Design of a small, walk-behind trencher
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1. Team Purpose

1.1 Mission Statement

Ground Breakers is devoted to exceeding our client’s expectations within the marketing, design and profitability aspects of our resourceful products. Our intent is to provide a product promoting the company’s growth and development within the competitive marketplace.

1.2 Problem Statement

Our objective is to market, design and produce a small, walk-behind trencher with design specifications provided by The Charles Machine Works Inc. that serves a specific audience within a profitable business plan.

2. Statement of Work

2.1 Statement of Work

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); maximum trenching depth of 20 inches with variable depths; and maximum trenching width of 3 inches. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.

Comparing the potential prototype to key competitors, the small trencher will be targeted towards rental yards, in addition to construction and landscaping businesses. The prototype could be used by the construction and landscaping industries for preparing areas for electrical (TV and Internet) cables intended for homeowners. However, this product has the potential to be marketed through major home improvements stores, such as Home Depot or Lowe’s – targeting homeowners with similar projects of installing fencing and irrigation.

2.2 Location of Work

Research, design and product development design is taking place in the Biosystems and Agricultural Engineering computer lab at Oklahoma State University in Stillwater, Okla. The construction of the prototype will take place in the Biosystems and Agricultural Engineering lab. Additional product testing will take place at Cowboy Motorsports, located at Lakeview and Western in Stillwater, Okla.

2.3 Period of Performance

Dec. 9, 2010, Ground Breakers are presenting preliminary designs and marketing strategies for constructing a small, walk-behind trencher. Beginning in January 2011 our group will gather materials to
begin the construction of the prototype. We are setting March 11, 2011, as our construction deadline. We are planning to complete product testing and revisions by April 1, 2011. This will allow for marketing and campaigning strategies to be completed for final presentations during dead week.

2.4 Deliverable Schedule
The following deadlines we must meet and complete in order for our group to be successful:

<table>
<thead>
<tr>
<th>Date</th>
<th>Task</th>
<th>Deliver to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 1, 2010</td>
<td>Preliminary sketches</td>
<td>Team</td>
</tr>
<tr>
<td></td>
<td>Work Breakdown Structure</td>
<td>Instructors</td>
</tr>
<tr>
<td>Nov. 5, 2010</td>
<td>Marketing meeting with Matt Collins at Ditch Witch</td>
<td>Ditch Witch</td>
</tr>
<tr>
<td></td>
<td>Return Groundhog T-4</td>
<td>Ditch Witch</td>
</tr>
<tr>
<td>Nov. 15, 2010</td>
<td>Proposal Report – 1st draft</td>
<td>Instructors</td>
</tr>
<tr>
<td>Dec. 9-10, 2010</td>
<td>Fall Presentations</td>
<td>Instructors/Ditch Witch</td>
</tr>
<tr>
<td>Dec. 13, 2010</td>
<td>Self, peer &amp; class evaluations</td>
<td>Instructors</td>
</tr>
<tr>
<td></td>
<td>Group Web page due</td>
<td>Instructors</td>
</tr>
<tr>
<td>Dec. 17, 2010 (nlt)</td>
<td>Deliver list of materials to client</td>
<td>Ditch Witch</td>
</tr>
<tr>
<td>March 11, 2011</td>
<td>Construction/building prototype</td>
<td>Team/Ditch Witch</td>
</tr>
<tr>
<td>April 1, 2011</td>
<td>Complete testing, repairs &amp; revisions</td>
<td>Team/Ditch Witch</td>
</tr>
<tr>
<td></td>
<td>Begin marketing and campaigning strategies/tactics</td>
<td>Team</td>
</tr>
<tr>
<td>April 28-29, 2011</td>
<td>Final Presentations</td>
<td></td>
</tr>
<tr>
<td>May 6, 2011 (nlt)</td>
<td>Deliver prototype, research, final report and campaigning tactics</td>
<td>Ditch Witch</td>
</tr>
</tbody>
</table>

2.5 Special Requirements
Ground Breakers will need to travel (in January-March) to Perry, Okla., to visit Ditch Witch to receive various parts and an engine for the prototype. Further in the report, a list of materials is provided before the holiday in preparation of receiving the majority of our materials in January. However, in a team/client meeting on Nov. 19, 2010, Ditch Witch explained that some materials can take longer to
receive. In addition, we will be traveling to Ditch Witch periodically next semester to meet with the communications and marketing personnel as we develop a business plan and campaigning strategies.

3. Task List

3.1 Product Development

- Initial research (Before Oct. 22, 2010 - completed)
  - Ditch Witch’s purpose, products and resources
  - Industry and market size
  - Competitors’ purpose, product, resources, business plans and campaigning strategies
    - Product test top competing products to identify competing products’ advantages/disadvantages
  - Identify audience (Create survey – Nov. 12, 2010)
    - Conduct survey to identify specific audience
    - Identify their needs and wants for uses of the product
  - Dealers and suppliers
  - Patents
  - Technical characteristics
  - Safety issues
- Business plan (Nov. 2-14, 2010)
  - Develop budget (Nov. 8-14, 2010)
  - Marketing strategies (Nov. 2-8, 2010)
  - Campaigning tactics (Nov. 2-8, 2010)

3.2 Design/Construction

- Review initial research and notes (Oct. 22 - Nov. 14, 2010)
- Sketch possible mini-trencher prototype(s) in Solid Works (Oct. 22 - Nov. 14, 2010)
- Develop list of materials and provide to client
- Build and construct mini-trencher prototype (Beginning in January 2011)

3.3 Testing/Evaluation

- Test prototype for product durability, reliability, maintenance needs and safety issues (March 11 – April 1, 2011)
• Evaluate prototype through product testing (March 11 – April 1, 2011)
• Adjust/repair prototype to fix any problems or improvements identified during product testing (March 11 – April 1, 2011)
• Finalize construction (By April 1, 2011)
• Retest, evaluate and improve as needed

3.4 Market product
• Web page for prototype, intended for Ditch Witch’s website (March 2011)
• Trade Show materials/info-folders (audience: rental yards and homeowners) (March – April 20, 2010)
  • Brochures
  • Spec sheets/product testing results
  • Quote sheet
  • Safety sheet
  • Create website management tactics to track Trade Show traffic on site
• Field rep info-folders (audience: rental yards) (March – April 20, 2010)
  • Include spec sheets,
  • safety sheets
  • market pricing,
  • product testing results,
  • business cards,
  • performance rating brochure
• Video (Film at final prototype testing on April 1, 2010)
  • Video final product testing to promote prototype to client and potential audiences
  • Capture some features to differentiate prototype from competitors
• Create advertisements for primary trade publications (April 2011)
4. Market Research

4.1 Demographic characteristics of audience

Although Ground Breakers’ goal is to make the small, walk-behind trencher accessible and usable for anyone, we narrow Ditch Witch’s audience to males between the ages of 25 and 55 – regardless of industry. In verbal communication with Matt Collins and Jeff Smith of Ditch Witch on Nov. 5, 2010, the demographics of the audience we identified is synchronized with the demographics they plan to target in their marketing efforts.

4.2 Industry performance

The following analysis of three key industries targeted includes economic status, general characteristics, psychographic characteristics, and industry size and growth. Supporting industry reports can be found in Appendix C.

**Rental Yards**

According to the IBIS World Industry Report, “Tools, Equipment and Other Rental Centers in the U.S.,” the rental industry has seen a 4.7 percent decline since 2005, falling to $4.42 billion in revenue. However, IBIS World Reports predict the industry revenue to improve by 2015, rising to an average annual rate of 8.2 percent and $6.56 billion. As of October 2010, the rental industry has 7,515 contributing businesses. Positive predictions of the U.S. real estate market encourage economic growth in residential, industrial and commercial construction industries. Although industry reports provide evidence that residential construction is currently “hindered by poor development conditions,” (Andrews, October 2010, p. 5), “the value of the industry includes new construction and renovations of single- and multi-family homes” (Andrews, October 2010, p. 5). A significant share of the industry originates from leasing equipment to homeowners, landscapers and contractors.

According to Jeff Smith, Ditch Witch design team manager, rental yards receive more return on investment within one year of purchase, receive profit in the second year of ownership, and liquidate the used equipment during the third year of ownership. Furthermore, rental yards lease equipment to contractors expecting to receive greater returns on investment in managing equipment — rather than building with it. In addition, Smith said rental yards receive depreciation tax deductions. Therefore, these reasons motivate rental yards to offer highly rentable products for the specified geographic region, in addition to demanded products for propelling industries.
Large rental firms in the U.S. have managed the five-year (2005-2010) decrease by diversifying their product-line – offering a wider range of equipment and services. Since Ditch Witch is a medium-sized supplier, offering another product to a wider audience is in the company’s economic favor.

**New Construction (Residential)**

According to the IBIS World Industry Report, “Single-Family Home Building in the U.S.,” about 327,320 businesses contribute to the single-home construction industry revenue of $168.5 billion. Since 2005, the industry has seen a 20.4 percent decline. However, the 2010-2015 annual growth rate is projected to increase by 16.5 percent to $361.57 billion. In 2011 alone, the industry is expecting an 11.4 percent increase in revenue growth. Although real estate values, housing demand and financing activity are estimated to improve, IBIS World does not project the industry revenue to peak above the 2005, $526.63 billion mark in the near future.

According to IBIS World, “the number of households increases with strong economic conditions, as individuals increase living expenses, disposable income and consumer confidence.” (Andrews, August 2010, p. 6). As disposable income fluctuates, the demand for industry services reflects that inconsistency. Unemployment is also a key contributor in industry performance. Therefore, additional spending on renovations and personal projects are preserved until economic conditions pick up. As a country, consumers, businesses and developers rely heavily on financing for business and personal purchases. IBIS World offers the Great Recession – which technically has ended, was due to the tightening of the credit markets because the U.S. society is heavily dependent on debt. Since 2007, businesses and individuals have not had the funding available to promote growth in the real estate and construction industries.

IBIS World estimates the housing industry to begin feeling a demand for new construction homes between August 2010 and 2015. The organization also predicts industry employment and wages to increase by 11.9 percent and 13.3 percent within this time frame. The rise in consumer profitability will promote industry growth, increasing the expected number of industry enterprises to 582,634. The industries positive predictions to 2015 support economic growth and the development of small trencher to compete in the market.
Landscaping (Designing and planning)

According to the IBIS World Industry Report, “Landscape Design and Planning Services in the U.S.,” the landscaping industry had a 2.1 percent decrease in revenue since 2005. Like many other industries currently, reduced annual income has forced companies to cut employees and wages. Although, IBIS World reports the landscaping industry reacts to the construction industry’s economic status. Since the construction industry saw a 20.4 percent decline, the demand for landscaping services obviously decreased. However, although most industries have seen a drastic decrease in economic growth, it is apparent the landscaping industry has seen a much smaller strain in cutting costs – especially, compared to the construction and real estate industries.

Approximately 84.7 percent of landscape design businesses are small players or sole proprietors and produce 18.8 percent of the industry revenue. With 35,832 businesses in the industry, IBIS World predicts the landscaping industry to increase by 5.1 percent or $7.5 billion by 2015 since demands for landscape design are expected to increase.

4.3 Current and potential market size

In conducting research to rent potential competing products, we found nationwide and local rental yards in Oklahoma only carried a limited number of small, walk-behind trenchers. Most rental yards contacted did not offer two competing products. After contacting 15 rental yards in Oklahoma, only ABC Equipment Rental of Tulsa, Okla., carried a Ground Hog T-4. ABC Equipment Rental quoted Ground Breakers $150 rental fee per day, $9.50 environmental fee, $18 damage waiver fee, and $200 refundable deposit. However, most Home Depot locations in Oklahoma City and Tulsa carried a Groundsaw EZ-1900. The rental rate for the Groundsaw EX-1900 was $60 for 12 hours and $85 for 24 hours. In addition, many rental yards and home improvement stores (Home Depot) advertised online the availability of the Ground Hog T-4 or the Vermeer RT60, but did not actually have the product available for rental usage in Oklahoma. Many times, their employees did not have knowledge of these products. Currently, we have yet to locate a Vermeer RT60 in Oklahoma Rental Yards. According to Richard Sharp, Mike Buck and Jeff Smith, on Sept. 29, 2010, competing small, walk-behind trenchers may not have the capability to perform in Oklahoma soils and designing a prototype suitable for Oklahoma soils has increased potential to serve other comparable geographic regions – expanding our geographic area.
4.4 Market research

Before designing a prototype for Ditch Witch, Ground Breakers set a goal to product test competing small trenchers. However, Ground Breakers was only able to locate one competing trencher, due to availability at Oklahoma rental yards.

On Oct. 25, 2010, Ground Breakers tested a Ground Hog T-4, a top competing trencher, received from Ditch Witch at no cost. The product testing demonstrated product performance and assisted Ground Breakers in designing the prototype for Ditch Witch.

Another aspect to include when marketing the new prototype trencher is mode of transportation. Since the trencher will be less than 200 pounds (which is light enough for two to three people to lift), Ditch Witch specified the need for an alternative approach for customers to transport the product. Ground Hog offers a transportation device for the Ground Hog T-4 to hook on a receiver hitch, which can be hauled with SUV-like vehicles. Although we have minimal research completed in this area, we feel a comparable design is in Ditch Witch’s favor to offer in conjunction with the small trencher. However, Ground Breakers is not responsible and does not guarantee a design of a transportation/receiver hitch prototype to include in the project.

4.5 Applicable standards and regulations

Heavy Construction Equipment Rental & Leasing

According to the IBIS World Industry Report, “Heavy Construction Equipment Rental & Leasing,” OSHA regulations requiring all equipment to be continually monitored, modified, and adjusted to comply and meet any changes in standard and regulations for its use in operation. OSHA has the support of the United States Standards regulations. If rental businesses fail to give sufficient or adequate information on safe use to custom hires before renting the equipment they are liable under the liability regulations.

Land Development in the US

“The industry operates in a highly regulated environment, as contractors must comply with a wide range of state and local laws and regulations relating to: land use zoning, treatment of waste, construction materials, density requirements, building design, and minimum elevation of properties.” (Andrews, August 2010, p.31-32) This industry is heavily regulated and has many different regulations.

Single-Family Home Building in the US
“There is no national regulatory control of industry participation although state housing authorities impose varying methods of regulating the industry and participants are required to register or be licensed to undertake business within each state or district jurisdiction. Health and Safety regulations require that protective clothing and helmets be worn on site and that safe conditions are provided for the workers (e.g. scaffolding and ventilation). The Federal Occupational and Safety Health Administration (OSHA) enforce standards for the construction industry which are contained in Title 29 of the Code of Federal Regulations (CFR) Part 1926. State authorities assess and enforce this code. Currently, a broad range of codes govern activity in this industry including, general building codes, residential codes, mechanical codes, plumbing codes, electric codes, fire codes, accessibility codes, zoning codes, state codes, local codes and ordinances.” (Andrews, August 2010, p. 32-33).

4.6 Acceptance Criteria/Safety information

After searching safety regulations, our most dependable source was Ditch Witch. According to our client, the following are important safety features Ground Breakers is aware in order to provide a small, walk-behind trencher.

- Kill/stop switch, safety chain guard over the chain boom
- Keep others at least six feet away
- Use personal protective equipment
- Color codes for utility markings
- Use proper tie-downs for transportation
- Provide information about 811
  - (a service that marks where telephone, gas and other cables are buried)

4.7 Key industry gatherings

According to the Association of Equipment Manufacturers, trade shows are the best way to accomplish business-to-business marketing strategies. In addition, most product research is conducted at trade shows. Ditch Witch attends 12 major industry association trade shows annually, including the Rental Industry Association, International Construction and Utility Equipment Exposition. The Rental Industry Association trade show attracts leaders serving the construction and homeowner industries. According to the International Construction and Utility Equipment, its annual exposition attracted: 12
percent of phone and cable utility contractors; 2 percent of landscaping businesses; 15 percent equipment dealers; distributors and rental yard; and 9 percent of equipment manufacturers. Therefore, about 30 percent of attendees would be primary audiences in promoting the small trencher.

4.8 Key trade publications

According to Ditch Witch, the company utilizes the following key trade publications to promote product development: *Construction Equipment; Equipment World; Landscape and Irrigation; Landscape Contractor Magazine;* and *Rental Equipment Register*. Supporting research can be found in Appendix D.

*Construction Equipment*, a paid-subscription publication, circulates to 76,000 managers and construction equipment fleets. Their website, in conjunction to the publication, offers evaluations of machinery, a comprehensive directory of manufacturers, distributors and rental outlets, and a database of equipment specifications allowing individuals to compare competing models. The monthly publication provides the latest in new product information, such as; product development; product technology; and machine acquisition; disposal and maintenance. Presenting ideas and insight for equipment professionals is the main purpose of the magazine.

*Equipment World*, a paid-subscription publication, data-driven circulation targets leaders in the heavy construction industry with a monthly subscription. The publication credits itself for editorial integrity, circulation intelligence and innovative advertising and marketing programs since 1989.

*Landscape and Irrigation*, a paid-subscription, provides a monthly magazine to decision makers including residential contractors, commercial ground managers, public works professions, and irrigation and water management professionals within the landscaping industry. The publication offers advice from industry professions, coverage of specified projects, details on the latest products and innovations and top international news.

*Landscape Contractor Magazine* offers the publication through a free print and online subscription. The website did not give a specified target audience or circulation. However based on experience within print media, most free-subscription publications have a shorter shelf-life and do not reach the intended audience. Many times readers throw away the publication after reading it once. Instead, readers who purchase subscriptions are more apprehensive to throw away a publication they had to purchase. (Lisa Brown, member of Ground Breakers, interned for a paid, print publication – *High Plains Journal* – and this is understood within the publication industry.) In addition, these readers will be more likely to refer back to past issues when they keep them longer.
Rental Equipment Register reaches 21,204 entities spending $21.8 billion annually in the rental industry, providing advertisers a valuable audience to target. Through RER’s magazine and website, reports, product wire e-newsletters, buyer’s and rate guides, industry event calendar and special reports are offered an innovation marketing scheme to reach a wide audience.

4.9 Further Market Research

<table>
<thead>
<tr>
<th>Product</th>
<th>Production Cost</th>
<th>Retail Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermeer RT60</td>
<td>$3,200</td>
<td>$3,800</td>
</tr>
<tr>
<td>Ground Hog T-4</td>
<td>$2,400</td>
<td>$3,000</td>
</tr>
</tbody>
</table>

*Information gathered from Matt Collins, Ditch Witch project manager, on Nov. 18, 2010.

4.10 Management team and key people involved

The Ditch Witch management team includes Jeff Smith, design team manager; Mike Buck, mechanical designer; Richard Sharp; and Matt Collins, product manager. Additional key people include Tiffany Sewell-Howard, CEO and Ed Malzahn, founder of Ditch Witch and president of the Board of Directors.

4.11 Product line

The product line for the small trencher prototype will best fit in the walk-behind trencher line that Ditch Witch currently offers. Ditch Witch offers three walk-behind trenchers. However, their current products are designed for large-scale trenching projects. The smallest walk-behind trencher Ditch Witch offers weighs 930 pounds with a trenching depth of 30 inches and width of 4 to 6 inches. To make the product more appealing to small business owners and homeowners, Ditch Witch is planning to release a product on much smaller scale. For the small, walk-behind trencher prototype, we anticipate low maintenance and repair costs for Ditch Witch and its customers, as we are trying to match our design to better incorporate parts currently carried and used in their related products. Anticipated input suppliers include Honda, Briggs & Stratton, Ditch Witch and other small part suppliers (will be furthered researched).

4.12 Manufacturing expertise and capacity

Located on 80 acres in Perry, Okla., Ditch Witch has the manufacturing expertise and capacity which include the ability to make rods and chains, in addition to assembling, painting and testing their products in their factory.
4.13 Marketing Techniques
Ditch Witch uses a website, Ditch Witch Mobile, the Underground (Ditch Witch’s publication), various trade shows, dealers, sales representatives and product guarantee as the company's main marketing techniques.

4.14 Brand, Reputation and Trademarks
“Ditch Witch” was something Ed Malzahn called his compact trencher invention in 1949. As the name and logo implies, consumers developed an association of compact trenchers with Ditch Witch. Like other companies, Ditch Witch’s reputation goes back to the product and customer service. Current Ditch Witch trenchers carry the tradition of the original design consisting of “outstanding power, rugged frames, operator convenience, extraordinary durability, and lengthy list of innovative standard features.” (Ditch Witch, 2010, Trenchers and Plows Web page). Providing product guarantees, customer satisfaction, appreciation and respect.

The Charles Machine Works Inc. has the following Trademarks: Ditch Witch®; CMW®; Subsite®; Jet Trac®; AutoCrowd®; Fluid Miser®; Roto Witch®; Super Witch®; Pierce Airrow®; and The Underground®.

4.15 Distribution/dealers
Ditch Witch has dealerships nationwide. Their dealerships and sale representatives promote distribution to rental yards and major construction landscaping companies. When contacting rental yards for product testing, often times the business did not carry light-weight trenchers. However, every business offered either the RT12 or RT10 – popular Ditch Witch models. This first-hand experience demonstrates that Ditch Witch has accomplished a positive reputation for the product, in addition to distributing their products to local and nationwide dealers.

4.16 Ditch Witch’s financial condition
According to Matt Collins in a meeting on Nov. 5, 2010, Ditch Witch will be financing itself in the development of the new small, walk-behind trencher. With Ditch Witch researching new product development of a small-scale product mainly to stay competitive in their markets, demonstrates Ditch Witch will continue to serve as a main contributor in their industry. In addition, their broad distribution also provides us with good indication Ditch Witch is not any major financial trouble. However, we have not been given Ditch Witch's balance sheet, income statement and cash flow data. We were only provided the Pro Forma Overview for the small, walk-behind trencher – found in Appendix A.
4.17 Available financing  
Ditch Witch offers two financing options through Ditch Witch Financial Services. The first financing option is the Ditch Witch® Platinum Plus Card, intended for purchasing professional grade Ditch Witch parts, maintenance and service. The card promotes “enhancing businesses’ buying power, opening credit lines, and tracking expenses with an easy-to-read monthly statement.” (Ditch Witch, 2010, Financing Web page). With a dedicated line of credit, the card requires no annual fee, no interest charged if the balance is paid in full monthly, minimum 25-day grace period, flexible repayment terms, and quarterly special promotions. Supporting research can be found in Appendix A.

Large equipment purchases are offered in the second financing option. Ditch Witch’s experienced professionals help business buyers map their financing plan, such as monthly payments, rent-to-own, or customized leases.

4.18 Market Shares  
Ditch Witch does not publish market share data since it is a privately-owned company.

5. Design Research  
5.1 Scientific Literature Review  
The trenchers we found similar to our conceptual ideas have many of the same specifications and features included in their design. Some characteristics on existing products include chain and rotary trenching types, shark and bullet type digging blades, trenching depth control, loading handles, and ground drive assists. Table 1 below shows specifications by each brand and model.

Table 1 Existing Product Specifications

<table>
<thead>
<tr>
<th>Brand/Model</th>
<th>Engine/HP</th>
<th>Trench Type</th>
<th>Max Depth</th>
<th>Width</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermeer RT60</td>
<td>Honda 5.5</td>
<td>Chain</td>
<td>12&quot;</td>
<td>3&quot;</td>
<td>270 lbs</td>
</tr>
<tr>
<td>E-Z Trench 9100</td>
<td>Honda 8</td>
<td>Rotary Disk</td>
<td>13&quot;</td>
<td>2.5&quot;</td>
<td>250 lbs</td>
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<tr>
<td>Kwik-Trench KT100</td>
<td>B&amp;S 5.5</td>
<td>Direct Chain</td>
<td>8&quot;</td>
<td>3&quot;</td>
<td>430 lbs</td>
</tr>
<tr>
<td>Kwik-Trench KT2400B</td>
<td>Honda 8</td>
<td>Triple V-belt</td>
<td>12&quot;</td>
<td>4&quot;</td>
<td>216 lbs</td>
</tr>
<tr>
<td>Ground Hog T-4</td>
<td>Honda 5.5</td>
<td>Chain</td>
<td>12&quot; or 18&quot;</td>
<td>3&quot; or 4&quot;</td>
<td>230 lbs</td>
</tr>
</tbody>
</table>
5.2 Durability, reliability, maintenance costs, maintenance programs
The durability, reliability and maintenance aspects of this project are similar to the existing types of small trenchers and the companies producing them. Most of the companies producing small trenchers are relatively large, with many resources to provide to their products and their customers. Along with operator's manuals to show the customer how to use the machine, the companies also provide troubleshooting information by customer service representatives via phone and e-mail. Maintenance resources are available within these existing companies to provide the customers with replacement parts.

5.3 Characteristics Technically Possible
Most of the features we found on existing products are relatively similar within their design. With the design intent of mini trenchers, many components on larger trenchers are undesirable for smaller trenchers due to size, weight and cost limitations. Simplicity of design is essential for small trenchers to support functionality, size and weight limitations. Some characteristics on larger trenchers are hydrostat drive control, axle differential lock for straight trenches, a pivot on the trencher arm for curved trenches, and electrical switches and components. All of these characteristics are technically possible. However, they will not satisfy the limitations for size, weight and cost. Characteristics technically possible would be depth control, ground drive assist, loading handles, axle lock for transporting, emergency shutoff, small attached toolbox, soft handle grips, and tie-down hooks.

5.4 Safety Issues
Safety issues that must be addressed include, but are not limited to, a kill switch and a leveling system. Since this is a heavy piece of machinery used to cut into the ground, it has sharp moving parts that are dangerous. If the machine is operated on unlevel ground it could easily tip over, potentially causing serious harm to the user. Therefore, we need to address the issue of having a way to keep the trencher level on unlevel ground. If the trencher should begin to tip or if the user happens to fall away from the trencher a kill switch is needed, comparable to kill switches used on water-jets.

5.5 Patent Searches
We discovered three patents relevant to our trencher. Each patent’s abstract, claims, and drawing sheets can be found in the Appendix E.

   PN 7805864: The walk-behind trenching machine patent is relevant to our design of the small trencher prototype because it incorporates a trenching boom with an endless chain, which can be
movable between an operating position and a transport position. This patent is useful since Ditch Witch wants a light-weight, easily transported small trencher prototype.

PN 6832443: The cutting chain patent, which was invented by our sponsor Ditch Witch, is a very useful and important patent. The chain is designed to more effectively and efficiently drag out soil, broken materials, and other underground materials to the surface providing a much cleaner trench, improving the trenching performance of the cutting chain. We could use this design to help make a smaller chain for the small trencher prototype.

PN 6658768: The trencher patent is relevant because it is designed to dig a curved trench and transition between excavating a straight section and curved section of trench. We could use this in the design to help widen our customer focus since not everyone needs to dig straight section trenches all the time.

5.6 Physical Testing & data collection

Physical testing and data collection included testing an existing Ground Hog T-4, supplied by Ditch Witch. Measure components and understanding of its design were also analyzed.

5.7 Modeling and Simulation

Three-dimensional Solid Works CAD drawings will model the conceptual machine. Animated simulation of the device will be produced using the CAD software. From a bill of materials, the parts will be drafted to scale and sent to the Ditch Witch Product Development Center or BAE shop for fabrication. The machine will be assembled by Ground Breakers and any modifications will be completed, as needed.

6. Product Specifications

6.1 Production Specifications

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); trenching depth of 21 inches and trenching width of 3 inches. There were no specifications provided on how fast the trencher must dig. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.
7. Customer Requirements

7.1 Customer Requirements

Ditch Witch has given specifications, but no requirements for the small, walk-behind trencher. However, from meetings and personal conversations with Jeff Smith, Ground Breakers comprehends that including a ground-drive assist in our design will be more accepted than if we do not include it. In addition, online forums suggest consumers are willing to pay more a product with ground-drive assist, such as the Vermeer RT60. (Landscape Design & Installation Forum). Therefore, Ground Breakers will incorporate a ground-drive assist in our final design.

8. Design Concepts

8.1 Generation of Design Concepts

We have begun and are continuing to generate design concepts to meet the specifications provided by our client, provide a reliable, customer-oriented product and produce an aesthetically marketable product. The process of generating design concepts consisted of research and testing of currently existing products similar to our ideological concepts. Our designs are created from existing parts and products with an emphasis on simplicity of design, constructability and performance, while minimizing the overall weight.
8.2 Design Process
8.3 Design Concepts

**Figure 1:** Honda GS190; 5.2hp; 30.4 lbs. This engine will provide suitable power for the digging chain as well as the ground-drive assist.

**Figure 2:** Digging teeth that will be attached to the chain. These teeth are used Ditch Witch’s current trenchers.
**Figure 3:** The figure above represents the digging arm in which the digging chain will rotate around.

**Figure 3:** The figure above shows the layout for the power transmission. The mandrel shaft will be driven by a sheave/v-belt from the pto. The mandrel shaft will drive the main shaft by a chain/sprocket, as well as the input shaft for the planetary gear train for the ground drive assist.
9. Design Evaluation

9.1 Feasibility evaluation of possible designs

We have selected the Honda GS190 engine, which, compared to other engine models, will provide the product with sufficient power and torque ratings for the trencher and ground drive assist. The power transmission will consist of a mechanical friction clutch, which will engage the trencher when the rpm is increased, connected by a v-belt to a sheave with a small chain sprocket on the same shaft. The small sprocket will drive a large sprocket connected to the main shaft of the trencher.

The ground drive assist will be powered from the power transmission as well. A planetary gear train will be used for a speed reduction for the wheel shaft. The shaft from the planetary gear train will have a small gear which will drive a larger gear on the wheel shaft for speed reduction. The drive assist will be controlled from the handle bar, allowing the user to engage it when needed. The alternating teeth design is on most trenching cutting chains and is the best design for us to use in order for the teeth alignment to achieve optimum soil cutting. They will be attached to the chain to fit our specifications and design, and aligned alternating from one tooth on the left to one tooth on the right.

The frame will be fabricated with 3/16” thick sheet metal, which will minimize the weight, while providing a sufficient amount of material for strength and stability.

9.2. Determination of suitable designs

Determining the shaft sizes according to torque was our first step. The main shaft was calculated to be one inch in diameter, while the mandrel shaft was calculated to be one-half inch in diameter. Our rpm for the chain sprocket/main shaft was desired to be ~380 rpm. For this desired speed, an overall speed reduction was calculated to be 9.5:1, which was met through a reduction from sheaves and a reduction from sprockets.

For the ground drive assist, a desired rpm was that less than 2 rpm. For this, we have selected to use a planetary gear train to largely reduce the shaft speed.

The chain was figured to be a #35 (3/8” pitch). The small sprocket has 11 teeth, while the large sprocket has 45 teeth.

The angle for our maximum trenching depth was determined to be 40 degrees from the horizontal.
10. Project Schedule

10.1 Gantt Chart
See Appendix A for a detailed project schedule.

11. Project Budget

11.1 Budget

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<th>Product Specification</th>
<th>Product/Order Number</th>
<th>Vendor</th>
<th>Quantity</th>
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Grand Total 83 $1,311.00
Specified Cost Constraint $1,750.00
12. References

12.1 Conversations/Personal Communication
Smith, Jeff, Mike Buck and Ditch Witch of Ditch Witch, business meeting/personal communication in Perry, Okla., on Sept. 29, 2010.

Smith, Jeff and Matt Collins of Ditch Witch, business meeting/personal communication in Perry, Okla., on Nov. 5, 2010.

Smith, Jeff, Mike Buck and Richard Sharp of Ditch Witch, business meeting/personal communication in Perry, Okla., Nov. 19, 2010.

12.2 Related research


Culbert, Kevin. (June 2010). IBISWorld Industry Report 54132: Landscape Design & Planning Services in US. Publisher: IBISWorld Inc.

Wilson, Michael. (September 2010). IBISWorld Industry Report 53241: Heavy Construction Equipment Rental & Leasing in the US. Publisher: IBISWorld Inc.

12.3 Patents


13. Appendices

13.1 Appendix A – Ground Breakers
13.2 Appendix B – The Charles Machine Works Inc.
13.3 Appendix C – Design Research
13.4 Appendix D – Industry Research
13.5 Appendix E – Market/Campaign Research