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8:20 AM ***PumpMinder***
Frey 110 Presented by Robert MacBride, Shane Braunworth, and Matthew Eshleman

Many NGOs install equipment to provide access to clean water and wish to have the ability to continue to provide clean water for many years to come. Therefore, our project aims to continue the sustainability of the installed hand pumps in rural Ghana, while our client, Water4, hopes to lay the foundation for sustained access to clean water for the community. We hope that by charging fees for water usage to help maintain the pump, we will provide not only the clean water needed for each community, but also a dependable source of work for community members. PumpMinder's goal is to enable Water4 to meter hand pump use in order to collect maintenance fees and ensure the long-term presence of water assets. The PumpMinder team has designed a device necessary to monitor the fees charged by the local pump minder. As the project continues, we have been working to refine and increase the functionality of its units and accelerate the growth of the project by defining a more consistent manufacturing process.

8:40 AM ***Remote Monitoring of Hand Pumps in West Africa***
Frey 110 Presented by Paul Zwart, Roque Dietrich, and Nicholas Sum

Although millions of households in sub-Saharan West Africa rely on hand pumps installed by various non-government organizations, 30 to 50 percent of these pumps are currently inoperative. Under the sponsorship of AlignedWorks, the Intelligent Water Project (IWP) is continuing to develop remote monitoring devices that track the usage and health of hand pumps. These devices allow organizations to catch pump failure early so that these water pumps can remain operational, continually providing fresh water. After installing thirteen of these devices in the summer of 2017, the IWP has been working to correct problems that were discovered from these field tests, while also improving system accuracy and robustness, and preparing for mass manufacturing.

9:00 AM ***Muscle-Activated Prosthetic Hand for 11 year old client***
Frey 110 Presented by Erin Cressman

Due to the rapid growth of children, and the complexity of myoelectric technology, children are not given the same opportunities to use myoelectric prosthetics as adults. The Muscle Activated Prosthesis (MAP) team is working to create an affordable, trans-radial myoelectric prosthesis for an eleven year-old girl. The basic mechanism by which this device operates is as follows: a muscle contraction emits an electrical signal that will be detected and used to control the hand in various set patterns of grip. Comprised in this device will be an EMG sensor, electrodes, a development board, motors and tendons to emulate finger motion, feedback, and a battery. We have created a prototype "bionic hand" prosthesis that will be tested by our client in summer 2019.

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9:20 AM ***Safety testing of 3D printed prosthetic sockets***
Frey 110 Presented by Erik Dyrli, Thomas Pond, and Jared Rider

The ROCK (Rapid Orthotics for CURE Kenya) team is partnered with CURE International's Orthopedic workshop in Kijabe, Kenya to create a system that rapid-prototypes customized prosthetic and orthotic devices using a 3D scanner, several 3D manipulation programs, and a 3D printer. We specialize in transtibial sockets (below the knee) and ankle-foot orthotics (AFOs). The orthopedic technicians are trained in producing 3D printed sockets and have successfully created a transtibial socket from start to finish using our system as of September 2018!

Since prosthetics replace a missing appendage, they have a higher priority of verifying patient safety in its use because they need to be able to withstand the weight of the patient, unlike orthotic devices. For this reason, we are running our prosthetic sockets through different mechanical tests to ensure it aligns with international safety standards. Once our sockets meet or exceed these standards, we will be confident in recommending our 3D printing system's product for everyday use by patients around the world.

9:40 AM ***Village Water Ozonation Systems: The Challenges of International Water Projects***
Frey 110 Presented by Daniel Ma, Brandon Blackhurst, and Daniel Mewha

Safe drinking water is a basic human necessity. People around the world face issues like water scarcity, severe contamination, and limited access on a daily basis. Alleviating global water-related illnesses and deaths remains a prevailing challenge to overcome. Therefore, the Village Water Ozonation Systems (VWOS) team contributes to the worldwide effort to increase access to safe drinking water. For the past two years VWOS had the privilege of walking alongside our partner communities in Mexico, Pakistan, and Nicaragua to develop sustainable drinking water solutions. Through collaborations with several Christian organizations such as Forward Edge International in Mexico, Full Gospel Assemblies of Pakistan and, more recently, Friends in Action International in Nicaragua, the team has acquired an increased awareness of drinking water needs and issues across the world. Each individual partnership presents unique challenges with regards to culture, economics, and local environment that require a complete understanding of our partners' needs, the proper application of water treatment knowledge, and the prioritization of health in all aspects of the design process. In order to address the unique challenges facing each of our partners, the team relies on past experience as well as new research to develop the most appropriate solution, evaluating the feasibility of a project from technical, financial, and cultural perspectives.

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10:00 AM ***Cunningham Clubfoot Brace***
Frey 110 Presented by Katherine Prelog and Dylan Gillisse

Clubfoot is a musculoskeletal birth defect that describes several foot abnormalities characterized by an inward-rotated foot. The current method for correction involves several casts and a boots-and-bar maintenance brace. This method requires 5 years of bracing and has issues with compliance, comfort, and social stigma. The Cunningham brace reduces treatment time to 2-3 years. It can be concealed, reducing the social stigma, and improves the child's mobility while encouraging muscle growth and development throughout treatment. The Collaboratory Cunningham Clubfoot Brace project seeks to increase accessibility to the brace and test the effectiveness of the design. The project has shown that the brace can be 3D printed using a reinforced nylon polymer. The 3D models developed by the team have allowed our client and brace designer, Mr. Jerald Cunningham, to move forward with injection molding of the three parts of the brace. Currently, we are working on validating the Cunningham Brace by measuring the biomechanical forces created and applied by the brace. This will happen through a series of pressure sensors that are attached to the brace and then placed on a child's foot. Along with a clinical study that was started in Kijabe, Kenya and the patient data analysis being conducted by Dr. Emily Farrar, this data will hopefully provide the needed evidence that the Cunningham Brace works so that it will be more widely accepted and used for treatment around the world.

10:20 AM ***Flight Following System Redesign***
Frey 110 Presented by Jonathan Carter

Outside radar range, small planes flying in remote locations must be tracked by other means. Emergency relief, humanitarian development, and missionary organizations need to follow such flights, for safety and management. The Automatic Flight Following System (AFFS) owned by JAARS has been safety tested and used extensively for this purpose but has been replaced in many cases by new options. Thus, the Flight Tracking and Messaging Systems (FTMS) team has been working with stakeholder Cary Cupka to redesign AFFS 1.0 with updated and more advanced technology modes to increase its value in the field. For proof of concept testing, this includes replacing internal components of the existing AFFS Aircraft Control Unit (ACU) with a new single board computer (SBC A62), upgraded custom display board, and new HF transceiver (LimeSDR). In addition, the ground monitoring unit will have a matched LimeSDR HF transciever, and UDOO QUAD computer with display. Currently the team is developing code for the aircraft (FLIGHTsoft), for the ground unit (GROUNDsoft), and configuring the HF communications link.

10:40 AM ***Developing a Low-Cost Optical HIV Viral Load Detection System***
Frey 110 Presented by Caleb Bornman and Lily Gaudreau

The DVD project is partnering with the Macha Mission Hospital in rural Zambia to create a point-of-care (POC) device to quantitatively detect the presence of HIV from a human blood sample. The device aims to provide results in under an hour using fluorescence correlation spectroscopy (FCS) as the mode of quantification. Essential to this process is the use of a fluorescently-tagged protein probe which attaches to the virus and is measured by single-photon sensitive detectors. Traditional detectors are expensive and have power requirements not suitable to a POC device. As such, we have developed a novel silicon photomultiplier sensor for capturing the photons and registering their arrival by a digital pulse. To test the efficacy and limits of our device in a pre-clinical setting, we developed a nanoparticle simulating Human Immunodeficiency Virus (HIV) and preliminary tests have been performed. Ongoing research aims to integrate each step of the methodology into a finalized POC device.

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10:40 AM ***Living Love Ministries - Kenya Land Development***
Frey 150 Presented by Jonathan Robinson, Justin Blest, and Cheylee Smith

The Land Development in Kenya team has partnered with Living Love Ministries (LLM), an organization that operates a children's home in Ol Kalou, Kenya, to design an irrigation system to help grow year-round produce and crops to increase self-sufficiency at their facility. The LLM community experiences a significant hot and dry season that affects their ability to grow crops during this time, and they have requested that the Land Development team initially design a system to irrigate two acres of cultivated fields at the children's home. The irrigation system will tie into LLM's elevated water tower currently used to supply water for daily operations. Water will overflow from this tower to an auxiliary storage tank to provide additional water capacity for the irrigation system. A booster pump will be used to pressurize a main trunk line of a drip irrigation system that will feed a series of emitters which control irrigation specific to plant types and row configurations over a nominal 2-acre area. The team has planned a site trip to Kenya in late May 2019 to install the main components of this initial system, and hopes to modularize the system so that LLM will be able to expand their irrigation in a simple and effective manner.

11:00 AM ***Panama Bridge Project***
Frey 110 Presented by Seth Brewster, Eric Denlinger, Troy Harris, Jr., and Calvin Trimble

The Panama Bridge project has partnered with Rio Missions Panama to design a bridge for the village of Peñas Blancas, Panama. The mountain community of Peñas Blancas experiences heavy rainfall during the rainy seasons. A stream runs along the community, with mountainside homes to the north, and the main village to the south. While passable during dry seasons, the stream floods and becomes impassable after heavy rains. The mountain residents are effectively cut off from the village during this time.

To accommodate this need, the Panama Bridge Team has spent the 2018-2019 school year designing an aluminum truss bridge, spanning 80 feet. The design includes a unique construction strategy to deal with challenging site constraints.

11:00 AM ***Fire Protection for Developing Communities***
Frey 151 Presented by Jacob Film, Lake Bender, Victor Defrance, and Conner Reyer

The Institute for Affordable Transportation (IAT) is a non-profit public charity "devoted to improving the lives of the world's poor by providing simple, low-cost vehicles in order to facilitate community transformation." The centerpiece of their work is the Basic Utility Vehicle, known as the "BUV", which they distribute to developing rural communities in several countries around the world. Upon recognizing the need in these communities for proper firefighting resources, the IAT partnered with the Collaboratory to develop a way to equip the BUV with firefighting capabilities. The proposed solution is a "firefighting insert" which can be easily placed into the bed of the BUV. The insert design process has proceeded with an emphasis placed on simplicity, durability, versatility, and cost efficiency in order to provide its users with straightforward yet flexible operation and to minimize initial investment and maintenance requirements. The current design utilizes a wooden frame (called the skid) which supports water storage tanks, houses the necessary plumbing, and holds a small pump, engine, output manifold, and hoses. The components selected enable versatile operation which is not limited to firefighting applications, making the insert valuable for everyday usage in addition to fire protection. At the end of the Spring 2019 semester, the fully constructed design will be turned over to the IAT along with manuals for its construction and proper operation.

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1:00 PM ***The Prosthetic Knee Project***
Frey 110 Presented by Vaughn Chambers

The Prosthetic Knee Project addresses the need of the Centre for the Advancement of the Handicapped in Mahadaga, Burkina Faso. The Centre can construct an entire prosthetic leg except for the knee locally. While the Centre used to receive prosthetic knees through donations, these donations were exhausted over five years ago halting the production of full prosthetic legs. The Centre was in need of a design for a low-cost, locally manufacturable prosthetic knee that is compatible with the rest of the prosthetic leg that can be made there. In previous semesters, we successfully designed a working $20 prosthetic knee made almost entirely out of local materials. Along with this knee, we have designed low-cost adapters to replace the expensive pyramidal adapter connection pieces that the Centre used to buy. We have also designed a flexion-offset plate to allow less-flexible amputees to better accept a prosthetic leg. With the help of applied health science majors, we have also been working on a rehabilitation protocol that will put amputees through an exercise program to keep them in shape after leg amputation before receiving their prosthetic leg. Since we have a working, low-cost product, we have decided to add Cure Kenya as a second client. We will be traveling there this summer to find out how we need to alter our design for them. This past semester, we focused on fatigue testing our design, finalizing the adapter design, finalizing the rehabilitation protocol, and preparing for our trip to Kenya this summer.

1:00 PM ***Sawyer Point One Water Filter Test System***
Frey 150 Presented by Joseph Franken and Nathan King

The purpose of the Sawyer Point One Water Filter Test system is to test the structural integrity of the hollow fiber membrane as each filter passes 100,000 gallons at a pressure of 10 psi. Structural integrity of the filter is directly related to the filters ability to remove bacteria. Governmental regulation mandates log 6 removal of bacteria for safe drinking water. The Sawyer Point One Water Filter Test System is a project dedicated to designing a system that tests the longevity of these Sawyer Point One Hollow Fiber Membrane Filter and there ability to perform bacterial removal at a standard of log 6.

1:20 PM ***Destruction of Landmines with the Hybrid Thermal Lance***
Frey 110 Presented by Rachel Siepelinga and Daniel Sidell

The Landmine Neutralization Project undertaken by the Messiah College Collaboratory serves to create a safer way to destroy landmines, IEDs, and other unexploded ordnance (UXO). Currently, the most common method of destroying UXO is to use a small explosive charge to detonate the mines in place. However, due to the risks associated with this method the team has been asked to develop an alternative. To accomplish this, the project team partnered with the HALO Trust, the world's largest demining NGO, to develop the hybrid-thermal lance (HTL). The HTL is based upon the principles of hybrid rocketry with slight modifications to provide a precise flame and heat to pierce through the outer casings of several types of UXO and burn the explosives within. This process rendered the UXO inert without causing detonation. This year the team has advanced their project through several parametric studies to better understand the characteristics and capabilities of the HTL as well as the development of an automated control circuit to allow the process to be run remotely.

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1:20 PM ***Design of a Gravity Fed Water System to Deliver Safe Drinking Water to Villages in Vanuatu***

Frey 150 Presented by Nathan Hardman, Jamar Gittens, and Kurtis Platteel

In the Big Bay region of Espiritu Santo island, Vanuatu, approximately 1350 people living in 30 rural villages lack direct access to safe and potable water. This deficiency can have significant negative effects on the health and livelihood of these communities and may limit their ability to grow both socially and economically. Therefore, the Gravity Fed Water - Vanuatu project, in partnership with Friends in Action International, has designed a gravity fed water system to be implemented to provide easy access to clean, safe, and drinkable water. The system consists of an intake structure at the water source and continues with about 16 miles of pipe to deliver water from the source to storage tanks in the villages along the route; the system requires no external energy to run. Friends in Action International plans to begin construction of the system in the summer of 2020. The team hopes that implementing the gravity fed water system will help to improve the health and livelihood of the villagers and to provide more opportunities for social and economic growth.

1:40 PM ***Sustainable Mobility for Persons Living with Disability in West Africa***

Frey 110 Presented by William Feczko, Brit Haseltine, and Alexander Mantsevich

The Sustainable Mobility Project empowers people living with a disability in the developing world to fully participate in family and community life and makes possible the pursuit of educational and work opportunities. The Collaboratory 3-wheeled off-road wheelchair design is well-regarded among mobility practitioners. Our design has already transformed the lives of dozens of clients through a partnership with the Center of Hope in Fada, Burkina Faso. Now to reach more people in new locations with more partners, the Sustainable Mobility team is reducing manufacturing time and cost, developing supply chains to bring parts and materials to build sites, and developing a turn-key business model that puts local fabricators to work building tricycles wherever they are needed. With our client, SIM Burkina Faso, we are establishing a mobility manufacturing center in Fada, Burkina Faso. Finally, we will work to facilitate the formation of a new independent entity to manage supply chains and to facilitate the formation of additional small businesses that will produce our design in the developing world.

1:40 PM ***Mechanized Percussion Well Drilling***

Frey 150 Presented by Cole Hiduk

The Mechanized Percussion Well Drilling Project seeks to design a simple mechanized well drilling system to be used for drilling shallow water wells in Burkina Faso, Africa. These systems will be operated by local drilling teams, allowing them to earn an income for themselves and their families. Currently our client, Open Door Development, has trouble drilling through hard rock layers, and often must abandon holes due to inadequate equipment. The goal of this project is to enable our client to efficiently drill through these rock layers with a mechanized percussion rig and supporting drilling equipment.

One of the areas the project has focused on this year was increasing the life of the cathead, a critical piece of the drilling rig which severely wore during in-country testing in the summer of 2017. The team determined that the aluminum cathead was not able to resist the wear of the rope, which had particles of dirt and rock embedded in it. The team tested catheads made of steel, wood, and different plastics, and steel was found to be the most viable solution. In order to verify the life of the cathead, the team designed and manufactured an automated testing rig. This rig will allow the team to test the cathead continuously and determine if a steel cathead will last for at least 50 hours of drilling.

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2:00 PM ***Pico Hydro Design for the Developing World***
Frey 110 Presented by Andrew Reedy and Ben Morral

Access to renewable and sustainable energy plays a vital role in eliminating poverty and enabling economic opportunities. The Pico-Hydro team has the unique opportunity to design a product that gives a point of access to renewable and sustainable energy via small scale hydro power. This presentation outlines the team's progress toward a general hydro prototype which will be deployable in streams worldwide fitting certain stream parameters, as well as a site-specific hydro design opportunity in Panama.

2:00 PM ***Nicaragua Manual Block Press***
Frey 150 Presented by Joshua Charney

The Block Press project is developing a manual block press to produce compressed earth blocks used to construct various buildings on the east coast of Nicaragua. Friends In Action International tasked the project to design an easily mobile, lightweight (2-3 people can carry), simple manual press for the Rama community requiring only 1-2 people to operate. The press needs to make an interlocking 12"x6"x4.25" clay-sand-cement brick efficiently (~200 a day) to be used for the new buildings. A SolidWorks model was designed, analyzed and used to fabricate the first block press that was tested in Nicaragua in June 2017. The first press was brought back to Messiah College and modifications were made. A second press made of stainless steel to combat the rusting problem in the first press was fabricated by E&E Metal Fab. Inc., based on the modifications done to the first press. The second press's viability as well as five block mixtures are currently being tested by the 2018-2019 Block Press team. This testing allowed for an improved design for a third press. The 2018-2019 team has sent the part files and engineering drawings to E&E Metal Fab. Inc. for fabrication. Once tested and assured of the third press's viability, it will be given to Tim Johnston and Friends In Action International. Two to three more presses will be fabricated for Friends In Action International from this third press design if the testing goes well.

2:20 PM ***Design of a Solar Powered Water Pumping System for Living Love Ministries in Ol Kalou, Kenya***
Frey 110 Presented by Steven Carpenter and Collin Binford

The Solar Photovoltaics team is working with Living Love Ministries (LLM) in Ol Kalou, Kenya to help meet water needs for domestic use and irrigation with a solar powered water pumping system. LLM currently relies on a diesel generator to power their well pump. Solar power will be both more reliable and more financially practical in the long-term. Stanley Earth has partnered with the Solar PV team and LLM to donate a motor, pump, and pump controller system as well as a second backup system. Some important design questions considered this year were solar array sizing, wire sizing, panel mounting location, and the effect of mounting orientation. The Solar team is traveling to LLM this May to install the well pump and a 26 panel, 6.9kW solar array on Pamoja Hall at LLM to power the pump.

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2:20 PM ***Energy Monitoring and Management System***
Frey 150 Presented by Joseph Wambach, Trieu Luu, and Justin Martin

The Energy Monitoring and Management System facilitates access to electric power in regions with limited energy by increasing energy conservation and education. The solution consists of a meter which allocates a configurable daily energy limit per facility, and a display that provides practical information to the user including reporting how much energy they have used and how much they have left before their power is automatically cut off until the next day.

The current version of the system has successfully been installed in multiple facilities in Burkina Faso and Zimbabwe. Currently, the team has completed the redesign of the system's power sense module to increase performance to meet client specifications. In addition, we have increased the manufacturability of our enclosure through redesigning our baseplate. Finally, we developed a full manufacturing process for our meter as we are traveling to Zimbabwe this May and needed to manufacture 35 meters. This presentation will detail the steps made to redesign the power sense module as well as baseplate redesign and manufacturing process leading up to our Zimbabwe site team trip.

4:00 PM ***Paxton Ministries Site Drainage***
Frey 110 Presented by Brenden Good, Kimberly Cunningham, and Eric Weaver

Paxton Ministries, located in Harrisburg, PA, is a Christ-centered, nonprofit organization providing affordable housing and support services to adults in need, many of whom are challenged with poverty, mental illness, or intellectual disabilities. Currently, there are drainage and temporary flooding problems that occur following appreciable rainfall events from a storm drainage pipe discharging onto their property. The flooding submerges the tennis court area on the property, and the stormwater drains to a sinkhole location on the site.

The Collaboratory partnered with Paxton Ministries to investigate solutions for their site drainage problems. The project consisted of three phases: defining the problem, developing feasible alternatives, and designing a stormwater management solution. Defining the problem and developing feasible alternatives was completed during the 2017-2018 academic year. In the fall of 2018, two preliminary designs were generated to help Paxton Ministries understand their options to manage the stormwater, along with order of magnitude costs for construction.

Upon review of the preliminary designs, Paxton Ministries directed the team to develop a more detailed design for a long-term solution, identified as the Spring Creek Discharge Design. The design treats the stormwater for pollutants using Best Management Practices that include a sediment forebay and rain garden. Once treated, the stormwater is conveyed off-site by a 1,600-foot pipe and channel network that discharges nearby into Spring Creek. The team has prepared design drawings to construct the project and has submitted the drawing package to Paxton Ministries to allow for final design and permitting to be completed by a professional engineering firm, as well as refine the construction cost estimate to explore sources of funding for the project.

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4:20 PM ***Oakwood Hills Pedestrian Access***
Frey 110 Presented by Justin Witters, Adam Barley, and Treavor Moore

This year, the Oakwood Hills Pedestrian Access Team has been working with Rider Musser Development, LLC to expand their trail network with the creation of a pedestrian crossing of the on-site stream. The team has worked to determine possible options and assess them to find solutions that would satisfy the crossing criteria. In determining the most suitable option, the team has created a decision matrix, stream survey and conceptual Type, Size, and Location report to deliver our findings to Rider Musser.

4:40 PM ***Sight and Sound Remote Latching System***
Frey 110 Presented by Ben Schott, Brandin Dyche, and George Noble

The Sight and Sound Latch team is partnering with Sight and Sound Theatres in Lancaster, Pennsylvania to develop a remote-operated latching system for the theater to use in its shows. Sight and Sound Theatres produces Biblical-based musical performances, uses massive set pieces for visual displays and stages for actors to perform on. Sometimes these need to be connected together to complete the display. Currently, Sight and Sound uses hand operated latches to do so. Occasionally these latches are in hard-to-reach places or need to be operated at inopportune times. The goal of our team is to develop a remote latching mechanism which will eliminate the need for these hand-operated latches.

Our team began by looking at various latching mechanisms and ultimately decided to base our design on a common cabinet latch. The basic design involves having a pneumatic cylinder on one set piece which extends towards a latching mechanism on the other set piece which, connects to the cylinder rod and allows the pneumatic cylinder to pull the two set pieces together. For this use, we had to scale up the original design of the latch mechanism from a common cabinet latch and modify the design significantly. Using a computer modeling program, we were able to model the mechanism parts and, using 3D printers, we were able to produce plastic prototypes of our latching mechanism. After revisions were made based on these models, a prototype in steel was created.

This metal prototype was tested in different configurations and for reliability, wear, and strength. This led to more design changes and retesting. The final design was attached to real set pieces and it was confirmed that the latch functioned as desired.

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5:00 PM ***Sustainable Agriculture***
Frey 110 Presented by Lexi Bane, Daria Eshelman, and Isaac Underhill

The Sustainable Agriculture team is working with Sheltering Wings (SW), in Yako, Burkina Faso to troubleshoot and fix the currently installed aquaponics system. The team will deliver an operational procedure on how to build, run, and maintain an aquaponics system to Sheltering Wings, for use in their agricultural school. In order to fully understand how an aquaponics works to make suggestions to the current design, the team has developed a system prototype. The aquaponics system process starts with fish that produce waste, which contains high levels of ammonia. Using nitrifying bacteria that grow in the system, the ammonia is converted to nitrite, then to nitrate. This water containing the nutrients cycles from the fish tank, through a clarifier, into media beds where the plants are growing. The plants absorb the nitrates before the water is cycled back to the fish tank. The prototype design implements the use of two media beds with pea gravel arranged in a parallel configuration. The entire flow of the system runs by gravity until the water is pumped back up into the fish tank to cycle through again. The team plans to use and develop this prototype into a best practice aquaponics system. The team will then reproduce this system in Burkina Faso with the available materials and make modifications as necessary. In collaboration with SW, members of the community will be trained on how to build, run, and maintain an aquaponics system.