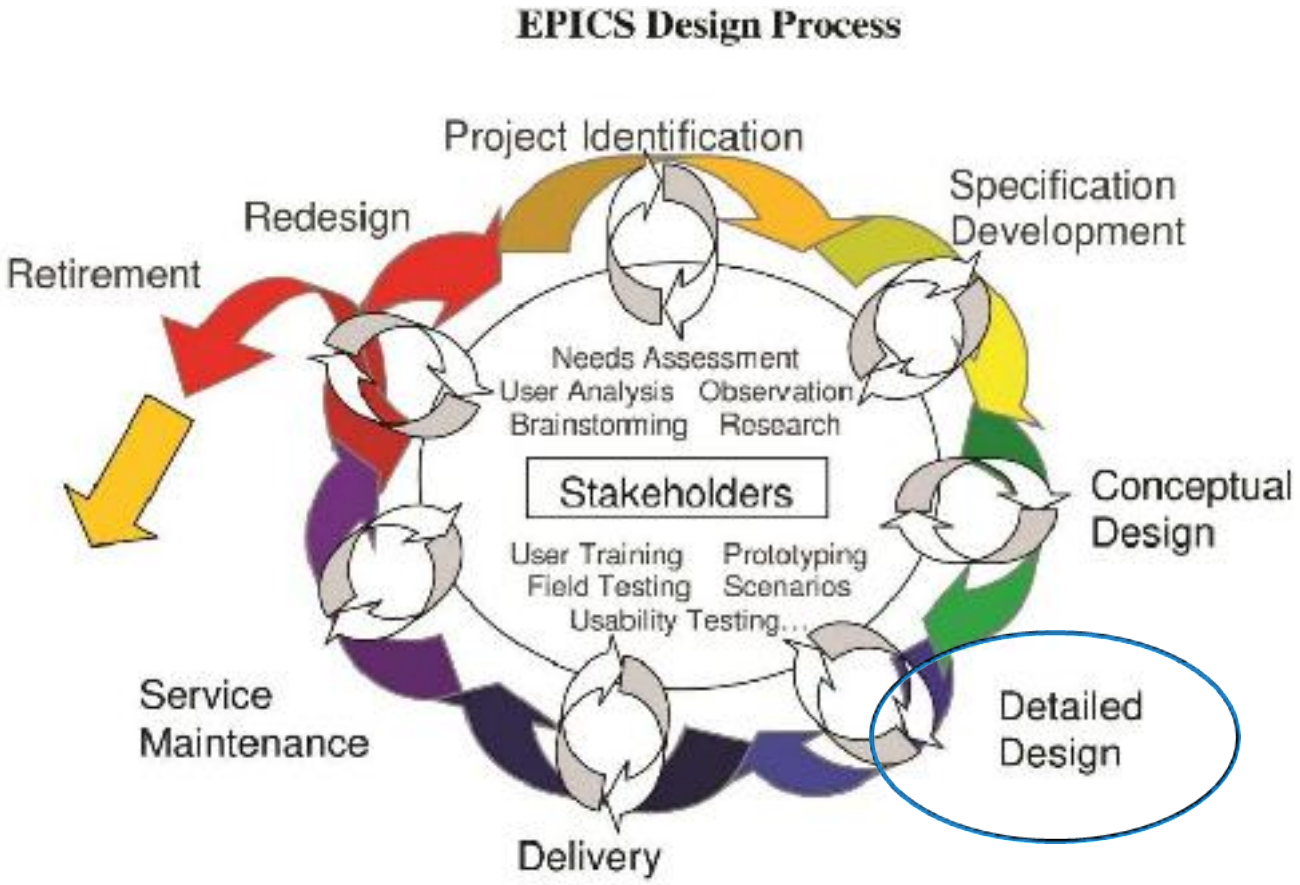
Criteria

- “Natural” and camouflaged
- Long lifespan (plant re-establishment)
- Must not let soil detach due to runoff
- Safe around pets/wildlife
- Withstand water flow (runoff)
- Easy to install
- Does not leave harmful residue/pollutants

Constraints

- Must trap (average) 2 inches of soil behind every berm (allows for plant re-establishment)
- Must allow for plant re-establishment on the test plot

EPICS Design Process



Semester Progress

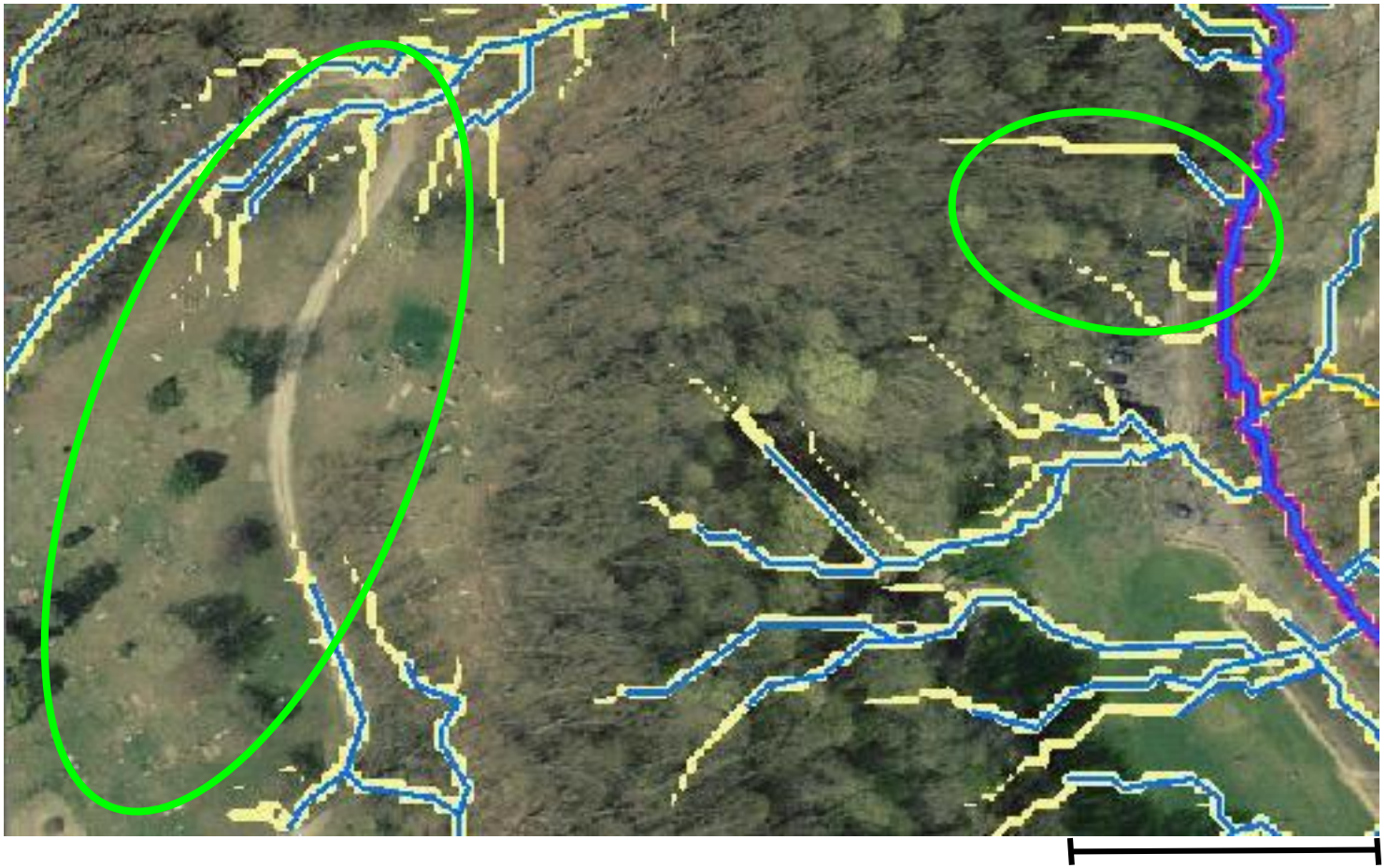
- GIS analysis
- Onsite water flow analysis
- Trees and shrubs planted
- Took and analyzed soil samples from several locations
- Installed additional signage
- Finalized pamphlet and door hanger
- Selected two new hills and gathered data

Primary Testing Site (North Hill)

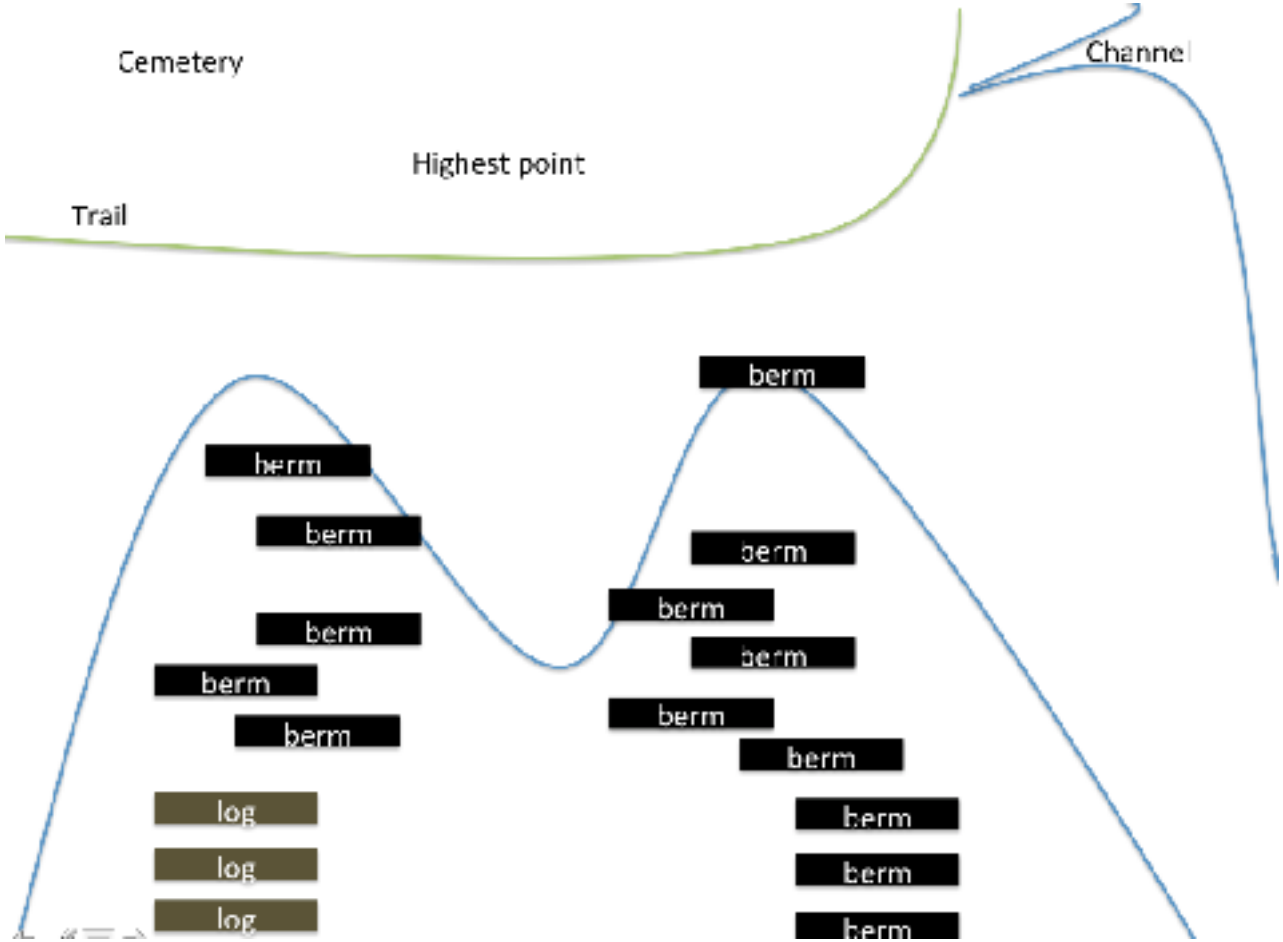
Taken at Happy Hollow Park, April 2016

GIS Analysis

GIS Analysis



Water Flow Analysis



Prototype 1 – Spring 2015

Taken June 2015

Taken August 2015

Test site from Spring 2016

April 2016

September 2016

EPICS at PURDUE

Plants Used Spring 2016 (Page 2-3)

- Creeping Red Fescue
- Annual Ryegrass
- Columbine
- Jacob's ladder
- Blue wood aster

Taken from:
http://m5.i.pbase.com/g6/26/411626/2/78880705.9YK57Ybu.jpg

Shrubs and Saplings

Flowering dogwood
(Cornus florida)

Taken from:
http://www.mtcubacenter.org/images/plant-finder/Cornus_florida_2.jpg

Allegheny Serviceberry
(Amelanchier laevis)

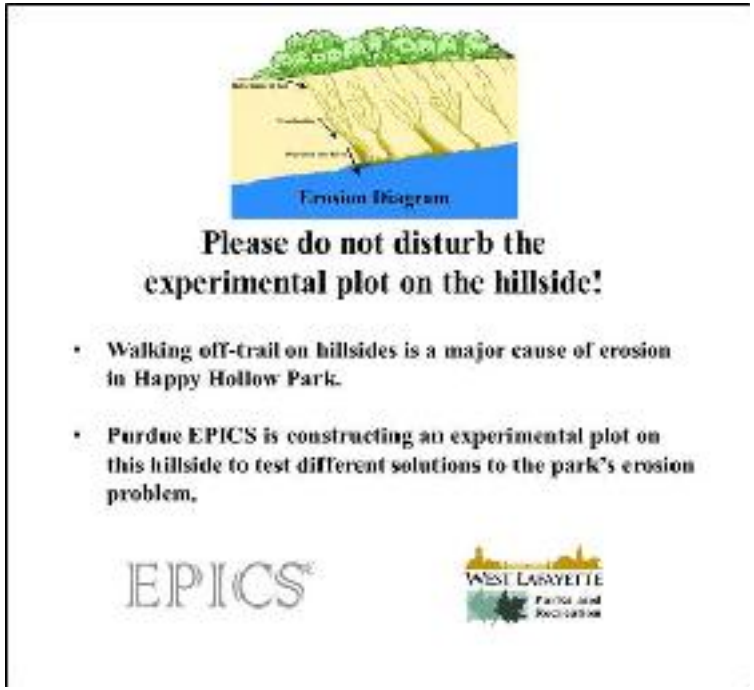
Taken from:
http://67.227.221.91/~ncwildflowerorv/images/plants/amelanchier_laevisMaxPatch2004.jpg

Spicebush
(Lindera benzoin)

Taken from: http://awaytogarden.com/wp-content/uploads/2008/04/lindera-detail.jpg

EPICS PURDUE

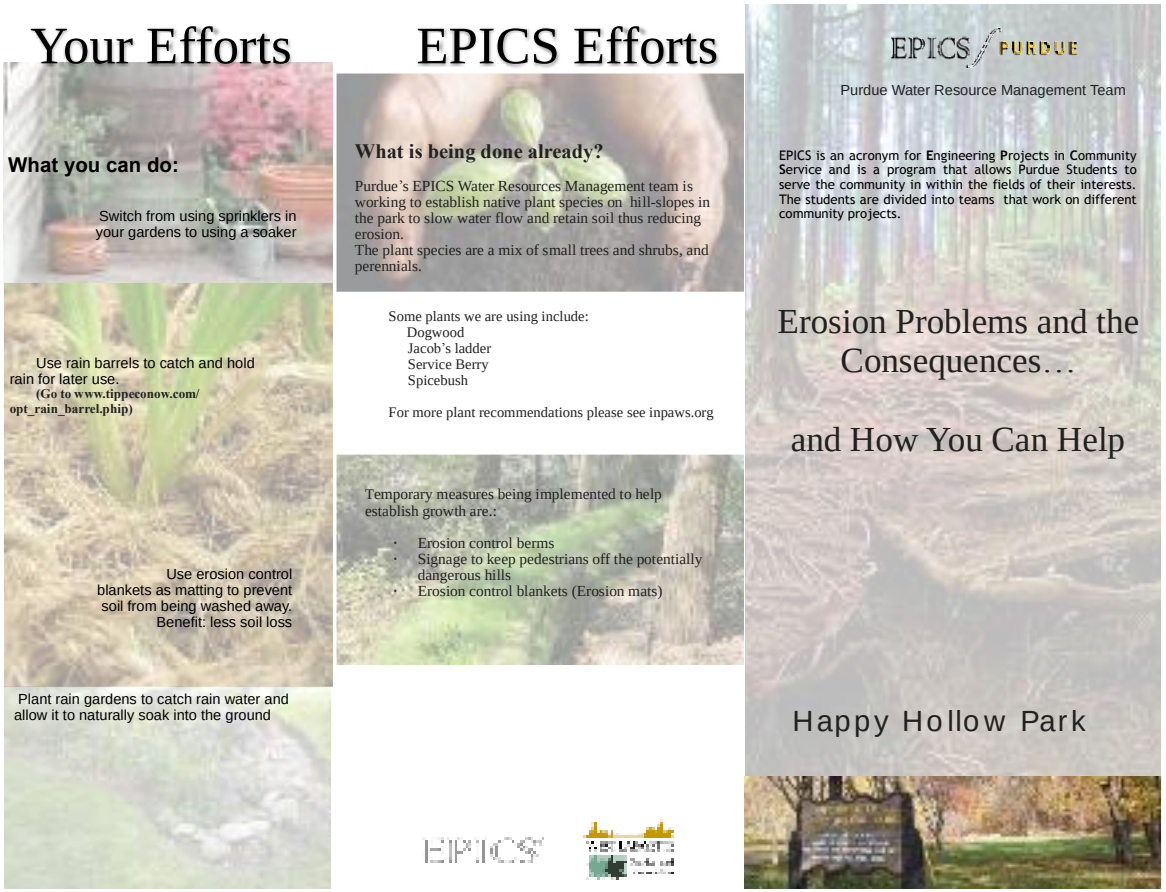
Old Signage (Page 4)



Taken April 2016

New Signs (Page 4)

Pamphlet Design (Page 5)



Pamphlet Design (Page 6)

Doorhanger Design (Page 7)

- To be distributed next semester

Budget

Description & Justification	Fall 2016 Predicted Expenses	Fall 2016 Actual Expenses	Spring 2017 Predicted Expenses
Plants for the hillside	$250.00	$250.00	$1,250.00
Erosion Mat			$250.00
Berms (10ft) x 15			$800.00
Compost	$30.00	$30.00	
Signs	$120.00	$119.50	
Posts for the signs	$30.00	$125.70	
Printing Costs for the Pamphlets	$80.00		
Printing Costs for the Door Hangers	not accounted for		
TOTAL	$510.00	$525.20	$2,300.00

Preparing for Delivery

Middle Hill

South Hill

Soil Test Report (Page 8)

- Samples from several locations on all three hills

Results:

- pH- more basic than desired
  - North: 8.5
  - Middle: 8.6
  - South: 8.5
- Organic matter
  - 1.1-1.5% parent material
  - 3.1- 4.0% compost and berm material
- Calcium levels- high
  - Shows calcareous parent material
  - 88.2-92.8%

Final Report Started

- Includes:
  - Background
  - Past Semesters
  - Educational Component
  - Progress on test site and new test sites
  - Plan for future
  - Financial Statements

Plans for Delivery

- January 2017 – Finalize budget, order plants
- February 2017 – Draft of final report, site layout
- March 2017 – Community outreach for volunteers, order compost and berms
- April 2017 – Site delivery, media coverage of community involvement or final product

Questions and Feedback?

Taken at Happy Hollow Park, October 2013

Hydroponics

Photo taken: January 2015 at Purdue Greenhouse

Introduction

- Steven Bjankini, Design Lead
  - *Junior, Electrical Engineering*
- Nicholas Bitner, Financial Officer
  - *Freshman, First Year Engineering*
- Andrew Duke, Project Partner Liason
  - *Freshman, First Year Engineering*
- Anwesha Sanyal, Project Archivist
  - *Freshman, First Year Engineering*
- Yihan Xie, Webmaster
  - *Junior, Agricultural and Biological Engineering*
- Eric Brill
  - *Freshman, First Year Engineering*
- Tyler Son
  - *Senior, Mechanical Engineering*

Agenda

- Overview of project background
- Goals and objectives
- Semester progress
- Remaining tasks
- Questions and feedback

Habitat for Humanity

- Mission:
  - To make a world where "everyone has a decent place to live" (lafayettehabitat.org)
- Contact is Doug Taylor, Executive Director for Lafayette branch, but project will be delivered to Oakland High School or The Crossing.
- Working to build a small-scale hydroponic system for educating pre-professionals.

Oakland High School

- Limited enrollment high school and member of the Lafayette School Corporation
- Contact is James Koval, a social studies teacher who runs their two current hydroponics systems
- Pros:
  - Hydroponics already integrated into curriculum
  - Sufficient sunlight and space
- Cons:
  - Would need to run power to field for pump
  - Already have 2 systems and a relatively small number of students.

http://ohs.lsc.k12.in.us/

The Crossing

- The Crossing provides a state accredited academic education as well as providing students with job training.
- Contact is Zachary Martin, director of Hydroponics at the Crossing.
- Would be installed at Hamilton, IN site.
- Pro
  - Established program for preprofessionals in hydroponics
- Cons
  - Distance has been prohibitive. Many unknowns remain.

Project Specifications

- Must be nutrient film technique system
- 16’x5’ maximum area for system
- Low operating cost
  - Fertilizer, disinfecting, desalting, and electricity
- All parts must be easily replaceable and food safe
- Produce crops of comparable quality to supermarket

Project Deliverables

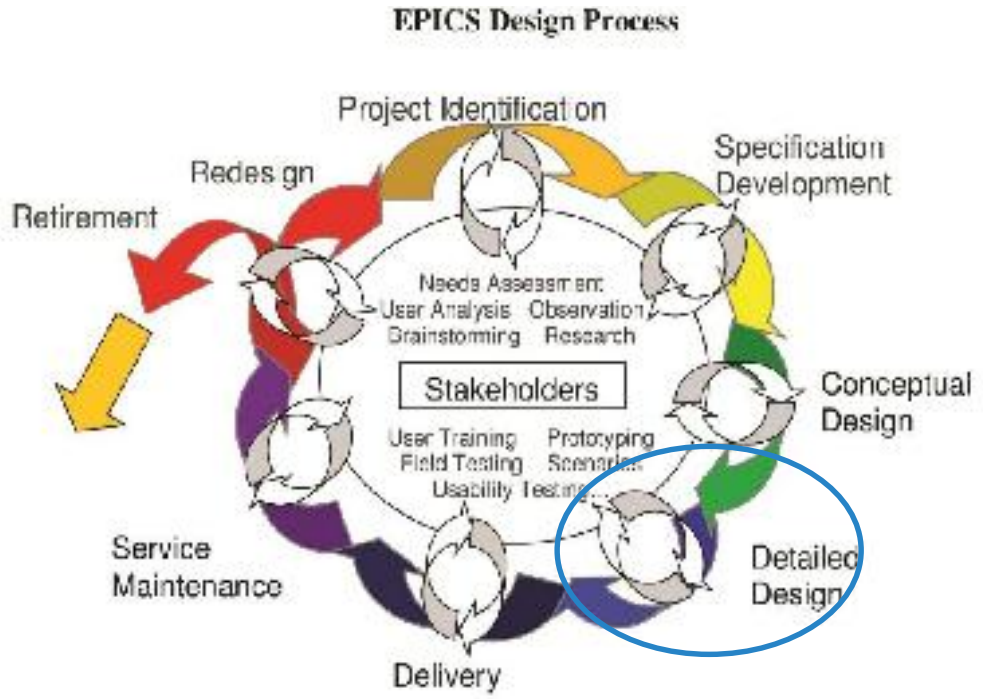
- Hydroponics system used for
  - Education of benefactors
  - Provides produce for the local community
  - Microbusiness opportunity
- User manual for maintaining and operating the system
  - Simple enough to be maintained by students
- Educational materials

Semester Goals

- Improve the irrigation/reduce the pressure
- Purchase new appropriate pump for the test bench
- Collect testing data
  - Distribution uniformity
  - Sunlight at proposed project site
  - Fertilizer comparison
- Select best fertilizer for the price

Current Phase in Design Process

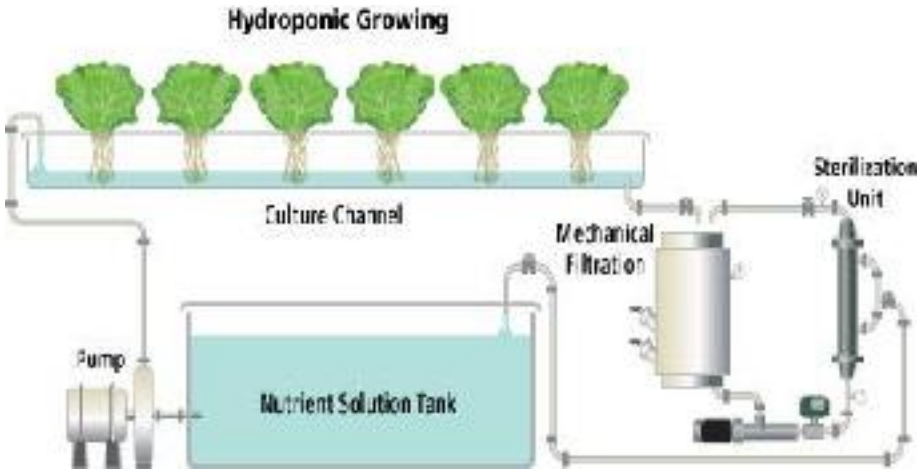
- Currently in Detailed Design
- Progress since mid-semester
  - Sunlight testing:
    Bean Bag ruled impractical
  - Investigated two potential sites
  - Updated DFMEA
  - Trial of fertilizer testing completed
  - Expanded materials safety
  - Pump and fittings purchased
  - Test bench updated



What is Hydroponics?

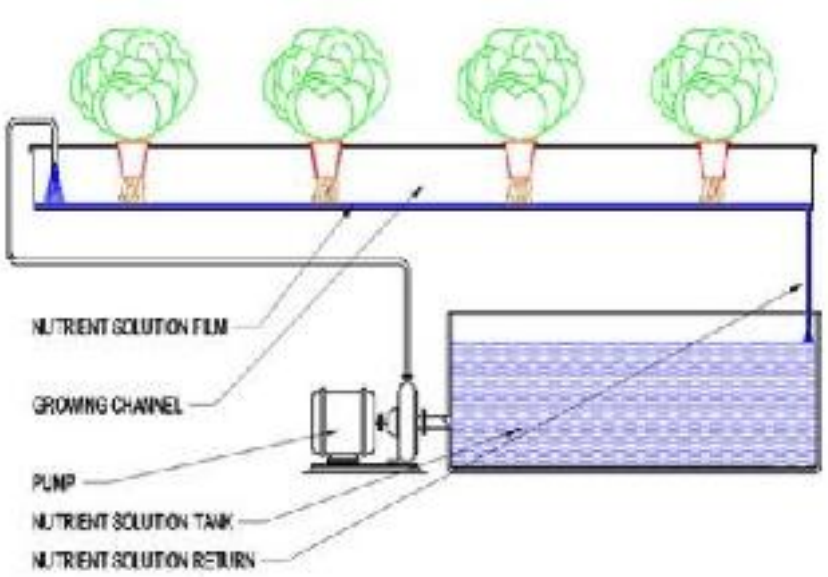
- Cultivation of plants by placing the roots in liquid nutrient solution rather than in soil

- Growing plants without a soil medium



Taken from: www.andnowuknow.com

What is an NFT Hydroponic System?



Taken from: www.hydor.eng.br

- Solution trickles down channel over plant roots
- Drains into tank
- Pumped back to top of channel thereby recycling solution
- Our system uses a capillary matting
  - Safety net if something in the system fails

Why NFT Over Other Systems?

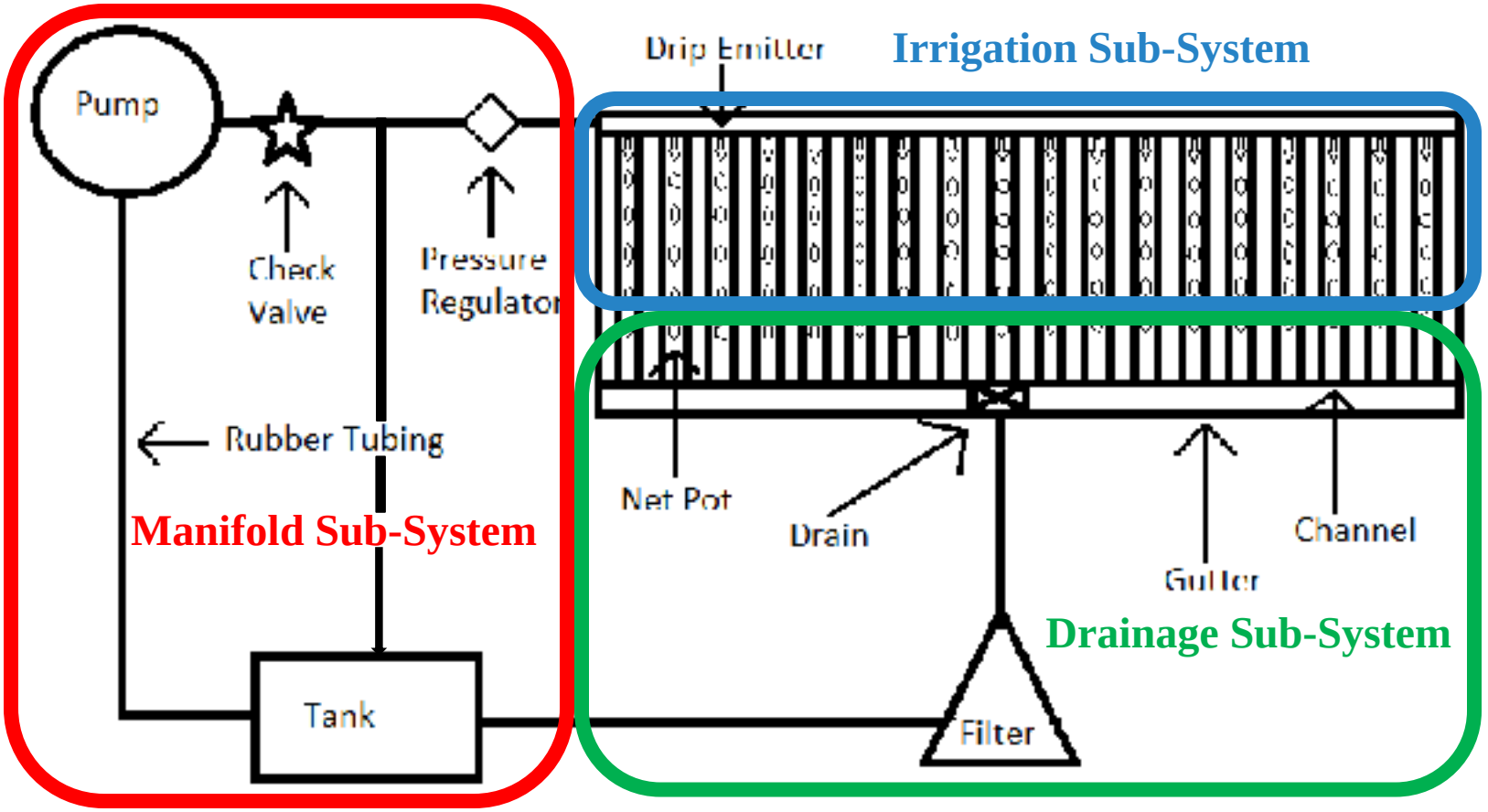
Consistent Flow

- Simultaneous access to water, oxygen, and nutrients
- Consistent access to water for crops is time efficient which leads to greater leafy green production.
- More uniform pH
- Reduces salt build up on plants

Less Obstructive Medium

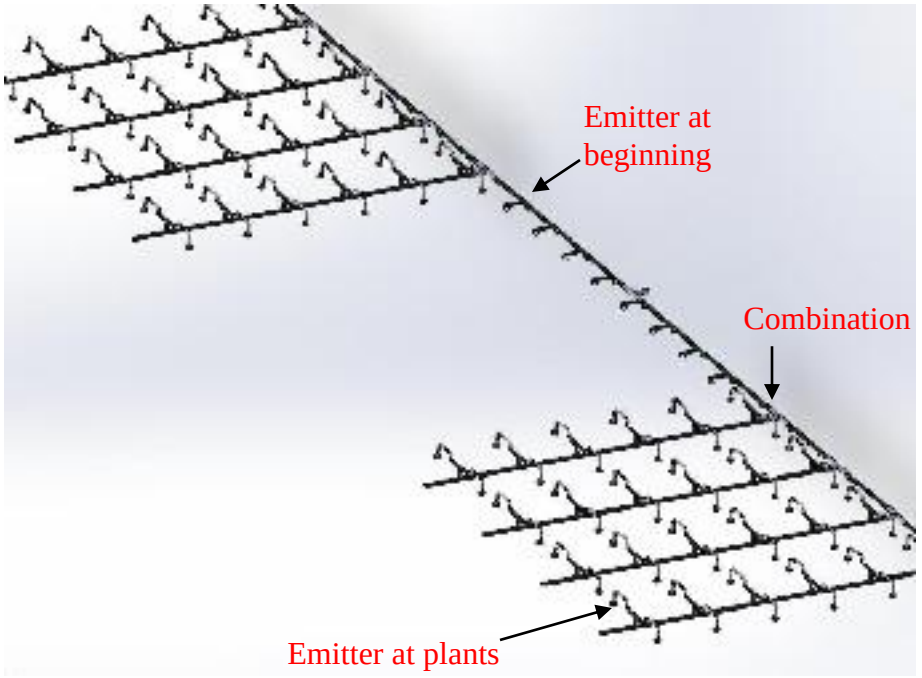
- Easy to disinfect
- Easy to inspect for disease or inadequacy
- Easier to observe for educational purposes

Overall System Explanation

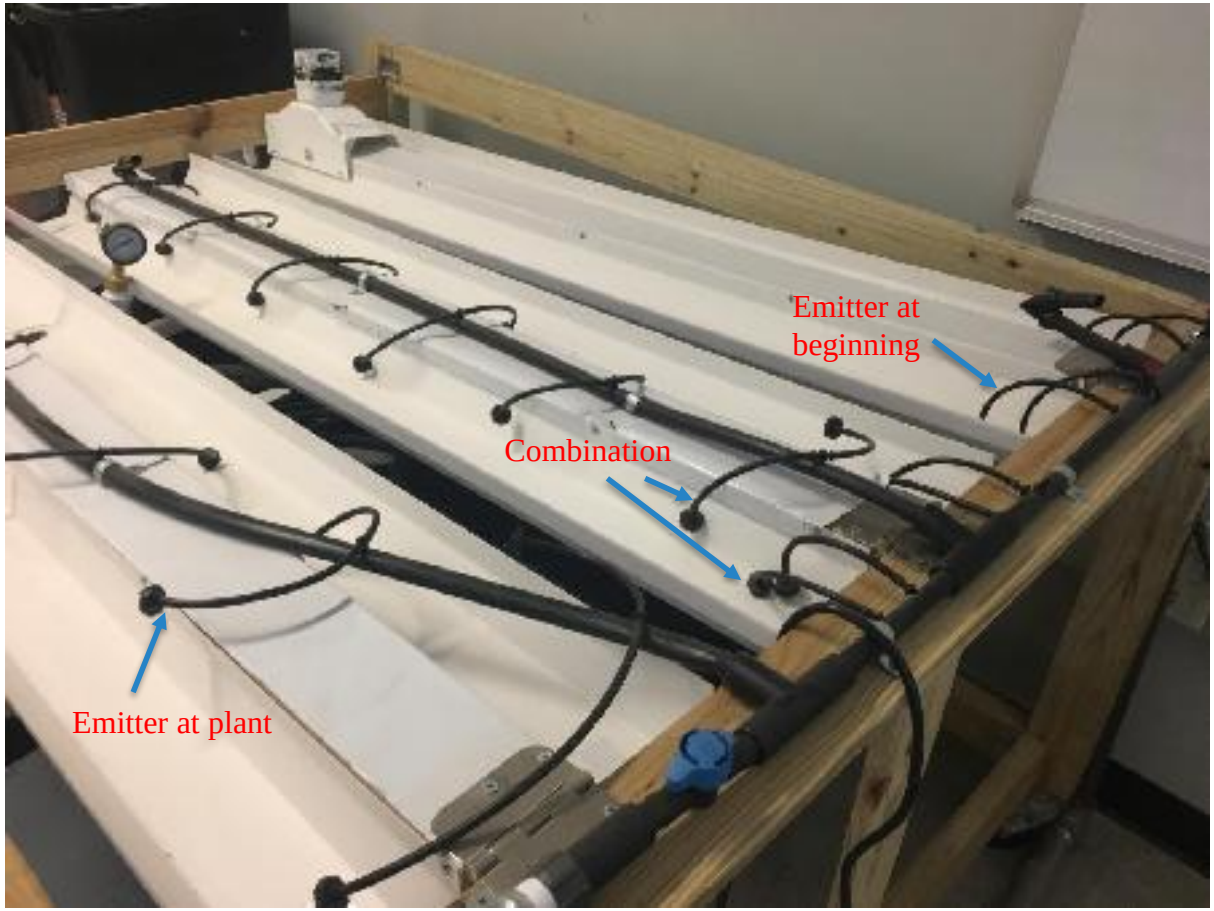


Irrigation Sub-System

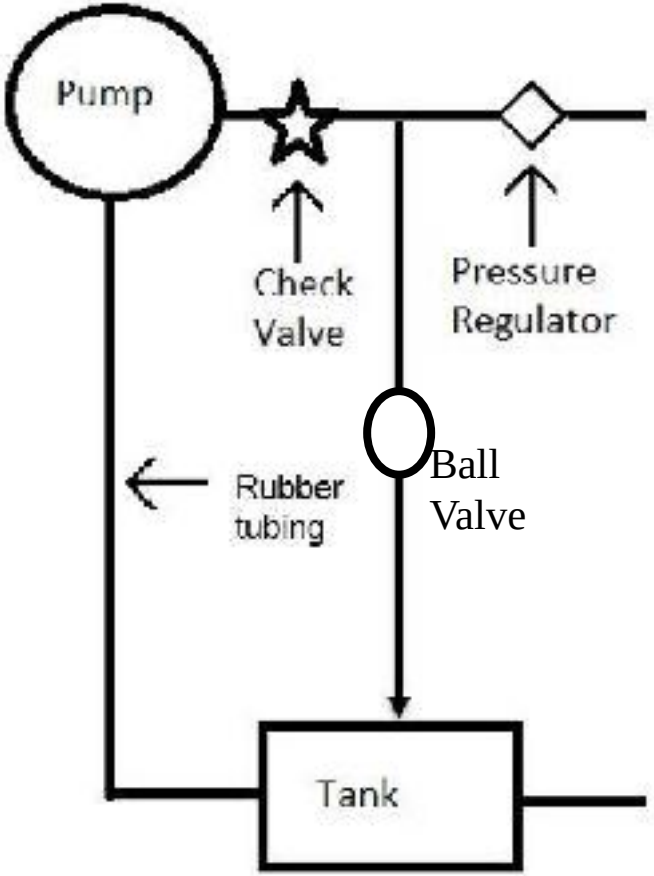
- Supplies water and nutrients
- All supplied by ½" mains (one per channel)
- Three application methods
  - Drip emitter at beginning of channel only
  - Drip emitters applied to individual plants
  - Combination of the above



Application Methods



Manifold Sub-System



- Pump
- Check valve
  - Prevents backflow
- Pressure regulator
  - Prevents spike above set pressure
- Tank
  - pH/nutrient control
- Ball Valve
  - Controls flow back to tank

Semester Progress

- Sunlight testing: Bean Bag ruled impractical
- Investigated two potential sites
- Updated DFMEA
- Trial of fertilizer testing completed
- Expanded materials safety
- Pump and fittings purchased
- Test bench updated

Sunlight Testing

- Habitat's Bean Bag community center bordered by a berm raised 25 feet
- Lettuce requires 6 hours of direct sunlight
- Based solely on the berm this could only be achieved from March 20th to September 20th
- Growth not recommended for hottest month
- 5 month maximum growing season was decided by both Doug Taylor and the team to be unacceptable

Design Failure Mode & Effect Analysis (Pages 9-12)

- Provided context for evaluating assigned values
- Recognized algae buildup as a potential risk after viewing similar systems in Purdue greenhouses
- Prepared design solutions to reduce algae buildup
- System issue with highest values:
  - Tubing clogging
    - Frequency and severity will be researched with test bench
    - Algae prevention plan ready if needed

Algae Prevention

- Algae growth dependent upon phosphorus, nitrogen, light levels, pH, and temperature
- Goal: reduce light and heat reaching water
- Solutions:
  - Cover channels with polyethylene weed barrier
    - Inexpensive, durable, food safe, relatively unobstructive
  - Nonsubmergible pump: less heat

Fertilizer Testing

- Semester Goals:
  - Ensure both fertilizer blends, Jack's 16-4-17 and Miracle Grow plus MOST, meet nutritional needs
  - Ensure triweekly pH testing is sufficient
- Conclusions:
  - Both fertilizers meet needs
  - Triweekly pH testing sufficient

Fertilizer Testing

- Growth slow:
  - Purchased electrical conductivity meter to verify concentration is correct
  - Purchased mesclun mix lettuce microgreens seeds for faster growth and quicker testing
- Miracle Grow plus MOST will be tested first in hydraulic bench
  - 55% price of Jack's 16-4-17
  - Less soluble, better to investigate clogging

Materials Quality (Page 13)

- Food Safety
  - FDA approval of all components in contact with nutrient solution except one pressure gauge to be used in the test bench
- Durability
  - Researching warranties and pressure limits
- Light permittivity
  - Light breeds algae
  - PVC presents potential issues, but can be covered in foil

Hydraulic Test Bench

- The hydraulic test bench is a small scale prototype of the final system
  - New pump, bulkhead fitting, pressure gauges, misc. fittings
  - Replaced PVC with hose for easier assembly/disassembly
- We are going to use this prototype to test for:
  - Irrigation uniformity and performance
  - Pump curves and testing
  - Fertilizer/crop care trials post seedling phase

Pump Comparison

- Former pump:
  - Diaphragm pump: Pressure fluctuations damaged pressure and flow gauges
  - Purchased for test bench, too small for full scale system
- New pump:
  - Centrifugal pump: constant pressure
  - Slightly oversized for system
    - Aquarium pumps too small, pool pumps too large

	Pump Requirements	Pump Specifications*
Pressure (PSI)	17.3	16
Total Flow (gph)	192	1080
*Pump specifications are for maximum efficiency		

Semester Spending

Part Name	Number of units	Price per unit	Total cost
Cast Iron 1/3 HP Centrifugal Pump 115/230V	1	$331.17 /ea	$331.17
100 PSI Pressure Gauge	2	$9.98 / ea	$19.96
Pro Flo Zinc Female Hose Mender	2	$4.98 / ea	$9.96
Pro Flo Zinc Male Hose Mender	2	$4.98 / ea	$9.96
6' Pump Power Cord With Standard 3-Prong Plug SPX1250WA	1	$19.99 / ea	$19.99
Mesclun Mix Lettuce Microgreens Seeds	1	$2.95 / ea	$2.95
HM Digital COM-80 Electrical Conductivity (EC) and Total Dissolved Solids Hydro Tester	1	$31.52 / ea	$31.52
Reducing Hex Nipple	1	$4.37 / ea	$4.37
		Total spent:	**$429.88**
		Projected:	**$597.00**

Plans for Next Semester

- Visit the Crossing and choose site
- Recover parts from Bean Bag
- Crop trials in test bench
  - Update maintenance manual with new data
- Greenhouse funding and installation
- Educational standards and materials
- System installation

Questions and Feedback?

Photo taken: April 2015