EVALUATION AND DESIGN OF POTTING PRODUCTION PROCESS IMPROVEMENTS FOR THE NON-PROFIT ORGANIZATION, GROWING GROUNDS FARM

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INTRODUCTION

This report focuses on the potting production process for the non-profit organization (NPO) Growing Grounds Farm (GGF), and aims to promote a standardized workflow system to enhance the working experience for Transitions-Mental Health Association employees and volunteers.

In this project, problems within GGF's potting production area were identified for improvement. One of the biggest issues that employees often face during their three hour shift at the potting area is discomfort. For example, in the cases where four-inch flats and one-gallon pots are the types of containers being worked with, employees must travel long distances, intersect the paths of other workers, perform tasks simultaneous to others, lift up heavy loads of soil from the ground onto the potting bench prior to completing the potting process. Raw material and finished products are transported back and forth throughout the potting shed while the production process is taking place. Lack of workflow and standardize job distribution leads to seemingly increased cycle times. GGF operates as a non-profit organization to acquire profits as a wholesale supplier for nurseries, restoration and landscaping projects while integrating their social vision of providing TMHA's patients with a comfortable community that works at a steady pace. In response to these discoveries, the objectives to be met upon the completion of this project aim to alleviate some of the issues GGF addressed. The objectives of this project are listed below:

- Standardize and increase work flow
- Decrease potting production cycle time and increase total output
- Provide a solution that is both economically and socially viable

In order to reach these objectives, observations and data will be collected to develop a baseline of the current potting process. This will provide us with an idea of what issues are being faced by employees under the current process. An extensive literature review on existing nursery practices and methods being used in other locations will aid in the development of a prototype of a new potting method that fits in with GGF's culture and produces a more efficient process. Factors such as the size of GGF, the demand quantity, the nursery layout, and other features will be considered. By utilizing principles from Project Management, Process Improvement Fundamentals, Facilities Planning and Design, Simulation, solutions are proposed to target specific issues in the facility's layout.

As specified in the listed objectives, this project delivers a design of the prototype for increasing efficiency. While this design will then be submitted for additional research and review upon completion, it must be noted that the implementation of the proposal will not be within the scope of this project. Rather, it will be included as a suggestion for future Cal Poly students as a senior project. The objectives also aim to provide a list of potential organizations to contact for the funding of the proposed solution.

The rest of this report will first provide background information on GGF and a more in-depth description of what problems are being addressed. A literature review is then summarized to provide insight on the background of non-profit organizations with an emphasis on social enterprises, existing businesses similar to GGF, and common methods other nurseries practice. Afterwards, the proposed changes of the redesign facility and tools will be discussed, followed by experimentation. Finally, a discussion of the results and future recommendations will be provided.

BACKGROUND

History

In the early '80s, Barbara Fisher worked for SLO Mental Health Association as executive director. At this time, the SLO Mental Health Association and the SLO Transitions Association were separate entities. As Barbara and other employees worked with special-need clients on a regular basis the need to create employment opportunities became a prominent motif. This surfaced because common resumes from SLO Mental Health Association and SLO Transitions often encompassed prerequisite gaps. More often than not, the gaps were overlooked and the public market could not meet SLO Mental Health Association and SLO Transitions clients' needs. Therefore, Fisher exploited the well-recognized void within the job market. In order to foster the prospect of employing such clients, Fisher worked with others to generate a business plan. Barbara Fisher partnered with James "JT" Hass, an engineer at PG&E and a board member on the SLO Mental Health Association, to secure PG&E owned land to house the business proposition. The proposition was to create a Growing Grounds Farm (GGF) that would employ clients, as well as generate revenue to sustain the business. During this time, SLO Mental Health Association and SLO Transitions Association merged to create Transitions-Mental Health Association (THMA). The year was 1998. While the two associations were merging, James Hass acted as one of the main forces in not only creating the contract between PG&E and GGF to utilize PG&E's land, but also helped to create GGF in 1984 through volunteer work. He also helped catalyzed the adhesion between the two separate associations to create TMHA. Obviously, these two were not the only people that contributed to the development of the two new business plans but they were given credit for seeing the development through to the end.

Today, GGF is a wholesale plant grower partnered with Transitions-Mental Health Association (TMHA) to supply a variety of plants to various contractors as well as provide transition services to customers seeking healthy development opportunities. Growing Grounds Farms have successfully been in operation for more than 25 years and have expanded their operation to include a GGF in Santa Maria, CA. The co-operative between the Growing Grounds Farms and the Transitions-Mental Health Association is a non-profit organization that seeks to provide social service support to those who suffer from a mental illness. The social services provided through this co-operative include work, housing, and community and family support services. In part, it is through the Growing Grounds Farms that the co-operatives' mission is self-sustained.

TMHA's mission establishes a 'double bottom line' as it operates traditionally as a non-profit organization and non-traditionally as a social enterprise. A nonprofit organization is a charitable trust, corporation, or association that must not distribute any earnings to private shareholder or individuals (Internal Revenue Service, 2012). A social enterprise is "a business with primarily social objectives whose surpluses are principally reinvested for that purpose in the business or in the community, rather than being driven by the need to maximize profit for shareholder and owners", according to the United Kingdom government's Department of Trade and Industry (2002). Thus, the double bottom line is verified by the fact that "social ends and profit motives do not contradict each other, but rather have complementary outcomes" (Cornelius et. al, 2007, pg.1). Therefore, the GGF's goal to focus on its social capital is supported through revenue generating operations.

GGF employs adults through TMHA's Supported Employment Program and SLO's County Mental Health Program to support healthy development and transition into the job market. By operating through GGF, the previous gaps in clients' early resumes are minimized. GGF's motto is "Hope through horticulture – Nurturing plants and people". Horticulture therapy (HT) is the way in which GGF aims to benefit its employee development and transitions into healthy habits. HT is a practice that utilizes plant-based activities to holistically achieve treatment goals for special-need individuals (Gigliotti & Jarrott, 2005). The initial idea of horticulture therapy was popularized by Dr. Benjamin Rush, one of the signers of the Declaration of Independence, who said that "garden settings held curative effects for people with mental illness" (growinggrounds.org). Also concluding a comprehensive case study it was found that "HT activities are a viable and desirable choice for [special-need] programs because they successfully engage groups of participants in an activity that elicits high levels of active engagement and positive effectual responses" (Gigliotti & Jarrott, 2005). The TMHA co-operative mission is supported and sustained alongside GGF's operations and culture to meet wholesale demand as well as the needs of its employees.

The demand that Growing Grounds Farm must meet is contingent upon the contracts that typically come from nurseries, restoration and mitigation projects, and landscape jobs. Although it is GGF's first goal to supply the demand provided through these contracts, GGF also supplies a long list of plants that are sold to the public through both their downtown retailer called Growing Grounds Downtown (GGD) and once a month at the Growing Grounds Farm location. In the next section, the potting system utilized by GGF and layout of activities will be described further to gain a better understanding of their process and illustrate problematic areas.

Removing Plants From Pots

Located at one end of the potting shed, the first station is used for removing plants from flats (trays with newly propagated plants) or small plastic containers and preparing them to be repotted. There is one employee who works at this station. The plants being prepared are usually repotted into the four-inch and one-gallon containers. First, the employee obtains a tray of the correct plant type from a trailer outside of the potting shed and brings it to the table. The plants are carefully removed either by hand or pushed out by a tool that fits through a hole on the bottom of the tray. The removed plants are placed into a large basket and the emptied containers are tossed onto the other side of the worktable. When one basket is full (a batch size of 12 per), the worker places a small plastic label in it to indicate the name of the plant. Sometimes, miniature flags are also placed into the bowl to indicate if they will need to be watered, weeded, or placed in the "Not for Sale" area after potting. The completed bowl is then walked over and set on a rack located approximately six feet away. Once all the flats from the trailer for one order is completed, the employee will stack up the emptied containers and clean up the station.

Inventory and Equipment

The inventories of all plastic plant containers are stored next to the potting shed. They are placed in stacks on the ground and separated by size with wire fencing. The soil for the pots is stored outside on the open end of the potting shed (opposite of the plant potting preparation area). It sits in a pile on the ground and is covered by a plastic tarp. Inside the shed is the potting bench. The potting bench takes up at least half of the space in the shed, stands at approximately three feet tall, and has a U-shape. Inside the U-shaped table is a ledge that sits lower than the table and holds 4-one-gallon pots. If an employee was to stand in the middle of the table, they could effectively push the soil into the containers. Four to six employees may work around and inside the potting bench simultaneously.

Potting Plants

4" Container Process

When preparing the four-inch pots, an employee must manually strip pots from their initial stacks and then place them in a flat. Each flat holds 16 plants. When that flat is full, it is set on the ground next to the soil heap. A shovel is used to fill up the pots. Afterwards, the employee must bend over to smooth out and remove unwanted soil from the top before stacking it next to the potting bench. When an employee from the potting bench is free, he/she will retrieve a soil filled flat from the ground and a bowl of plants from the rack and bring it to the table. Using their fingers, the employee makes a hole in one of the four-inch pots and places a plant from the bowl inside. The soil is then packed firmly around the plant. When all the pots in the flat are finished, it is walked to a trailer outside of the potting shed to be transported to its respective area.

1-Gallon Container Process

For the one-gallon pots, an employee retrieves a stack of empty pots and places it next to the potting bench to use. Meanwhile, another employee uses a shovel to fill fifteen-gallon pots with soil. The fifteen-gallon container is transported over to the potting bench and lifted up to pour the soil onto the table. An employee standing in the middle of the U-shaped table pushes the soil from the table into the one-gallon containers set on the ledge. Once filled, he/she moves the pot from the ledge to either side of the table where another employee is waiting. During this time, the employees on the side acquire a bowl of plants from the queue rack to work with. Using their hands, they make a hole in the soil of the one-gallon pot and place a plant in. Then, using the soil from the table, they firmly pack the areas around the plant down before transporting the pot to a trailer outside.

LITERATURE REVIEW

This section provides information necessary to understand the breadth of this project and provides a background on how conclusions were developed given accredited sources.

The Nonprofit Sector

The mission statement for TMHA and GGF is to operate as a "nonprofit organization dedicated to eliminating stigma and promoting recovery and wellness for people with mental illness through work, housing, community and family support services" (Transitions Mental Health Association). In 1913, the year when corporate tax was initiated, the federal government pioneered the term nonprofit as well as defined its parameters under which it operates (Rendall, 2004). The co-operative is classified as a nonprofit organization (NPO) under the 501 (c) (3) section of IRS requirements (growinggroundsfarm.org). According to the Internal Revenue Service, this type of organization classification is commonly referred to as a "charitable" organization which holds distinguishing features. Some key features of the 501 (c) (3) classification include: not being able to engage in political and legislative lobbying activities, earnings of the organization may not "inure to any private shareholder or individual", and the organization must be structured as a trust, corporation, or association. In the case with Growing Grounds Farm, they are structured as an association and are partnered with Transitions Mental Health Association. The non-profit-distribution constraint helps to define NPO's as private organizations with a public purpose. These key characteristics of a nonprofit organization enable its eligibility to qualify under the 501 (c) (3) tax-exempt section of the federal government (IRS, 2012). Nonprofit organizations operate as third sector organizations that are structured in such a way as to provide services to particular areas of society without the sole objective to maximize profit. This constraint helps to distinguish the ambiguities between for-profit and nonprofit organizations. Although the Internal Revenue Service definition helps to identify how such organizations are classified under taxation parameters, the definition unfortunately does not describe third sector organizations in a holistic manner.

To clarify, the structure and interests of third sector organizations are further addressed. The structure of a nonprofit organization despite their economic development was presented by social scientists in 1997 by Salamon and Anheier through their John Hopkins Comparative Nonprofit Sector Project (JHCNSP). The project identifies five structural characteristic that support the operations of the nonprofit sector. The identifying terms are listed below (Salamon and Anheier, 1992, 1997):

1. Organized – institutionalized to some degree in terms of their organizational form or system of operation
2. Private – institutionally separate from government
3. Non-profit-distributing-not returning any profits generated to their owner or director but ploughing them back into the basic mission of the agency

4. Self-governing – equipped with their own internal apparatus for governance
5. Voluntary – involving some meaningful degree of voluntary participation, either in the operation or management of the organization's affairs

Salamon and Anheier argue that entities that are distinguished by the umbrella of the nonprofit sector will operate in such a manner as to hold each one of the identifiers listed above. The structure presented also provides a common criteria and platform to facilitate communication between the nonprofit sector and other various sectors as issues may arise. Further research suggests critiques of this study and within the International Journal of Voluntary and Nonprofit Organizations, Susannah Morris argues that the interests of the nonprofit sector must also be addressed. In her study released in 2000, called *Defining the Nonprofit Sector: Some Lessons from History,* she conveys three important interests of the nonprofit sector in order to further clarify the ambiguity found within nonprofit sector definitions. The first category identifies the need of effective performance measures, since the government subsidizes the sector through public funding. The second category states that these organizations must function separately from for-profit organizations. This is due to the fact that nonprofit organizations must provide services for consumers who suffer financial, personal, societal, or community disadvantage (Billis & Glennerster, 1998). The third category states that although public goods or services might be produced, a primary focus of the organization is to foster their social capital. Furthermore, the interests of the nonprofit sector was somewhat dictated by the historical funding trend.

Unfortunately, funding efforts have not been consistent throughout history. Over the past two decades there have been significant reductions in funding patterns for nonprofit organizations provided by the government (Emerson, 1999a, p. 5). As trend of public funding for private NPO's decreases, the demand for NPO's to mitigate social problems and community needs continue to increase on a global scale (Boschee, 2001: Horsnell & Pepin, 2002). Subsequently, the development of a new business market called social enterprises became recognized. Social enterprise is one way to mitigate the discrepancy between nonprofit and for-profit boundaries. The idea of social enterprise came with the "rediscovery of non-profit organizations (mainly associations) as social service providers and work-integration organizations" with many today "coupled with the strengthening or cooperatives' concern for the community that paved the way for an increasing convergence" (Galera & Borzaga, 2009). Social Enterprises "provide work for the unemployed and generally offer innovative products and services previously overlooked by the private and public sectors" (Cornelius et. al, 2007, pg. 358). It is with both of these definitions, non-profit and social enterprises, that the co-operative between THMA and GGF can be effectively described because GGF was in operation after the governmental funding cuts took affect.

Double Bottom Line: Profit Meets Workers' Needs

The difference between social entrepreneurial ventures (SEV) and entrepreneurial ventures (EV) becomes apparent when the process of leveraging resources is identified. Since this project evaluates the non-profit organization, Growing Grounds Farm, structured as a social enterprise with potential interest in social entrepreneurial ventures for funding the focus is heavily weighted on similar business models. However for clarity purposes it is important to clear up the discrepancy in terminology used to conduct this literature review. Social entrepreneurship is not concurrent to corporate social responsibility although the terms have been used incorrectly. According Dorado's research on social entrepreneurial ventures (Dorado, 2006, p.322),

> "Socially responsible companies are those whose primary goal is profit; and, for most of them, their socially responsible behavior is motivated by the belief that it will improve the bottom line."

As for SEV's financial development and growth is secured through both the economic and social value (the double bottom line) of the organization business model they support. As public financing for non-profit organizations continues to shrink the necessity to seek out SEV's as a strategy to limit dependency on government subsidies, grants, and other various forms of donations becomes apparent. The differentiating factor is the fact that non-profits seek out profit generating elements as a means to self-sustain the organizations initial social mission.

> "EVs can be valued exclusively in financial terms, while SEVs cannot. Considering SEVs strictly in financial terms would imply that they are not different from socially responsible ventures (as cited by Waddock and Graves, 1997) when, in fact, fundamental to the nature of SEVs is that they serve a social mission that is not overshadowed by profit maximization" (Mair and Marti, 2006).

Furthermore, the opportunities social enterprises tend to seek out are gaps found within the market where social development is not valued as a viable opportunity in comparison to traditional enterprises concerned only with the economic bottom line. Fortunately, there are SEVs with philanthropic motives that fund non-profit social enterprises whose mission is to satisfy the social gap in the previous market. Some philanthropic investors that could potentially support the Growing Grounds Farm – TMHA initiative include the Acumen Fund, Central Fund, City Light Capital, Investors' Circle, TBL Capital, Triodos Bank, and Underdog Ventures (Admin.??). As mentioned in Dorado's research, non-profit SEVs (or SEV's I am not sure, but let's be consistent) engaged in self-sustaining profit-generating operations can lead the organization to change its original mission over time. For this reason, this project takes careful consideration into the process improvements proposed so to support the double bottom line of economic and social objectives. A non-profit organizations' ability to stay loyal to its social goals is ultimately exemplified through the organizations structural governance. Often organization's structural governance is evident through observing the cultural dynamic.

Nursery Plant Production Process

According to Mason, there are typically four stages in container nursery production: propagation, transplanting, growing-on, and marketing (Mason, 2004).

- *Propagation* refers to the sexual or asexual methods of plant reproduction. Sexual propagation uses the exchange of genetic material from two parent plants (example: seeds or spores). Asexual plant propagation uses material from a single parent (example: cuttings or bulbs). Some nurseries choose not to undertake on-site propagation because it requires a high level of skill.
- *Transplanting / Potting* is the process of taking newly propagated or container-grown plants, and placing them into the appropriate growing media. Generally, if plants are left in the same medium for too long, they will begin to suffer. By transferring plants into a larger container, they can continue to grow and thrive.
- *Growing-on* is the stage where transplanted plants grow into a desired size. Factors such as location, spacing, pests, diseases, watering, fertilizing, and etc., must be given careful consideration during this stage of production to ensure products reach the saleable size and appearance.
- *Marketing* identifies the customers and what products to carry. By identifying how much output is required and what plant materials are needed, the nursery can adapt their operations to ensure success and profit.

Following this section, the transplanting and potting stage will be described further to provide information over the process and methods of choosing a potting system.

Choosing a Transplanting / Potting Method

The process of potting can be generalized into the following steps:

1. Bring soil mix from storage pile to potting area and placing it in a potting machine or potting benches.
2. Bring containers from storage area to potting area.
3. Bring plants from propagation area, which are either in flat trays or small plastic cups, to potting area.
4. Perform potting operations
    a. Strip containers from sleeves.
    b. Fill containers with soil mix.
    c. Make a hole in soil for plants.
    d. Remove one plant from the flat or a plastic cup.
    e. Place plant in the soil and firm soil around it.
5. Remove potted container from potting bench and place it on a trailer.
6. Transport trailers with freshly potted containers to field.
7. Place potted container in field beds and return to potting area.

Since a number of these operations require transportation and manual labor, many potting equipment and tools can be implemented to aid in the process. In the past few years, nurseries have adopted a variety of potting systems that include machines with varying levels of sophistication and different rates of operating speed. These machines help reduce the time needed for potting so that staff may focus on their assigned tasks.

There is no "one size fits all" solution when it comes to selecting the right process for any specific nursery; having the latest equipment does not necessarily signify an efficient system. The nursery's organization and the techniques, allocation of tasks, level of comfort, and skills of the staff and management all have an effect on the production rate. A number of factors are also taken into consideration before deciding on which method to switch to, including the number of plants in production, the types of plants, the different pot sizes, location of potting, and more (Drury, 2004).

The different types of potting systems can be broken down into three categories: hand potting, machine assisted potting, and machine potting (Franklin, Brown, & Radajewski, 2001). This paper focuses on improving the ease at which Growing Grounds Farm employees work, additional research was only conducted on the first category. The remaining two categories were not considered because they are more suited for for-profit organizations whose mission is to only increase profit margins.

Hand potting consists of all systems in which tasks in the potting stage are carried out manually. While tools and equipment within this category can be employed to aid the worker, they do not perform the task directly. Subcategories within this definition are:

- *Standard Potting Bench*: A standard bench is a workstation in an area specifically for this task. A table holds a quantity of soil or other forms of media for the potting process.
- *Modified Potting Bench*: A potting bench includes a hopper to feed soil or other forms of media onto the bench, and uses conveyors to transport plants, pots, etc.
- *Mobile Potting Bench:* A mobile bench is a standard or modified bench on wheels. It is transported to the part of the nursery where plants are to be put down. Examples of this include a trailer being towed behind a tractor, a rear tray of a utility or truck, or a truck mounted hopper.

An example of a modified potting bench used within practice includes the addition of conveyors. According to managing director of Hortec Grow with Technology "One of the biggest problems is getting the plant into the right growing position. Without a conveyor, staff [must] get the plant from the potting machine into a trailer, then [must] take the tractor to the bed, just to put the plants down. The staff works with their backs bent, all day, everyday. Conveyors save a lot of time and money." However, he also warns that this system only works with clear bed space. "With a conveyor, you can have the plants straight onto the floor, no tractors and trailers and, with a pot fork, no bent backs" (Fowler, 2004). By implementing a conveyor system, many nurseries are able to improve the working conditions of their potting area, as well as increase their productivity.

Another example of equipment being utilized in the potting area within the modified potting bench was exemplified at the Bransford-Webbs Plant Company in 2010. There, they increase their potting rates by more than 50 percent by focusing on moving their potting operation into the house in which the plants are grown, utilizing a double pot dispenser that can cope with second hand pots, and potting onto CC trolleys (Sidders, 2010). However, nurseries must keep in mind that the success of these examples was achieved in conjunction with the employees who work there.

HEAR: Design Methodology

This chapter discusses the unique nature of this project and the specific design process it was modeled after.

Choosing a Design Process

Since Growing Grounds Farm is structured as a non-profit organization whose mission is to provide services to the area of society that experiences mental disorders and whose objective is to maximize the social support foundation for such constituents, a systematic design thinking approach was utilized to coincide with GGF's dynamic culture. This approach differs from the usual academic design thinking approach because instead of validating theoretical hypothesis, the design thinking approach is geared towards translating insights to improve the lives of others (Brown, 2009). IDEO's design consultants pioneered the Human-Centered Design (HCD) toolkit "specifically for people, nonprofits, and social enterprises in low income communities throughout the world" (HCD Toolkit). The toolkit is available to the public in PFD format and is accredited by numerous innovations such as the "HeartStart defibrillator, CleanWell natural antibacterial products, and the Blood Donor System for the Red Cross – all of which have enhanced the lives of millions of people" (HCD Toolkit).

The HCD process consists of three separate design phases each with its own set of steps to accomplish throughout the project. The three phases are coined *Hear, Create, and Deliver*. Although the HCD toolkit was utilized to address the overarching social theme of the project it was not utilized verbatim due to the projects' unique proposition. The HCD toolkit was paired with industrial engineering design principles and processes taught within Cal Poly's accredited curriculum. Specifically, it was paired with the organized, systematic approach of the engineering design process (EDP). The engineering design process according to Tompkins *Facility Planning* textbook (1996, p.9) lists the following steps:

1. Define the problem.
2. Analyze the problem.
3. Generate alternative designs.
4. Evaluate the alternatives.
5. Select the preferred design.
6. Implement the design.

The decision to integrate both of these well-recognized design processes is to ensure that both the social and economic viability of the project is accounted for. The need to incorporate both aspects into this project is what makes it unique.

The Integration: HCD and Engineering Design Process

This section will cover the details of each design step completed through the duration of the project. Since the HCD process was created for non-profit organizations like GGF our design process is mapped out as a modified version of HCD with the traditional engineering design process integrated appropriately. Figure 1 illustrates a Venn diagram of the three competing constraints of this projects solution; desirability, feasibility, and viability. Each constraint is weighted more heavily in its corresponding phase within the design process, such as desirability, which was weighted heavier in the first 'hear' phase of the design process than in the second 'create' phase. Although the conflicting constraints prevail in its respective phase, they inevitably overlap one another. The movement between each step throughout the design process occurred as an iteration of the previous or preceding steps. In other words the process did not follow a straight linear path.

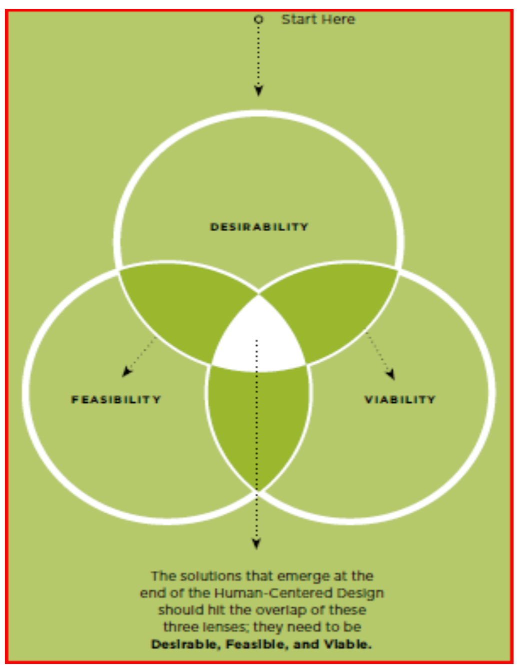


Figure 1: The three overlapping lenses of the HCD Process

Figure 2 shown below depicts the three phases of the design process and their themes as time passes. An important idea of the arc is to notice how the arc moves from concrete to abstract back to concrete concepts.

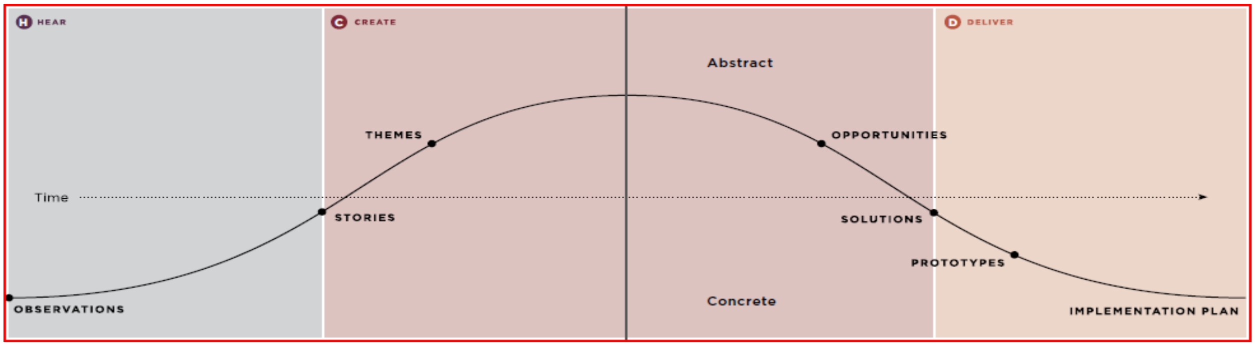


Figure 2: The process arc of the HCD Process

Brief Overview of the Current Potting Production System

Q. What is to be produced?

A. Plants are to be potted in larger containers, formally know as trans-potting.

Q. How are the products to be produced?

A. Through a series of assembly steps in the potting production barn. Each step requires manual labor of some sort. There is absolutely no automation in the current process. Some steps or jobs occur simultaneously within the production process.

Q. When are the products to be produced?

A. Every Tuesday and Friday the transplanted plants are to be produce during the hours of 11AM to 2PM.

Q. How much of each product will be produced?

A. This value varies depending on the workers performance rating. During the 1-gallon process, a low efficiency rate produces far less plants than a high efficiency performance rate (about 750 plants).

Q. For how long will the products be produced?

A. Until GGF decides to stop this operation. Basically this is an infinite system.

Q. Where are the products to be produced?

A. Currently the transplanted plants are produced in GGF production barn.

Identifying the Problems

As part of the first step of the HCD process, Hear, several steps were taken to establish concise problem statements to ensure our proposed alternatives addressed both the economic and social aspects of the potting process. First, visual observations were made during the process to gain a better understanding of what steps are required at each workstation. Questions presented to the employees provided a better understanding of the ease at which they performed their functions with the tools given to them. Volunteering opportunities were available and taken to gain first hand experience as part of the potting process. Through these measures, a draft of all the issues observed was created. A brainstorming session was then scheduled with several employees of GGF to expand on these initial efforts and identify the objectives of the project.

The brainstorming session consisted of two main portions: detailing the steps of the potting process and brainstorming all the issues found and felt in each step from different employees' viewpoints. The contributors included the GGF program manager, two crew leads, and two potting employees. As listed in the meeting agenda (See Appendix C-1), the specific steps of each workstation was evaluated and recorded. It is important to note that many steps often occur simultaneously and employee responsibilities overlap unintentionally. As a result, the steps defined in this report will serve as the baseline and standard for the entire project (See Appendix A-1, Appendix A-2). After determining the steps, an open atmosphere for sharing was established before brainstorming to make sure all contributors would be in a comfortable environment for stating their thoughts and opinions. This was accomplished with the HCD brainstorming rules that welcomed and encouraged creative ideas while minimizing judgment (See Appendix C-2). The contributors were then reminded that the two main goals of the meeting were to address the efficiency and comfort of the production process. With that, each contributor was given a stack of Post-It notes with a writing tool to jot down as many problems that they saw in specific areas as they could. Each thought was written on one Post-It. Posters of the facility layout were hung up around the room for the Post-It's to be stuck on. After five minutes, the Post-It's were read out loud and the contributors were welcomed to expand on any issues that they heard. Oftentimes, this would prompt further discussion from other employees and additional ideas were brought up and noted. In addition to identifying the problem opportunities present within the system, solution opportunities were also discussed. This practice of building off the ideas of others is one of the most valuable characteristics of brainstorming as described by the HCD toolkit, "brainstorming gives permission to think expansively and without any organizational, operational, or technological constraints...the practice of generating truly impracticable solutions often sparks ideas that are relevant and reasonable" (HCD Toolkit, 83).

The accumulation of all the problem ideas were brought back to the design team to be summarized based on workstations:

Pulling Bench

- The process of unplugging is time consuming (plugs pulled one at a time).
- Baskets are not visually organized by plant type and are mixed up easily.
- The pulling bench has a small work surface and the height does not accommodate most employees.
- There are long walking distances between the tray queue, the pulling table, the basket queue, and the potting bench.

Soil

- Moving soil from the heap to the table requires multiple trips over a long distance to supply the potting table. Moving the soil requires heavy lifting and is physically exhausting.
- Bottlenecks occur on potting table due to long soil transportation process.
- The 4-inch containers require constant bending to fill up; bending is strenuous on worker.

Potting Bench

- The bench only accommodates 4 planters at one time and is not ideal for employees of all heights. It is also warped and has splinters.
- Work surface is not big enough and too much soil accumulates on the ground, making the potting bench unleveled.
- There is no continuous flow of all raw materials to the potting bench and planters need better access to soil.
- There is no standardized placement or method for finished goods; finished goods build up on table until orbiter picks them up.
- 1-Gallon containers get stuck together and must be constantly moved from inventory to potting table.
- There are no designated queue areas for empty 1-gallon containers after being unstacked or for filled 4-inch trays; currently, they are placed around the potting bench where space is available.
- Employees must constantly bend over to lift up containers and trays.

Other

- Job positions are undefined and there is too much overlap between different positions, causing traffic jams and confusion.
- There is too much distance between each workstation.

Utilizing these problem statements, trends and patterns were identified to create a list of design objectives. The design objectives were translated into questions (See Appendix D) to prompt the first co-designing session with the constituents. These questions are not meant to address all of the individual problem statements; rather, they were developed to challenge the contributors during the co-designing session to consider the overall constraints constructively.

Due to the overwhelming number of problems in each area, the scope of this project only focused on improving the material flow and standardizing the process to increase efficiency. In order to further GGF efforts to improve the system, the need for a second-generation design team was identified and selected. Other problems identified but not addressed in this report will be integrated into the design developed by them. The following section dives into more detail of the idea generation during co-design sessions.

Co-designing with Constituents

For the second step of the design process a participatory co-design meeting was developed. With the appraisal of the current system, it was determined that there was a lack of local expertise and knowledge and is why the co-design approach was necessary. It was realized that solutions that created from the outside ran the high risk of not being easily adopted. Therefore valuable design team members from GGF were identified and two co-design sessions were scheduled to aid the movement from the current state to future possibilities.

In preparation, a framework was created to drive the success of the co-design sessions. According to HCD's toolkit, a framework is typically a visual representation of the system that identifies the different elements and the relationships between those elements (HCD toolkit, p.100). The framework consisted of the layout posters utilized during the brainstorming session as well as a physical model of the existing facility constructed from recyclables (Refer to Figures 3 and 4) . Both of these visuals were utilized as reference material.

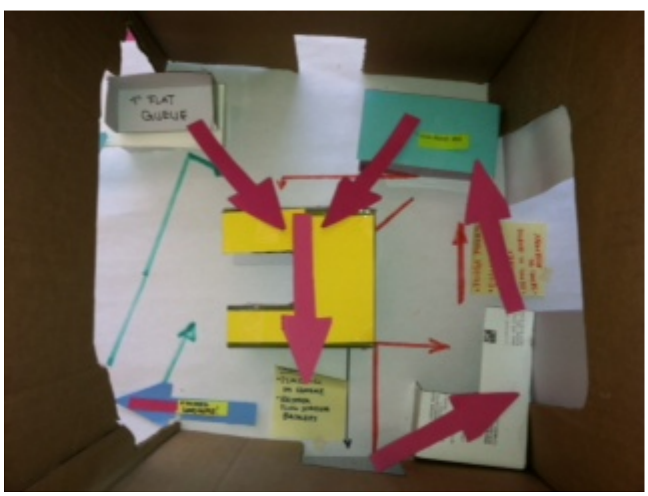


Figure 3: Physical Model

The opportunity statements, or questions rather, generated during the brainstorming step were applied to create future possibilities. The opportunities statements were based on desirability not feasibility and the goal were to generate as many ideas as possible rather than quality driven ideas. At the co-designing session prototypes were constructed to bring all the great ideas generated to life. The prototypes were utilized as disposable tools throughout the development process to help generate and validate ideas. The prototypes were then evaluated by answering the question statements presented prior to the co-design session. Other questions were addressed as they came up such as, who will benefit from this idea? What is the value to the end customer? How is this alternative better than other options? Both positive and negative feedback was recorded and was applied to the next iteration of prototypes. This step took the co-design team and project leads from concise problems statements to abstract idea generation and provided the foundation for our solutions.

In addition to the two co-design sessions, local nurseries such as the Cal Poly Conservatory was contacted and visited to gain further expertise and insight present within the area. The most valuable knowledge obtained was from the Cal Poly Conservatory. Instead of potting plants at a potting bench like GGF does, they used individual soil filled carts to ensure continuous access to soil. These carts basically mimic a large, round rubbish can on wheels. The main difference identified between GGF and the Cal Poly Conservatory is that GGF's potting production operation produced greater volume than the later did.

Generation of Alternatives

With the *Hear* phase completed and the *Create* phase on its way to completion, we began to move from the abstract idea generation to more concrete solutions. At this point we had gained valuable insight, assimilated trends and patterns, generated prototypes, as well as recorded data via industrial engineering tools. Our next step in our design process required the generation of alternative solutions. Here the solutions mainly addressed the feasibility constraint while still keeping the desirability constraint in mind. A small list of objectives was developed to guide the approval or dismissal of potential solutions. A solution had to address most if not all of the objectives listed. The list included the following: the design must decrease cycle time or increase productivity, promote fluid workflow, and be both economically feasible and socially viable. Our solutions dwindled down to two alternatives.

To minimize the cost of flow two perspectives were considered. The first alternative aimed to minimize material handling by reducing travel distances and motions. The second alternative aimed to eliminate manual handling through automating flow. Both of the alternatives help to eliminate non-value added elements of the system so that workers were able to spend full time on their assigned tasks, which improves efficiency. The first alternative we called the minimum viable alternative since its goal was to minimize the overall cost. The second alternative we called the maximum viable alternative since its goal was to maximize efficiency. We then constructed physical prototypes of each alternative to evaluate how each one might or might not address our three objectives.

The minimum viable alternative features the following:

- Unnecessary items within the facility are eliminated to increase space
- The ground is leveled and a tarp is fixed to eliminate the mixture of potting soil with dirt
- All of the existing furniture is kept but rearranged to enhance flow
- New shelving units are purchased to reduce motion and travel distance
- A cart for one-gallon containers is purchased to reduce motion and travel distance
- Visual aids are purchased for the finished goods to separate work orders
- A plug popper is purchased to eliminate plug bottleneck
- Jobs are standardized to promote work flow

The maximum viable alternative features the following:

- All of the minimum viable alternative features are implemented
- A hopper is purchased to store soil above ground
- A conveyor is purchased to streamline the flow of materials
- Individual workstations are purchased to provide soil continuously

After creating these two alternatives we evaluated their value with industrial engineering tools such as a cost benefit analysis, 5S principles, facilities planning methodologies, and a simulation.

Evaluation Methods

At this time, the gains of the minimum alternative proved to satisfy the objects more appropriately than the maximum alternative. The minimum alternative was both economically and socially viable because it improved the work flow and increased productivity. The maximum alternative, on the other hand, was not as economically nor socially feasible as its alternative. Therefore, the minimum alternative was selected and thoroughly assessed using a facility evaluation and a simulation. The design of these methods is to be explained in the next two sections.

Facility Layout

According to Tompkins, the flow of materials, people, equipment, information, and ultimately money provides a basis for decision making in the facility planning process (ref p.79). The next crucial step of our design process was taking measurements, illustrating the facility layout, mapping its flow paths, and creating various charts to quantitatively analyze the current system. These sub-steps are described in the following paragraphs.

The current potting production layout is broken up into three main departments, which are the containers, plugs, and soil. Within the production barn two different processes take place for the container size being worked with. This project focused only on the four-inch and one-gallon container processes. Figure 3 depicts the layout illustration and its dimensions.

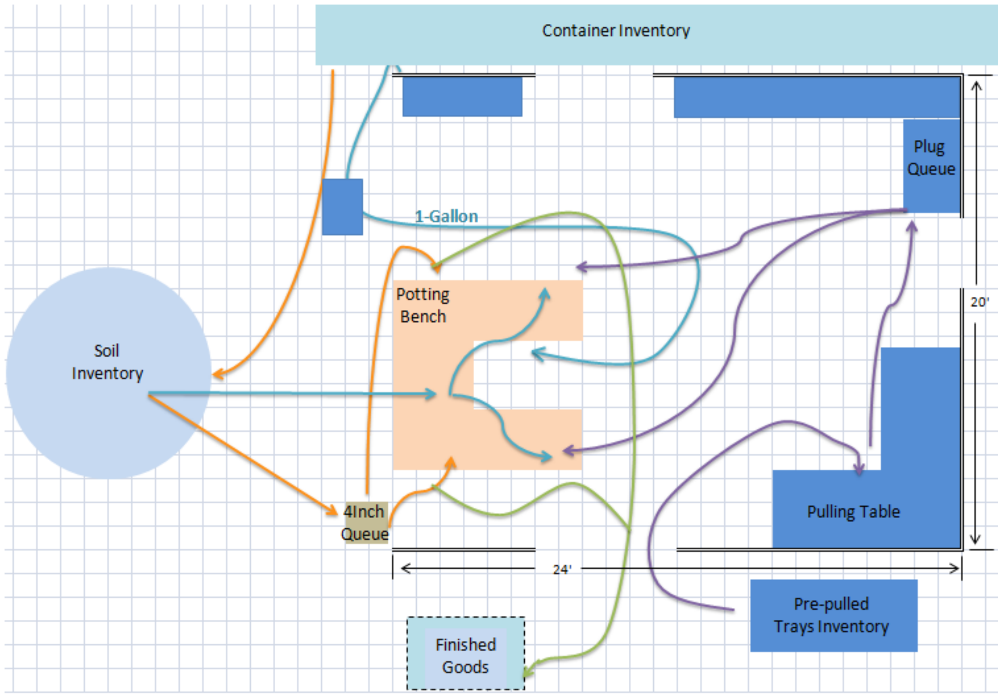


Figure 4: Current Facility Layout

In the bottom right of the diagram, the flow lines for the plug department are shown. The plug department requires employees to obtain tray inventory from the queue outside and bring them to the pulling table to prepare the seedlings for re-potting. To prepare, the plugs are dismounted individually. Then, the employee places a batch of seedlings in the queue area, which are later transferred to the potting bench by an “orbiter”. Although the lines are unidirectional in the illustration, realistically they are bi-directional as backtracking occurs between stations.

The right section of the illustration looks congested due to the intersection of flow paths for all other interactions between the container and soil department. The orange lines represent the container department and the blue lines represent the soil department. The four-inch container process requires employees to transfer a flat of 16 containers to the soil inventory and then to the queue area. From there the soil filled flat is transferred to the potting bench where the potting process takes place, which is depicted with the blue lines. The 1-Gal Container process requires the same tasks except material flows from and to different areas, as shown. The additional red lines represent the "orbiters'" path, which is not a part of aforementioned departments.

Finally, the "orbiter" transfers the batches of plugs from the plug queue to the potting bench and transfers the finished plants from the potting bench to the finished good trailer. With all of these together, you can see the flow is not streamlined creating inefficiency. According to Tompkins, "a directed flow path is an uninterrupted flow path progressing directly from origination to destination" (Tompkins, 1996, p.89). This concept was exploited to generate various alternatives that promoted flow. The design was also constrained by the location of the entrances and exit as well as by the flow within and between departments.

To help quantify the system a number of tools were utilized. First, measurements of the facility were taken and recorded. Then, a relationship chart was created to identify the proximity requirements among the activities that take place (see Appendix E). If a strong relationship between two activities is identified then we wanted to place these in close proximity to one another. Along with the relationship chart, flow process charts were created to record the activities of a particular department as they happen. Flow process charts are an accurate representation of the process operations and were used to identify the non-value added elements of the process. The types of non-value added elements noticed in this layout include wasted space, long distances between departments, and large wait times.

Simulation

A simulation of the current potting system and the recommended changes were made using ProModel to identify the benefits of the alternative layout and process. The "As-Is" model of the facility was used as the baseline to which the "To-Be" models were compared to and analyzed. Since the 1-gallon potting procedure requires usage of all the workstations, it was used to analyze the full facility. For the simulation, time study data was collected on the total number of plants processed in a three-hour shift and the work-in-process at each station. This helped to determine any bottlenecks or capacity constraints that occurred within each part of the system. By comparing the results of both models, an economic justification was made on how the recommended changes will increase the number of finished goods delivered per day and the efficiency of the potting process was determined. Due to the dynamic and complex nature of the current system, the arrival and processing times of each entity was calculated as the accumulation of various steps, and the moving times were based on a walking speed of 3 miles/hour for the employees (Refer to Table 1).

Since Growing Grounds Farm hires employees with and without mental illness backgrounds, the speed at which tasks were completed varied depending on the person. To simulate this as accurately as possible, a triangular distribution was used. Triangular distributions are generally used to describe what we know or believe about certain unknown variables. It is a triangular curve with a total area of 1, set to zero at a given low value and a given high value, and peaks at an expected value. In this case, the minimum time is set as the most experienced workers (such as the manager), the maximum time as the least experienced workers (such as new employees or volunteers), and the most likely time as those who work there on a normal basis.

Table 1: Arrival and Processing Times for Simulation

Entity	Action	Processing/Moving Time
1-Gallon Containers	Obtain stack of 16 containers and un-stack them for queue	t(1,2,5) min
	Walk 1 container from queue by potting bench	4.7 sec
Plugs	Dismount 12 plugs from tray, place into a basket	3 min
	Walk 1 basket to queue	1.4 sec
	Move basket from queue to potting bench	4.1 sec
Soil	Fill 15-gallon container with soil and unload onto potting bench surface	t(2,3,6) min
Filled Containers	Fill one 1-gallon container with soil	t(2,3,4) sec
Potted Plants	Put a plug into a filled container	t(15, 30, 45) sec
	Wait to be picked up by orbiter to be moved to finished goods area	t(4, 6, 10) min
	Move finished plant to finished goods area	4.5 sec

Additional design assumptions for the model include the following

- A tray always has 96 plugs.
- Containers come in stacks of 16.
- 15 gallons of soil arrive to the potting bench at one time.
- A work shift is 3 hours per day.
- Employees are not allocated break time.
- Job responsibilities do not overlap (i.e. planters only place plugs into containers).
- There is no fallen or wasted soil (one arrival of soil always fills up 15 1-gallon containers).
- Each planter at the potting bench can hold a maximum capacity of 10 containers (filled or potted) at one time.

CREATE: Evaluation of Alternatives

With the baselines for the current facility layout and simulation completed, the recommended changes were inputted to test its effects on the system.

Facility Evaluation

5S is a Japanese management methodology that improves productivity, quality, and safety in various types of business by using visual aids, organization, and standardization. By implementing the 5 steps of this principle, the profitability, efficiency, and safety of the system should increase. The five steps are:

- Sort: distinguish needed items and eliminate unneeded items
- Straighten: organize needed items in place for easy retrieval
- Shine: implement method to keep workplace neat and clean
- Standardize: make 5S become part of the regular routine

- Sustain: maintain established procedures

To address these principles we included eliminating unnecessary items, leveling the ground, rearranging existing equipment, standardizing job descriptions, and introducing visual aids in our design. This would increase the space, comfort, workflow environment, and quality control. It was also estimated that implementing a cart for one-gallon containers and shelving space for four-inch flats and finished goods would increase production capacity as well as decrease travel distance. Lastly, it was estimated that by purchasing an automated plug popper the bottleneck within the plug department would be eliminated. To test our hypotheses for the quantitative metrics, the facility layout path network was re-mapped, flow process charts were updated, and the proposed model was simulated.

Simulation

For the "To-Be" system, the arrival time of the plugs, the moving times between workstations, and the waiting time of the finished goods on the potting bench were changed in the baseline model to evaluate the effects of its changes. It was estimated that using a plug popper would decrease the production time of each basket since the tedious task of manual dismounting would no longer be required. The main responsibilities of the puller in the proposed system would be to quality check the already dismounted plugs and place them into baskets. The new moving times between workstations from rearranging the facility were determined by multiplying the estimated new distances by the assumed walking speed (3 miles/hour). The waiting time of the finished goods on the potting bench were eliminated due to the addition of separate finished good queues by the planters; the potted plants no longer have to wait on the potting bench to be transferred to the finished goods area, thus, increasing the capacity on the bench for planters to work on. Specific changes to the simulation times can be found in Table 2.

Table 2: Arrival and Processing Times (Highlighted Areas Changed)

Entity	Action	Processing/Moving Time
1-Gallon Containers	Obtain stack of 16 containers and unstack them for queue	t(1,2,5) min
	Walk 1 container from queue to potting bench	0.7 sec
Plugs	Dismount 12 plugs from tray, place into a basket	1 min
	Walk 1 basket to queue	0.2 sec
	Move basket from queue to potting bench	1.3 sec
Soil	Fill 15-gallon container with soil and unload onto potting bench surface	t(2,3,6) min
Filled Containers	Fill one 1-gallon container with soil	t(2,3,4) sec
Potted Plants	Put a plug into a filled container	t(15, 30, 45) sec
	Wait to be picked up by orbiter to be moved to finished goods area	0 (arbitrary because finished goods area is no longer on potting bench)
	Move finished plant to finished goods area	1.1 sec

From the results of the "To-Be" model, it was noticed that with the proposed changes, there was a bottleneck in the system from the soil arrival. To evaluate this further, two additional simulations were run with the soil arrival time changed to 1 minute (an estimation based off of purchasing a hopper to store the soil and fill the containers faster) in the "As-Is" and "To-Be" systems to test if it made a significant impact on the overall output.

DELIVER: Proposed Design Results

Flow Process Results

The results of the new facility layout decreased the distances traveled between workstations, which ended up saving time and money spent on various activities. The flow within the facility layout was constrained by the location of the entrance and exit. The general flow pattern enhances efficiency by decreasing the number of interrupted paths and by having the material enter and exit the system through the same opening. The proposed layout is modeled after this general flow pattern to do just that.

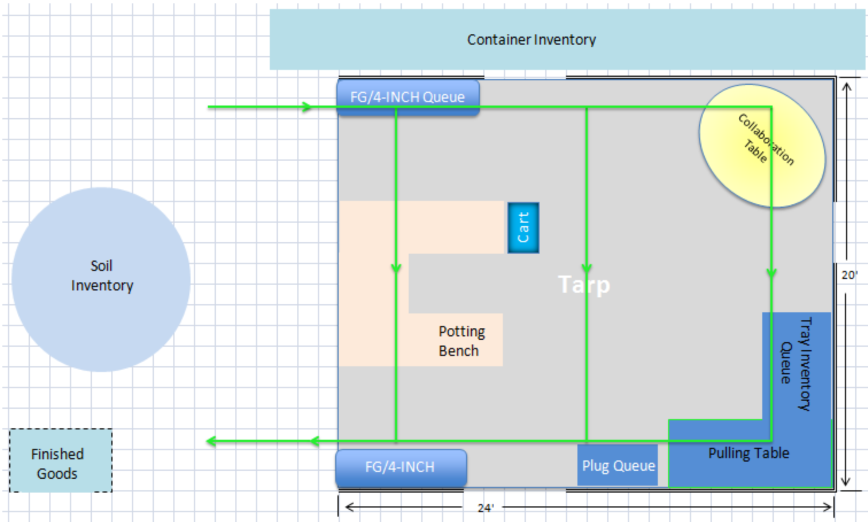


Figure 5: Proposed Facility Layout

By eliminating unnecessary items and rearranging the plug department as depicted in the bottom right of the illustration, the overall space available is increased by 10%. This was calculated by taking the square feet of the removed items and taking its percentage against the total amount of space in the barn. By moving the tray inventory queue inside, material-handling cost was reduced. This chart only accounts for the production of 96 plants, which is noted in the assumptions list. The potting production process runs two days out of the week for three hours and these figures can be applied appropriately. For instance, within a three hour period a worker used to be able to produce approximately 58 baskets by completing the tasks of pulling inventory from the queue, de-plugging the individual plugs, batching twelve of them in a basket, and transferring them to the plug queue. Now a worker is able to produce approximately 174 baskets in a three-hour period by completing the same tasks. The distance between workstations and the purchase of the automated plug popper gave these results. Please refer the process charts (Appendix E1-3) to see the reduced distances for each department.

Although the results of adding visual aids to separate work orders, leveling the ground for a leveled work facility, and introducing standardized job descriptions to reduce overlaps of responsibilities are difficult to quantify without implementation, the three issues were addressed during the brainstorming and co-designing sessions and there is feedback to suggest that they will be beneficial to the system. For the visual aids, the employees have tested out using colored index cards to separate orders and found that it has been helpful. However, index cards are flimsy and can easy be lost because it is separated from the finished goods. A need for a leveled ground and to catch fallen soil was expressed during the sessions as well because the facility has not been cleared out in the past few years. The job descriptions (See Appendix G) were written to match the process under the proposed changes. With the implementation of designated queues for the filled 4-inch and 1-gallon containers, there is less ambiguity for the soil filler. Placing the finished goods on the shelf and obtaining a basket will be the responsibilities of the planter. This eliminates the need of an orbiter to take finished goods from the table periodically, increasing the potting bench capacity, and eliminates the time for planters to wait for an orbiter to retrieve new baskets. The orbiter's main responsibilities would be to transport finished goods to their areas and to unstack containers, reducing the amount of paths he/she has to take.

Simulation Results

The results of the simulation from the "As-Is" to the "To-Be" models showed expected improvement in the overall output of the system, but created a bottleneck in the soil queue. Further simulation showed that an addition of a hopper would address this bottleneck and increase the overall output (See Table 3).

When the "As-Is" model was simulated for a three-hour shift, it had a total output of 715 plants. With the proposed changes, the "To-Be" system increased the number of finished goods by approximately 4.90%. This value was lower than expected because the recommended changes were meant to address the plug and container bottlenecks in the system. In addition, because many non-value added steps would be taken out and the capacity of the potting bench would increase. Looking at the work-in-process of all the entities, it was revealed that although the plugs and containers were arriving to their respective queues faster under the proposed changes, the soil arrival time remained the same. As a result, the container and plug queues build up.

Table 3: Simulation Results of Total Output and Percentages

	Current System	Current System w/ hopper	Proposed System	Proposed System w/ hopper
Total Output	715	718	750	1147
Percent Increase	0.00%	0.42%	4.90%	60.42%

To test the significance of the soil's arrival time on the overall system with and without the proposed changes, two additional simulations were conducted. The results of for increasing the soil's arrival time in the current system showed that the total output increase by approximately 0.46%. This confirmed the initial suspicions that the soil was not the main bottleneck and that multiple factors had to be addressed in order to increase the efficiency of the overall system. The results of the second change showed that adding a hopper to the proposed changes increased the total output by 60.42%.

Overall, the simulation confirmed the theory that the proposed changes would increase the efficiency of the system, but the results were lower than expected due to an additional bottleneck. With more research and planning to increase the flow of the soil, the total output would increase by 55.52%. Although this report specified adding in a hopper to alleviate this problem, there are also other solutions that could be implemented that would also fit in with GGF's work environment and constraints. With this need in place, a second-generation industrial engineering senior group has been started to continue and improve this project's design.

Economic Viability

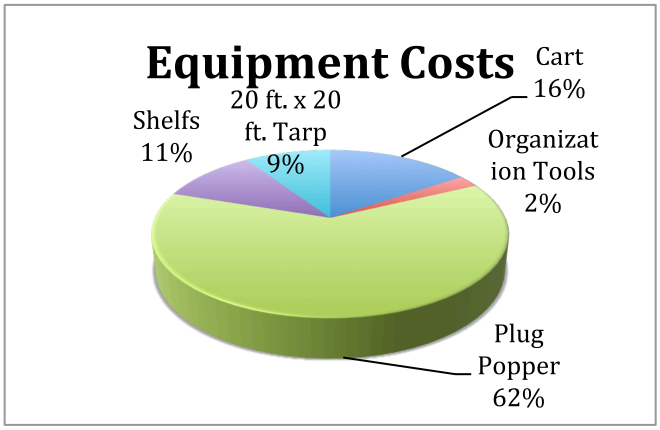
A cost-benefit analysis was calculated for the minimum alternative of this project, as it is the recommended design. First, the total cost of implementation was calculated. The cost of construction materials was taken from local home improvement businesses such as Home Depot and the cost of smaller materials such as the grocery dividers were taken from online sources. The cost of labor to clean up the facility and install new equipment were estimates based on a wage of $8.00/hour per employee (See Table 4).

Table 4: Cost Estimates for Design Implementation

Equipment		
Quantity	**Description**	**Total Cost**
1	Cart	$100.00
1	Visual Dividers	$15.00
1	Plug Popper	$400.00
2	Shelfs	$67.94
1	Sigman 20 ft. x 20 ft. White Heavy Duty Tarp	$59.97
Total		$642.91

Time and Labor				
Description	**Time (hrs)**	**Labor ($/hr)**	**Employee (qty)**	**Cost**
Plumbing	3.00	8.00	1.00	$24.00
Boxes	1.00	8.00	2.00	$16.00
Cabinet	0.50	8.00	2.00	$8.00
File Cabinet	0.33	8.00	2.00	$5.28
Leveling Ground	3.00	8.00	2.00	$48.00
Implement New Equipment	4.00	8.00	5.00	$160.00
Total				$261.28

The total cost came out to be approximately $900. The majority of costs came from purchasing the plug popper and having new equipment such as the finished goods queues assembled (See Figure 6). The plug popper recommended in this project is one that is automated and can be adjusted to fit trays of various sizes. While this product is more feasible because it saves time and can adapt to different trays, a manual alternative could be designed as a cheaper alternative. The cost of materials for building the shelves is a rough estimate, as it assumes that there will be little to no



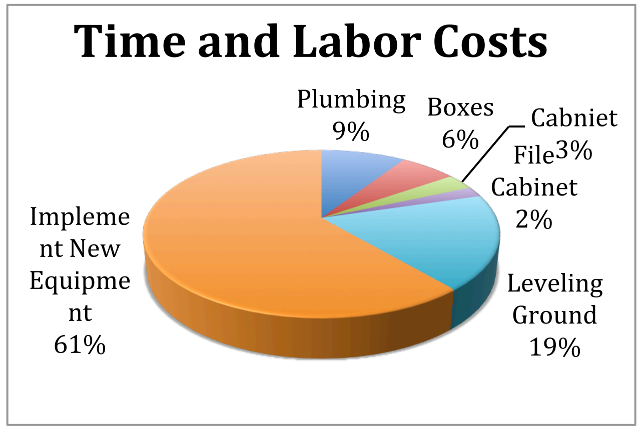
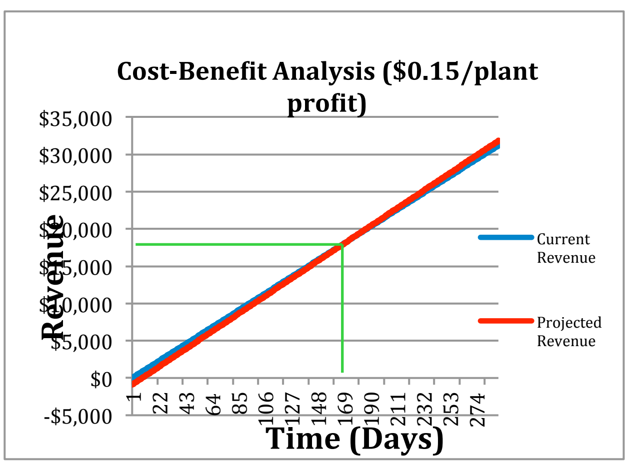


Figure 6: Equipment, Time, and Labor Cost Distributions

scrap and that contracting tools are available. The cost of having the larger items thrown away are not included because many of them can be recycled or donated to charity.

Using these estimates, break-even graphs were created for two ranges of profitability: \$0.15/plant and \$0.50/plant. This is because the plant types and sizes range depending on the types of order so the profit margins vary. For the higher and lower profitability, it is calculated to reach the break-even points after 51 and 171 days respectively (See Figure 6). This is based on a three-hour work shift per day and assumes that the simulation output is accurate. It also only takes into account the profitability of the potting process under an infinite number of orders per day and neglects the other operations at GGF.



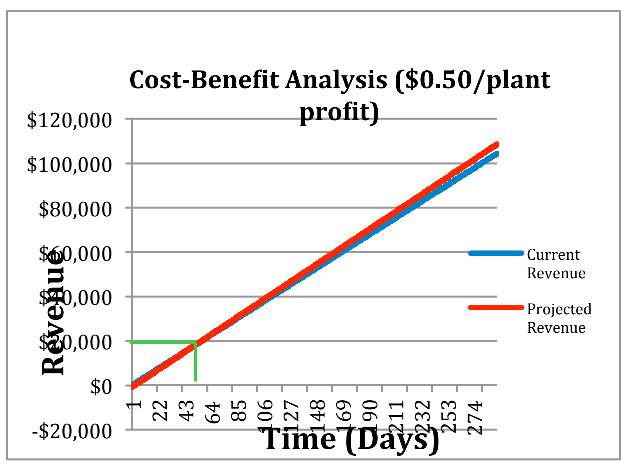


Figure 7: Break-even Points of Lower and Higher Profit Margins

Another analysis was conducted to compare the cost-benefit of purchasing a hopper in addition to the recommended changes in this report. The hopper was estimated to cost approximately $1,800. Based on the same two ranges of profitability, the break-even points after 13 and 42 days for the higher and lower profits (See Figure 8).

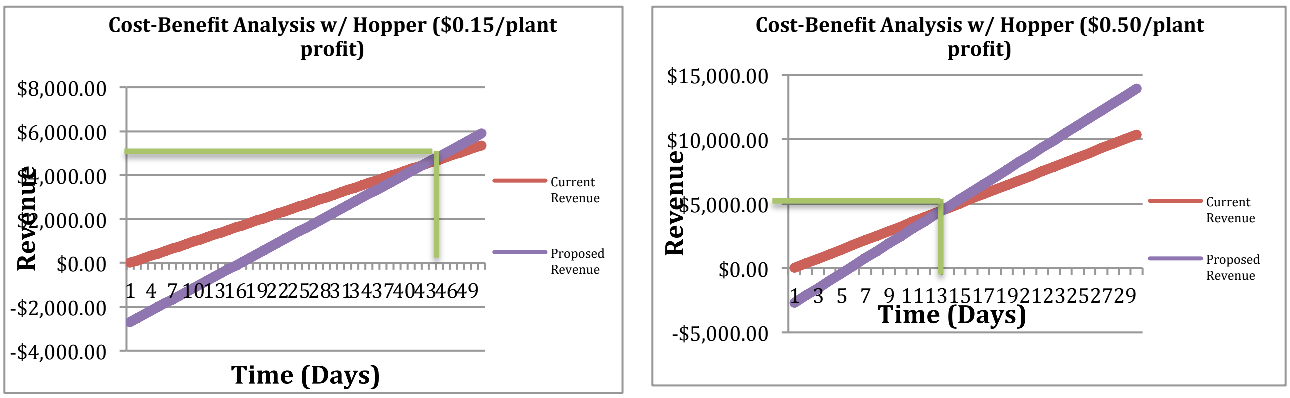


Figure 8: Break-even Points for Higher and Lower Profit Margins for Proposed Changes with Hopper

Looking at the costs for the recommended changes and for the option with the hopper and taking into account the effect on total output for the two are 4.90% and 60.42% respectively, it would be more economically viable to purchase a hopper in addition to the design of this report. Although it requires a higher upfront cost, the material flow and output would increase by a higher percentage because the soil bottleneck would be addressed and the break even points for the lower and higher range of profitability would be shorter at 12 to 42 days. The addition of a hopper would also address the issue of ergonomics for the employee transporting and lifting a 15-gallon container of soil from the heap to the potting bench. However, the process of implementing a hopper and how it would be incorporated into the current process was not researched and so additional research must be conducted before making any significant conclusions regarding it's viability.

Social Validity

The social viability of this project can be justified through the Human-Centered Design process used during the "hear" and "create" phases. At the start of the brainstorming and co-designing sessions, time was allotted for everyone (the employees, managers, and industrial engineering student designers) to reflect and write down their thoughts. These thoughts included but were not limited to opinions on the potting process as a whole, specific problems experienced with the facility, or potential solutions to existing issues. Afterwards, everyone went around and shared what they wrote. As ideas were brought up, additional input would often spark from others in the group and further discussions revealed the roots of different problems. This process of allowing each person to contribute individually ensured that their voices and opinions were heard and addressed; the discussions opened up communication between constituents at all levels and challenged everyone's view the current and proposed systems from different perspectives. Using the ideas from these meetings, prototypes of various designs were developed and brought back for further feedback. This continuous feedback loop elicited more changes and improvements for the final design. The outcome of this project, as a result, is a cooperative effort between the workers, managers, and industrial engineering students; it is a design created through partnership and involvement with the employees and for them.

Having a standardized set of job responsibilities, visual indicators for different orders, and better workflow will also result in better communication and a more positive atmosphere between employees during work shifts. Under the current system, job responsibilities often overlap or are unclear, which leads to lags or unfulfilled positions in the facility. This miscommunication also causes disturbances in the workflow, which can lead to negative feelings from those who are putting in more effort. The confusion of wrong orders also leads to mistakes and potential blame, which is not healthy for the work environment. By decreasing the risk of these problems arising and promoting a more efficient process, it is hoped that the employees will benefit mentally and physically.

Environmental Impact

The biggest form of environmental impact from this project will be from the initiatives to clear out the facility and rid of any non-value added items. This includes removing any boxes filled with unused containers, under-utilized cabinets, unnecessary shelves, and random tools. Although the majority of items will most likely be thrown in the garbage, the shelves and cabinets could be utilized elsewhere at GGF or donated to reduce waste. Otherwise, the remainder of changes in the system will have little to no impact on the environment. The leveling of the ground after clearing out the facility will be recycled back into the outdoor areas since it is fallen soil from years of planting. Materials used to post up job descriptions and utilize visual indicators will be small aspects of the facility and should be used for years before replacements are required. Hand-potting methods will continued to be used and the facility will not employ any automation, therefore, no additional resources or emissions will result from the project's implementation.

Conclusion

This project addresses the following problems in the potting production process and aims to address each of these as part of the objectives:

- Undesignated areas for queues
- Long distances between work stations
- Lack of continuous material flow
- Confusion between job responsibilities and orders
- Bottlenecks for material preparation

Since GGF is a non-profit organization that hires many employees from the Transitions-Mental Health Association, the overall objective of the final design must meet the needs of GGF economically and socially. To do so, the approach to the design was based off of IDEO's Human-Centered Design to create a solution based on the employee's needs and feedback.

The final design included redesigning the facility and standardizing the process. From the evaluation process, it was found that these proposed changes would:

- Increase material workflow by rearranging the layout and decreasing workstation distances, which increased total output by 4.90%. With the addition of a soil hopper or faster method of filling containers, this would increase to 60.42%.
- Standardize potting process using principles of 5S. This includes:
    - Visual aids to separate work orders
    - Removing all unwanted tools and equipment which increased facility space by 10%
    - Leveling the ground
    - Posting specific job responsibilities
    - Designated queue areas

Based on these results, the original design of this project addresses the main problem statements and meets the economic and social requirements. However, additional research and design must be conducted and tested to fix the soil bottleneck before implementation can be recommended.

Some key elements that must also be taken into account for the future design is the incorporation of the employee's feedback to ensure the social aspects are met. Although discussions took place for the prototypes, the final design is currently an integration of all the ideas and feedback that took place. Additional standardization methods and methods to increase the efficiency such as a pull system rather than the current push system may also be beneficial for the process but was not within the scope of this project.

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APPENDIX

Appendix A-1: Steps of 4-Inch Container Process

Pulling Table (1 Puller)

1. Obtain list of what orders are needed.
2. Gather plants and move to barn area on trailer.
3. Carry plants in barn and place on pulling table.
4. Poke plants out one at a time from flats using a dowel.
5. Check quality of plug.
6. Place 16-32 plants in a basket.
7. Place tag indicating plant type in basket.
8. Move basket to queuing shelf.

Soil Filling Station (1 Soil Filler)

1. Put flats on ground.
2. Place 16 4-inch containers in each flat.
3. Use shovel to fill 4-inch containers with soil.
4. Use hands to smooth out surface of soil.
5. Stack filled flats on queue next to potting bench.

Potting Bench (4 Planters)

1. 4 planters work at the potting bench (2 on each side).
    a. Each planter has one flat and shares 1 basket between them.
2. Planter creates hole in a 4-inch container with fingers.
3. Planter puts a plug from basket into hole and tucks it in.

1 Orbiter (sometimes the same person as the puller or soil filler and works at both)

- Moves finished flats from potting bench to trailer.
- Replaces empty baskets on potting bench with full ones from queuing shelf.
- Transports and unloads full trailers at designated locations.

Appendix A-2: Steps of 1-Gallon Container Process

Pulling Table (1 Puller)

1. Obtain list of what orders are needed.
2. Gather plants and move to barn area on trailer.
3. Carry plants in barn and place on pulling table.
4. Poke plants out one at a time from flats using a dowel.
5. Check quality of plug.
6. Place 16-32 plants in a basket.
7. Place tag indicating plant type in basket.
8. Move basket to queuing shelf.

Soil Station (1 Soil Filler)

1. Shovel soil into 15-gallon container.
2. Carry filled 15-gallon container to potting bench.
3. Lift container to pour soil onto work surface.
4. Repeat steps 1-3 (takes 5-6 trips to fill entire work surface).

Potting Bench (1 Soil Filler & 4 Planters)

*** 9:00-10:00 AM Set-Up: 1 person separates 1-gallon containers and places them on ground by the filling station on bench*

1. Soil filler standing in the middle of the U-shaped potting bench places empty 1-gallon containers on table ledge and pushes soil from table into pots.
2. Soil filler lifts filled containers onto work surface for planters.
3. 4 planters work at the potting bench (2 on each side).
    a. Planters share 1 basket between them.
4. Planter creates hole in container with fingers.
5. Planter puts a plug from basket into hole and tucks it in.

1 Orbiter (sometimes the same person as the puller or soil filler and works at both)

- Moves finished plants from potting bench to trailer.
- Replaces empty baskets on potting bench with full ones from queuing shelf.
- Transports and unloads full trailers at designated locations.
- Separates 1-gallon containers for soil filler.

Appendix B: Brainstorming Session: Agenda

(5 min) Welcome -Precilla

Individual Intros – How long have you worked here?

(5 min) Have you brainstormed before? - Maiya

(1 min) Define brainstorming -Maiya

(5 min) Brainstorming Rules - Maiya

(4 min) Outline goals of brainstorming session - Precilla

1. Understand process from their perspective step-by-step to support our initial observations and data collection; want to get rid of any assumptions.

2. Make the materials flow through the potting process more smoothly.

3. Make process more comfortable.

Questions?

(15-20 min) Step-by-Step Process Confirmation – Maiya & Precilla

----

5 Min Break

(2 min) Brainstorm Time – Maiya

- Not looking for solutions right now, but identifying what should be looked at

Maiya – Share her own experience as example for what to write.

(**5 min) Post-Its – Precilla**

- One idea per Post-It

(30-45 min) Read off Post-Its and Discuss - Maiya & Precilla

Add more Post-Its as more ideas come up

Thank you for participating! - Precilla

Appendix C: Brainstorming Session: Guidelines

1. **Defer judgment.**
   - There are no bad ideas at this point.

2. **Encourage wild ideas.**

   - To create real innovation

3. **Build on the IDEAS of others.**

   - Think of terms of 'and' instead of 'but.' If you dislike someone's idea, challenge yourself to build on it and make it better.

4. **Stay focused on topic.**

5. **Be visual.**

   - Try to engage the logical and creative sides of the brain.

6. **One conversation at a time.**

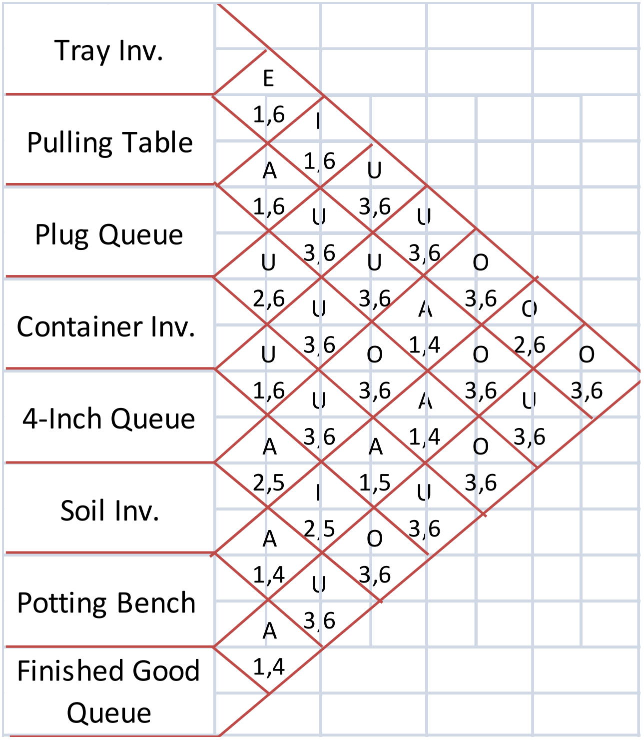
7. **Go for quantity.**

   - Goal of a least 50 ideas! There is no need to make a lengthy case for your idea since no one will be judging them at this point. Ideas should flow quickly

Appendix D: Co-Designing Session: Design Objectives

- How does the soil get from the ground to the potting bench?
- Where do finished goods go?
- How can we incorporate and/or rearrange existing furniture to create a better flow?
- Does this process require physical exertion?
- Are workers comfortable?
- Does the distance between each station affect the process negatively or positively?
- How many jobs does one person fulfill?

Appendix E: Relationship Chart and Tables



Value	Closeness
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness OK
U	Uniportant
X	Undersirable

Code	Reason
1	Frequency of use high
2	Frequency of use medium
3	Frequency of use low
4	Information flow high
5	Information flow medium
6	Information flow low

Appendix E-1

Flow Process Chart

Model Assumptions: 1 flat holds 16 containers
A total of 6 flats per session (96 plants)
Worker are paid $8/hr

Location: Growing Grounds Farm	**Summary**				
Activity: SOIL (4-INCH)		**Event**	**Present**	**Proposed**	**Savings**
Date: 02.23.2013		Operations	4	4	0
Operator: N/A	Analyst: Maiya Bourland	Transport	4	4	0
Circle Appropriate Method and Type		Delay	2	2	0
Method: Present Proposed		Inspection	-	-	-
Type: Worker Material Machine		Storage	-	-	-
Remarks:		Time (min)	2.159	0.1212	2.0378
		Distance (ft)	42	32	10
		Cost	$0.29	$0.02	$0.27

Event Description	○	⇨	D	□	▽	Time (min)	Dist (ft)	Notes/Method Recommendation	Proposed Time	Proposed Distance
Obtain 4" Container Stack & Flat			●			0.0417	11		0.0417	11
Bring Matl. To Soil Heap		●								
Fill Flat with 16 Containers	●					1		according to Craig's estimate		
Fill Flat with soil	●									
Place flats in Queue		●				0.0378	10	based on 3mph walking speed	0.0189	5
Obtain 4" Container Stack & Flat			●			0.0417	11		0.0417	
Bring Matl. To Soil Heap		●								11
Fill Flat with 16 Containers	●					1		according to Craig's estimate		
Fill Flat with soil	●									
Place flats in Queue		●				0.0378	10	based on 3mph walking speed	0.0189	5
					Total =	2.159	42		0.1212	32

Appendix E-2

Flow Process Chart

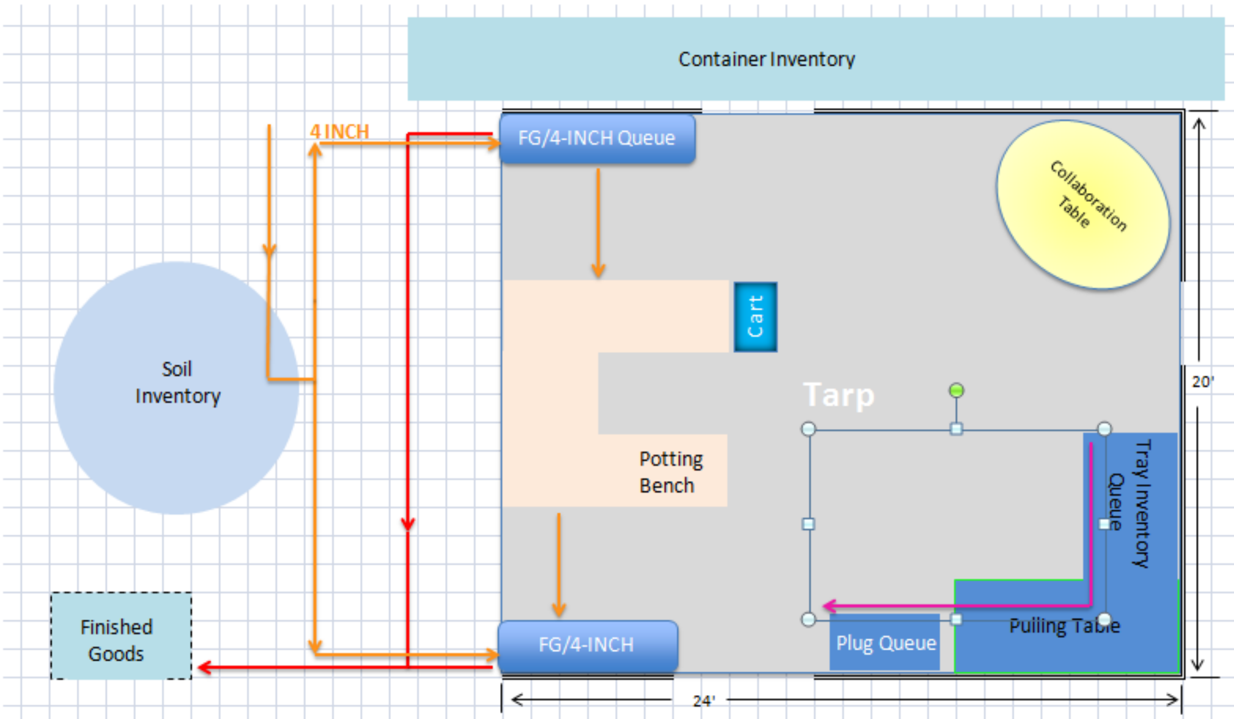
Model Assumptions: 1 Tray of Inventory fills 4 baskets (a total of 48 plants)
Workstation can only fit one tray of inventory
A total of 2 trays of inventory per session (96 plants)
8 Baskets total 96 plants
Minimum Wage is $8/hr

Location: Grow ing Grounds Farm
Activity: De-plugging Station
Date: 02.23.2013
Operator: N/A   Analyst: Maiya Bourland
Circle Appropriate Method and Type
Method: Present   Proposed
Type: Worker   Material   Machine
Remarks:

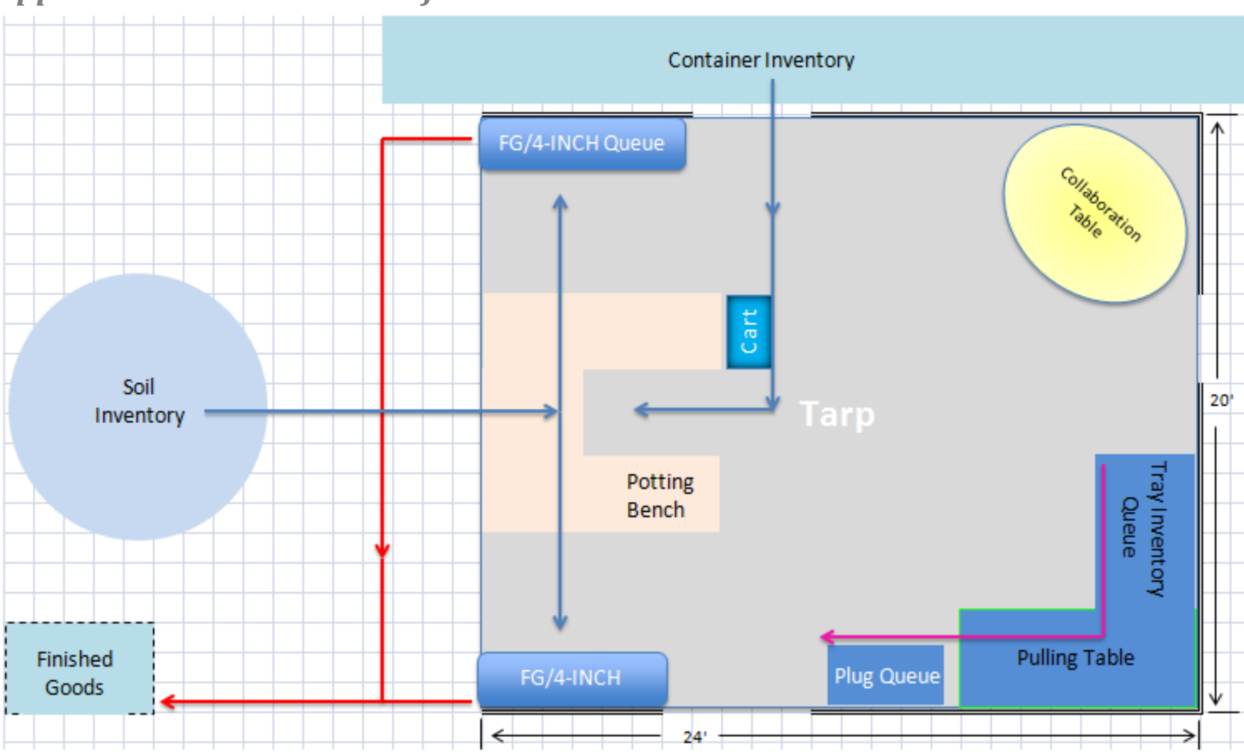
Summary			
Event	**Present**	**Proposed**	**Savings**
Operations	15	15	
Transport	10	10	
Delay	0	0	
Inspection	8	8	
Storage	0	0	
Time (min)	9.4967333	8.2083333	1.2884
Distance (ft)	94	20	74
Cost	$1.27	$1.09	$0.17

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation	Proposed Time	Proposed Distance
Pull Inventory from Queue	○	➡	D	□	▽	0.0909	24	12 ft there 12ft back	0.0075	2
De-plug individual plants	●	⇨	D	□	▽	3		according to Craig's estimate	1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽	3			1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽				1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽				1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
Pull Inventory from Queue	○	➡	D	□	▽	0.0909	24		0.0075	2
De-plug individual plants	●	⇨	D	□	▽	3		according to Craig's estimate	1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽				1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽				1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
De-plug individual plants	●	⇨	D	□	▽				1	
Batch of 12 in basket	●	⇨	D	□	▽					
Inspect basket	○	⇨	D	■	▽	0.0167			0.016666667	
Plug Queue	○	➡	D	□	▽	0.0227	6		0.0075	2
Clean workstation	○	⇨	◗	□	▽					
					Total =	9.4967	96		8.208333333	20

Appendix F: Flow Process for Four-Inch Containers



Appendix F-2: Flow Process for One-Gallon Containers



Appendix G: Standardized Job Descriptions

Puller

Set-Up:

1. Obtain lists of what orders are needed.
2. Gather plants and move to queue area in barn.

Shift:

4. Remove plugs using popper.
5. Check quality of plug.
6. Place 12 plugs in basket.
7. If new order, place visual aid in first two baskets for planters.
8. Move basket to queuing shelf.

Soil Transporter

1-Gallon Process

1. Fill up 15-gallon container with soil.
2. Walk container to potting bench.
3. Unload soil onto potting bench.
4. Repeat steps 1-3 until potting bench is full.

4-Inch Process

1. Put flats on ground.
2. Place 16 4-inch containers in each flat.
3. Use shovel to fill 4-inch containers with soil.
4. Use hands to smooth out surface of soil.
5. Stack filled flats on queue under finished goods shelf.

Soil Filler (1-Gallon)

1. Place empty 1-gallon containers on ledge.
2. Push soil into empty containers.
3. Lift filled containers onto potting bench for planters.
4. Repeat steps 1-3.

Potting Bench (4 Planters)

1. Obtain filled containers from shelf for 4-inch containers and from potting bench for 1-gallon containers.
2. Create hole in soil of container with fingers.
3. Place plug in hole and tuck it in.
4. Place plant on finished goods shelf.
5. Repeat steps 1-3 until basket is empty.
6. Obtain new basket from queue.
   - 6.1 If there is a visual aid in basket signifying new order, place the divider on finished goods shelf next to thee previous order to separate different plants.

1 Orbiter

- Moves finished flats from potting bench to trailer and unload full trailers to designated locations.
- Transports and unloads full trailers at designated locations.
- Unstacks 1-gallon containers and places them into cart queue if empty.