4-19-2019

Cost Analysis of Swine Manure Separation

Lucas Meyer
Iowa State University, meyer152@iastate.edu

Mason Moeller
Iowa State University, mmoeller@iastate.edu

Todd Muell
Iowa State University, tmmuell@iastate.edu

Shweta Chopra
Iowa State University, schopra@iastate.edu

Jacek A. Koziel
Iowa State University, koziel@iastate.edu

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Problem Statement
Smithfield Foods Inc. was founded in 1936 by Joseph W. Luter and his son Joseph W. Luter, Jr., with the name Smithfield Packing Company. The company name was later changed to Smithfield Foods in 1974. Smithfield Foods Inc. is quite proud of their guiding principles (Responsibility, Operational Excellence & Innovation) and this small excerpt defines their company as a whole, "We will seek fresh ideas in all aspects of business, including ways to work smarter, serve customers better, and make Smithfield a better company." (Smithfield Foods, 2019).

The issue that we worked on was how swine producers want to decrease the inefficiency of hauling raw manure slurry and increase manure application systems by separating solids and liquids produced in a typical shallow pit barn with an external manure storage system. There is a moderate amount of research that has been done on swine manure separation, but quite a bit of it is outdated. The current application of raw manure slurry is altogether expensive and inefficient by the traditional method of transporting the manure by large tanks, while post-separated manure could be transported further distances more efficiently. The increasing manure application possibilities and transporting regulations have been a large part of the project in the context of the future of swine production.

Given the elements of the project:

- Minimal research has been completed on current swine manure separation methods
- Manure separation is expensive, and its feasibility is all dependent on a producer's budget and the overall size of their operation
- Multiple costs associated with implementing a separation method (Solid & liquid storage, separation equipment, additional labor, etc.)

It is critical for producers/growers to comprehend the true benefits of implementing a separation method at this time before future regulations become required. The cost analysis tool will give producers the capability to view several costs associated with a particular separation method. When adopting a separation method, there two important benefits; higher efficiency of transporting manure farther distance and the cost-effectiveness increase tremendously.

Disciplines
Bioresource and Agricultural Engineering | Industrial Technology

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Cost Analysis of Swine Manure Separation

Lucas Meyer [a], Mason Moeller [b], Todd Muell [c], Shweta Chopra [d*] and Jacek A. Koziel [e*]

[a] Agricultural Systems Technology, ABE, ISU, meyer152@iastate.edu
[b] Agricultural Systems Technology, ABE, ISU, mmoeller@iastate.edu
[c] Agricultural Systems Technology, ABE, ISU, tmmuell@iastate.edu
[d] Dept. of Agricultural and Biosystems Engineering, ISU, 4344 Elings Hall, Ames, IA 50011, schopra@iastate.edu, 515-294-4898
[e] Dept. of Agricultural and Biosystems Engineering, ISU, 4350 Elings Hall, Ames, IA 50011, koziel@iastate.edu, 515-294-4206

*course instructors and corresponding authors.

Client: Smithfield Foods (Hog Production), 2124 90th Avenue, Algona, Iowa, 50511, smithfieldfoods.com

- Contact(s):
  - Bob Coffelt, Director of Business Development, bcoffelt@smithfield.com
  - Ray Foerster, Regional Production Manager, rfoerster@smithfield.com
  - Scott McLaughlin, Environmental Resource Specialist, smclaughlin@smithfield.com
  - Kellie Welter, Environmental Resource Specialist, kwelter@smithfield.com

1 PROBLEM STATEMENT

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Business Case Statement

Smithfield needs a cost analysis tool that aids producers in the first stages of implementing a swine manure separation method within their operation. Each method has its positive and negative features, and the feasibility of each method is dependent on a few key components. A producer will benefit from the estimations our tool provides because if taken advantage of at this time, they will be ahead of future rules and regulations.

2 GOAL STATEMENT

Our overall goal was not to find the most effective method overall, but to provide a tool for producers to utilize when deciding to implement solid and liquid separation. This tool provides insight into what might be a financially justifiable method of manure separation for a particular operation. The benefits of this tool will be readily available to Smithfield Foods Inc. and their associates.

- The main objective is to allow producers a way to estimate what the cost would be to implement a separation method into their operation. This gives producers the ability to justify the financial aspect of the implementation and choose which method works the best for them.
- A tutorial video will be included that goes over the essential functions of the tool and cover a small and large producer example.
- **Specific objectives include:**
    - Establishing a cost analysis tool that meets all the client's criteria and constraints

      Criteria
        - Costs for each separation method
        - Financial justification and easily operational

      Constraints
        - Based off of researched swine manure separation methods
- **Rationale**
    - Smithfield producers will be capable of determining which separation method best suits their operation
    - A tutorial video allows anyone to view examples covering different situations

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- **Reference Materials**
    - For the duration of this project, a variety of resources aided our team in the creation of our tool for Smithfield's Hog Production division.
    - Our team utilized an array of sources ranging from journal articles to Extension publications.
- **Data collection**:
    - Data pertaining to this project mainly focused on the five swine manure separation methods that our tool references and the estimated costs to implement each of those separation methods.
        - Separation method specifications required to get a fairly accurate estimate of the costs required for adopting a method.
        - Knowledge of Microsoft Excel was needed to create our cost analysis tool and ensure everything within the tool was accurate to the best of our knowledge.
- **Skills**:
    - The team working on this project had prior knowledge of the different facilities incorporated in swine production and how those facilities operated.
    - All group members had some prior knowledge of Microsoft Excel, and as the project progressed, information related to coding was introduced. That information was covered while all members of the group were present, ensuring everyone understood what was going on.
    - Courses that aided in the progression of our project include:
        - TSM 115, TSM 210, and ABE 160
- **Proposed Solutions**:
    - We were able to build a tool using various resources, along with ensuring that the requirements that our client gave us were accomplished.
    - Additional factors that contributed to our project's success include:

        - User-friendly interface
        - Accurate costs associated with swine manure separation
        - Constantly keeping in contact with our Smithfield contacts and asking questions to figure out exactly what they were expecting.
        - Having face-to-face meetings with faculty for additional information
    - Smithfield helped out at the very beginning of the project by providing insight on previous research that had been completed. By working in conjunction with Smithfield throughout the duration of this project, we were successful in creating this tool.
- **Organization:**
    - The team met at least once a week throughout both semesters to discuss project progress with the instructors and to discuss project updates.
    - Other meeting times were added as necessary to meet specific project deadlines.
    - Routinely met with Smithfield to show them our progress and to gather their input on the progression of the project.
    - Team members with beneficial outside knowledge were assigned tasks accordingly.
    - Throughout team collaboration and different ideas, the following list of milestones was created.
        - Define and analyze the limitations of solid and liquid separation
        - Research solid and liquid separation methods
        - Calculate post separation solid and liquid values
        - Design an effective and functional tool containing all researched information
        - Document all requirements needed to operate the tool effectively and efficiently
    - The team members collaborated effectively and overcame any setbacks to complete the project within the given timeline. The reinforcement of all group members and the even distribution of the workload, the project would not have been possible.

4 RESULTS

Results/Deliverables

- At the beginning of the project, a list of deliverables was provided that played a key role in how this project was structured (Koziel, 2018; Vanstrom, 2018). Each of the major milestones is documented below each one including the date that each one was completed
    - Define and analyze the limitations of solid and liquid separation
        - 11-19-2019
    - Research solid and liquid separation methods
        - 1-15-2019
    - Calculate post separation solid and liquid values
        - 2-28-2019
    - Design an effective and functional tool containing all researched information
        - 3-26-2019

- Document all requirements needed to operate the tool effectively and efficiently.
  - 3-29-2019

Project Deliverables:

- Swine Manure Separation Cost Analysis tool
- Standard Operating Procedure video was created to aid in the use of the tool and eliminate confusion

5 Broader Opportunity Statement

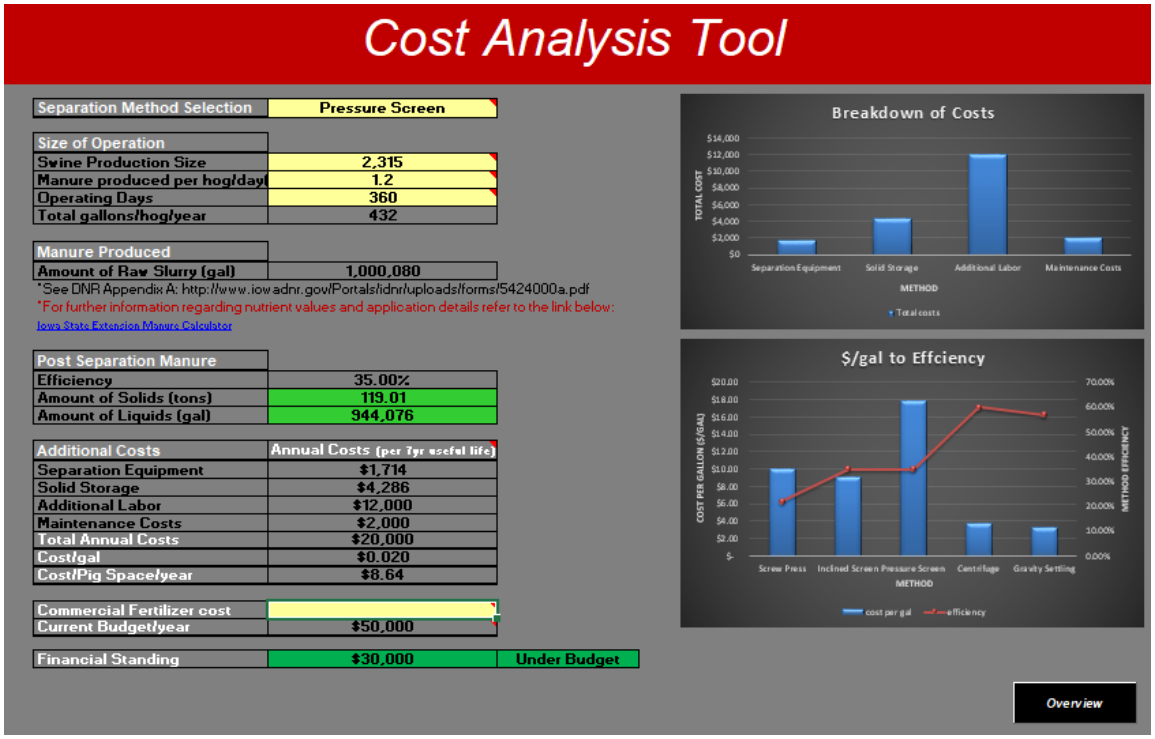
With the implementation of this swine manure separation cost analysis tool, Smithfield Hog Production can present it to their producers that are looking to increase the manure transportation efficiency. The tool will give them an estimation of the method that best suits their operation based on several factors. This tool has the potential to be more than just a resource for Smithfield Foods and their producers; it could be useful to anyone that is looking into separating their raw manure slurry.

6 Project Scope

Project Scope

- To research and develop a tool that producers can access and when using certain variables can view how certain separation methods would fit into their operation. Two key variables that will dictate whether or not a method is justifiable are operation size and a producer's current budget.
  - To calculate the value of the solids and liquids after they have been separated
  - To provide features (nutrient values of solids and liquids) for increases in cost-effectiveness

7 Graphical Abstract



8 REFERENCES

"Smithfield Foods." *Smithfield Foods Inc.,* www.smithfieldfoods.com.

Dr. Jacek Koziel, ISU Course Instructor, personal communication, Oct. 2018 – Apr. 2019.

Joe Vanstrom, ISU Course Instructor, personal communication, Oct. 2018 – Dec. 2019.

Dr. Shweta Chopra, ISU Course Instructor, personal communication Jan. 2019 – Apr. 2019.

Dr. Daniel Andersen, ISU Associate Professor, personal communication, Oct. 2018 – Apr. 2019.

Tim Shepherd, ISU Lecturer, personal communication, Oct. 2018 – Apr. 2019

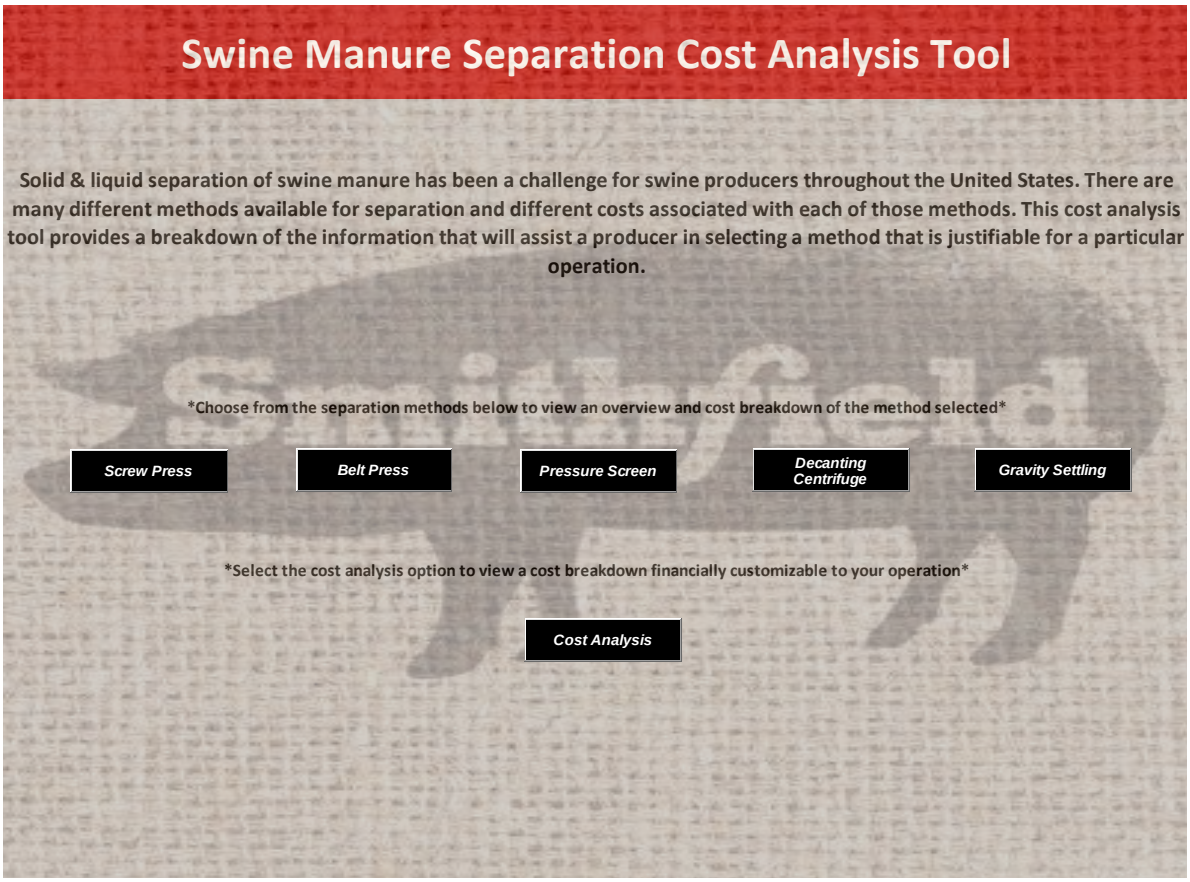
Robert Coffelt, Smithfield Director of Business Development, personal communication, Oct. 2018 – Apr. 2019

Ray Foerster, Smithfield Regional Production Manager, personal communication, Oct. 2018 – Apr. 2019.

Scott McLaughlin, Smithfield Environmental Resource Specialist, personal communication, Oct. 2018 – Apr. 2019.

Kellie Welters, Smithfield Environmental Resource Specialist, personal communication, Oct. 2018 – Apr. 2019.

9 APPENDIXES



The overview section of the Cost Analysis tool

Screw Press

A screw press has a slow turning screw inside it which conveys the raw manure slurry through the main case and into a pressurized zone where the slurry is compressed against a screen or filter. The screen or filter only allows the liquid portion of the slurry to pass through while the solid portion is discharged in a different direction. Simple operation and less mechanical equipment involved in a screw press method achieves a relatively easy system to implement and utilize in a solid & liquid separation management plan.

- Easily piled
- Consistent moisture results
- Automated systems interface for ease of use
- Low maintenance costs

Separation Equipment	$55,000
Solid Storage	$30,000
Additional Labor	$10,000
Maintenance Costs	$5,000
Efficiency	22.00%
Moisture of Solids	50.00%

Overview | Belt Press

Screw Press Overview

Belt Press

The X-Press is a further engineered mechanical separation machine thaty utilizes compression to separate manure. The cascading rolling system compresses the manure between to rollers up to three times depending on the desired dry matter output. The X-Press is designed to work in conjunction with a sloped screen separator or vertical dewaterer.

- Maximum cake solids
- Low power requirements
- Mobile or portable units are available
- High dewatering capacity

Separation Equipment	$65,000
Solid Storage	$30,000
Additional Labor	$10,000
Maintenance Costs	$5,000
Efficiency	35.00%
Moisture of Solids	70.00%

Overview | Pressure Screen

Belt Press Overview

Pressure Screen

Pressure screens separate manure by directing the raw manure slurry over a inclined screen, the solids are then captured on the top side of the screen while the liquids pass through the screen. A pressurized water system, sometimes called an auto washer, can be used in conjunction with a screen to clean the screen after each separation cycle. Vibration systems can also be utilized as an option to the screen to further increase separation efficiency by keeping the manure moving over the screen and allowing the throughput of the machine to increase, while keeping solid and liquid separation consistent.

- Lowest equipment cost method
- Simple mechanical equipment
- Add on options for increased consistency
- Ability to increase solids concentration of cake

Separation Equipment	$12,000
Solid Storage	$30,000
Additional Labor	$12,000
Maintenance Costs	$2,000
Efficiency	35.00%
Moisture of Solids	50.00%

Overview | Decanting Centrifuge

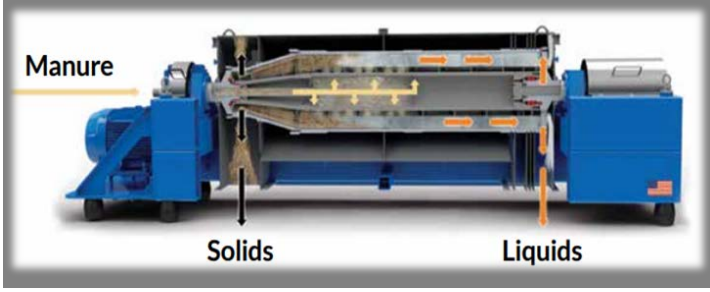
Pressure Screen Overview

Decanting Centrifuge

Incorporating a decanting centrifuge into a manure separation operation is a head on approach to efficiency and moisture control of solids output from the machine. Decanting centrifuges have high variability in settings, such as centrifugation time and RPM of the machine. When compared to traditional methods of separation, centrifuges have had an advantage of solid output control, capturing more solids out of total raw slurry throughput. A decanting centrifuge can act as a centralized stand-alone piece of separation equipment, compared to other systems, which may need multiple pieces of separation equipment.

- Lower lagoon management
- Versatile
- Cleaner flush water, pivot irrigation more applicable
- Industrial control panel interface provides ease of use and setting change capability

Separation Equipment	$200,000
Solid Storage	$30,000
Additional Labor	$20,000
Maintenance Costs	$20,000
Efficiency	60.00%
Moisture of Solids	40.00%



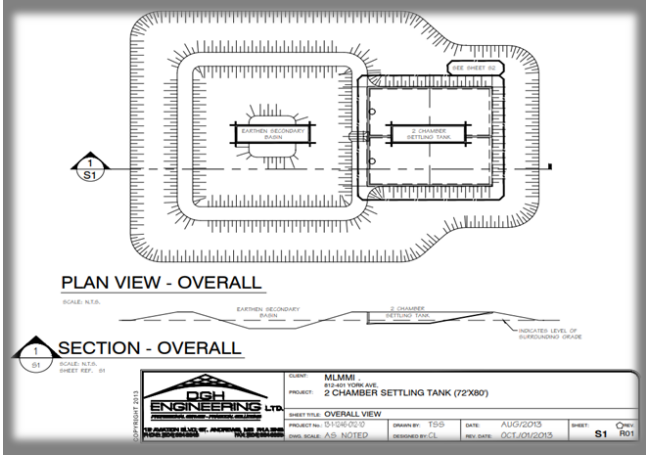
Overview | Gravity Settling

Decanting Centrifuge Overview

Gravity Settling

The efficiency recovery of solids utilizing gravitational settling has the potential to be greater than that of mechanical separation, be means of implementing a two chamber settling tank, and a secondary holding basin, both with a six month holding capability. The gravitational settling method we determined to be the most effective utilizes a multi-cell settling design for manure handling efficiency, with a trade off in moisture content of the solids. Due to this specific design not implementing a covered settling area, precipitation has the potential to increase or decrease the effectiveness of the settling of the solids.

- **2 chamber settling tank**
- **Lower maintenance costs**
- **Agitation expenses not required**



Separation Equipment	**$0**
Solid Storage	**$280,000**
Additional Labor	**$30,000**
Maintenance Costs	**$1,000**
Efficiency	**57.00%**
Moisture of Solids	**75.00%**

Overview ***Cost Analysis***

Gravity Settling Overview

Associated Costs	Screw Press	Belt Press	Pressure Screen	Decanting Centrifuge	Gravity Settling
Separation Equipment	$55,000	$65,000	$12,000	$200,000	$0
Solid Storage	$30,000	$30,000	$30,000	$30,000	$280,000
Additional Labor	$10,000	$10,000	$12,000	$20,000	$30,000
Maintenance Costs	$5,000	$5,000	$2,000	$20,000	$1,000
Efficiency	22.00%	35.00%	35.00%	60.00%	57.00%
Moisture of Solids	50.00%	70.00%	50.00%	40.00%	75.00%

Calculations:

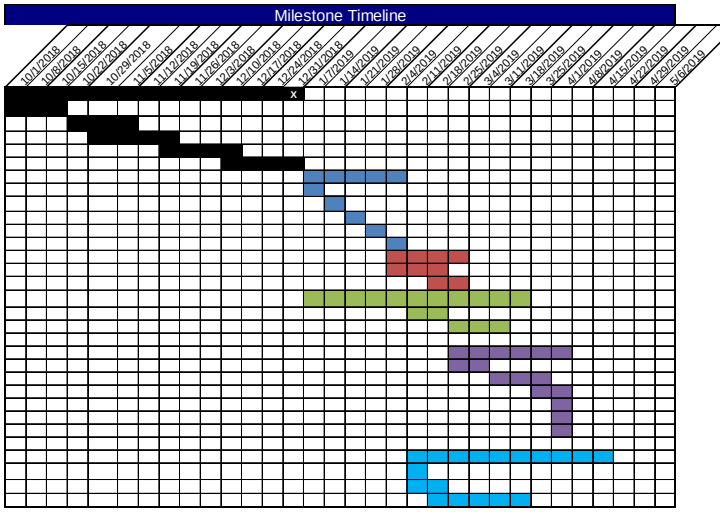
Standards		Method	Total costs	Cost per gal	Efficiency
% Solids in Raw Slurry=	8%	Screw Press	$100,000	$10.00	22.00%
Lbs/Gal=	8.5	Belt Press	$110,000	$9.09	35.00%
		Pressure Screen	$56,000	$17.86	35.00%
		Centrifuge	$270,000	$3.70	60.00%
		Gravity Settling	$311,000	$3.22	57.00%

Data used in the calculations within the Cost Analysis tool

Milestone Performance

Work Breakdown Structure		Summary/Measurable	Verification Date	On / Off Schedule
1.0	Compile feasible base plan	Measureable		On
2.0	Application rates of manure from producers (solid vs liquid)	Measureable	11-Nov	On
4.0	"Optional/additional" equipment required for solid application	Measureable	11-Nov	On
5.0	Gather data on budget analysis from producers	Measureable	11-Nov	On
7.0	Set up meeting with Dr. Lee Schulz to discuss cost justification	Summary	26-Nov	On
8.0	Get in contact with Tom Olsen on usage of swine manure calculator	Summary	26-Nov	On
2.0	Define and analyze limitations of nutrient/solid-liquid separation	Measureable		On
1.0	Define logistical limitations	Measureable		On
1.0	Specify methods for different producers and their effectiveness	Measureable		On
2.0	Determine cost effectiveness for each method	Measureable		On
2.0	Define physical limitations	Measureable		On
1.0	Quantitive requirements for different sized producers	Measureable		On
4.0	Calculate post separation solid and liquid values	Measureable		On
1.0	Meet with Dr. Manure to verify calculations	Measureable		On
1.0	Questions for meeting with Dr. Manure	Measureable		On
5.0	Build excel sheet showing cost effectiveness of separation	Measureable		On
1.0	Compare cost analysis on different separation methods	Summary		On
1.0	Change poster for Smithfield Grand Banquet	Summary		On
2.0	Prepare tool for viewing at Smithfield banquet			On
6.0	Bring all data together for poster and final binder for Smithfield	Measureable		On
1.0	Get started on Final Report for Client	Measureable		On
1.0	Finalize Final Report rough draft for client approval	Measureable		On
2.0	Start on Final Presentation for Capstone Day	Measureable		On
1.0	Start on instruction video	Measureable		On
3.0	Give practice presentation	Measureable		On
1.0	Invite students and faculty to practice presentation	Measureable		On
2.0	Email report and presentation to Smithfield for review	Measureable		On
7.0	Complete final touches on project	Measureable		On
1.0	Work on 3 min Powerpoint that will assist with final presentation	Measureable		On
1.0	Complete 3 Minute Presentation for 3/8/2019 class	Measureable		On
2.0	Complete PPT for Capstone Day	Measureable		On

Milestone Timeline



Work Breakdown Structure