Bio-Itzá Reserve Eco-Cottages
Final Design Report

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Final Design Report

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Additionally, the team would also like to thank:

- Robin Steele, the team's Project Advisor, who has coached us through the entire project and facilitated design by introducing the team to eco-tourism experts as well as other professors and solar system advisors.
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Executive Summary

The Final Design Report not only serves to document the design of the Bio-Itzá Reserve Eco-Cottages, but to highlight all aspects of the project including the steps taken by the Eco-Engineers towards the final site design. This unique project required extensive community engagement work. The community engagement was accomplished through regular conversations with local stakeholders, a community workshop, on site conversations with rangers and local experts. The project began by identifying stakeholder groups and the project scope. Then, the team created low, medium and high cost options which were presented at a preliminary design review. After receiving client feedback, the team continued to design for a mixture of the options presented and developed the idea by reaching out to ecotourism experts. With a more developed plan, the team used models and calculations to validate the design presented in the intermediate design review. Immediately after the review, the team traveled to Guatemala to conduct a stakeholder engagement workshop and get feedback on the design from community members and clients. On the trip, the team also gathered geotechnical data and a site survey. In preparation for the final design, the team has used the lessons learned in Guatemala and continuous client communication to refine the design.

In addition to addressing the team's methodology, the report breaks the project down into the the engineering analysis of each subsystem. The civil section includes information on structural loading, foundation design, and the overall site layout. The water and wastewater section explains how a model was used to estimate the required rain catchment area and storage volume. The section also explains the current status of the existing septic system. The power section discusses the required amount of solar panels and batteries required to supply power to the desired electrical appliances. The final sections of the report discuss how the subsystems should be integrated and the cost breakdown of the project as well as the team's recommendations on future site design an the project's next steps. The appendix contains construction drawings and maintenance instructions. The project management component of the project is documented and supplemented by a work breakdown structure, project schedule, and budget.

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1. Introduction (PDR)

A. Project Background

The Bio-Itzá Reserve Eco-Cottages project involves upgrading the current Bio-Itzá Biosphere Reserve site, a 36 km^2 forest reserve located 24 km northeast of San Jose, Guatemala (Figure A1). The Bio-Itzá Association is an eco-cultural organization that runs a Spanish school and the conservation reserve as part of their mission to preserve the Maya-Itzá culture and promote education on tropical forest ecology. The reserve is ecologically important because it is a buffer zone between the rainforest in northern Guatemala that is threatened by the development around San Jose as well as slash and burn agriculture. The association is culturally important because the Maya-Itzá people, descendants of the Yucatan Mayas, were targeted during a Guatemalan genocide in the 1980's and their population is nearly extinct. According the the Bio-Itzá Association, there are only 15 people who speak Maya-Itzá. The reserve and school therefore offer an opportunity to preserve and protect both the Maya-Itzá culture and the ecology that their culture is centered around. Tourists, both families and students, can travel to San Jose from around the world and enroll in the Bio-Itzá Spanish immersion school. For an additional fee, tourists also have the option to travel to the Bio-Itzá Biosphere Reserve for a day trip or overnight experience. Both options include participating in Maya-Itzá rituals and learning about the medicinal properties of plants. However, the overnight experience additionally includes onsite accommodations, preparing authentic Maya-Itzá food, and cultural immersion activities like plant collection, hikes in the rainforest, and cenote showers. The overall purpose of the eco-tourism reserve is to act as educational experience to spread awareness for and to protect the Maya-Itzá culture and its deep connection to the plants and animals in the reserve.

The Bio-Itzá Association has faced challenges with securing consistent funding which has led the reserve to fall in and out of disrepair. In February 2018, the Bio-Itzá Reserve Eco-Cottages clients, Mike Hormell and Michelle Roark, traveled to the Bio-Itzá Biosphere Reserve and soon established funding for the reserve through the Resource Foundation. The clients' motivation for funding this project is rooted in a desire to promote eco-tourism to support the local Maya-Itzá community and preserve the Mayan knowledge of plant medicine and their language. Eventually, the clients want the reserve to generate enough revenue to run without outside funding. One solution that the clients have identified for more sustainable business practices is repairing the existing structures on the Bio-Itzá Biosphere Reserve and to design more luxurious guest cottages. The improved facilities may appeal to more eco-tourists and in turn develop a more consistent stream of revenue. With more revenue, the Bio-Itzá Association will be able to better meet its cultural, educational, and ecological goals.

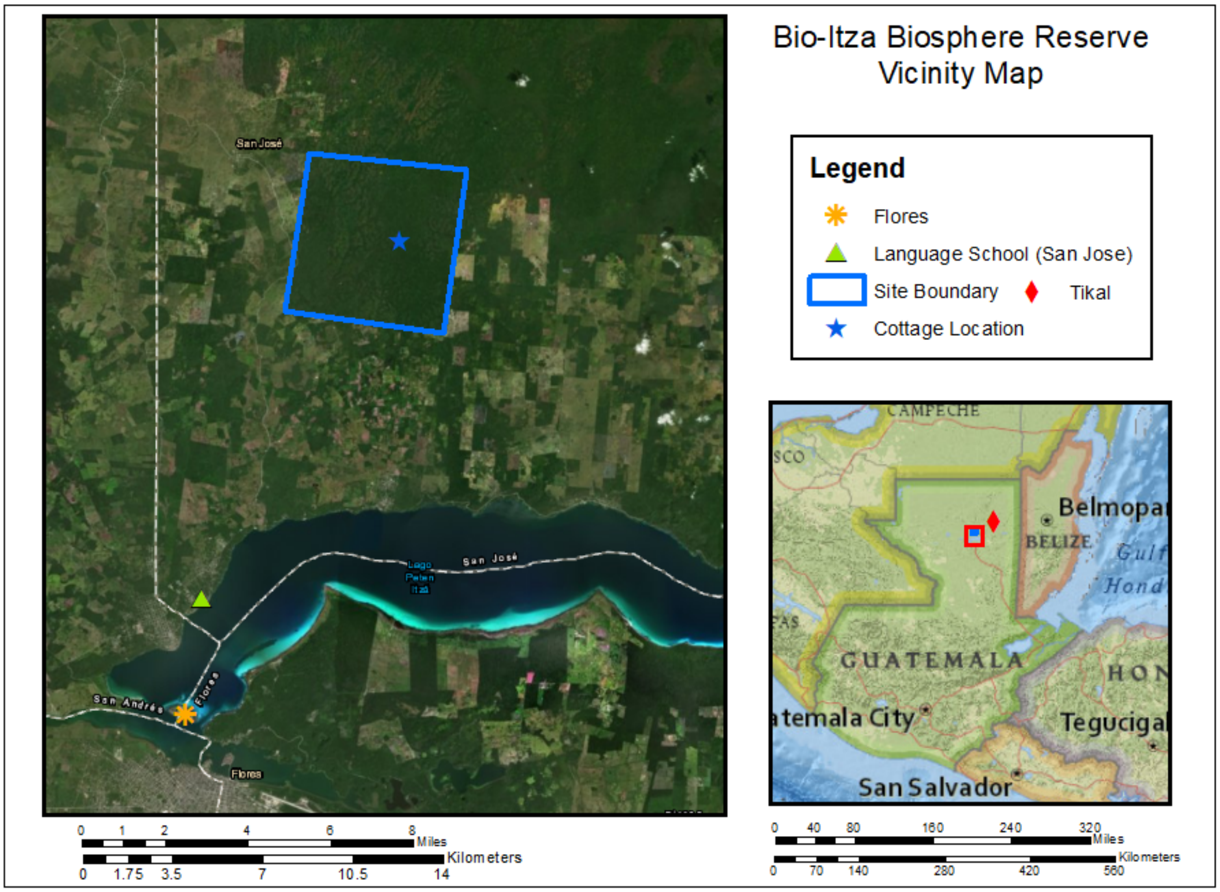


Figure A1: The Bio-Itzá Biosphere Reserve Vicinity Map. Created by Maggie Guinta and Spencer Schrandt in ArcMap, April 8, 2019

B. Project Overview

The purpose of the Bio-Itzá Reserve Eco-Cottages design project is to design and model a self-sustaining eco-village on the Bio-Itzá Biosphere Reserve. The team broke the project down into three technical subsystems that addressed water, power, and living accommodations as well as two project management subsystems to address community engagement and project logistics. Three preliminary designs with low, mid, and high cost options emerged as the initial ideas for the project and were presented at the preliminary design review (PDR). The design included a potable water system, a power generation system, plans for three additional cottages, and a walkway. The preliminary designs are explained in depth in the section titled Approach and Methodology: Initial Design and Refinement. Client feedback was used to identify new project criteria such as a site budget and creating the designs for marketing. The team also reached out to members of the Bio-Itzá Association to ensure that their visions were being represented and their feedback influenced the decision to create cottages inspired by tree-houses. Moving forward, the team researched popular eco-lodges and reached out to eco-tourists to determine what they deemed important in the design. Then, the team brainstormed all possible ideas for the interior, exterior, and amenities to make the project stand-out and narrowed down the ideas by feasibility. Finally, the information was presented to the clients and decisions were made on what features would fit within the cottage design scope.

The lessons learned from the PDR and subsequent project exploration were incorporated into the intermediate design review (IDR). Major design changes included adding full bathrooms to each cottage with an outdoor shower. The team also planned on replacing the roofs of existing structures for rain catchment and solar panel mounting. Additionally, the team planned to design a utility shed to house the water and power equipment and an outdoor pavilion as a space for education workshops and for additional rain catchment. After the IDR, the team traveled to the site in Guatemala where the team gained valuable insight from the community engagement workshop, conversations with the local community and the clients, and a site investigation. The site investigation provided elevation and bedrock data to influence the design of the site and the community engagement gave feedback on the IDR. Feedback from the community addressed the cottage designs, layouts, and building materials. For example, the rangers helped identify what native trees would be ideal for building, when the site experiences drought, problems with the septic system, and wants and desires not previously considered.

After the IDR and the site visit, the team has continued to design the site with feedback from community members and the clients used as design criteria. The following sections of the final design review (FDR) will detail out the specifications of each subsystem and the integrated site design. Ultimately the team decided on a collection of three cottages with rain catchment and off-grid power systems to best accomplish the community's conservation goals. With the development of the cottages, the team also has designed for building a power and water utility shed, a rain catchment and educational pavilion, and a walkway. Due to the large scope of the project, there were elements of the design that the team could not adequately address. These topics are covered in the Future Recommendations section.

C. Project Constraints and Considerations

Client Needs and Wants

The wants and needs of the client were very important to the progress and success of this project. In the beginning phases of the project, the team and the clients collaborated to create a client wants and needs table that can be seen in Appendix DI. This table encompassed the desired functions and features of the cottage design and site development at the beginning of the project. As the project continued, this table was adjusted to reflect the updated client needs and wants. When generalized, the wants and needs can be broken down into five main categories: Deliverables, Water Treatment, Power Generation, Cottage Construction and Design, and

Community Engagement. These categories were the main driving force behind the creation of our subsystems teams and influenced the scope of the project.

Scope

The scope of the design project was established through the clients' needs and wants for an easily-maintained, authentic Maya-Itzá experience and through an iterative approach of assessing the goals of the project. The goal of the initial project was to collaborate with both the clients and community members in Guatemala to develop a conceptual site upgrade that will appeal to eco-tourists and rangers while helping to restore and protect the reservation. Later, the team learned that is was also a goal to use the deliverables for the final project for marketing and fundraising for the future implementation of the project. With the goals of the project in mind, the following project scope was created:

- Design 3 cottage structures with the capacity to built 2 more
- Design a potable water system to deliver water to the cottages, kitchen, and bathroom
- Design a power system to run the water system, lights, fans, and a freezer
- Design an elevated walkway between the cottages as well as an area for a garden
- Conduct a civil survey of the cottage area for elevation data
- Conduct a geotechnical survey of the cottage area to determine bedrock strength
- Conduct a survey of the existing wastewater system and evaluate future options
- Conduct a community engagement workshop to reflect local culture, values, and materials
- Retrofit existing structures to accommodate new systems as needed
- Provide the following accompanying documentation:
    - Cost Estimation and Budget
    - Construction Drawing Set
    - Maintenance Plan
    - Proof of Concept
        - AutoCAD Files
        - Virtual Sketchup Model and Walkthrough Video
        - Physical Model of Site and Cottages
        - Design Calculations

Stakeholders

The outcome of the Bio-Itzá Reserve Eco-Cottage project largely depended on genuine community and stakeholder engagement from local community members, clients, reserve rangers, and potential users of the cottages. In order for the team to make useful and impactful designs for the Eco-Cottages, the team engaged in the Sustainable Community Development practices of community engagement participatory design. Some of the identified stakeholders were mapped out in Figure A2.

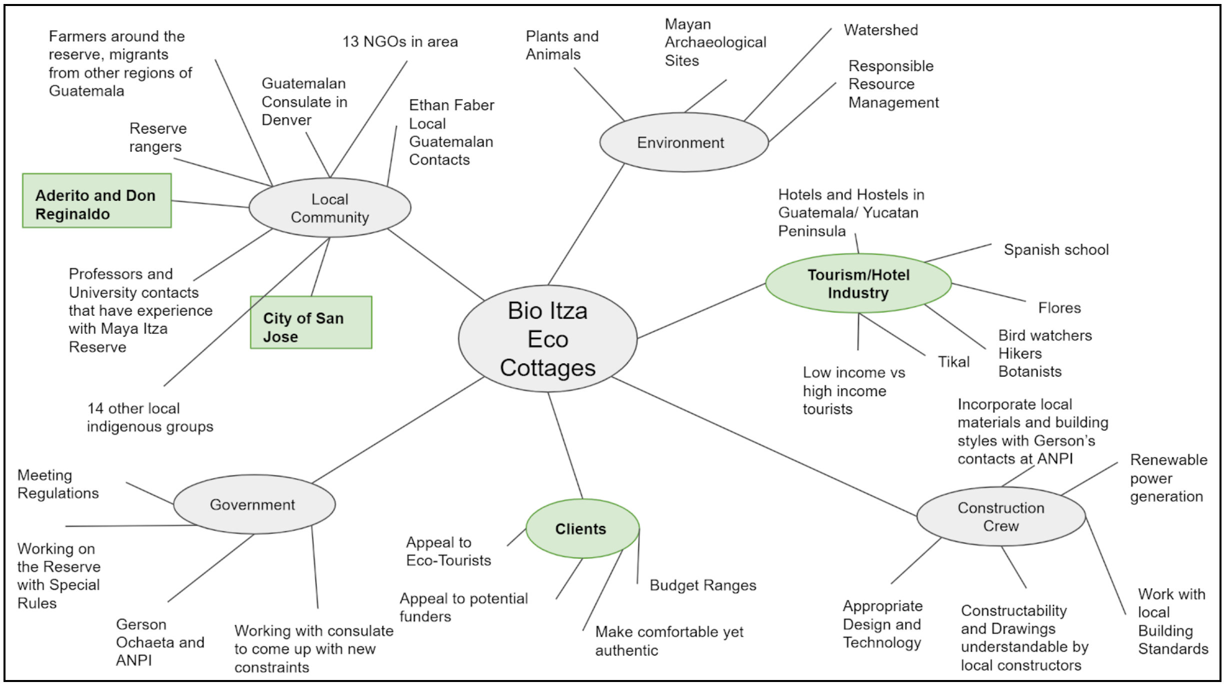


Figure A2: Stakeholder Actor Network

The team highlighted specific stakeholders that were necessary to engage with early and often in the project which include: clients, leaders of Bio Itzá Association (Aderito and Don Reginaldo), community members around San Jose, and the Guatemalan tourism industry. The other stakeholders in the figure were important, but communicated with less often than the main stakeholders. Communication with the primary stakeholders led to additional stakeholders including eco-tourists.

2. Approach and Methodology

A. Subsystems

The cottage design was divided into subsystems to better address the technical and business aspects of the project. Figure B1 shows the five subsystems and the main systems each subsystem addresses. The two business subsystems are the Project Management and Community Engagement subsystems. While the Project Management subsystem covers the teams budget, communication, and task assignment, the community engagement team communicates with contacts in Guatemala and developed the methods used to engage the community during the site-visit in Guatemala. The three remaining technical subsystems are the Environmental Systems, Power Systems, and Civil System teams.

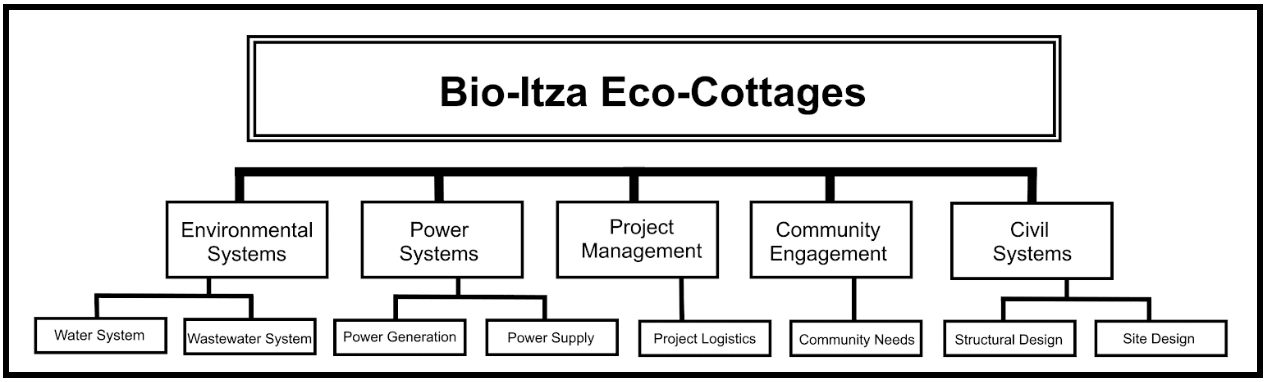


Figure B1: *Work breakdown structure of Bio-Itzá Reserve Eco-Cottage Project*

B. Initial Design and Refinement

In the PDR, the team proposed three options: a low, medium, and high cost site layout. Since the project was to create a layout for the site that would be able to help raise money for the reserve, the team was not given an initial budget. The team pitched the three options to the clients to ensure the a desirable final design was chosen. Each subsystem had there own low, medium, and high cost options that could be mixed and matched. The three site layouts included cottage location on the site, water models and power systems. The three proposed site layouts can be seen below in Figure B2 and examples of the cost options are shown in Figure B3.

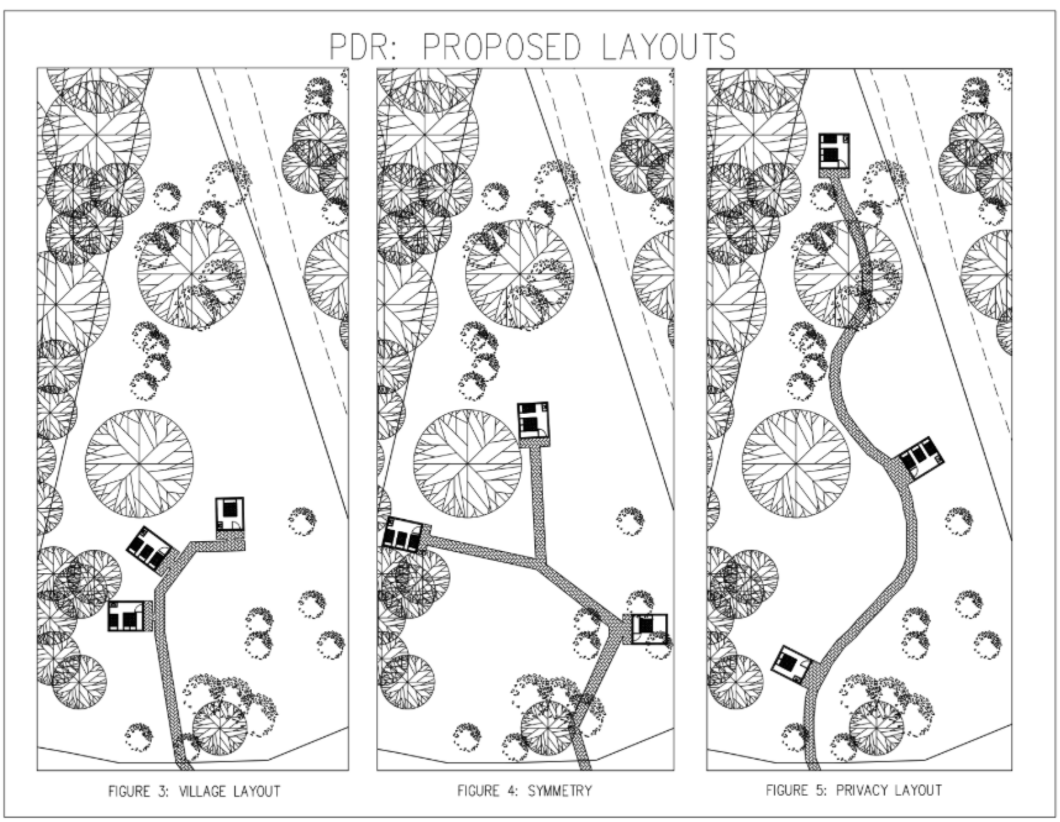


Figure B2: Initial Cottage Layouts

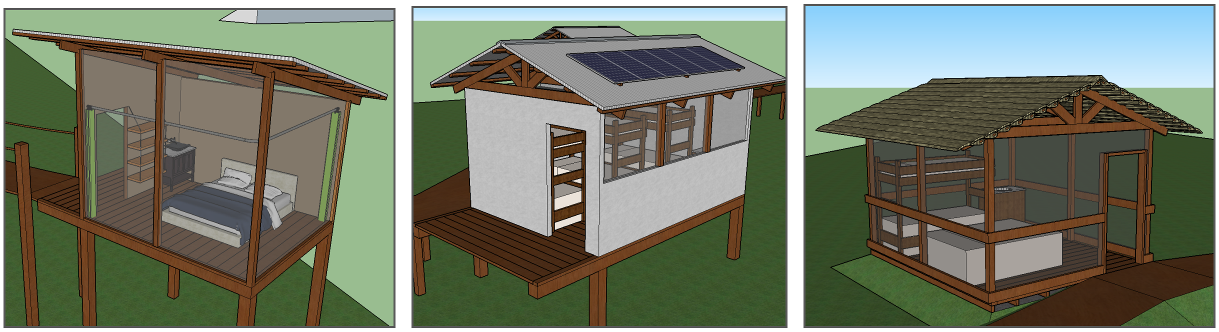


Figure B3: a, b, c: Original High, Medium, and Low Cost Cottage Options

The initial low cost design layout can be seen in the Village Layout in Figure B1. This option was designed to be the most inexpensive and the cottages were composed of a timber frame for structural support with screen wrapped around the building envelope (Figure B3.c). The roof would be composed of palm thatch leaves tied around purlins and to minimize structural requirements and material costs, the cottages would be built on grade. The water system would include a five foot tall PVC and cinder block frame with a large tarp draped over it that would act as the water catchment surface. The tarp would then attach to a gutter system with a collection filter that would remove any large debris. Using the potential energy and the height gain from the elevated tarp, the water would flow into storage tanks. Three new storage tanks, in addition to the existing storage tank, would be used to store all the water necessary for the site and would be pumped to the bathroom where a porous filter would be put in place. The cottage would not have any water supply attached directly. The power system would be an individualized model, where each load is fed by a separate solar panel, battery, and switch. This system would entail building a seperate system at every cottage which would decrease the necessary amount of wiring but could be more costly with future cottage additions.

The initial medium cost option was presented as the symmetry layout seen in Figure B2 and included a two, four, and six person cottage that were constructed out of timber and drywall (Figure B3.b). Screen windows would be installed to allow natural light and airflow into the cottages and a corrugated steel roof would be used to convey water to the gutters. The cottages would be supported on timber pile foundations five feet above ground and there would be raised walkways of equal height to the cottages to connect the structures. The water system would consist of a large pavilion-like structure with a catchment area composed of a corrugated steel roof and open sided shelter that would supply water to new and existing water tanks. The tanks would be placed on an elevated surface and will be routed to the water treatment system housed in the bathroom structure. This would include a UV disinfection system and a sediment filter. In addition to the catchment structure, the cottage roods will also serve as a water catchment system that would be routed directly to a tote that will be raised of the ground and placed on a small structure next to the cottages that will create enough hydraulic head to allow for sufficient water flow into the cottage sinks. The power system would be a dual centralized model where two large solar structures would feed the total power system. Each system would have its own battery backup, but would make security more difficult. The two structures would have reduced complexity of coordination and reduced wiring costs and each system would have a smaller loads.

The initial high cost option was presented as the privacy layout seen in Figure B2, and included a two, four and six person cottage that were constructed of timber and drywall (Figure B3.a). The exterior walls would be covered in timber siding and there would be screen windows to provide natural light and ventilation while keeping insects out. The roof would be composed of timber trusses with corrugated steel roofing to convey rainwater to gutters for catchment. The structures would be raised on ten foot tall timber posts that would be piled into the ground to support the structures. The cottages would be connected by ten foot tall raised timber walkways. The water system featured a large catchment area that would provide a shelter space that be utilized for community events. The gutters would flow directly into a treatment and storage facility housed in a wooden shed with an extended roof for additional catchment. A UV disinfection system would disinfect the water and remove sediment. A pump would be used to deliver hot and cold water to the cottages, bathroom and kitchen. The wastewater system will utilize the existing septic tank and grey water system. The power system would be a centralized system where one large solar area would be built and would act the central station where all loads on the site would be fed from. All solar panels and battery backup systems would be located at one centralized site and all wiring would lead from this location to the various loads. This would allow for easier security, reduced the need for panel boards, and easily allow the addition of new solar panels for power expansion. All of the power equipment would be located in one centralized location so that only one additional storage unit would need to be built.

Moving forward, the team and the clients decided to utilize a combination of each of the subsystem designs and refined the details based on cost point and optimal designs. A few aspects of each design stuck out to the clients but the higher cost options seemed more appealing. The clients also decided that the proposed costs were lower than expected and were urged to increase the luxury or “wow” factors. The was achieved by setting a budget range of $30,000 to $100,000 for the site. The team then researched amenities and design factors that could be used for fundraising and would attract the most tourists. This included making connections with the ecotourism industry and asking tourists what would turn them away from our site and cottage accommodations in Guatemala. Some major features that were repeatedly mentioned included in-suite bathrooms, heated water, fans, and patios. From the new budget criteria and the ecotourism advice, each subsystem focused on refining the details on the current design. The proposed site plan was updated with the new locations of the cottages, water system, power system, and utility shed in the IDR. The specific details of the IDR can be reviewed in the Intermediate Design Report. This report was then presented to the clients and taken to Guatemala for feedback.

After travelling to the site in Guatemala and meeting with the community, the team redesigned aspects of the cottages. The roof material became a topic of debate during the site visit that required the team to discuss options with almost all of the stakeholders to determine if the existing structures should be retrofitted with corrugated steel or left as thatch. The engagement revealed that tourists wanted the thatch roofing because it was more authentic, but the rangers who lived on the site wanted anything but thatch because thatch requires a lot of maintenance. Ultimately, the team decided to not replace all of the existing thatch roofs but to create new structures with metal roofs. This and other topics are discussed more in detail in the Community Engagement section. The feedback from the clients and community members on the IDR was used to create the FDR. The notable changes that will be covered in the following sections include a re-evaluated water and power system layout, a walkway roof for optimal solar panel placement, outdoor showers in all cottages, and an updated pavilion and utility shed combination. The IDR plans have also been developed to greater detail and the calculations have been redone to reflect the new design plans.

C. Community Engagement and Sustainability Criteria

Since the beginning of the project, the team spoke via WhatsApp or email with community leaders and stakeholders (Don Reginaldo and Aderito of the Bio-Itzá Association and Gerson of AMPI) once every two weeks. Through these conversations, the team was able to understand more about the project and the project site. However, the team struggled to understand the history, purpose, and current use of the reserve as well as the many needs and desires of community members in the area. Augustana University professors that bring students down annually were also consulted to discover more about the community, the site, and the student groups that stay there. Additionally, the team consulted with Ecotourism experts like travel writers and Ecotourism trip organizers to better understand the preferences and amenities that are important to ecotourists.

When the opportunity to travel to Guatemala presented itself, Community Engagement team members made plans to learn from the community members and foster strong collaborative relationships through a community meeting and design workshop. Before going to Guatemala, the team members consulted with humanitarian engineering faculty Dr. Juan Lucena, Dr. Beth Reddy, and Ethan Faber to get advice and guidance for organizing and leading a community meeting. The team was then able to create the framework for the community meeting and speak to local contacts to ensure the meeting would be productive for all parties involved. The team's main Guatemalan contact, Aderito, is a community leader in the association that invited and encouraged participation from the Maya-Itzá community.

Thanks to the help of Aderito, translators, the local organizers, and the genuine engagement and concern of the Bio-Itzá Association, the community meeting went very well. Community leaders, reserve rangers, Spanish teachers, and other Association members (shown in Figure B4) participated and engaged in conversations about the reserve, the community, eco-tourism, the cottage and subsystem designs, and other project opportunities. Through the community meeting, the team gained important insights into critical components of the project like to roofs and Bio-Itzá Association members were happy to have a community gathering and discuss new ways to promote and preserve their reserve and culture. A local engineer was present who helped identify design features that were not feasible or that could be simplified. He also answered question about the availability of local labor and resources.

Figure B4 a,b: Community Engagement Workshop

Despite the team's best efforts to learn about the site beforehand, there were some things that could not be communicated over the phone or through email. From the moment the team arrived at the reserve, Don Regginaldo and Aderito expressed their deep love for the environment and the Mayan culture through their actions. In the workshop, the community members in attendance reinforced this responsibility to the environment and their culture. The team found that people did not want to cut down healthy trees to clear space or for the building materials of the new cottages. While learning about the history of the reserve, the team found that security has been an issue with items being stolen when no rangers are on the site. Moving forward with the design, the team determined there was a need to secure solar panels and the cottages to ensure nothing would be stolen. During the workshop, one of the most interesting takeaways was the sentiment towards palm thatch roofs. For the rangers and elders in the community such as Don Reginaldo, there was a sense of pride associated with the existing thatch roofs because it was very difficult to create and maintain these structures and demonstrated local knowledge of the plants and the appropriate times to harvest the palms. While these key stakeholders were proud of their roofs, they asserted that they wanted the new cottages to have metal roofs. Metal roofs would represent the modernization of the site and it would require much less maintenance. The team initially wanted to create more thatch roofs because they were visually appealing for tourists and showed off the knowledge of the community. The team was then able to factor this information into the final design. When speaking directly with the rangers, the team found that if rangers are not comfortable with a new piece of technology, they will not use it. This idea was later translated into a maintenance plan to give the rangers clear instructions for each new addition to be installed. The last major takeaway was all of the concrete on the site was poured by community members. People were very proud of their work and they did a quality job. Moving forward, the team wanted to play into the communities strengths and provide an opportunity for local job creation in creation of new structure's foundation.

After the community meeting, the team went to the reserve where they conducted topographical, geotechnical, solar, and water surveys. On the reserve, rangers and community leaders taught the team about traditional medicine, the history of the reserve and Association, the existing structures, traditional building materials, and the challenges and opportunities of building in the jungle. Through the workshop and the on site communication, the team gained critical insights for the project and local community members made important design decisions about the eco-cottages and other aspects of the project. The team also learned more about the next steps for this project and the important non-technical components to ensure this project contributes to a sustainable stream of funding for the protection of the reserve and the continued efforts of the Association.

As a humanitarian engineering project, it also required special efforts to be taken so that the project empowers the community and is designed with the community as the center. Throughout the design process, the team used Bridger and Luloff's Criteria (B&L Criteria) for sustainable community development to guide the decision making process [7]. The B&L Criteria are as follows:

1. Local Economic Diversity
2. Self-determination
3. Reduction of Energy & Materials
4. Biodiversity
5. Social Justice

While each criterion covers a different aspect of the project, they work in conjunction to maximize benefits to the community. Through the community engagement plan and continued conversation, the team believes that the following designs maximize opportunities to use local materials and labor while protecting the biodiversity of the site and minimizing waste creation. The site visit also confirmed that the community has extreme ownership over the project and they are working in collaboration with the clients. Finally, the team believes the project is addressing the social justice criterion by allowing the Mayan people to preserve their right to their culture and language indirectly. The success of this project will help generate revenue to help the community keep the reserve as a method of preserving their culture. The team recommends that the project continue to be evaluated against these criterion.

D. Site Investigation

Before traveling to the project site, the team relied on Google Earth images, the client's pictures of the site, the information and measurements of the site that local contacts were able to share, assumptions on amount of sunlight, USGS meteorological data, and satellite images. Once on the site, the team was able to gather topographical, geotechnical, solar, water, and wastewater data as seen in Figure B5. The team brought surveying equipment including a Pentax Total Station, a Solar Pathfinder, and a tripod from the United States to Guatemala. The team used rudimentary tests using a long piece of rebar and a hammer to understand the soil, the subsurface, and the bedrock. The rebar was hammered into the ground at many points around the potential construction area and the number of blows and depth of the rebar were recorded and correlated to soil strength and depth of bedrock. The survey and geotechnical data were then built into a model to show areas ideal for supporting a building. The team also investigated the existing water tank and septic tank and learned that it does not have a bottom. Conversation revealed important information about the precipitation patterns and occupancy at the reserve.

Figure B5: Team Collecting Septic Tank and Topographic Data

3. Engineering Analysis

A. <u>Civil Systems (Structural, Architectural, Drainage)</u>

<u>Introduction</u>

The civil subsystem included the design and analysis of the three cottages, walkways, pavilion, and the site layout.

<u>Cottage Design</u>

From the start of the project, the team worked with the clients and project stakeholders like Don Reginaldo and Aderito to brainstorm and formulate ideas for the design of three cottages. The clients desired more luxurious and private hotel-like accomodations than the current existing structures of the guest house and community center. On a phone call with stakeholders, Don Reginaldo's dream of having tree houses was expressed. For the Preliminary Design Report (PDR) the team proposed three different cottage designs at three different price points. The designs included cottages with the floor level on ground level and two different cottages lofted on pillars. The clients selected a timber lofted cottage to be raised 8 feet off the ground with an outdoor patio. The team spoke with architects and brainstormed with community members at the community meeting and settled on a final design.

The final design, seen in Figure C1a-b, is three - eight foot lofted cottages on timber pillars with bracing. In each cottage, stairs will lead up to a small, covered entry porch from the raised wooden walkway. The cottage designs include a patio on the bedroom level and a raised deck to look over the tree line of the forest. The roof of the cottages will be peaked with exposed timber framing to allow flow of the hot jungle air. Rangers, community members, and clients expressed a desire for new buildings to have more modern roofs that are easier to maintain and harbor fewer insects; therefore, the new cottage roofs will be made of corrugated metal instead of traditional thatch. The roofs are important pieces of the water collection system and should be selected with the recommendations outlined in the water section. An important aspect of the sustainability of the project is that the timber will be locally sourced, sustainably harvested wood from a local business that the Bio-Itzá Association has worked with before.

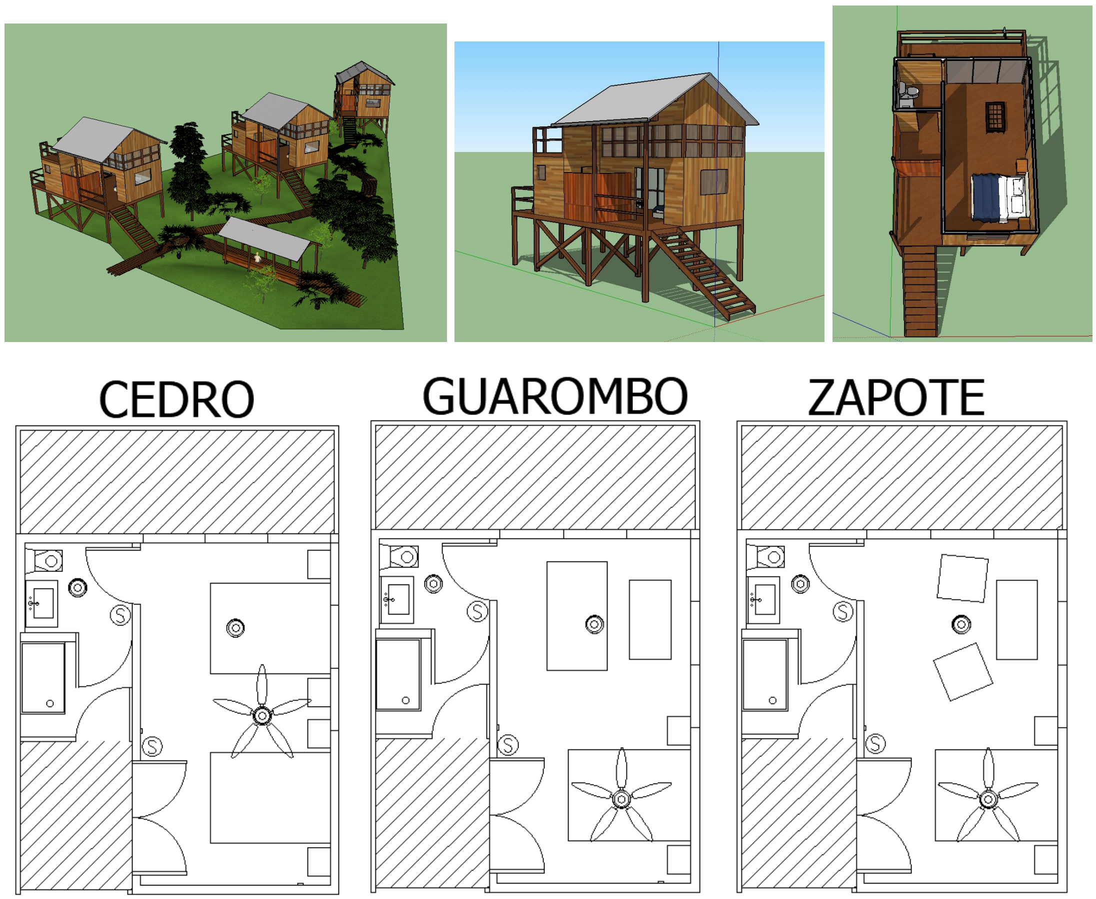


Figure C1 a,b,c,e, f, g: Cottage Design and Layouts

Figure Ce-g show three proposed layouts each named after important medicinal plants in the region. (Cedro, Guarumbo, and Zapote mean mahogany, trumpet leaf, and chiclet and are all trees found on the reserve). The Cedro and Guarombo cottages will accommodate up to four people, and the Zapote cottage will accommodate two people. The first cottage will have two queen beds, and seating areas on the patio (none inside). The second cottage will have two twin beds that can be pushed together to make a king bed and a queen size futon in the sitting area. The third cottage will have two twin beds that can be pushed together to make a king bed and a sitting area. Each cottage has a bathroom with a toilet, sink, and outdoor shower.

Open Air Pavilion Design

In order to accommodate other subsystems, the team designed an open air pavilion with a utility closet to house the battery backup system, as seen in Figure C2. This open air pavilion can be used as a gathering space for visitors and a learning space for herbal medicine courses and spanish language courses. The roof is sufficiently sized to capture all the rainwater for the site with gutters emptying into the storage tank. The floor of the pavilion will be poured concrete. The structure will be timber framed with trusses supporting a corrugated metal roof.

Figure C2: Pavilion Design

Walkway Design

To connect the cottages to the existing site and structures and to protect visitors from the mud during the rainy season, the team proposes building a timber, raised walkway, seen in Figure C3, through the garden and the site to the public restrooms, the open air pavilion, and connecting to other existing pathways on the site. In the garden area of the site, the team designed a covered area for visitors to sit and enjoy the garden area, protected from the sun. This covering is also in the sunniest area of the site so it will be the ideal place for solar panels to be mounted. The entire length of the walk way will be lit by individual, off-main-grid solar lights; this information is included in the power section.

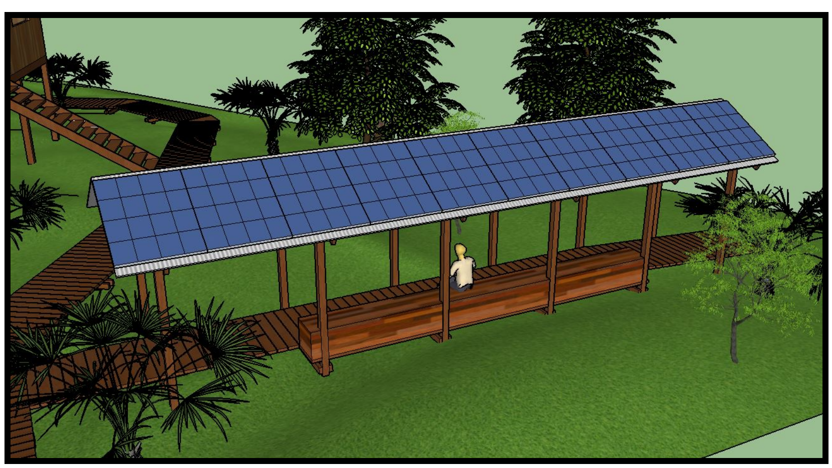


Figure C3: Walkway Design

Material Selection and Framing

In the Preliminary Design the team proposed several different potential cottage designs made from different materials. From the design reviews, the clients expressed the desire for timber framing and natural looking wood paneling. This desire was strengthened and reaffirmed by the local community when the team went to the site. The Bio Itzá Spanish School recently had an addition made from locally sourced, sustainably harvested wood with timber framing and paneling, seen in Figure C4. The community is very proud of the beautiful new structure and approved of the idea of cottages being designed to look similar and be made from the same materials.

Figure C4 a,b: Bio Itzá Spanish School

While on the site, the reserve rangers shared their knowledge of trees and timber and suggested that the framing be made out of the local, strong hardwoods like the Madre de Cacao or the Chico Zapote. The structural framing of the cottages will be made from these strong woods; while the paneling will be made from a lighter weight wood like a spruce. The properties of these materials are shown in Table C1.

Table C1: Wood Properties

Wood Properties							
	Density (kg/m^3)	Modulus of Rupture (N/mm^2)	Modulus of Elasticity (N/mm^2)	Impact Bending (m)	Crushing Strength (N/mm^2)	Janka Hardness (N)	Source
Madre De Cacao	1025.3	119.8	6629.2	0.65			[1]
Chico Zapote	1040	184.2	20410		85.8	13210	[2]
Spruce	425	70	11030		38.2	2270	[3]

Load Calculations

The civil subsystem performed load calculations on the timber framed, lightly-loaded cottages for the Bio-Itzá Reserve. This analysis included calculating the potential load combinations for the structures using ASCE 7, which is an industry standard that includes different guidelines for determining the many different loads on structures and the design requirements for different types of structures [4]. These calculations are essential for sizing the structural members and for determining load exerted on the soil.

The team used ASCE 7, Section 2.3.2 Equation 4 because this yielded the greatest factored load, this formula is shown in Equation C1 [4].

Equation C1:

$$1.2D + 1.6W + L + 0.5(Lr \text{ or } S \text{ or } R)$$

Dead Loads:

The dead load calculations were based on assumptions on the timber framing and the weight of the materials; these assumptions are in Appendix BIA.

Wind Loads:

The wind loads were calculated using predicted 100 year return period peak gust wind speeds at a height of 10 m in flat open terrain from ASCE 7 [5]. In the Peten region of Guatemala the wind speed is predicted to be around 90 miles per hour as seen in Figure C5.

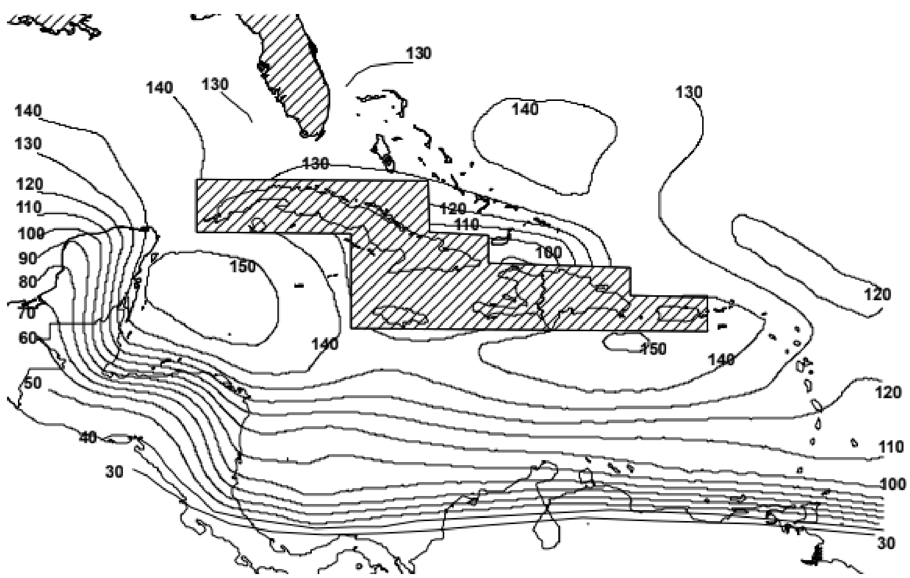


Figure C5: Peak Gust Wind Speeds [5]

The calculations are also based on the cottages profiles. Using ASCE 7 and the current cottage design and profile, the calculations in Appendix BIB were produced. Equation C2 shows how total Wind Load was calculated using ASCE 7 [4].

Equation C2: Wind Load

$$W = p_s = \lambda I p_{30}$$

Live Loads:

The live loads were calculated based off of ASCE 7 guidelines for occupancy and use [4]. The calculations for live loads are shown in Appendix BIC.

Rain Loads:

The rain loads will be zero because the sloped roofs will not accumulate precipitation.

Total Factored Loads:

The total factored load for a single lightly loaded timber frame cottage is about 84,200 lbs. This factored load considers the dead load (or predicted weight of building materials), the live load (or the combined weight of occupants and furnishings), the wind load (determined from average wind speed in the region and the building profile), and the rain load (which is zero because sloped roofs do not allow for rain water accumulation). The individual loads are included in Table C2.

Table C2: Unfactored Component Loads and Total Factored Load

D, Dead Load	6,055 lbs.
L, Live Load	72,713 lbs.
Lr, Roof Live Load	5,835 lbs.
W, Wind Load	815 lbs.
R, Rain Load	0 lbs.
Total Factored Load (from Equation C1)	**84,200 lbs**.

The factored load of 84,200 lbs means that the footings or foundation of the cottages will have to distributively support 84,200 lbs.

Geotechnical Considerations

The first semester, the team did not have much empirical data about the site or information about the geology. The team was aware that karst topography, or limestone which is prone to sinkholes and dips in the bedrock, is prevalent in the region. To understand more about the site geology and to help decide where to construct the cottages, when the team went to Guatemala, the team conducted some rough geotechnical surveying by hammering a ½” rebar into the soil and recording the number of blows and depth to reach bedrock. From this, the team was able to determine that bedrock was fairly close to the surface throughout the site. The team also identified where topsoil was weaker and where there were dips in bedrock and avoided those spots of the site for the cottage layout. The three positions for the proposed cottages were selected based on strength of soil and client and community preference to be close to the tree line. The team also identified two other potential positions for cottages that can be constructed in the future; these are indicated in the site layout in Appendix A.

The team consulted with several professional engineers and civil engineering professors and received feedback based off rule of thumb that a three to five foot deep timber pile foundation should be sufficient for the eight-foot raised, lightly loaded cottages. The foundation for the cottages will be timber piles from the columns that go five feet into the ground surrounded by poured concrete. Due to the shallow bedrock, a hole approximately two feet in diameter will have to be excavated into the bedrock about three to four feet, depending on the depth of the topsoil. The timber pile will be placed vertically in this hole and then filled with concrete, as seen in Figure C6.

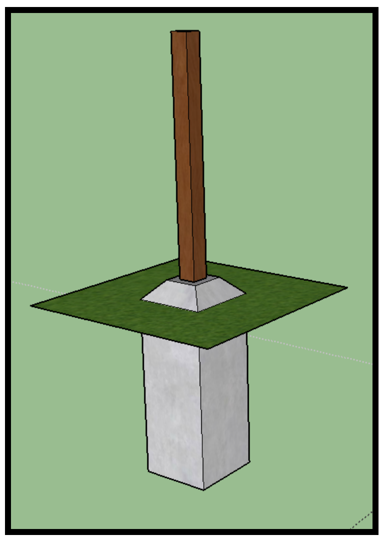


Figure C6: Foundation Illustration

<u>Structural Analysis</u>

The team did a preliminary structural analysis of the timber framing plan using the Portal Method and the calculated lateral and vertical loads. This analysis was done to verify the bracing, connections, strength of the materials, and to predict how these loads will affect the cottages. The result of the analysis verified that the framing should be sufficient for the predicted loads. These calculations are shown in Appendix BID.

B. Water and Wastewater Systems

Introduction

For this site, a rain catchment system has been proposed due to the abundance of rainfall as well as the difficulty of conducting a geotechnical investigation and drilling a well in the karst subsurface. The following steps were taken to design the rain catchment system and each step is summarized in the following sections:

1. Making educated assumptions about:
    a. Seasonal precipitation and drought expected at site
    b. Seasonal site occupancy
    c. Range of development supported by site
2. Calculating the required water demand
3. Modeling different combinations of catchment areas and storage capacities to support the proposed site and future expansion
4. Hydraulic analysis of the water conveyance system
    a. Verifying that catchment system will convey water by gravity
    b. Selecting fixtures such as toilets, showers, and sinks
    c. Sizing pipes and fittings
    d. Calculating required pump based on total dynamic head
5. Validating the treatment processes selected
6. Selecting water heating method for the cottages
7. Modeling internal plumbing of the cottages
8. Modeling septic system
    a. Anticipated loading from system used and sizing pipes
    b. Evaluating capacity of current septic system

The following sections are categorized as 'Assumptions,' 'Method,' and 'Design.' The following sections also include a discussion on installation and system maintenance. Future recommendations for the water system are available in the Future Recommendations section.

Assumptions: Precipitation, Occupancy, Phases of Construction

Precipitation data for the site was assumed to match data from a weather station at Tikal, Guatemala approximately 30 kilometers northeast from the site [8]. The precipitation data used, shown in Table W1, included precipitation data in millimeters for every month from 1988 to 1998 as well as the number of days of observed precipitation per month. The data was validated by comparing yearly rainfall across all years, calculating the mean yearly rainfall, and finding a relative standard deviation of 0.06. This value indicates that rainfall did not significantly vary during the 10 years and shows that the dataset provides an accurate representation of monthly rainfall for the time period. The data was also compared to more recent precipitation data from the Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (INSIVUMEH) online database [9]. Though this data is thought to be less reliable due to frequent gaps in weather station data, the data from the weather station in Flores, Guatemala from 2011, 2012, and 2017 is comparable to the data estimated from Tikal in 1988 to 1998. A weather website in Flores was used as a third weather source for comparison [10]. The comparison of the Tikal data, Flores ISIVUMEH data, and reported values from Flores is provided in Appendix BII.A.

Table W1: Precipitation Data Summary [8]												
Average Monthly Precipitation in Tikal for 1989-1997 Water Years												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (in)	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6	8.6	6.5	4.9	3.7
Average (mm)	58.7	30.2	22.5	67.6	110.4	139.2	97.7	116.8	217.7	165.3	124.5	95.0
# Rain events	10.3	5.0	3.6	6.3	6.9	11.6	13.8	12.3	18.1	15.4	12.2	11.2
Consec. Drought Days	6	12	17	9	7	5	4	2	1	1	2	5

The validated precipitation data was summarized to find the average precipitation per month and the average number of rain events per month. The analysis showed that the region of Guatemala gets about 49 inches of rainfall per year with a dry season from February to April and a wet season from September to October. In Table W1, the yellow cells indicate the dry season and the red values indicate the wet season. The table also shows the average number of consecutive drought days expected per month. The amount of days without rainfall is important to the design because the system we need to be able to store enough water to meet the demand even during droughts.

Site occupancy was assumed based on community conversations and design criteria. The cottages are design to accomodate 10 people per day and the site is capable of supporting up to 30 large group guests in the dormitories. The rangers and the clients also stated that the site be designed to support cottage or large group guests, but never a combination of guest types. The site is to be managed by a minimum of three rangers at all times with an additional ranger for every three cottage guest or every five large group guests as well as a maintenance staff member when any guests are on site.

The site has historically experienced high occupancy from February through April (due to the favorable weather and blooming flowers), low tourism from August through October (due to the rainy season), and average tourism in the remaining months. The fluctuation in tourism creates a need to map the expected number of guests and rangers for “High,” “Medium,” and “Low” tourism levels. These monthly models of site occupancy can be viewed in Appendix BII.B and are summarized in Table W2. The occupancy was calculated by first calculating the maximum number of guests in each group per month (Appendix BII.B, Table 4). Then, the percent occupancy was calculated as the estimated number of monthly guests per month over the maximum number of monthly guests. The occupancy numbers appear to be low, but are more favorable after considering the calculation method.

Table W2: Occupancy Summary					
Tourism Level	Large Group Guests		Cottage Guests		Rangers
	% occupancy	Total people/month	% occupancy	Total people/month	Average/day
High	22%	195.0	49%	148.0	6.3
Medium	12%	110.0	45%	136.0	5.8
Low	6%	55.0	41%	122.0	5.6

The final assumption made was the the site will be expanded in the future to accommodate two additional cottages and that the construction of the site will take place in stages to ensure that the site is continuously operational. For example, the rangers would like to begin constructing the cottages and water system immediately; however, the site occupancy may not be up to the modeled occupancy for several years because it will take time for the site to gain popularity. Therefore, the complete rain catchment area does not need to be built immediately and can be built in stages. Eventually, the site owners would like the site to support not only the modeled occupancy, but also future users. This was done by creating another occupancy map assuming four additional cottage guest could stay at the site.

Assumptions: Water Demand

Water Demand is the amount of water that will be required by the site for its intended use and is used to calculate the catchment area and storage capacity required in the rain catchment system. The design demand of the system assumes that each guest and ranger will use 24.8 gallons of water per day, as shown in Table W3. The flow rates were taken from the specification sheets of selected fixtures (Appendix CII). The maximum water demand created by each user group was calculated by multiplying the water demand per person by the maximum number of people in each user group, Table W4. To adjust the monthly demand by occupancy, the maximum monthly demand in Table W4 was multiplied by the expected monthly occupancy in Table W2.

Table W3: Community System Per Person Water Demands				
Fixture	Demand per Unit	Unit	Unit/Person/Day	Demand/Person/Day
Toilet - Dual flush, solids	1.6	flush	2	3.2
Toilet - Dual flush, solids	1.1	flush	4	4.4
Showerhead	1.5	min	5	7.5
Sink/Hygiene	1.2	min	6	7.2
Drinking Water	1	day	1	1
Dishwashing	0.5	meal	3	1.5
Total Demand Per Person				24.8

Table W4: Max Water Demand			
System	Number of People (Max)	Demand (GPD)	Demand (GPmonth)
Cottages			
1	2	37.8	1134
2	4	75.6	2268
3	4	75.6	2268
Community System			
Rangers Usage	10	248	7440
Cottage Guests Usage	10	59	1770
Large Group Usage	30	744	22320
Total	50	1051	31530

Method: Model for Tank and Catchment Area Sizing

The fluctuation in rainfall and site occupancy means that the rain catchment area and tank can not be accurately sized by looking at yearly rainfall and yearly usage. Instead, a model was created to assess how water storage will fluctuate throughout the seasons and which combinations of tanks and rain catchment area can provide sufficient water storage to meet the water demand and avoid depleting the system during droughts. Full model documentation is available in Appendix BII.B and the full model will be given to the clients for future use. The initial model of the system showed that system would need to be massive to accommodate the lack of rain and high tourism level in February, March, and April. The team therefore proposes a dry season reduction during these months where guests would be encouraged to reduce their water usage. The dry season reduction was built into the model using a dry season reduction value equal to 0.83. This value is equivalent to users reducing their shower, sink, and dishwashing demand by 25%. The dry season reduction can also be obtained by asking guests to only flush solid waste.

Figure W1 shows the user interface of the final model. A higher resolution image is provided in Appendix BII.B. The cells in yellow indicate values that were manually entered. The dry season reduction, maximum occupancy, occupancy adjustments are all assumptions that were previously discussed in this report. The roof efficiency was set at 90% with the assumption that the roof will be made of corrugated metal [11]. Then, the catchment area and required water storage capacity were determined by varying the area and capacity until a combination was achieved. A successful combination did not drain the tank in any of the months and maintain the minimum volume to resist drought. This was indicated by a complete year without a water deficit and the level in the tank at the end of the month exceeding the drought storage needed. The model in Appendix BII.B also shows that the model was continued for three years. A combination of 24,000 gallons in tank capacity and 3520 square feet of catchment area achieves a system capable of meeting demand year-round. This assumes that the system start-up will occur in September and that the system will not be used for drinking water in the first month. It also assumes that the catchment area of each cottages will equal 340 square feet and that 2500 square feet of additional catchment area will need to be provided.

User Input Table 1: Catchment and Demand		
Catchment and Storage		
Roof area of Pavilion	2500	sf
Roof efficiency	0.9	-
Storage Capacity	24000	gal
Demand		
Max Rangers	10	people
Max Cottage Guests	10	people
Max Large Group Guests	30	people
Dry Season Reduction	0.83	-
All Demand assumptions in "Demand Control" Tab		

User Input Table 2: Occupancy Adjustment Summary			
Occupany Adjustment			
Adjust Anticipated Occupany in Monthy Model Tab; See Summary Below and use Monthly Model to interpret			
	Tourism Level		
Group	High	Medium	Low
Large Group	0.22	0.12	0.06
Cottage Guests	0.49	0.45	0.41
Rangers	0.63	0.58	0.56

User Input Table 3: Monthly Senarios		
Month	Dry Season	Tourism Level
Jan	No	Medium
Feb	Yes	High
Mar	Yes	High
Apr	Yes	High
May	No	Medium
Jun	No	Medium
Jul	No	Medium
Aug	No	Low
Sep	No	Low
Oct	No	Low
Nov	No	Medium
Dec	No	Medium

	Start up model (tank empty)											
Start Month:	Sep											
Year:	2022											
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
System Use:	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Catchment Calculations											
Rainfall (in)/month	8.6	6.5	4.9	3.7	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6
Collection Capacity (gal)	16983.8	12836.6	9676.8	7307.0	4542.2	2369.8	1777.4	5332.1	8491.9	10861.7	7504.5	9084.3
	Demand Calculations											
Total Usage	0.0	6225.4	7870.4	7870.4	7870.4	8649.6	8649.6	8649.6	7870.4	7870.4	7870.4	6225.4
	Tank Model											
Tank Level at beginning (gal)	0.0	16983.8	23594.9	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7
Tank Level at end (gal)	16983.8	23594.9	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7	9744.7
Water Deficit (gal)												
Drought storage (gal)	0.0	207.5	524.7	1311.7	1574.1	3459.8	4901.4	2594.9	1836.4	1311.7	1049.4	415.0

Figure W1: Model to Size Catchment Area and Tank

Figure W2 provides an overview of the water system needed to meet the demands of two more cottages. In this model, 4770 square feet of catchment area will be required along with a 26000 gallon tank. If the roofs of the five cottages (each 340 square feet) are used, then 3000 square feet of additional catchment area would be needed.

User Input Table 1: Catchment and Demand		
Catchment and Storage		
Roof area of Pavilion	3750	sf
Roof efficiency	0.9	-
Storage Capacity	26000	gal
Demand		
Max Rangers	12	people
Max Cottage Guests	18	people
Max Large Group Guests	30	people
Dry Season Reduction	0.8	-
All Demand assumptions in "Demand Control" Tab		

User Input Table 2: Occupancy Adjustment Summary			
Occupany Adjustment			
Adjust Anticipated Occupany in Monthy Model Tab; See Summary Below and use Monthly Model to interpret			
Group	Tourism Level		
	High	Medium	Low
Large Group	0.22	0.12	0.06
Cottage Guests	0.49	0.43	0.41
Rangers	0.75	0.69	0.67

User Input Table 3: Monthly Senarios		
Month	Dry Season	Tourism Level
Jan	Half	Medium
Feb	Yes	High
Mar	Yes	High
Apr	Yes	High
May	Yes	Medium
Jun	No	Medium
Jul	No	Medium
Aug	No	Low
Sep	No	Low
Oct	No	Low
Nov	No	Medium
Dec	No	Medium

	Start up model (tank empty)											
Start Month:	Sep											
Year:	2022											
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
System Use:	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Catchment Calculations											
Rainfall (in)/month	8.6	6.5	4.9	3.7	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6
Cottage Collection (gal)	4921.4	3719.7	2804.1	2117.4	1316.2	686.7	515.0	1545.1	2460.7	3147.4	2174.6	2632.4
Community Building Collection	19058.5	13675.3	10309.1	7784.4	4839.0	2524.7	1893.5	5680.5	9046.8	11571.4	7994.8	9677.9
Collection Capacity (gal)	23979.9	17395.0	13113.2	9901.8	6155.2	3211.4	2408.5	7225.6	11507.5	14718.9	10169.4	12310.3
	Occupancy Adjustment											
Large Group	6%	6%	12%	12%	12%	22%	22%	22%	12%	12%	12%	6%
Cottage Guests	41%	41%	43%	43%	43%	49%	49%	49%	43%	43%	43%	41%
Rangers	67%	67%	69%	69%	69%	75%	75%	75%	69%	69%	69%	67%
	Demand Calculations											
Large Group Usage (gal)	0.0	1364.0	2728.0	2728.0	2455.2	3868.8	3868.8	3868.8	2182.4	2728.0	2728.0	1364.0
Cottage Guests Usage (gal)	0.0	1309.8	1368.8	1368.8	1231.9	1255.5	1255.5	1255.5	1095.0	1368.8	1368.8	1309.8
Rangers Usage (gal)	0.0	5952.0	6200.0	6200.0	5580.0	5356.8	5356.8	5356.8	4960.0	6200.0	6200.0	5952.0
Total Usage	0.0	8625.8	10296.8	10296.8	9267.1	10481.1	10481.1	10481.1	8237.4	10296.8	10296.8	8625.8
	Tank Model											
Tank Level at beginning (gal)	0.0	23979.9	26000.0	26000.0	25605.0	22493.0	15223.3	7150.7	3895.2	7165.2	11587.3	11459.9
Tank Level at end (gal)	23979.9	26000.0	26000.0	25605.0	22493.0	15223.3	7150.7	3895.2	7165.2	11587.3	11459.9	15144.4
Water Deficit (gal)												
Drought storage (gal)	0.0	287.5	686.5	1716.1	1853.4	4192.4	5939.3	3144.3	1922.1	1716.1	1372.9	575.1

Figure W2: Model to for Future Expansion

Method: Hydraulic Analysis and Pump Sizing

To model the hydraulics of the water system, it was first drawn in AutoCAD, as shown in the Construction Drawings provided in Appendix A. The layout as well as elevation data was used to collect information on the lengths of pipe needed, the fittings required, and the change in elevation between components of the system. To make the entire water system easier to visualize, it was broken down into the collection, distribution and sewage disposal systems which each have the components summarized in the Table W5.

Table W5: Summary of Pipe Network			
System	Component	Beginning	End
Collection			
Catchment	Main	Cottage 1	Storage Tank
	Cottage 1 to main	Cottage 1	Main
	Cottage 2 to main	Cottage 2	Main
	Cottage 3 to main	Cottage 3	Main
	Pavillion East side to main	Pavillion East	Main
	Pavillion West side to main	Pavillion West	Main
Distribution			
To Treatment	Storage to Pump	Storage tank	Inlet of Pump
	Pump to Filter	Pump outlet	Filter Inlet
Treatment	Treatment System	Filter Inlet	UV system Outlet
Treatment to Structures	Main	UV Outlet	Cottage 1
	Main to cottage 1	Main	Cottage 1
	Main to cottage 2	Main	Cottage 2
	Main to cottage 3	Main	Cottage 3
	Main to Kitchen	Main	Kitchen
	Main to Bathroom	Main	Bathroom
Sewage Disposal			
Septic System	Septic Main to Existing Main	Cottage 1	Main @ Bathroom
	Existing Main	Bathroom	Septic Tank
	Cottage 1 to septic main	Cottage 1	Septic Main
	Cottage 2 to septic main	Cottage 2	Septic Main
	Cottage 3 to septic main	Cottage 3	Septic Main
	Ex bathroom to existing main	Bathroom	Main @ Bathroom
	Kitchen to existing main	Kitchen	Main before septic tank

The collection component relies on gravity to transport the water from the catchment areas downslope to the underground tank. The ability for the system was validated by confirming that the water would flow from high elevation to low elevation. The main pipe was also design so that it would be buried a minimum of 6 inches and travel downhill at 0.5% slope to the storage tank. The slope requirement was used to determine the depth at which the tank would be buried.

The three segments rely on a pump to pressurize the treatment system and distribution system to transport water and therefore were used to size a pump. The first step in designing pumps is to estimate the maximum required flow rate by finding the flow rates required by each appliance and estimating a reasonable flow rate so that multiple appliances can be used at once. In the segment through the treatment system, the UV system requires a flow rate of 15 gpm or less. Therefore, the flow rate is constrained at 15 gpm. In the segment to the cottages, the flow rate was designed so that all three toilets could flush at once with the two shower. This amounts to a flow rate of 14 gpm and the design flow rate is 15 gpm to add a factor of safety. Table W6 summarizes the flow rates of appliances.

Table W6: Flow Rate Required [5]			
Appliance	Required Flow Rate (gpm)	Qt	Total (gpm)
Faucet	2.5	3	7.5
Toilet	3	3	9
Showerhead w/ flow restriction	2.5	2	5
Max Demand			21.5
The probability of all of the appliances running at once is low, design to meet shower, toilets, plus			
Design Demand			15

The pump was designed by calculating the power requirement which is based off of the total dynamic head of the system. The total dynamic head was calculated by summing the static head difference, frictional head losses, and pressure requirements. The static head is the difference between the pump height and the outlet height at the tallest cottage. The values used are based on the survey of the site. The frictional losses were accounted for by estimating the material and size pipe network components and the Hazen-Williams Equation. The design pressure, 50 psi, was calculated based on the fixtures in Appendix CII. The head calculations are provided in Appendix BII.C. Finally, the power required for the pump was calculated as shown in Table W7. The calculated power requirements and the design flow rates were used to select the ¾ HP pump shown in the construction drawing package.

Table W7: Horse Power Requirements					
System	Flow Rate (gpm)	Total dynamic head (ft)	Pump Efficiency	Power Req. (HP)	HP Design
From tank to cottage 1	15	280.7	0.7	0.745	3/4 HP

<u>Method: Treatment Validation</u>

Guatemala does not have water treatment regulations. Instead, the system will be designed off of the requirements set by the Colorado Department of Public Health and the Environment (CDPHE) Regulation 11 [12]. Though there is no water quality information from rainwater in Guatemala, the primary concern will be viruses and bacteria that contaminate the rainwater when it falls on the roofs. Because this water is exposed to the atmosphere, it is classified as surface water. The Surface Water Treatment Rule in Regulation 11 requires 4-log (99.99%) removal of viruses, 2-log (99%) removal of *Cryptosporidium*, and 3-log (99.9%) removal of *Giardia lamblia*. The turbidity or suspended solids should also be favorably below 1 Nephelometric Turbidity Units (NTU) but no greater than 5 NTU. The UV system specified will achieve 4-log removal of viruses and the 3-log removal of cryptosporidium and giardia if the system is properly maintained [13]. The turbidity removal will also be achieved by the 5 micron filter [14]. The filter, along with the leaf guards installed on the gutters, will also improve the performance of the UV system if it is installed prior to the UV unit. The specification sheets of the UV system and sediment filter are provided in Appendix CII.

The treatment validation was prepared by comparing the regulation standards against the specifications of the selected UV system and sediment filter. It was also compared to treatment requirements in Texas, a state that allows personal rain harvesting [11]. The Texas Manual on Rain Harvesting provides an overview of acceptable treatment methods. Although the equipment specifications match treatment requirements, there is a need to test the water quality over time. The system should be sampled and tested to ensure proper removal of turbidity, viruses, and bacteria. Sampling could also identify other contaminants of concern like zinc. See construction sets for proposed sampling point locations.

Method: Septic System Loading Calculations and Existing Septic Tank Evaluation

Appendix BII.D contains the calculations required for the septic system. The existing site has a septic tank that was previously thought to have a capacity of 20,000 gallons but was investigated to have an actual capacity of about 6400 gallons. Investigating the site also revealed that the septic tank does not have a bottom. Because the geography of the region is karst and the dominant soil type (mollisols) has a high infiltration rate, the sewage is likely infiltrating directly into the ground without being detained. The lack of detention means that the sewage is not being treated. The septic system also lacks a soil treatment area or leach field which means that the layer of bacteria that treat sewage in typical septic systems is not present. Ideally, the septic tank should be replaced immediately as the sewage is infiltrating directly into the ground and causing contamination; however, the project is unique in that the site is not located near any wells, is not heavily used, and the site is not in a country that has the infrastructure that makes it easy to replace the septic system. The septic system were therefore evaluated for how long it could be inplace before it would need to be capped due to the volume of sludge. USing the loading rates in the calculation section, the tank could be used for 60 years before it would need to be pumped or capped. This allows plenty of time for a more viable solution to be constructed.

Calculations were also completed for sizing an ideal septic tank. To design a septic tank system, the required capacity and the sludge storage capacity required must first be calculated. The capacity of a septic tank is equal to the daily flow into the septic tank, 920 gpd, (which is equal to the water demand multiplied by the maximum number of users) multiplied by the desired retention time. In the United States, septic tanks are designed with a retention time of 3 days [15]. To calculate the sludge storage capacity, the number of people using the site, the desired number of years before sludge removal, the rate of sludge accumulation, and a climate dependant sludge digestion factor are multiplied together. Typically, septic tanks are pumped every 10 years, a person produced 6.6 gallons of waste per year, and the sludge digestion factor in a warm climate is 1 [15]. After adding the required capacity and the sludge storage capacity required, the required septic tank capacity is estimated to be 4000 gallons and should have soil treatment area. Other options include installing a bio-digester or installing a greywater system to reduce the amount of waste water being discharged to the septic tank. These options are discussed more in the Future Recommendations section.

Design: Catchment Roofs

To meet the catchment area requirements, the team also proposes designing to meet catchment area required for future use with the cottage roofs and by reroofing the existing community building and constructing an outdoor pavilion with a roof. The community building roof currently has an area around 1500 square feet. Therefore, the pavilion roof will need to be 1500 square feet to meet the 3000 square feet of additional area needed for future use. The clients expect that it will take time to meet the modeled occupancy levels and that the roofs can be built in phases. Therefore, the pavilion and cottage roofs should be connected to the system first with a total catchment area of 2520 square feet. This is less than the modeled catchment area required (3520 square feet). Therefore, the community building roof will need to be replaced before full site occupancy is achieved and the system is exhausted.

The dimensions of the roofs are provided in the construction drawings in Appendix A. The quality of the roofing material will greatly affect the quality of water collected because the roof is the starting point of all water collection. To prevent contamination, each roof should be smooth, angled, made of inert material, and periodically cleaned. The team recommends that corrugated Galvalume (55% aluminum and 45% zinc-alloy coated sheet steel) be used to roof each rain catchment structure. The zinc coating on the galvanized metal will seal the metal and prevent rusting. The team recommends coating the roof in a NSF 61 approved sealant or testing the water quality from the roof to ensure low zinc concentrations in the water.

Design: Storage Tank

The team proposes a water system design that anticipates the future expansion. Therefore, a 26000 tank should be built. This tank has been called out in the construction drawings in Appendix A. It should have interior dimensions of 22 feet by 20 feet by 8 feet deep and each wall (all sides, bottom, and top) should be made of concrete poured 1 foot thick. The tank will also need to be buried two feet. The resulting area that will need to be excavated will be 24 feet by 22 feet by 12 feet deep. Upon construction, different dimensions can be used, but the same volume will need to be achieved. The bottom of the tank should also be graded slightly so that the lowest point in the tank is in the corner closest to the utility shed. In case of unexpected water surges, a 3 inch overflow pipe should be connected to the tank at the top of the tank and drain water away from the tank.

Design: Collection System

To catch the water running off of the roofs, 5 inch or comparably sized PVC or vinyl gutters will be installed. For the cottages, a gutter will be installed along the roof edge for three of the four sides of the structure and the gutters will be sloped to direct flow to a common low-point where there will be a 2 inch downspout. The pavilion will have gutters along the two longest sides with a downspout on each side. Refer to the Utility Plan in the construction drawings to locate the downspout on each structure. To increase the longevity of the system and prevent unnecessary particles from entering the water tank, leaf guards will be placed in the gutters. In the absence of leaf guards, ¼ inch mesh screens can be fit around a wire frame to create a mesh box and placed on the downspout. A first flush diverter will also be installed along each downspout to prevent debris from entering the storage tank.

A water main will run from the furthest cottage directly to the storage tank. The main pipe will have a diameter of 3 inches while the downspout pipes will have a diameter of 2 inches. The main pipe will be buried 0.5 ft below ground surface at the furthest cottage and will slope 0.5% to just below the top of the tank which is buried 2 feet below ground surface. The downspout pipes will connect the main using a flow through tee and the main will connect to the tank through a water-tight inlet. The fittings and pipe lengths are called out in the construction drawing sets.

Design: Treatment and Pump

The water will be treated and then distributed to the cottages, kitchen, and bathroom. The distribution system will require a pump to displace the water to the cottages. Both the pump and the treatment system will be placed in the utility shed under the pavilion. The pump will be connected to the tank via a 1 ¼” pipe and then will pump the water first through the sediment filter and then through the UV system. The pump, filter, and UV system have all been sized to be compatible with the 15 gpm flow rate and will achieve the required sediment and bacteria removal to use the water for drinking water. The system will also include bypasses for system maintenance and sample taps to monitor the water quality both before and after treatment. The system can be visualized using the water system details in the construction drawing set.

Design: Distribution System

After passing through the treatment system, water will flow past a pressure gage and switch into a water main connected to the system fixtures. The system will be pressurized. The pressure switch will be set to a maximum of 60 psi and a minimum of 15 psi so that the pump will turn on when the pressure drops below 15 psi in the system and turn off when the pressure is above 50 psi. 15 psi is the minimum pressure required for the fixtures to operate properly and 50 psi is the maximum operating pressure for the sink. The pressure drop will drop in the system when a site user turns on water in the cottages, bathroom, or kitchen. The construction drawing set shows the size and lengths of the pipes used in the distribution system.

Design: Solar Water Heater

Through many meetings with the clients, the desire for heated water for the showers was discovered. The team initially proposed using point-of-use water heater to meet this goal. However, after further research it was determined that the power demand for this type of water heater was much too high for the current power system. The final design decision to create warm water was to use solar water heaters attached to the roofs of each cottage. These water heaters work as a passive system that self circulates warmer water as the sun heats it. This design was ultimately selected because it will achieve the desired water temperatures, while not adding any additional load on the power system.

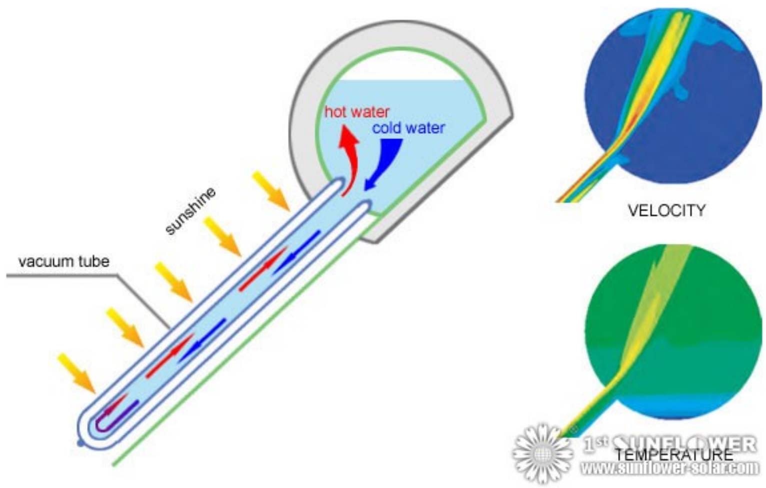


Figure W3: Solar Water Heater Diagram

<u>Design: Wastewater System Recommendations</u>

Wastewater is conveyed from the cottages by being drained from the sink, shower, and toilet into a new 4 inch PVC sewage main. The new main then connects to the existing main located near the bathroom. Finally, a small sewage line connects from the kitchen to the existing sewage line using a tee. To work properly, the sewage should discharge into the septic tank where the solids settle out and leave behind a liquid layer at the top of the septic system. When the tank fills to a certain level, the liquid top layer is decanted through a pipe network to a leach field, Figure W4. At the leach field, the septic water is percolated over a large surface area of permeable soil through a system of pipes with small irrigation holes. This process works to treat the water because it allows a microbial colony to thrive in the top layers of the soil and the microbes consume the carbon and nutrients found in the wastewater. As part of the maintenance of this system, the solids in the septic tank need to be pumped out, dried, and deposited in a landfill every 10 years. However, the existing system does not appear to have a treatment mechanism like a leach field. Instead, the sewage will likely percolate into the bottomless tank and into the groundwater below. This solution is not recommended as the best option; ideally, the site would rebuild a septic tank immediately and pump it out as needed or invest further investigation into other treatment options like a biodigester.

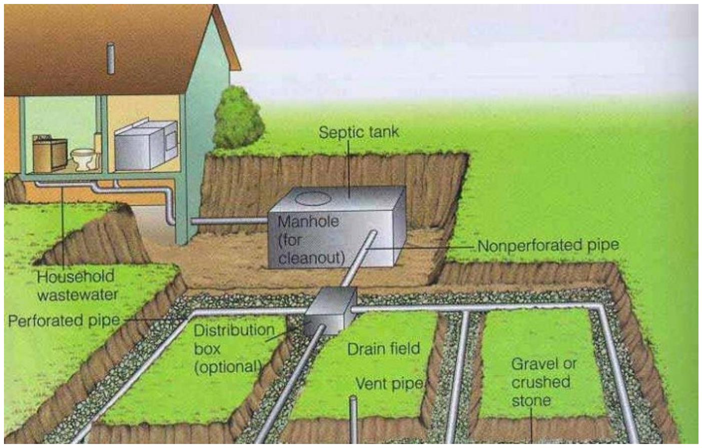


Figure W4: Septic and leach field system diagram [16]

C. Power System

Introduction

One of the desired final deliverables for this project was a renewable power system that could feed the various appliances on site. The power subsystem team then proceeded to determine the best method to design such a system. Through client communication, consultation with various experts, and individual research done by the team, it was determined that the best and most efficient design would be to create a solar array that would power the site. This would be backed up by a battery system bank that would power the site and reduce the intermittency issues associated with power.

Initially, it was determined that the site would be split into two centralized systems, where two separate solar arrays would be constructed with battery backup. One system would feed the north side of the camp, while the other would feed the south. This was the chosen design up until the team visited the site in Guatemala. After surveying and gathering solar data, the team determined that the best course of action would be one solar location centralized in the camp. Surveying indicated that the optimum solar harvest occurs farthest from the tree line which surrounds the site. The issue arose that there would be no structure in this location and an additional building would need be designed to hold the solar panels at the optimal location. The team decided to build a covered walkway which would hold the solar panels and create another shaded space for tourists to lounge. The main centralized system will then be fed into a utility shed which will house the electrical components of the system. From the utility shed, the power will feed back out into the site and will power the three cottages, the various existing structures, and the utility shed.

System Setup

The system will contain ten solar panels that will be mounted atop a bridge structure (See Walkway Design in the Civil section on page 21). See solar panel sizing calculations below on page 40. See power recommendations on page 44 section for solar panel installation. The panel array wiring will then feed downward, directly into the ground. The PVC conduit that houses the wire from the panels will be buried approximately 1 foot into the ground. This will be buried in the same trench as the water piping; but the two systems will be buried at least 1 foot apart, partly for safety, but also to leave adequate space for future work.

The power line will then be fed through the site to the utility shed (See the CAD model). This power line will then be fed into a cable splitter that will feed a 2500W 24VDC-120VAC converter and an MPPT point charger. The converter will feed into a two way manual switch. The MPPT charger will feed into the battery bank array, which will contain 18 130AH batteries connected in parallel. Battery sizing calculations can be seen below in the battery array sizing section on page 40. The batteries will feed into the same manual two-way switch that the converter feeds into. This switch will act as the manual switch from power generated by the solar panels to battery generated power. The switch will then feed into a 12 pole panel board. Details of this portion of the design can be seen in the details of the CAD model.

A model of the 12 pole breaker can be seen in figure E1 This breaker will feed every device on site. Each dwelling will act as a singular circuit, and thus each will be tied to a singular 5A circuit breaker. The calculations to determine breaker size can be seen below in the panelboard calculations section. The panel board will be earth grounded outside of the utility shed. A solid copper rod with a 3/4 inch diameter and 8 ft length will be hammered into the ground and a copper grounding wire will feed from the internal grounding of the panel out to the rod. From the panel, the wires for the cottages will all be fed through one conduit. These conduits will branch off and feed each of the individual cottages. Another conduit will feed the guest house. A third conduit will feed the utility shed itself. A fourth conduit will feed the four remaining buildings: the bathroom, kitchen, ranger station, and the community center.

Other Features Which are not Connected to the Grid

In addition to the solar panels and appliances, there will also be singular solar lights that will line the raised walkways between the cottages. Each of these lights is powered by its personal solar panel and internal battery backup. The solar lights will be placed along the raised walkway, staggered on either side with each light sitting 4 feet apart. With a total walkway length of 335 feet, this would entail 168 solar lights. Also, the ¾ horsepower pump located in the utility shed will be powered by a separate 130AH battery. When the battery runs low, it can simply be exchanged with one of the batteries in the existing array located in the utility shed. This will allow the battery to recharge, while ensuring constant power to the pump.

Calculations

Power/Amperage Demands and Solar Array Sizing

The demand calculations determined the total power (in watts) and the total number of amps the system would require. All calculations for the demand were completed assuming an AC based power system, despite generation being done in DC. This was done because all of the devices will run on AC due to the greater availability of AC devices in Guatemala. The calculations can be seen in the Table E1 below.

Table E1: Power and Amperage Demand Calculations

Description of Appliance	Qty	Volts	Amps	Watts Each	Total Watts	Hours/ Day	Batteries WHR	Hours/ Day	Complete System WHR
AC Appliances				V x A	Qty x Watts		T Ws x hrs		
Ceiling Fan	12	120	0.625	75	900	8	7200	12	10800
Freezer	1	120	0.625	75	75	14	1050	24	1800
Lights	50	120	0.1	12	600	5	3000	6	3600
Outlet	3	120	2	240	720		0	3	2160
UV system	1	120	0.5	60	60	4	240	9	540
Total			19.63		2355		**11490**		**18900**

Table E1 above lists every device that the system is expected to directly power. The Amps column lists the total amps, the Total Watts column lists total wattage that the entire site would require. These are measurements done assuming that all devices on site are running. The solar panels found are rated at 290 Watts maximum output. This means that the site, in order to meet the wattage requirement of 2355 W, would need at least 9 panels:

Equation E1:

$$2355\ W / 290\ W = 8.1\ Panels$$

The team decided to add an extra panel to leave some extra space in the design as well as leave extra power to be diverted to charging the battery array. Ten panels will produce 2900 W:

Equation E2:

$$290\ W * 10\ Panels = 2900\ W$$

The power converter has efficiency of 90%, so after conversion from DC to AC, the panels will be generating 2610 W for the site when all panels are generating maximum output:

Equation E3:

$$2900\ W * 0.9\ \% = 2610\ W$$

The first Hours/Day column in Table E1 depicts the number of hours the various devices are expected to run during the night, before the solar panels begin generating. The second column lists the total number of hours the different devices are expect to run during the day. The totals at the bottom are measurements of Whrs or energy expected to be consumed in one day.

The first column is used to determine the amount of energy the batteries will be expected to handle in one night, and the second column is used to determine how long the batteries could sustain the site in the event of no solar. Both these will be explored later in the Battery Array Sizing section of the calculations.

The amperage calculations are primarily important in the role they play in safety as well as the panel board sizing, which will be explored further in the Circuit Breaker Size Rating/Panelboard calculations section.

Battery Array Sizing

The battery array size is an important calculation because it is the method the team used to determine the number of batteries that would be needed in order to power the site when no power is present. Table E1 (Power/Amperage Demands and Solar Array Sizing) lists the site as needing 11490 Whrs of energy when there is no solar power generation. The batteries are capable of producing 1560 Whrs of energy, as seen in Equation E4 below.

Equation E4:

$$130\ AH * 12\ V = 1560\ Whrs$$

The following calculation shows the number of batteries required if the site only needs 11490 Whrs, as seen in Equation E6 below.

Equation E6:

$$11490\ Whrs / 1560\ Whrs = 7.4\ batteries$$

Equation E6 indicates that the site requires at minimum 8 batteries. However, one of the requests of the clients was that the site be capable of running via battery backup alone. Looking back at Table E1, the third column lists the expected Whrs of the entire site at 18900 Whrs. Equation E7 indicates that the site requires at least 13 batteries in order to supply power for an entire day.

Equation E7:

$$18900\ Whrs / 1560\ Whrs = 12.1\ batteries$$

The team also wanted to determine what the optimal amperage draw from the batteries would be. At 2400 W (rounded up from 2355, see Table E1), a 12 volt system would require 200 A, as seen in Equation E8 below.

Equation E8:

$$2400\ W / 12\ V = 200\ A$$

From the specification data, the team determined that the system would work best if run with 18 batteries. This would require that each battery only generate 11.1 A, as seen in Equation E9 below.

Equation E9:

200 A / 18 batteries = 11.1 A

The team agreed that this was a reasonable amperage to draw from the battery array. 18 batteries will generate 49,680 whrs of energy, as seen in Equation E10 below.

Equation E10:

*1560 Whrs * 18 batteries = 49680 Whrs*

Equation E10 indicates that when the batteries are all at full charge, they will be capable of sustaining the site for approximately two and a half days without solar. It should be noted that this would only occur when the site was at maximum capacity.

Circuit Breaker Size Rating/PanelBoard Sizing

PANEL: P-BIO											
VOLTS: 120/208V								MOUNT: WALL			
AMPS: 100A								AIC: 22K			
PH/WIRE: 1PH/3W								LOCATION: UTILITY SHED			
CKT	**Trip**	**Circuit Description**	**CONDUIT**	**Poles**	**A**	**B**	**Poles**	**CONDUIT**	**Circuit Description**	**Trip**	**CKT**
1	5A	COTTAGE 1	2 #12 AGW; #12 GND (1/2" C)	1	363	60	1	2 #12 AGW; #12 GND (1/2 C)	BATHROOM	5A	2
3	5A	COTTAGE 2	2 #12 AGW; #12 GND (1/2" C)	1	363	230	1	2 #12 AGW; #12 GND (1/2" C)	RANGER STATION	5A	4
5	5A	COTTAGE 3	2 #10 AGW; #10 GND (1/2" C)	1	363	355	1	2 #12 AGW; #12 GND (1/2" C)	COMMUNITY CENTER	5A	6
7	5A	UTILITY SHED	2 #12 AGW; #12 GND (1/2" C)	1	405	180	1	2 #12 AGW; #12 GND (1/2" C)	KITCHEN	5A	8
9	5A	GUEST HOUSE	2 #10 AGW; #10 GND (1/2" C)	1	230				SPACE		10
11		SPACE							SPACE		12
TOTAL POWER (W):					2549						
TOTAL AMPS (A):					21.24166667						

Figure E1: Panel Board Schedule

The above picture depicts the panel board schedule, which can also be seen in the CAD details. To size the panelboard, the total amperage from Table E1 was taken and multiplied by 1.25 as recommended by the NEC.

Equation E11

$$19.625A * 1.25 = 24.53$$

This indicates that the panel had to have at least a 25A frame. A 100A frame was selected based on commercial availability. The other important calculation that the panel board shows is the wire sizing calculation. The wires were sized based off voltage drop calculations done. The grounding wire and conduit were then selected based on the conducting wire size chosen. This can be seen in the conduit section of the figure.

The circuit breaker sizes were determined in much the same way as the panel board size. To determine the size the total wattage of the circuit was divided by 120 VAC, and that current was multiplied by 1.25 as advised by the NEC. For example, the calculations for the guest house are as follows.

Equation E12

$$230W / 120V = 1.91A$$

Equation E13

$$1.91A * 1.25 = 2.4A$$

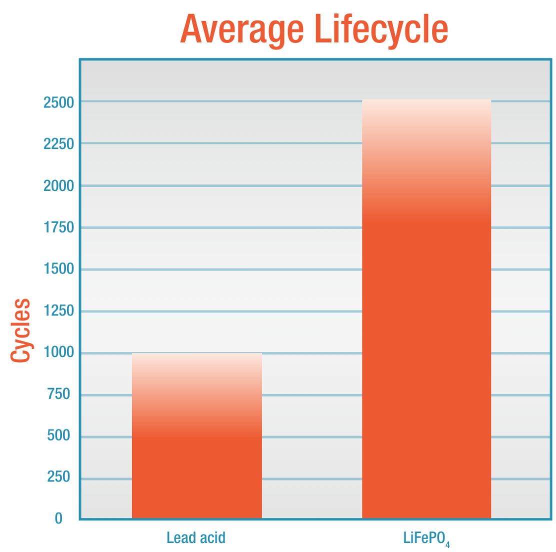
A 5 Amp trip unit was selected because it is the most commercially available.

Voltage Drop Calculations

All voltage drop calculations were run with respect to keeping all voltage drops between 3-5% as recommended by the NEC. [6]

Battery Selection

With the power demand calculations and battery sizing complete, the next step was to address what type of batteries to use. As chemical composition of the batteries varies, so do the physical properties of the batteries, therefore, some batteries will be more advantageous over others for this application. Some of the batteries considered for this project were lithium ion, deep cycle lead acid, and phosphorus lithium ion. Ultimately Lithium-ion batteries have been chosen for the off-grid power bank. Lithium-ion batteries have the largest charge density meaning that the batteries are much lighter and take up less space in order to generate the same power potential as other batteries. However, the size of the batteries isn't as important as the cost for the ECO cottages. Even though lithium ions batteries cost more you get the most for your dollar due to the life cycle of the battery. Lithium ions can be discharged fully at 100% on average 2000 times, where the lead acid will only sustain approximately 300 times at only 50%. Figure E1 a bar graph shows how on average lithium ion batteries can undergo many more complete discharges. Since the Lithium-ion batteries can be completely drained without damaging the battery you don't have to install as many batteries since they run at 100% installed capacity. Figure E1 b illustrates how lithium ion batteries can maintain a much higher constant voltage as the discharge approaches 100% whereas, the lead acid batteries voltage exponential decays as approaching 100% discharged. By utilizing Lithium-ion batteries you get the most out of your installed solar panel capacitance all while reducing environmental impacts due to the large battery life.



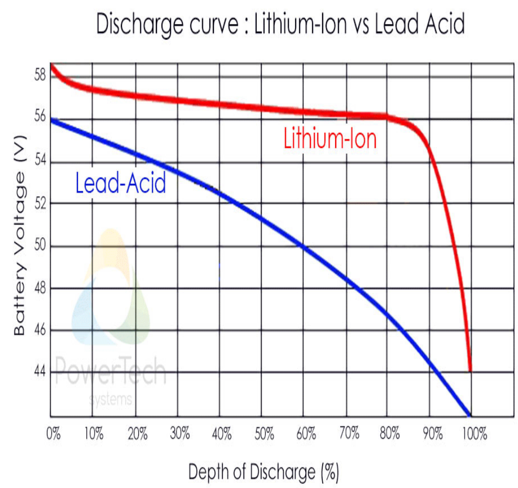


Figure E2 a,b: Lead Acid vs Lithium Ion

Assumptions

Some assumptions were made while doing the calculations and design for the power system. Firstly, Assumptions were made in the daily usage of different equipment. For example, it was assumed that the lights would be used about six hours a day. These assumptions were made based on conversations with the clients as well as members of the Bio-Itzá association.

Another assumption done in the demand calculations was that the calculations were done assuming the site was at maximum capacity of residents visiting, or in other words all the cottages were in use.

Recommendations

There is a certain level of danger when working with electrical systems, and because of this there are a few recommendations of best practice that the team would like to outline. Firstly, the electrical system, due to the high voltage output of the solar panels, should be constructed by someone with a background working with electrical systems, such as an electrician. Barring this, an electrician or other similar expert should at least be present for the construction of the system.

The system is fully powered by renewable energy, and thus the team recommends that the reservation be conservative in its power usage. Some ways to do this are listed below:

1. Encourage guests to be conservative with fan usage.
2. Be conservative with fridge usage
3. Only use outlets during the day when the sun is out.
4. Be conservative in water usage, only flush when necessary, only use sinks when necessary

D. Integration

Site Design

The subsystem teams worked together to integrate and optimize design of the project. The full system Site Plan and Utility Plan, available in Appendix A, help visual the integration. Several design features that were created to facilitate compatibility of subsystems include:

- Covered walkway in optimal area for solar collection with mounted solar panels.
- Raised wooden walkways connecting cottages and existing structures to provide protected path during rainy/muddy season.
- Solar lights on walkway to improve usability and safety of walkway
- The utility shed under the pavilion to co-house water system pump and treatment and the batteries for the power system.
- The power system design accommodates the water system's UV system and pump
- The civil system took into account the loads of both the water and power system
- The power system is compatible with the layout of the cottages
- The water and power system were both sized according the the occupancy design for in the cottages
- Pavilion floor is concurrent with the water system storage tank
- Utility trenches will house both power lines and water and wastewater lines.
- Roof angle and material of pavilion and cottages roofs designed to accommodate rain water collection into gutters and into tank.
- Raised cottages minimize soil disturbance and environmental impact.
- Water and power systems integrate existing structures

Cost Estimates

The final cost of the proposed project is estimated to be $84,422 and Table D1 show the cost by subsystem. The design budget was set between $30,000 and $100,000 and the proposed project is within budget. The cost of each subsystem and the itemized breakdown are available in Appendix E. The budget does not include labor and uses estimates of materials purchased in the United States. The overall cost may go up or down depending on the cost of materials and labor within Guatemala. The next step, once the design is approved, is to verify the availability and price of items in Guatemala.

Table D1: Cost Estimates

Subsystem	Estimated Cost
Civil	$45,600
Water	$20,324
Power	$18,498
Total	$84,422

4. Final Deliverables

A. Site and Cottage Model

The final deliverables for this project included a scale model of one cottage that can be used for fundraising and marketing after the completion of the project. The scale model used a 1:30 scale (30' built = 1' modeled) and was built from basswood and balsa wood to create the most realistic design. The model's roof is removable to show the layouts within the cottages.

The team also decided to model the site by 3D printing the topography from the team's surveying data. The model also includes 3D printed replications of the existing and designed structures, walkways, trees, and water tanks.

B. Construction Drawing Sets

The team created a set of construction drawings, available in Appendix A, detailing the different subsystems and specific structures and items. The Construction Drawing sets includes architectural drawings, civil site plans, structural plans, utility plans, water and wastewater plans, and power details.

C. Maintenance Plan

The goal of the maintenance plan is to create an easy to use guide that the on-site rangers and site caretakers can understand and implement. The plan is broken up into each of the three subsystems and documents the frequency that each task should be completed.

For the water subsystem, the water quality should be checked once a month to ensure the system is working. If the water quality is not within the set standards, the issue will probably be in either the water filter of the UV bulb. The civil subsystem maintenance is relatively minimal once the cottages are constructed. The largest concern is making sure that there is no excess water buildup underneath the cottages because this could affect the foundation. During the rainy season, the team recommends checking underneath the cottages on a monthly basis. During the dry season, the cottages only need to be checked once. The power system requires a manual switch to be changed every evening to switch the site from being powered by the solar panels to the battery bank. The rangers can schedule a time every day to flip the switch to ensure the power supply is uninterrupted throughout the day. In addition, if there is a low solar harvest predicted for the day, the rangers could switch to battery power earlier in the day. The pump battery should be changed out monthly. To switch out the battery, the depleted battery is replaced with one of the charged ones from the battery bank. To charge the depleted battery, it is placed in parallel with the rest of the batteries in the bank. Lastly, the solar panels should be cleaned and inspected every six months. The cleaning can be done with a soft brush and water to get dust, dirt and bird droppings off of the panels.

A simplified maintenance checklist has been attached below to make it easier for rangers to remember to complete the tasks.

Water

- ❏ Take monthly water samples
- ❏ Replace water filter cartridge every 6 months
- ❏ Clean the gutters every 6 months
- ❏ Change UV bulb every year
- ❏ Check the pump every year
- ❏ Inspect septic system every year

Civil

- ❏ Ensure the underside of the cottage does not get swampy
  - ❏ During rainy season: Every month
  - ❏ During dry season: Once
- ❏ Keep patios free of debris
- ❏ Maintain screens

Power

- ❏ Manual switch from the battery to the solar panels needs to be flipped daily at a set time
- ❏ Battery to pump must be switched monthly
  - ❏ Connect the dead battery to the battery bank to recharge
  - ❏ Take a charged battery from the bank and connect it to the pump
- ❏ Inspect and clean the solar panels every 6 months

D. File Ownership

At the completion of the project, all file pertaining to the project will be compressed into a single zipped folder that will be passed to the clients.

5. Future Recommendations

A. Septic System

The site currently has a functioning septic system that is sufficient for the current demand on the system. However, if the reserve receives significantly more visitors than expected, the current septic system will need to be reevaluated. This recommendation is based off of the observation that the septic tank does not have a bottom and is therefore seeping through the karst bedrock and contaminating groundwater. While there is no drinking water wells within the vicinity of the site, the contaminated water can travel down gradient with a significant concentration over time. The septic system would likely not pass inspection in the United States. Some officials in the local community, like Gerson from AMPI, have also expressed concerns about the current septic system and the lack of a floor in the septic tank. As a solution, Gerson recommended a biodigester that is starting to be used by several people in the area, seen in Figure G1. This could eliminate the potential hazard of waste water seeping into ground water and could provide gas that can be used for power or cooking in the kitchen. This biodigester would be buried and connected to the pi[es that are currently leading to the septic tank. The organic matter would be processed and filtered water would be released into a leach field. Clients and the Bio Itzá Association should consider this option when the septic tank is no longer able to handle all the waste water from increased visitors. Rangers should periodically check the level of the tank in order to see if the system is being overloaded.

Figure G1: Biodigester

B. Garden and Grey Water System

The team has incorporated plans for a garden that will be situated east of the proposed cottages and north of the existing community room and south of the proposed covered walkway. The garden has been designed to look like a labyrinth and to loosely incorporate phi proportions in align with the client's' wishes. The team recommends that rangers and local herbal medicine experts choose the plants that will be in the garden and the best places for these plants based on their knowledge. The team recommends the use of local flowering plants like orchids and medicinal herbs so that the garden can be a place for learning for the visitors.

The team also recommends that in the future, a grey water system could be used to water the garden. The grey water system could be made by redirecting water from the sinks and showers in the cottages through pipes that lead to the garden area. This would reduce loading on the septic system and redistribute rain water that had been collected and never reached the ground. If a grey water system is used, visitors will have to use natural and biodegradable soaps so as to not harm the plants.

C. Solar Array

As currently designed, the solar array system currently has 10 panels. This is a comfortable amount to house all the existing structures. This however, is insufficient to power any additional power consuming features that may potentially be added to the site in the future. If there are plans to expand the power demands of the site, it is recommended that new panels be added to the existing array. If new panels are added to the site it is recommended that new wire sizing calculations are done to the existing 350 AWG cable as this has been sized for the system as currently designed.

D. Additional Cottages

The three proposed cottages have the ability to house up to 10 guests at a time. If the clients and the Bio Itzá Association see an increased demand for the more luxurious accommodations, there is an opportunity and space to build two more raised cottages. The potential spaces for additional cottages are called out in the drawings in Appendix A. To accommodate two additional cottages, solar panels and batteries would have to be added to the power system, and water tie ins and an additional pump would have to be added to the water system.

6. Project Management

Over the course of the project, the team worked with two budgets, the first being the implementation budget for the future construction of the cottages and the second being the travel and model budget. The team was tasked with designing the eco-village with an implementation budget between cost range of $30,000 and $100,000. The team worked through iterations in the design and ended with a finalized budget of $84,422 . This cost estimate was calculated using US prices to show the worst case scenario. Additionally, this budget does not include labor costs because it was difficult to estimate from Guatemalan prices due to lack of available information. In order to estimate labor, it is necessary to understand the level of experience of the workers to determine how long the work will take. Without this information, it was difficult to estimate the actual implementation cost in Guatemala. In reality, the budget to implement will vary based on material costs bought in Guatemala. Attached in Appendix D is the budget tracker for this semester, this includes material costs for the model and the travel reimbursement. The second semester gantt chart is attached in Appendix D which shows the work breakdown structure over the course of the last few months.

7. Next Steps

A. Deliverable Hand-Off

With the completion of the Final Design Review, the next milestone for the project is the design showcase. At the review, the team will use a poster, a video of the team's trip, and the two physical models to show judges what the team has been able to accomplish. Following showcase, the team will host the last client meeting and project hand-off. At this point, the project will be completed and all deliverables will be passed to the clients. This includes the models, report, electronic files, poster and video. At this point, the team would also like to finalize the team's budget and ensure that both the team and the clients have been refunded. At the start of the project, the team and the clients decided on two budgets for the project. The first budget consisted of a low-budget scale model with a maximum cost of $500 as well as travel funding. The report printing and poster printing will also be included in this budget.

C. Recommendations for Future Project

With the completion of the senior design team's project, the following items will need to be addressed by the client and the Bio Itzá Association prior to site construction:

- Submit team's conceptual design to professional/ licensed engineer to approve, edit, and add to construction plans
- Translate plans to Spanish for construction and approval from Bio-Itzá Association
- Ensure that units in the drawings are appropriate for construction
- Work with Bio-Itzá Association to complete the Environmental Site Study that must be renewed
- Gather necessary funding
- Work with marketing experts to effectively promote the Association and reserve as a eco-tourism and learning destination

8. Lessons Learned

Throughout the course of the Bio-Itzá Cottages Senior Design project, the team learned many important lessons that will benefit each team member in their future endeavours. Specifically, the team learned how to take a project from a conceptual idea to reality. One of the biggest challenges involved maximizing user appeal of the design. In the first iteration of the design, the team focused on delivering the technical details such as the site layout and septic system layout. After delivering the first designs at the PDR, the team realized that a design that is just technically sound is not an ideal design. After the PDR, the team had a more sound budget set and focussed on delivering a more aesthetically appealing design that would 'wow' out clients and in turn the judges at the showcase. This process helped the learn how to create a design that will satisfy the desires of multiple clients.

In terms of the Bio-Itzá Cottage project, a good design is not just one that is aesthetically pleasing or functions appropriately, but one that fulfills the needs of the major stakeholders and users down in Guatemala. A good design is difficult to define as the design and requirements changed over the course of the project. At the start of the project, the team sat down and defined all needs and wants from the clients to determine the basis of a good design. As the project continued and the team faced challenges and scope additions, there were necessary design changes that deviated from the original design. As the scope and requirements changed throughout the semester, the team ensured that we were working towards the best design by getting constant feedback from all stakeholders related to the project. This was a great learning experience because very rarely in our past has the team been required to work on a project while the requirements are constantly changing.

Working with multiple disciplines was a new experience for most all of the team members. Each team member had specific tasks that may or may not overlap and had to learn the best way to work with members of other majors in order to accomplish those tasks. This was a great learning experience before going into industry where projects will be much more complex. During our scholastic time, most projects are simple and the team completely made of people in the same major. This senior design project helped teach members how people of different majors operate and how to best work together when parts of the project overlap.

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Appendix:

A: Construction Drawing Set

B: Calculations

BI:Civil

A. Dead Loads:

Dead Loads based on Timber Framing Plan				
x-section	area	bf	density	weight
2x4	0.0555555	1607.06	26.5319	2368.795143
2x6	0.0833333	1629.67	26.5319	3603.185348
2x8	0.11111111	28	26.5319	82.54368806
Total Load				6054.524179

B. Wind Loads:

Main Wind Force Resisting System (MWFRS)		
Simplified Design Wind Pressure for MWFRS, P_s =	$\lambda K_{zt} I P_{s30}$	(ASCE 7 Eq. 6-1)
Height and Exposure Adjustment Factor, λ =	1.00	(ASCE 7 Fig. 6-2)
Topographical Factor, K_{zt} =	1.00	(ASCE 7 Eq. 6-3)
Importance Factor, I =	1.00	(ASCE 7 Table 6-1)
P_{s30} for basic wind speed of 90 mph and roof slope of 30 degrees:		(ASCE 7 Fig. 6-2)

Load Case	Horizontal Pressures				Vertical Pressures				Overhangs	
	A	B	C	D	E	F	G	H	E_{OH}	G_{OH}
1	14.4	9.9	11.5	7.9	1.1	-8.8	0.4	-7.5	-5.1	-5.8
2	14.4	9.9	11.5	7.9	5.6	-4.3	4.8	-3.1	-5.1	-5.8

P_s given above constants:

Load Case	Horizontal Pressures				Vertical Pressures				Overhangs	
	A	B	C	D	E	F	G	H	EOH	GOH
1	14.4	9.9	11.5	7.9	1.1	-8.8	0.4	-7.5	-5.1	-5.8
2	14.4	9.9	11.5	7.9	5.6	-4.3	4.8	-3.1	-5.1	-5.8

Total load on sections in the transverse and longitudinal directions given cottage dimensions and P_s:

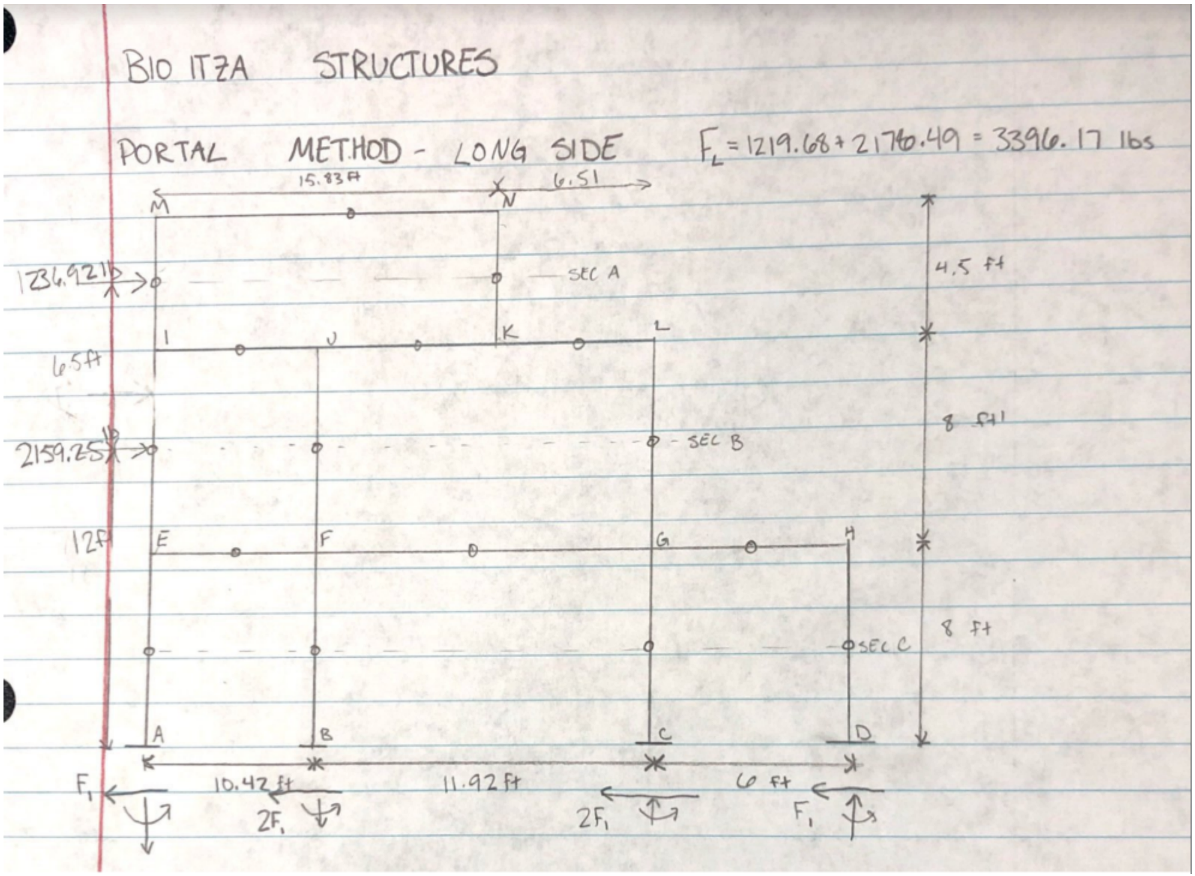
Load Case	Horizontal Pressures				Vertical Pressures				Overhangs	
	A	B	C	D	E	F	G	H	EOH	GOH
1 (psf)	14.4	9.9	11.5	7.9	1.1	-8.8	0.4	-7.5	-5.1	-5.8
2 (psf)	14.4	9.9	11.5	7.9	5.6	-4.3	4.8	-3.1	-5.1	-5.8
Transverse Area (sq. ft.)	74.68	35.66	209.51	71.31	52.00	52.00	104.00	104.00	5.20	10.39
Longitudinal Area (sq. ft.)	84.70	0.00	189.26	0.00	50.75	50.75	110.53	110.53	6.50	14.16
Transverse Load (Load Case 1) (lbs)	1075.392	353.034	2409.365	563.349	57.2	-457.6	41.6	-780	-26.52	-60.262
Transverse Load (Load Case 2) (lbs)	1075.392	353.034	2409.365	563.349	291.2	-223.6	499.2	-322.4	-26.52	-60.262
Longitudinal Load (Load Case 1) (lbs)	1219.68	0	2176.49	0	55.825	-446.6	44.212	-828.975	-33.15	-82.128
Longitudinal Load (Load Case 2) (lbs)	1219.68	0	2176.49	0	284.2	-218.225	530.544	-342.643	-33.15	-82.128

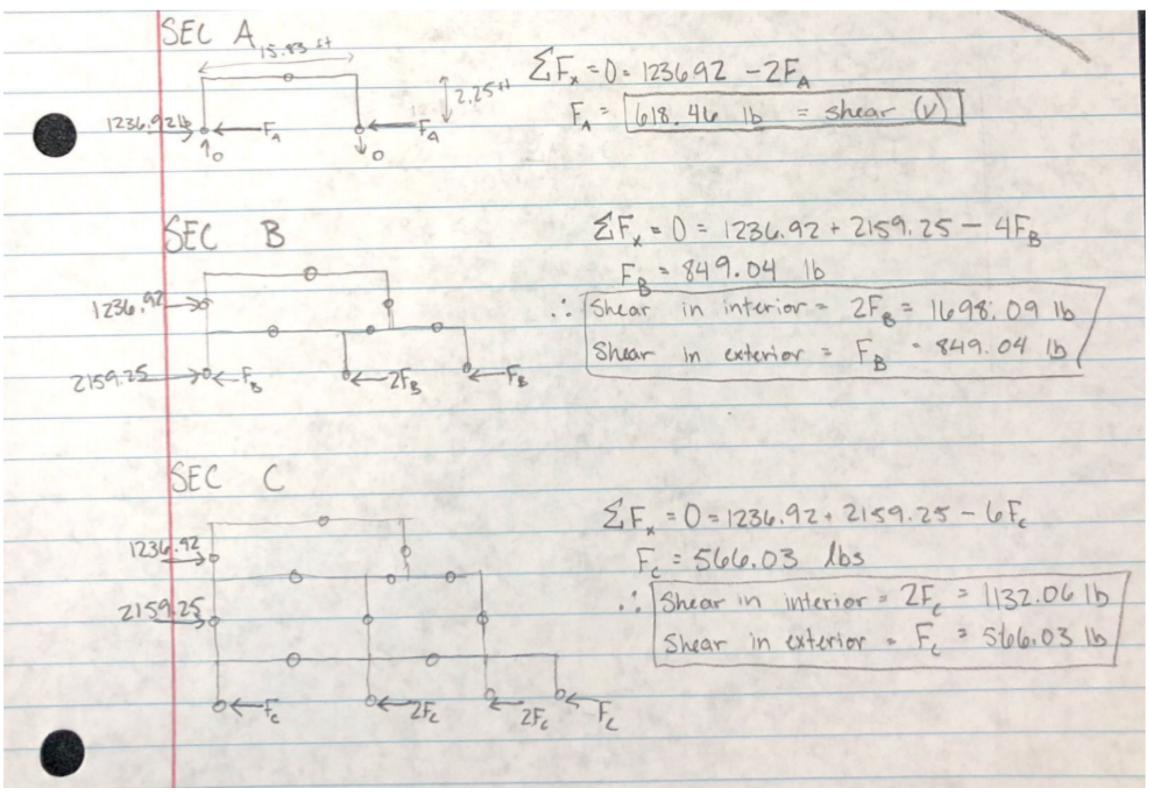
C. Live Loads

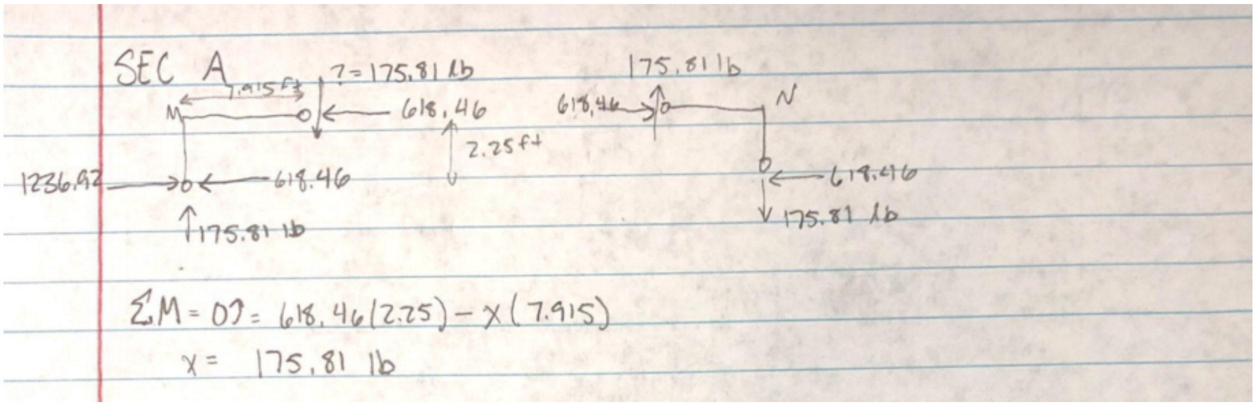
Live Load			
ASCE 7 Table 4-1			
	Occupancy or Use	Uniform psf	
	Balconies (exterior)	100	
	On one and two family residences and not exceeding 100 ft^2	60	
	Fixed Ladders		
	Residential Hotels and Multifamily houses		
	Private rooms	40	
	Public Rooms	100	
	Walkways and elevated platforms	60	
ASCE 7 Section 4.9 Minimum Roof Live Loads	Roofs used for assembly purposes	100	
ASCE 7 Section 4.9 Minimum Roof Live Loads			

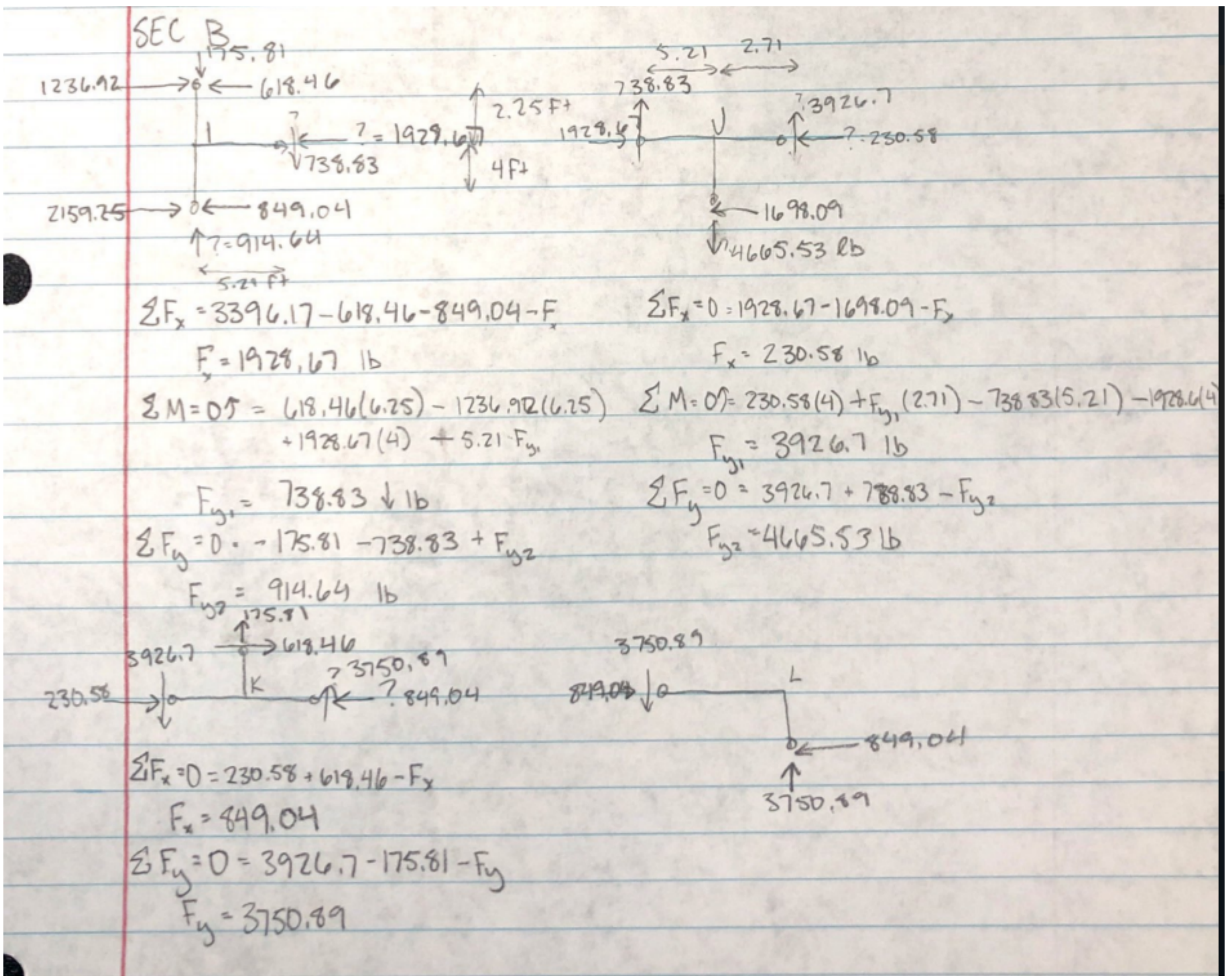
Solar Water Heater	Showers for cottages have been calculated to accomodate 5 minute, low flow showers for four cottage guests, resulting in a demand of 28 gallons per day. Solar water heater will be constructed with 2" pvc piping lines on roof.		
	Solar Heater Appliance Loads	Load (lb)	
	Water (52 gal* density water)	440.64	
	Solar Water Heater (Empty Tank + Heating System)	171.6	
ASCE 7 Eq. 4-2	Tributary area of each rafter (ft^2)	14.67	
	R1	1	
	F (number of inches of rise per ft)	7	
	R2	0.85	
	Lr	17	
Furniture and Fixtures			
	Fixture or Furniture for Four Person Cottage	Load (lb)	Website
	Twin Bed (Boxspring, Footboard, Headboard, Mattress, Rails)	145	
	Twin Bed (Boxspring, Footboard, Headboard, Mattress, Rails)	145	
	Futon (Queen frame and mattress)	200	
	Toilet	100	
	Table	50	
	Chairs (4)	60	
	Sink (lightweight wall mounted)	30	
	Fan	35	
	Shelving	125	
Cottage Areas	Area	SF	
	Lower balcony	104	
	Upper balcony	121.33	
	Entry balcony	57	
	Roof Horizontal Projection	343.2	
	Roof	396	
	Interior floor (incl. shower)	311	
Calculated Live Loads	Area	Load (lb)	
	Lower balcony	10400	
	Upper balcony	12133	
	Entry balcony	3420	
	Roof	34320	
	Interior floor (incl. shower)	12440	
	Total Load	72713	

D. Portal Method


BIO ITZA STRUCTURES
PORTAL METHOD - LONG SIDE
F_L = 1219.68 + 2176.49 = 3396.17 lbs
15.83 ft
6.51
M
N
SEC A
1236.92 lb
4.5 ft
I
J
K
L
6.5 ft
2159.25 lb
SEC B
8 ft
12 ft
E
F
G
H
SEC C
8 ft
A
B
C
D
10.42 ft
11.92 ft
6 ft
F1
2F1
2F1
F1


SEC A
15.83 ft
2.25 ft
1236.92 lb
FA
ΣFx = 0 = 1236.92 − 2FA
FA = 618.46 lb = shear (V)
SEC B
1236.92
2159.25
FB
2FB
FB
ΣFx = 0 = 1236.92 + 2159.25 − 4FB
FB = 849.04 lb
∴ Shear in interior = 2FB = 1698.09 lb
Shear in exterior = FB = 849.04 lb
SEC C
1236.92
2159.25
Fc
2Fc
2Fc
Fc
ΣFx = 0 = 1236.92 + 2159.25 − 6Fc
Fc = 566.03 lbs
∴ Shear in interior = 2Fc = 1132.06 lb
Shear in exterior = Fc = 566.03 lb





BII: Water

A. Precipitation Comparison

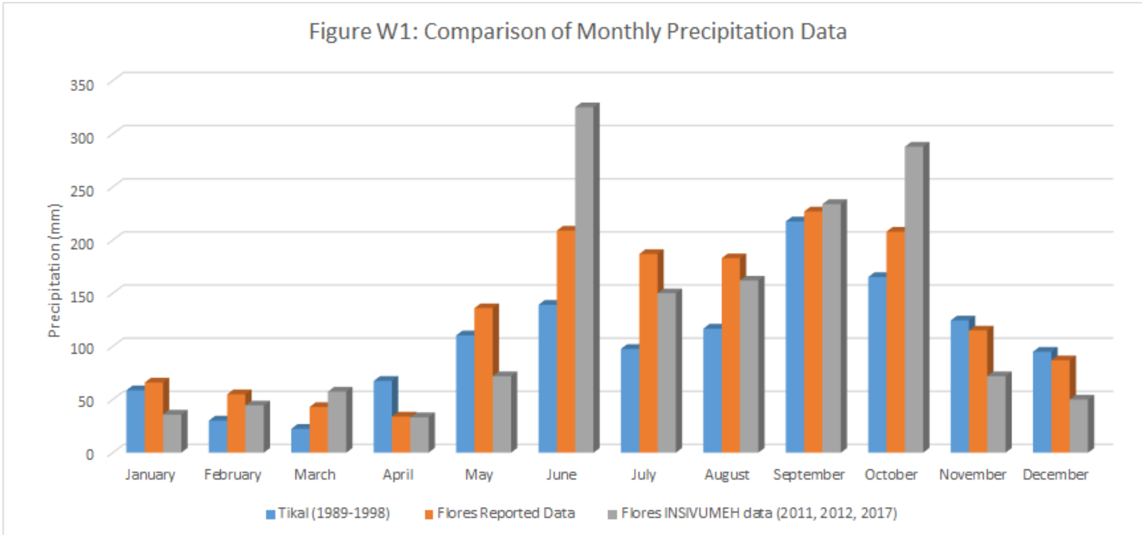


Figure BII.A.1: Precipitation comparison from Tikal, Flores, and ISIVUMEH data [2,3,4]

B. Water System Model

<u>Model Explanation</u>

Purpose	The purpose of this model is to determine the tank capacity and catchment area required to make the rain catchment feasible for the intended use of the site.	
	Demand Control	
		The average water demand of the site was calculated by first splitting the water system into the cottage system and the community system. Then, system use was categorized into cottage use, community system use by overnight guests, community use by day-guests, and community use by rangers. The demand per person for each user group was estimated by referencing the demand per use of low-flow appliances like toilets, sinks, and showers and then estimating the number of uses expected from each user category. The final water demand of the site was calculated by multiplying the expected number of users in each user group by the per-person demand for the user group. The sum of these demands equals the overall demand of the site. Because of the dry seasons, the site should encourage guests to limit their water consumptions in part of Jan/May and all of Feb-April). This is built into the model using the "Dry Season Reduction" number which represented the fraction of the original water demand that will actually be used.
	To Use:	Do not change (unless demand assumption needed)
	Collection Capacity	
	Explanation:	Precipitation data was collected from a weather station in Tikal and summarized by month. The data is referenced to determine how much rain can be expected to be captured for each month and to identify periods of the year with large

		consecutive dry seasons. The areas in the table represent the up-to-date areas of the roofs that will be used for rain catchment. None of the roof areas have been finalized, but the values entered into the table represent the estimated values with the current design except for the pavillion area. The pavillion area should be the first roof area changed and it can be adjusted in the model. This tab also includes the storage capacity which is adjusted using the model tab.
	To use:	Do not change
	Monthly Model	
	Explanation:	The use of the site is expected to change seasonally because there more favorable times to visit than others. There is also a need to account for large group trips that are known to have occured at the same time every year. In this version of the model, the tourism level can be "High", "medium" or "Low". Adjust the number of people at the site by each individual day. The occupancy rate is summarized in the tables beneath each calendar month
	To use:	change the number of cottage guests and large group guests. The ranger number auto populates
	Model and User Input	
	Explanation:	The model tab allows the used to model different scenarios by changing the following inputs: roof efficiency, pavilion roof area, storage capacity, max number of guests, dry-season reduction, the anticipated start-up month, and the dry season reduction and tourism level anticipated each month. The model includes three years to show how the tank will meet demand over time.
	To use	Use the drop down menu to select the start-up month; the team suggests July or Aug
		Insert the water tank capacity in the yellow cell at the top of the mode
		Select if the dry season reduction and tourism level of the month
		Change the dry season reduction factor, use the key on the "Demand Control" Tab
		Use the "Monthly Model" tab to change the occupancy level
		The ideal model will show a combination of assumptions, tank size, and catchment area where the tank level will never fall below 0 gallons and where the tank will be able to maintain capacity over time

Monthly Model

Table BII.B.1: High Occupancy Month							
Day	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Week 1							
Date	1	2	3	4	5	6	7
Lg Group	30	30	30	30	25	25	25
Cottage Group	0	0	0	0	0	0	0
Rangers	9	9	9	9	8	8	8
Week 2							
Date	8	9	10	11	12	13	14
Lg Group	0	0	0	0	0	0	0
Cottage Group	10	10	10	10	9	9	9
Rangers	7	7	7	7	6	6	6
Week 3							
Date	15	16	17	18	19	20	21
Lg Group	0	0	0	0	0	0	0
Cottage Group	8	8	7	7	6	6	6
Rangers	6	6	6	6	5	5	5
Week 4							
Date	22	23	24	25	26	27	28
Lg Group	0	0	0	0	0	0	0
Cottage Group	5	5	5	4	4	4	2
Rangers	5	5	5	5	5	5	5
Week 5							
Date	29	30					
Lg Group	0	0					
Cottage Group	2	2					
Rangers	5	5					

Table BII.B.2: Mid Occupancy Month							
Week 1							
Date	1	2	3	4	5	6	7
Lg Group	30	30	25	25	0	0	0
Cottage Group	0	0	0	0	10	10	10
Rangers	9	9	8	8	7	7	7
Week 2							
Date	8	9	10	11	12	13	14
Lg Group	0	0	0	0	0	0	0
Cottage Group	10	8	8	8	6	6	6
Rangers	7	6	6	6	5	5	5
Week 3							
Date	15	16	17	18	19	20	21
Lg Group	0	0	0	0	0	0	0
Cottage Group	6	6	6	4	4	4	4
Rangers	5	5	5	5	5	5	5
Week 4							

Date	22	23	24	25	26	27	28
Lg Group	0	0	0	0	0	0	0
Cottage Group	4	4	4	2	2	2	2
Rangers	5	5	5	5	5	5	5
Week 5							
Date	29	30					
Lg Group	0	0					
Cottage Group	0	0					
Rangers	5	5					

Table BII.B.3: Low Occupancy Month							
Week 1							
Date	1	2	3	4	5	6	7
Lg Group	30	25	0	0	0	0	0
Cottage Group	0	0	10	10	10	8	8
Rangers	9	8	7	7	7	6	6
Week 2							
Date	8	9	10	11	12	13	14
Lg Group	0	0	0	0	0	0	0
Cottage Group	8	8	6	6	6	6	4
Rangers	6	6	5	5	5	5	5
Week 3							
Date	15	16	17	18	19	20	21
Lg Group	0	0	0	0	0	0	0
Cottage Group	4	4	4	4	2	2	2
Rangers	5	5	5	5	5	5	5
Week 4							
Date	22	23	24	25	26	27	28
Lg Group	0	0	0	0	0	0	0
Cottage Group	2	2	2	2	2	0	0
Rangers	5	5	5	5	5	5	5
Week 5							
Date	29	30					
Lg Group	0	0					
Cottage Group	0	0					
Rangers	5	5					

Table BII.B.4: Maximum Occupancy		
Maximum Number of:	per day	per month
Cottage Guests	10	300
Large Group Guest	30	900
Rangers	10	-

Demand Control

- See Table W3 and W4

Table BII.B.5: Dry Season Adjustment			
System	Max Monthly (gal)	Dry Season (Gal)	Average (gal)
Rangers Usage (gal)	7440	6175.2	6807.6
Cottage Guests Usage (gal)	1770	1469.1	1619.55
Large Group Usage (gal)	22320	18525.6	20422.8

Collection Capacity

- See Table W1

Table BII.B.6: Rain Catchment Area		
Structure	Area (sf)	Expected Range
Cottage 1	340	300-350
Cottage 2	340	300-350
Cottage 3	340	300-350
Total Cottage Area	1020	-
Retrofitted roofs	0	1500
Pavillion	2500	As needed
Total Community Catchment	2500	-
Total Catchment Area	3520	-
Roof Efficiency	0.9	0.5-0.9

Model and User Input

- Yellow cells indicate cells entered by the user

User Input Table 1: Catchment and Demand		
Catchment and Storage		
Roof area of Pavilion	2500	sf
Roof efficiency	0.9	-
Storage Capacity	24000	gal
Demand		
Max Rangers	10	people
Max Cottage Guests	10	people
Max Large Group Guests	30	people
Dry Season Reduction	0.83	-
All Demand assumptions in "Demand Control" Tab		

User Input Table 2: Occupancy Adjustment Summary
Occupancy Adjustment

Adjust Anticipated Occupancy in Monthly Model Tab; See Summary Below and use Monthly Model to interpret			
Group	Tourism Level		
	High	Medium	Low
Large Group	0.22	0.12	0.06
Cottage Guests	0.49	0.45	0.41
Rangers	0.63	0.58	0.56

User Input Table 3: Monthly Scenarios		
Month	Dry Season	Tourism Level
Jan	No	Medium
Feb	Yes	High
Mar	Yes	High
Apr	Yes	High
May	No	Medium
Jun	No	Medium
Jul	No	Medium
Aug	No	Low
Sep	No	Low
Oct	No	Low
Nov	No	Medium
Dec	No	Medium

Start up model (tank empty)												
Start Month:	Sep											
Year:	2022											
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
System Use:	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Catchment Calculations												
Rainfall (in)/month	8.6	6.5	4.9	3.7	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6
Collection Capacity (gal)	16983.8	12836.6	9676.8	7307.0	4542.2	2369.8	1777.4	5332.1	8491.9	10861.7	7504.5	9084.3
Demand Calculations												
Total Usage	0.0	6225.4	7870.4	7870.4	7870.4	8649.6	8649.6	8649.6	7870.4	7870.4	7870.4	6225.4
Tank Model												
Tank Level at beginning (gal)	0.0	16983.8	23594.9	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7
Tank Level at end (gal)	16983.8	23594.9	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7	9744.7
Water Deficit (gal)												
Drought requirement storage (gal)	0.0	207.5	524.7	1311.7	1574.1	3459.8	4901.4	2594.9	1836.4	1311.7	1049.4	415.0

	1st full year											
Start Month:												
Year:	2023											
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
System Use:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Catchment Calculations											
Rainfall (in)/month	8.6	6.5	4.9	3.7	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6
Collection Capacity (gal)	16983.8	12836.6	9676.8	7307.0	4542.2	2369.8	1777.4	5332.1	8491.9	10861.7	7504.5	9084.3
	Demand Calculations											
Total Usage	6225.4	6225.4	7870.4	7870.4	7870.4	8649.6	8649.6	8649.6	7870.4	7870.4	7870.4	6225.4
	Tank Model											
Tank Level at beginning (gal)	9744.7	20503.0	24000.0	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7
Tank Level at end (gal)	20503.0	24000.0	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7	9744.7
Water Deficit (gal)												
Drought requirement storage (gal)	207.5	207.5	524.7	1311.7	1574.1	3459.8	4901.4	2594.9	1836.4	1311.7	1049.4	415.0

	2nd full year											
Start Month:												
Year:	2024											
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
System Use:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Catchment Calculations												
Rainfall (in)/month	8.6	6.5	4.9	3.7	2.3	1.2	0.9	2.7	4.3	5.5	3.8	4.6
Collection Capacity (gal)	16983.8	12836.6	9676.8	7307.0	4542.2	2369.8	1777.4	5332.1	8491.9	10861.7	7504.5	9084.3
Demand Calculations												
Total Usage	6225.4	6225.4	7870.4	7870.4	7870.4	8649.6	8649.6	8649.6	7870.4	7870.4	7870.4	6225.4
Tank Model												
Tank Level at beginning (gal)	9744.7	20503.0	24000.0	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7
Tank Level at end (gal)	20503.0	24000.0	24000.0	23436.6	20108.3	13828.6	6956.4	3638.9	4260.4	7251.7	6885.7	9744.7
Water Deficit (gal)												
Drought requirement storage (gal)	207.5	207.5	524.7	1311.7	1574.1	3459.8	4901.4	2594.9	1836.4	1311.7	1049.4	415.0

C. Head Calculations

Table BII.C.1: Static Head				
Source location	Elevation (ft)	Discharge Location	Elevation (ft)	Head (Ft)
Gravity System				
Cottage 1	130.94	Tank top	99.53	-31.41
Cottage 2	130.4	Tank top	99.53	-30.87
Cottage 3	131.2	Tank top	99.53	-31.67
Pavilion	114.23	Tank top	99.53	-14.7
Tank top	99.53	Tank bot	90.53	-9
Pumped System				
Tank bot	90.53	Treatment	103.23	12.7
Treatment	103.23	Treatment - Main	103.23	0
Treatment - Main	103.23	Main	100.9	-2.33
Main	100.9	To cottage 1	130.94	30.04
Main	100.8	To cottage 2	130.4	29.6
Main	100.7	To cottage 3	131.2	30.5
Main	100.9	To bathroom	107.9	7
Main	103.23	To kitchen	105.9	2.67

Table BII.C.2: Static Suction Head	
System	Elevation
Bottom of Tank	90.53
Pump	100.03
Total lift	9.5

Table BII.C.3: Total Equivalent Lengths			
System	Total Pipe	Equivalent Length Total	Total Length
Tank to Treatment	17.5	18.4999998	35.9999998
Treatment	16.4066	78.49999942	94.90659942
Main	297.7043	0	297.7043
To cottage 1	29	18.6666666	47.6666666
To cottage 2	37.2028	18.6666666	55.8694666
To cottage 3	43.4251	18.6666666	62.0917666
To bathroom	16.9858	24.8333332	41.8191332
To kitchen	122.25	43.333333	165.583333

Table BII.C.4: Head Loss by Friction, length, fittings						
System	Equivalent Length Total (ft)	Flow Rate (gpm)	Hazen Williams Coefficient	Diameter of Pipe (in)	Head (ft)	Velocity (ft/s)
Tank to Treatment	36.00	25	150	2	0.47	2.55
Treatment	94.91	15	150	1	4.73	3.92
Main	297.70	15	150	1	14.82	3.92

To cottage 1	47.67	4	150	1	2.82	3.12
To cottage 2	55.87	4	150	1	3.31	3.12
To cottage 3	62.09	4	150	1	3.68	3.12
To bathroom	41.82	9	150	1	2.20	3.51
To kitchen	165.58	1	150	1	6.65	1.96

Table BII.C.5: Pressure Head (operating pressure in psi to feet of head)				
System	Operating Pressure	Qt	Total	Total
Toilet	46.4	1	46.4	220.4
Shower	58	1	58	
Sink	116	1	116	

Table BII.C.6: Total dynamic head (ft)				
Static head	Static lift	Friction head	Pressure Head	Total head
27.97	9.5	22.84	220.4	280.7131463

D. Wastewater Calculations

Table B.II.D.1: Existing Septic System Characteristics		
Parameter	Value	Unit
Tank Width	2	m
Tank Length	4	m
Tank Depth	3	m
Tank Volume	24	m3
Tank Volume	6339.694944	gal
Soil percolation rate (Avg)	5.466535433	in/hr
Depth of Max Daily Discharge	18.48123902	inches
Retention Time	3.380795616	hr

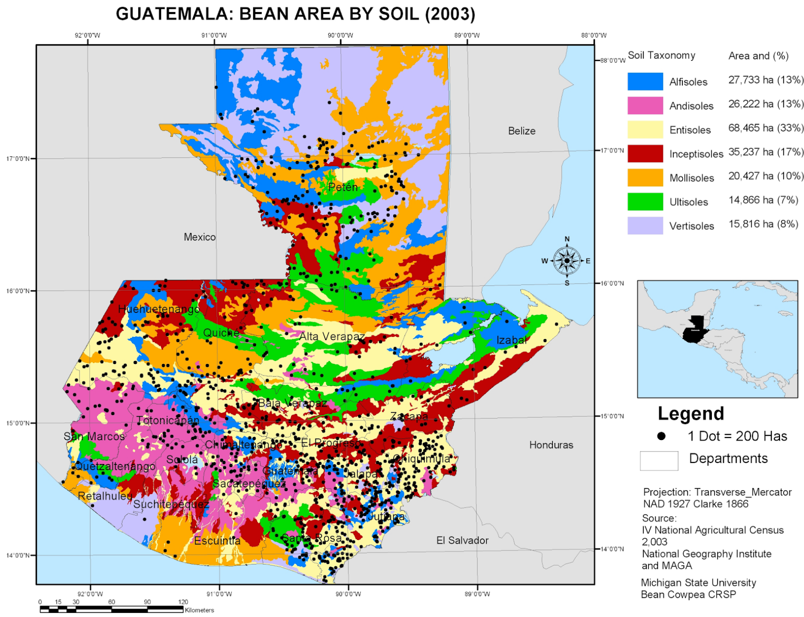


Figure BII.D.1: Soil Map [this]

TABLE 3 Infiltration Rates for Various Soils in Puerto Rico[a]

	Infiltration Rate (cm/hr)	
Soil Group	Minimum	Maximum
Vertisols	0.18	9.58
Entisols	2.32	27.55
Inceptisols	2.75	13.25
Alfisols	2.78	11.58
Mollisols	8.22	19.55
Oxisols	8.45	15.40
Ultisols	7.40	23.68

Figure BII.D.2: Soil Percolation Rate [this]

Table B.II.D.2: Design Septic Capacity		
Parameter	Value Unit	
Max Daily Flow	992	GPD
Retention Time (Min)	3	days
Required Capacity	2976	gallons
Number of people using system (avg)	15	people, average

Number of years before sludge removal	10	years
Rate of sludge accumulation	6.6	gal/year/person
Sludge Digestion Factor	1	(for warm climates)
Sludge Storage Capacity	990	gal
Total Volume Required	3966	gal
Design Volume	4000	gal

Table BII.D.3: Existing Septic Capacity		
Parameter	Value	Unit
Daily Flow (no graywater)	992	GPD
Retention Time	0.140866484	days
Required Capacity	139.7395521	gallons
Number of people using system	14	people, average
Number of years before sludge removal	60	years
Rate of sludge accumulation	6.6	gal/year/person
Sludge Digestion Factor	1	(for warm climates)
Sludge Storage Capacity	5544	gal
Total Volume Required	5683.739552	gal
Existing Tank Capacity	6339.694944	gal

C: Maintenance Plan/Cutsheets

CI: Civil

CII: Water

A. UV System

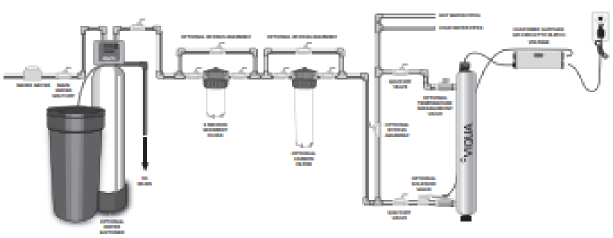
VIQUA
simply safe water

S5Q-PA, S8Q-PA, VH200, VH410 & VH410M

Ultraviolet Water Disinfection Systems from VIQUA

The quality of drinking water can change with time and become contaminated with harmful bacteria. The VIQUA **HOME family** of compact UV disinfection systems provide a **reliable**, **economical,** and **chemical-free** way to safeguard drinking water in any residential application. VIQUA's range of products have been designed and tested to ensure quality drinking water is at everyone's finger tips.

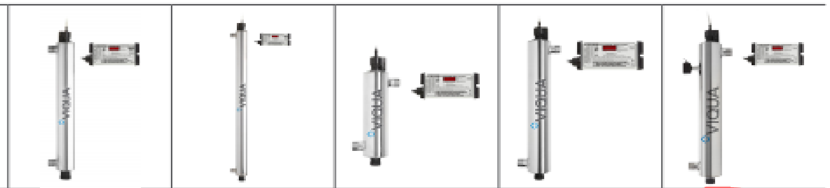
Regardless of your need, there is a VIQUA system to suit your requirements. **VIQUA offers systems that range in flow rates from just 6 GPM for a small home or cottage, up to 18 GPM for a larger home or small business.**



Features of VIQUA UV water disinfection systems

- Equipped to inactivate chlorine-resistant parasites such as **Cryptosporidium** and **Giardia**, harmful bacteria like *E.Coli*, and viruses not visible to the naked eye.
- Specially designed and tested Sterilume™-EX and -HO lamps provide **consistent and reliable** ultraviolet output over the entire life of the lamp (9000 hours) to ensure continuous purification.
- The system is simple to maintain and service allowing for easy lamp replacement.
- Built with a **durable stainless steel chamber** to prolong life and eliminate ultraviolet light degradation.
- Safety-Loc™ connector with interlock that ensures power is disconnected before lamp can be removed.
- The controller visually displays the remaining lamp life and will go into alarm if the lamp fails. Monitored systems are equipped with a UV sensor which provides a continuous readout of UV intensity.
- Monitored systems allow for the installation of an optional solenoid valve which will stop the flow of water through the chamber should the UV performance fall below a safe level.

Specifications



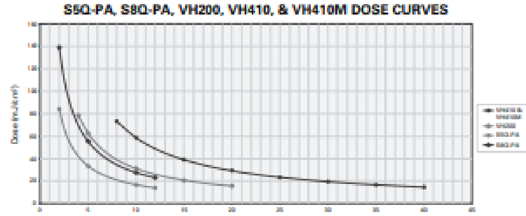
MODEL	S5Q-PA	S8Q-PA	VH200	VH410	VH410M
FLOW RATES (@ 95% UVT)					
US Public Health (16 mJ/cm²)	11 GPM (42 lpm) (2.5 m³/hr)	19 GPM (72 lpm) (4.3 m³/hr)	16 GPM (60 lpm) (3.6 m³/hr)	34 GPM (130 lpm) (7.8 m³/hr)	34 GPM (130 lpm) (7.8 m³/hr)
VIQUA Standard (30 mJ/cm²)	6 GPM (23 lpm) (1.4 m³/hr)	10 GPM (38 lpm) (2.3 m³/hr)	9 GPM (34 lpm) (2.0 m³/hr)	18 GPM (70 lpm) (4.2 m³/hr)	18 GPM (70 lpm) (4.2 m³/hr)
NSF/EPA (40 mJ/cm²)	4.5 GPM (17 lpm) (1.0 m³/hr)	8 GPM (29 lpm) (1.8 m³/hr)	7 GPM (26 lpm) (1.6 m³/hr)	14 GPM (54 lpm) (3.3 m³/hr)	14 GPM (54 lpm) (3.3 m³/hr)
DIMENSIONS					
Chamber	22" x 2.5" (56.1 cm x 6.5 cm)	35.5" x 2.5" (90.4 cm x 6.5 cm)	17.75" x 3.5" (45 cm x 8.9 cm)	23.5" x 3.5" (59.6 cm x 8.9 cm)	23.5" x 3.5" (59.6 cm x 8.9 cm)
Controller	7.25" x 3.25" x 2.5" (18.6 cm x 8.1 cm x 6.4 cm)	7.25" x 3.25" x 2.5" (18.6 cm x 8.1 cm x 6.4 cm)	7.25" x 3.25" x 2.5" (18.6 cm x 8.1 cm x 6.4 cm)	7.25" x 3.25" x 2.5" (18.6 cm x 8.1 cm x 6.4 cm)	9.25" x 3.25 x 2.5" (24 cm x 8.1 cm x 6.9 cm)
Inlet/Outlet Port Size	3/4" MNPT*	3/4" MNPT*	3/4" - 1" MNPT COMBO*	3/4" - 1" MNPT COMBO*	3/4" - 1" MNPT COMBO*
Shipping Weight	8 lbs (3.6 kg)	11 lbs (5 kg)	12 lbs (5.4 kg)	17 lbs (7.7 kg)	17 lbs (7.7 kg)
ELECTRICAL					
Voltage	100-240V / 50/60 Hz	100-240V / 50/60 Hz	100-240V / 50/60 Hz	100-240V / 50/60 Hz	100-240V / 50/60 Hz
Power Consumption	30 W	46 W	35 W	60 W	60 W
Maximum Operating Pressure	125 psi (8.62 bar)	125 psi (8.62 bar)	125 psi (8.62 bar)	125 psi (8.62 bar)	125 psi (8.62 bar)
Influent Water Temperature	2-40°C (36-104°F)	2-40°C (36-104°F)	2-40°C (36-104°F)	2-40°C (36-104°F)	2-40°C (36-104°F)
FEATURES					
Visual "Power On"	YES	YES	YES	YES	YES
Chamber Material	304 SS	304 SS	304 SS	304 SS	304 SS
Visual Lamp Life Remaining	YES	YES	YES	YES	YES
Audible Lamp Life Failure	YES	YES	YES	YES	YES
Audible Lamp Replacement Reminder	YES	YES	YES	YES	YES
UV Sensor	NO	NO	NO	NO	YES

* /2B - BSP

Replacement Parts

S463RL – UV lamp for S5Q-PA	**QS-410** – quartz sleeve for VH410 & VH410M
S810RL – UV lamp for S8Q-PA	**410867** – o-ring for quartz sleeves
S200RL – UV lamp for VH200	**RN-001** – retaining nut for all systems
S410RL – UV lamp for VH410 & VH410M	**BA-ICE-S** – electronic ICE controller for S5Q-PA and S8Q-PA
QS-463 – quartz sleeve for S5Q-PA	**BA-ICE-CL** – electronic ICE controller for VH200, VH410
QS-810 – quartz sleeve for S8Q-PA	**BA-ICE-CM** – electronic ICE controller VH410M
QS-001 – quartz sleeve for VH200	

S5Q-PA, S8Q-PA, VH200, VH410, & VH410M DOSE CURVES



Water Quality Parameters

Hardness	Iron	Tannins
< 7 grains (120 mg/L)	< 0.3 mg/L	< 0.1 mg/L

VIQUA simply safe water
425 Clair Rd. W, Guelph, Ontario, Canada N1L 1R1
t. 1.519.763.1032 • f. 1.519.763.5069 • tf. 1.800.265.7246 (US/CAN)
t. +31.73.7470144 (EUR) info@viqua.com • www.viqua.com
LIT-520329-R_RevB © 2017 VIQUA - a Division of Trojan Technologies Group ULC

Figure 2: Specification sheet of UV system [7]

B. Filter

Maintenance

Premium Whole House Water Filter

Your Pelican PC600/PC1000 Premium Whole House Water Filter requires care and cleaning after a period of 5 years. Replacement media and instructions can be ordered on-line at www.pelicanwater.com or by calling 877-842-1635. Model numbers for replacement media are PC600-R or PC1000-R.

Sediment Filter

It is recommended that the Sediment Filter be replaced every 6-9 months depending on the amount of sediment present in the water supply. If the system has been working properly and the pressure is slowing, it may be time to change the Sediment Filter. Check the Sediment Filter and replace if necessary. Replacement sediment filters can be ordered on-line at www.pelicanwater.com or by calling 877-842-1635. Model numbers for sediment filters are PC40 and PC80

Product Operation and Specifications

Specification Description	PC600	PC1000
Max Flow Rate	10 GPM	15 GPM
Minimum Working Pressure	25 PSI	
Maximum Working Pressure	80 PSI	
Maximum Vacuum	5 inch/127 mm Hg	
Operating Temperatures	36°F – 120°F	
pH Range	6 – 11	

Figure 3: Specification sheet of 5 micron filter [8]

C. Toilet

American Standard
Style That Works Better

H2OPTION SIPHONIC DUAL FLUSH ELONGATED TOILET
VITREOUS CHINA

H2OPTION SIPHONIC DUAL FLUSH ELONGATED TOILET

❑ **2887.216**
- Vitreous china
- High efficiency, low consumption
  - Full Flush (6.0 Lpf/1.6 gpf)
  - Partial Flush (3.8 Lpf/1.0 gpf)
- Elongated siphon action bowl with direct-fed jet
- Meets EPA WaterSense℠ criteria
- Qualifies in LEEDS Program
- 305mm (12") rough-in
- Fully glazed 2" Trapway
- Generous 9" x 8" water surface area
- Chrome plated top mounted push button actuator
- Sanitary bar on bowl
- 2 color matched bolt caps
- 100% factory flush tested
- 5 Year Limited Warranty on Total Toilet

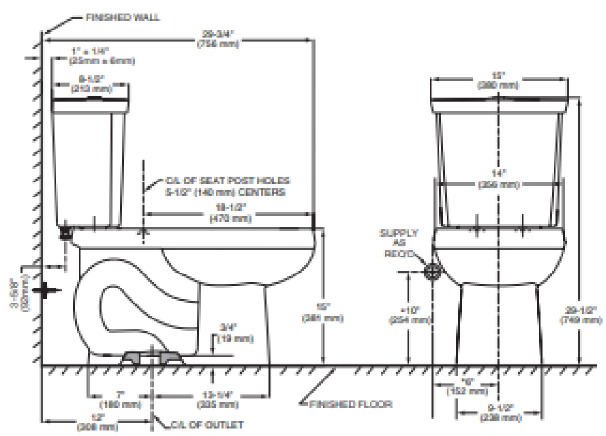
❑ **2887.516** Same as above, except with Tank with AquaGuard Liner

Separate Component Parts:
❑ **3706.216** Bowl
❑ **4339.216** Tank
❑ **4339.516** Tank with AquaGuard Liner

Nominal Dimensions:
756 x 380 x 749mm
(29-3/4" x 15" x 29-1/2")

Fixture only, seat and supply by others

Compliance Certifications -
Meets or Exceeds the Following Specifications:
- ASME A112.19.2-2008/CSA B45.1-08
- Los Angeles Department of Water and Power Supplementary Purchase Specification for Non-Adjustability
- US EPA WaterSense℠ criteria for HET's



To Be Specified:
❑ Color: ❑ White ❑ Bone ❑ Linen
❑ Seat: American Standard #5324.019 "Rise and Shine" solid plastic closed front seat with cover.
❑ Seat: American Standard #5311.012 "Laurel" molded closed front seat with cover.
❑ Seat: American Standard #5321.110 EverClean™ Elongated Seat with Cover and Slow Close Snap-Off hinges
❑ Alternate Seat:
❑ Supply with stop:

NOTES:
THIS COMBINATION IS DESIGNED TO ROUGH-IN AT A MINIMUM DIMENSION OF 305MM (12") FROM FINISHED WALL TO C/L OF OUTLET.
* DIMENSION SHOWN FOR LOCATION OF SUPPLY IS SUGGESTED. SUPPLY NOT INCLUDED WITH FIXTURE AND MUST BE ORDERED SEPARATELY.

IMPORTANT: Dimensions of fixtures are nominal and may vary within the range of tolerance established by ANSI Standard A112.19.2
These measurements are subject to change or cancellation. No responsibility is assumed for use of superseded or voided pages.

© 2009 AS America Inc.
Revised 7/09

D. Sink

KOHLER. Faucets

Elliston®

Single-handle bathroom sink faucet

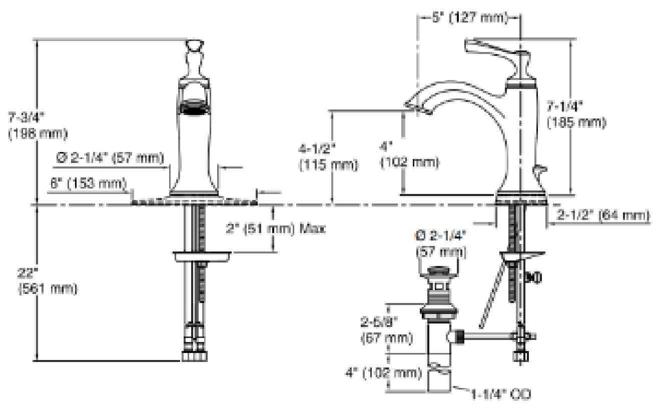
K-R72782-4D1

Features

- Single-handle bathroom sink faucet for single-hole or 4" center installations (includes escutcheon plate).
- KOHLER ceramic disc valves exceed industry longevity standards two times for a lifetime of durable performance.
- Constructed with premium materials for durability and reliability.
- KOHLER finishes resist corrosion and tarnishing.
- 1.2 gpm (gallons per minute) maximum flow rate.

Water Conservation & Rebates

- WaterSense®-labeled 1.2gpm faucets use at least 45 percent less water than standard 2.2-gpm faucets while still meeting strict performance guidelines.



ADA | **CSA B651** | **OBC**

Codes/Standards

ASME A112.18.1/CSA B125.1
NSF/ANSI 61
NSF/ANSI 372
All applicable US Federal and State material regulations
DOE - Energy Policy Act 1992
EPA WaterSense®
California Energy Commission (CEC)
ADA
ICC/ANSI A117.1
CSA B651
OBC

Technical Information

All product dimensions are nominal.

Faucet:

Flow rate:	1.2 gal/min (4.5 l/min)
Pressure:	60 psi (4.1 bar)
Drain included:	Yes
Drain tailpiece included:	Yes

Spout:

Spout reach:	5" (127 mm)

KOHLER® One-Year Limited Warranty

See website for detailed warranty information.

Available Colors/Finishes

Color tiles intended for reference only.

Color	Code	Description
	CP	Polished Chrome
	BN	Vibrant® Brushed Nickel

Notes

Install this product according to the installation guide.

ADA, OBC, CSA B651 compliant when installed to the specific requirements of these regulations.

1-800-4KOHLER (1-800-456-4537)
Kohler Co. reserves the right to make revisions without notice to product specifications.
For the most current Specification Sheet, go to www.kohler.com.
3-18-2019 13:20 - US/CA

THE BOLD LOOK OF KOHLER.

E. Showerhead

NEW TEMPESTA
COSMOPOLITAN 100
Shower Head 1 Spray
MODEL # 26051001

Pure Freude an Wasser

GROHE

GROHE America, Inc | 200 North Gary Avenue, Suite G, Roselle, IL 60172
Phone: +1 (800) 444-7643 | Fax: +1 (800) 225-2778 | us-customerservice@grohe.com

Product Description:
Shower Head 1 Spray

Standard Specification:
- Rain spray pattern (1 spray-rain)
- Rotating ball joint ± 15°
- 1/2" Connection thread
- **GROHE EcoJoy** 1.5 gpm (5.7 l/min) flow restrictor
- **GROHE DreamSpray** perfect spray pattern
- **GROHE StarLight** chrome finish
- **SpeedClean**® anti-lime system
- Inner WaterGuide for a longer life
- Min. recommended pressure: 15 psi
- Max Flow Rate: 1.5 gpm (5.7 L/min)

Applicable Codes & Standards:
- CalGreen

Color:
❑ 26051001 StarLight Chrome

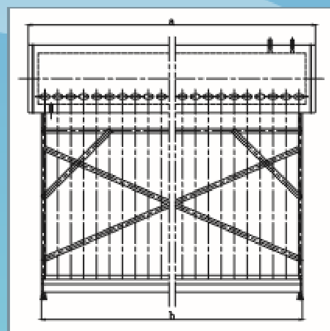
F. Solar Water Heater

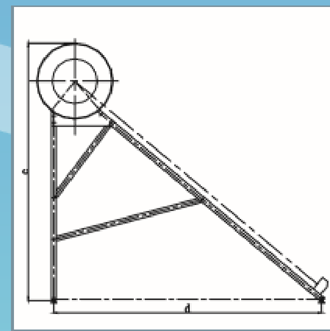
SFA Model: Thermosyphon Tubular Solar Water Heater

1st SUNFLOWER RENEWABLE ENERGY

Description:

The design of this type uses the principle of Thermosyphon. It is a natural circulation process. This type uses double layers glass solar tubes. The water fills in the tubes, which in turn is heated in the tank (which can vary between 85 and 220litres) by convection. It has obvious advantages: with a tank and the fittings are very low-cost.

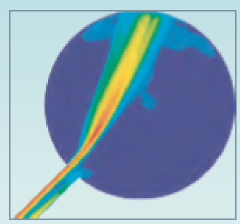




Item No.	Specification				Tank's Capacity	Total Capacity	Effective collector area M²	size(mm)				Qty(set)	
	Diameter of water tank	Qty. of solar tubes	Diameter of solar tube	Length of solar tube				a	b	c	d	20'ft	40'ft
SFA42154715	Ø 420mm	15pcs	Ø 47mm	1.5M	84.2L	104.4L	1.25	1170	1060	1307	1346	77	157
SFA42184715	Ø 420mm	18pcs	Ø 47mm	1.5M	100.5L	124.7L	1.49	1380	1270	1307	1346	66	134
SFA42204715	Ø 420mm	20pcs	Ø 47mm	1.5M	111.4L	138.3L	1.66	1520	1410	1307	1346	60	122
SFA42244715	Ø 420mm	24pcs	Ø 47mm	1.5M	133.3L	165.5L	1.99	1800	1690	1307	1346	52	105
SFA42304715	Ø 420mm	30pcs	Ø 47mm	1.5M	166L	206.3L	2.49	2220	2110	1307	1346	42	85
SFA47155818	Ø 470mm	15pcs	Ø 58mm	1.8M	132.3L	172.9L	1.89	1348	1228	1594	1655	50	101
SFA47185818	Ø 470mm	18pcs	Ø 58mm	1.8M	148.6L	197.3L	2.27	1591	1471	1594	1655	43	87
SFA47205818	Ø 470mm	20pcs	Ø 58mm	1.8M	164.9L	219L	2.52	1753	1633	1594	1655	38	78
SFA47245818	Ø 470mm	24pcs	Ø 58mm	1.8M	197.5L	262.5L	3.03	2077	1957	1594	1655	33	68
SFA47305818	Ø 470mm	30pcs	Ø 58mm	1.8M	246.3L	327.5L	3.78	2563	2443	1594	1655	26	54

Features:

1. Beautiful in design and very convenient for family use.
2. Reliable and efficient with twin-glass solar tubes.
3. No corrosion: It can prevent corrosion caused by chlorine ion, sea water, salt water or buck water.
4. No leakage: Apply for special anti-corrosion layer.
5. Sanitary water: The qualities showed above make it possible that water quality is pure and no twice pollution.
6. Using the polyurethane to preserve heat, which makes people enjoy hot water in cold evenings.
7. Designing the immersion heater hole in advance for the cloudy, snowy, rainy days.
8. Easy plug-in installation.



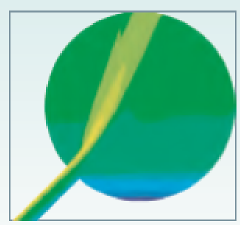
VELOCITY

Scope of Application:

SFA is very popular in Asia, Africa, torrid zone and warm area.

Notice:

1. The angle of the frame can be changed in the production process according to the local latitude condition of the customers. We can design the suitable angle for customers.
2. We offer the spare accessories and tubes for your orders for free.
3. We can offer water tanks, frames and tubes in different materials according to your request.
4. We offer the fittings of this system, such as immersion heater, water supplier, magnesium and so on. You can buy according to your requirement.



TEMPERATURE

Http:// www.sunflower-solar.com E-mail: info@sunflower-solar.com
This product performance is being improved unceasingly. We reserve the rights for change without prior notice.

CIII: Power

A. Solar Panel

RENOGY

RNG-300D

300W Monocrystalline Solar Panel

Key Features

The Renogy 300 Watt 24 Volt Monocrystalline Solar Panel is the first step to converting your house from an energy dependant home to a energy producing location.

- High module conversion efficiency
- Top ranked PTC rating
- Quick and inexpensive mounting
- 100% EL testing on all Renogy modules
- No hot spots guaranteed

Potential Uses

The Renogy 300 Watt Monocrystalline Panel can be primarily used in on-grid applications that include multi-panel solar arrays.

25 Years — Power Output Warranty

5 Years — Material and Workmanship Warranty

Renogy | www.renogy.com | techsupport@renogy.com | T: 800-330-8678
2775 E. Philadelphia St., Ontario, CA 91761

RNG-300D

300W Monocrystalline Solar Panel

Electrical Data

Maximum Power at STC*	300 W
Optimum Operating Voltage (V_{mp})	32.25 V
Optimum Operating Current (I_{mp})	9.33 A
Open Circuit Voltage (V_{oc})	39.82V
Short Circuit Current (I_{sc})	9.78 A
Module Efficiency	18.24%
Maximum System Voltage	1000 VDC UL
Maximum Series Fuse Rating	15 A

Mechanical Data

Solar Cell Type	Monocrystalline (6.14 x 6.14 in)
Number of Cells	60 (6 x 10)
Dimensions	64.96 x 39.25 x 1.57 in (1650 x 997 x 40 mm)
Weight	42.8 lbs (19.4 kg)
Front Glass	Tempered Glass 0.13 in (3.2 mm)
Frame	Black Anodized Aluminium Alloy
Connectors	MC4 Connectors
Fire Rating	Type 2

Thermal Characteristics

Operating Module Temperature	-40ºC to +90ºC
Nominal Operating Cell Temerature (NOCT)	47±2ºC
Temperature Coefficient of Pmax	-0.47%/ºC
Temperature Coefficient of Voc	-0.33%/ºC
Temperature Coefficient of Isc	0.03%/ºC

MC4 Connectors

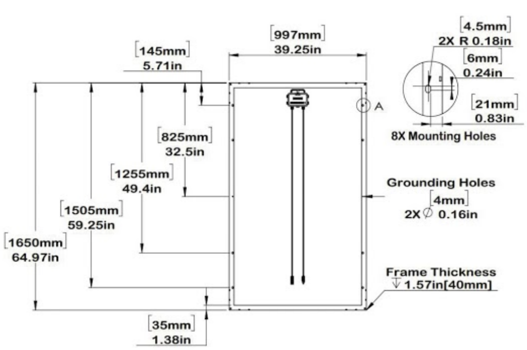
Rated Current	30A
Maximum Voltage	1000VDC
Maximum AWG Size Range	10 AWG
Temperature Range	-40ºF to 194ºF
IP Rating	IP 67

Junction Box

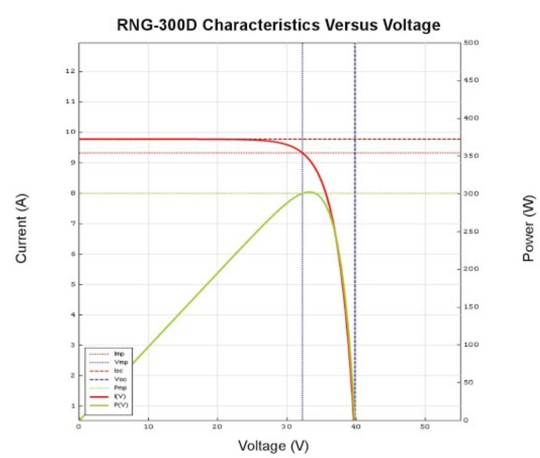
IP Rating	IP 67
Diode Type	SB3050DY
Number of Diodes	3 Diode(s)
Output Cables	12 AWG (2.79 ft long)

Certifications

Module Diagram



IV-Curve



*All specifications and data described in this data sheet are tested under Standard Test Conditions (STC - Irradiance: 1000W/m², Temperature: 25°C, Air Mass: 1.5) and may deviate marginally from actual values. Renogy and any of its affiliates has reserved the right to make any modifications to the information on this data sheet without notice. It is our goal to supply our customers with the most recent information regarding our products. These data sheets can be found in the downloads section of our website, www.renogy.com

B. Solar Walkway Lights

Dimensions

Product Depth (in.)	6.1 in	Product Length (in.)	6.1 in
Product Height (in.)	18.31 in	Product Width (in.)	6.1 in

Details

Actual Color Temperature (K)	2800	Lumens	10
Color Rendering Index (CRI)	80	Mounting Type	Ground
Color Temperature	Warm White	Number of Bulbs Required	1
Compatible Lighting Technology	Integrated LED	Number of Housings Included	1
Exterior Lighting Product Type	Walkway and Path Lighting	Outdoor Lighting Features	No additional features
Fixture Color/Finish	Oil-Rubbed Bronze	Pack Size	1
Fixture Material	Stainless Steel	Power Type	Solar
Fixture Material	Glass	Power Type	Solar
Glass/Lens Type	Textured	Product Weight (lb.)	1.21 lb
Included	No Additional Items	Returnable	90-Day
Included	Remote Control Included	Style	Modern
Landscape Lighting Application	Walk & Path Lighting	Watt Equivalence	0.12
Light Bulb Type Included	Integrated LED		

C. Battery

Simple Steps For Longer Battery Life

Trojan Battery Company has manufactured batteries for eighty years. Our experience shows that the key to achieving optimum performance and long life is a solid battery maintenance program using the simple procedures outlined here.

Equipment:

Trojan recommends the following equipment for use in battery care and maintenance:

- Wrench
- Distilled Water
- Voltmeter
- Hydrometer
- Post Cleaner
- Baking Soda
- Petroleum Jelly
- Goggles & Gloves

CAUTION: Always wear protective clothing, gloves, and goggles when handling batteries and electrolyte.

Inspection

1. Examine the outside appearance of the battery.
   - Look for cracks in the container.
   - The top of the battery, posts and connections should be free of dirt, fluids and corrosion. (If batteries are dirty, see Cleaning section.)
   - Replace any damaged batteries.
2. Any fluids on or around the battery may indicate that electrolyte is spilling, leaching or leaking out.
   - Leaking batteries must be replaced.
3. Check all battery cables and connections.
   - Look closely for loose or damaged parts.
   - Replace any cable that is broken or frayed.

WARNING: Do not smoke near batteries.

4. Tighten all wiring connections to the proper specification (following page.) Be sure there is good contact with the terminals.

WARNING: Do not over-tighten terminals. Over-tightening can result in post breakage, post meltdown or fire.

Proper Torque Values for Connection Hardware

Flooded

- Automotive: 50-70 in-lbs
- Side: 70-90 in-lbs
- Wingnut: 95-105 in-lbs
- LPT: 95-105 in-lbs
- LT: 100-120 in-lbs

Gel

- Button: 90-110 in-lbs
- LT: 100-120 in-lbs

Specific Gravity Testing

(Flooded batteries only)

1. Do not add water prior to testing.
2. Fill and drain the hydrometer 2-4 times before drawing a sample from the battery.
3. Have enough sample electrolyte in the hydrometer to completely support the float.
4. Take a reading, record it and return the electrolyte to the cell.
5. Check all cells in the battery, repeating the steps above.
6. Replace vent caps and wipe off any electrolyte that might have been spilled.
7. Correct the readings to 80°F:
   - Add .004 to readings for every 10° above 80°F.
   - Subtract .004 for every 10° below 80°F.
8. Check the state of charge using the table on the next page.

The readings should be within the factory specification of 1.277 +/-.007. If any specific gravity reading registers low, follow these steps:

1. Check and record voltage level(s).
2. Put batteries on a complete charge.
3. Take specific gravity readings again.

If any specific gravity reading still registers low, follow these steps:

1. Check voltage level(s).
2. Perform equalization charge. (See Equalizing).
3. Take specific gravity readings again.

If any specific gravity reading still registers lower than the factory specification, one or more of these conditions may exist:

1. The battery is old and nearing end of life.
2. The battery was left discharged too long.
3. Electrolyte was lost due to spillage.
4. A weak or bad cell is developing.
5. The battery was over-watered prior to testing.

Batteries in conditions 1-4 should be taken to a specialist for further evaluation or retired from service.

Open-Circuit Voltage Testing

For accurate voltage readings, batteries must remain idle (no charging, no discharging) for at least 6 hours, and preferably 24 hours.

1. Disconnect all loads from the batteries.
2. Measure the voltage with a DC voltmeter.
3. Check the state of charge with the table below.
4. Charge the battery if it registers 0-70% charged.

If battery registers below table values, these conditions may exist:

1. The battery was left discharged too long.
2. The battery has a bad cell.

Batteries in these conditions should be taken to a specialist for further evaluation, or retired from service.

% STATE OF CHARGE	SPECIFIC GRAVITY CORRECTED TO 80° F	OPEN-CIRCUIT VOLTAGE 6 VOLT	8 VOLT	12 VOLT
100	1.277	6.37	8.49	12.73
90	1.258	6.31	8.41	12.62
80	1.238	6.25	8.33	12.50
70	1.217	6.19	8.25	12.37
60	1.195	6.12	8.16	12.24
50	1.172	6.05	8.07	12.10
40	1.148	5.98	7.97	11.96
30	1.124	5.91	7.88	11.81
20	1.098	5.83	7.77	11.66
10	1.073	5.75	7.67	11.51

State of charge as related to specific gravity and open-circuit voltage

Watering

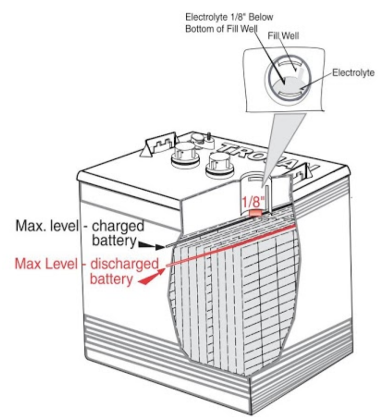
(Flooded batteries only)

Water should only be added after fully charging the battery. Prior to charging, there should be enough water to cover the plates. If the battery has been discharged (partially or fully), the water level should also be above the plates.

Important things to remember:

1. Do not allow plates to be exposed to air.
2. Do not fill the water all the way up to the cap.
3. Do not use water with a high mineral content.
4. Use only distilled or deionized water.

CAUTION: The electrolyte is a solution of acid and water, so skin contact should be avoided.



Procedure:

1. Remove the vent caps and check the electrolyte level; the minimum level is to the top of the plates.
2. If there is no electrolyte visible, add just enough water to cover the plates.
3. Replace and tighten all water vent caps.
4. Put batteries on a complete charge before adding any more water. (See Charging section.)
5. Once charging is completed, remove the vent caps and check the electrolyte level.

6. Add water until the electrolyte level is 1/8" below the bottom of the fill well.

7. Clean, replace and tighten all vent caps.

WARNING: Never add acid to a battery.

Cleaning

1. Check that all vent caps are tight.
2. Clean the battery top with a cloth or brush and a solution of baking soda and water.
   - Do not allow any cleaning solution or other foreign matter to get inside the battery.
3. Rinse with water and dry with a clean cloth.
4. Clean battery terminals and the inside of cable clamps with a post and clamp cleaner.
5. Reconnect the clamps to the terminals and thinly coat them with petroleum jelly.
6. Keep the area around batteries clean and dry.

Storage

Important things to avoid:

1. Freezing - Avoid locations where freezing temperatures are expected. Keeping batteries at a high state of charge also prevents freezing. (See table next page.)
2. Heat - Avoid direct exposure to heat sources, such as radiators or space heaters. Temperatures above 80° F accelerate the battery's self-discharge characteristics.

Procedure:

1. Completely charge the battery before storing.
2. Store the battery in a cool, dry location, protected from the elements.
3. During storage, monitor the specific gravity (flooded batteries) or voltage.
   - Stored batteries should be given a boost charge when they show a 70% state of charge or less. (See table previous page.)
4. Completely charge the battery before re-activating.

5. For optimum performance, equalize the batteries (flooded) before putting them back into service. (See Equalizing section.)

Electrolyte Freezing Point@Various States of Charge*

SPECIFIC GRAVITY	%STATE OF CHARGE	FREEZING TEMPERATURE
1.280	100	-92.0°F
1.265	92	-71.3°F
1.250	85	-62.0°F
1.200	62	-16.0°F
1.150	40	+5.0°F
1.100	20	+19.0°F

*Source: BCI Battery Service Manual 1995

Charging

Correctly charging batteries requires administering the right amount of current at the right voltage. Most charging equipment automatically regulates these values. Some chargers allow the user to set these values. For proper charging, refer to the instructions that came with your charging equipment.

Important things to remember:

1. Become familiar with, and follow the instructions from, the charger manufacturer.
2. Batteries should be charged after each period of use.
3. Lead-acid batteries do not develop a memory and need not be fully discharged before recharging.
4. Charge only in well-ventilated areas. Keep sparks or flames away from a charging battery.
5. Verify charger voltage settings are correct.
6. Check electrolyte level. (See Watering section.)
7. Tighten all vent caps before charging.
8. Do not overcharge or undercharge the batteries.
9. Never charge a frozen battery.
10. Avoid charging at temperatures above 120° F.

Equalizing

(Flooded batteries only)

WARNING: Do not equalize Gel or AGM batteries.

Equalizing is an overcharge performed on flooded lead-acid batteries after they have been fully charged. It helps eliminate stratification and sulfation, two conditions that can reduce the overall performance of a battery.

Trojan recommends equalizing only when low or wide ranging specific gravity (+/-.015) is detected after fully charging a battery.

Procedure:

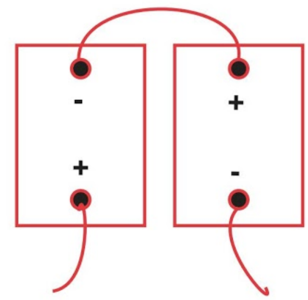
1. Verify that batteries are the flooded type.
2. Remove all loads from the batteries.
3. Connect battery charger.
4. Set charger to equalizing mode.
5. Start charging batteries.
6. Batteries will begin gassing and bubbling vigorously.
7. Take specific gravity readings every hour.
8. Equalization is complete when specific gravity values no longer rise during the gassing stage.

NOTE: Many chargers do not have an equalization setting, so this procedure cannot be used.

How To Increase System Power

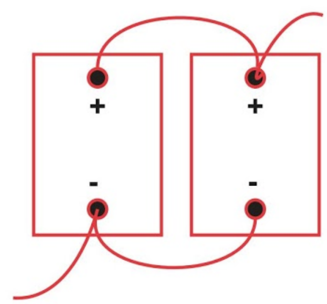
Two or more batteries can be easily connected to boost your system's voltage and/or capacity. There are three methods to obtain additional voltage and/or capacity, as described below:

To increase voltage, connect batteries in series.



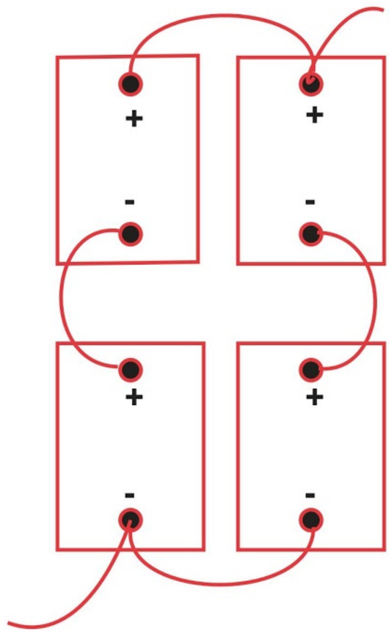
Battery System: 12 Volt, 225 AH
Using Two T-105 Deep Cycle Batteries
(6 Volts, 225 AH)

To increase amp-hour capacity, connect batteries in parallel.



Battery System: 6 Volt, 450 AH
Using Two T-105 Deep Cycle Batteries
(6 Volts, 225 AH)

To increase both voltage and amp-hour capacity, connect batteries in series/parallel.



Battery System: 12 Volt, 450 AH
Using Four T- 105 Deep Cycle Batteries
(6 Volts, 225AH)

NOTE: These systems can also be configured using 12-volt batteries. It is not recommended that you mix batteries of different voltages within the same system.

Battery Terms Explained

1. **Active Material** - In the positive plates, the active material is lead dioxide. In the negative, it's metallic sponge lead. When a circuit is created, these materials react with sulfuric acid during charging and discharging.
2. **Ampere (Amp)** - A unit of measurement for the electron flow or current through a circuit.
3. **Ampere-Hour (Amp. Hr., AH)** - A unit of measure for a battery's electrical storage capacity, calculated by multiplying the current in amperes by the time in hours. (Example: A battery which delivers 5 amps for 20 hours provides 5 amps x 20 hours = 100 AH of capacity.)
4. **Capacity Rating** - The time in minutes that a new, fully-charged battery will deliver 25 amperes or 75 amperes at 80° F and maintain a terminal voltage equal to or greater than 1.75 volts per cell.
5. **Cell** - The basic current-producing unit in a battery. It consists of a set of positive plates, negative plates, electrolyte, separators and casing. A cell's nominal voltage is 2 volts. (Example: A 12-volt battery has 6 cells.)
6. **Circuit** - The path followed by a flow of electrons. A closed, or short, circuit is a complete path. An open circuit has a broken path.
7. **Cycle** - One discharge of a battery plus one recharge.
8. **Depth of Discharge (DOD)** - The percentage of capacity actually removed from a battery compared to the total rated capacity.
9. **Electrolyte** - In a deep cycle battery, it is a dilute solution of sulfuric acid and water.
10. **Hydrometer** - A tool used to measure the specific gravity of the electrolyte solution.
11. **Equalization** - An overcharge performed on flooded lead-acid batteries after they have been fully charged. This maintenance step helps eliminate stratification and sulfation.

12. **Ohm (Ω)** - A unit of measurement for electrical resistance within a circuit.
13. **Open Circuit Voltage** - The voltage of a battery when there is no load attached (not receiving or delivering energy). This measurement is best taken when the battery has been at rest for at least 6 hours.
14. **Power Inverter** - An electronic device that converts direct current (DC) power from a battery into standard alternating current (AC) house power.
15. **Primary Battery** - An energy storage device that can deliver energy but cannot be recharged. (i.e., disposable flashlight battery)
16. **Secondary Battery** - An energy storage device than can deliver energy and can be recharged. (i.e., automotive or deep cycle battery)
17. **Separator** - A divider made of porous material that is placed between the positive and negative plates in a battery cell and allows current to flow through it, while preventing direct contact between the plates which would cause a short circuit.
18. **Specific Gravity (S.G.)** - A measurement of the strength of battery electrolyte by comparing its density to that of pure water.
19. **Stratification** - A condition where the concentration of acid is greater at the bottom of the battery than at the top.
20. **Sulfation** - The formation of lead sulfate on the positive and negative electrodes.
21. **Volt (V)** - A unit of measurement for electrical potential within a circuit.
22. **Watt (W)** - A unit of measurement for electrical power.
23. **Watt Hour (Wh)** - A unit of measurement for electrical power for a certain period of time.

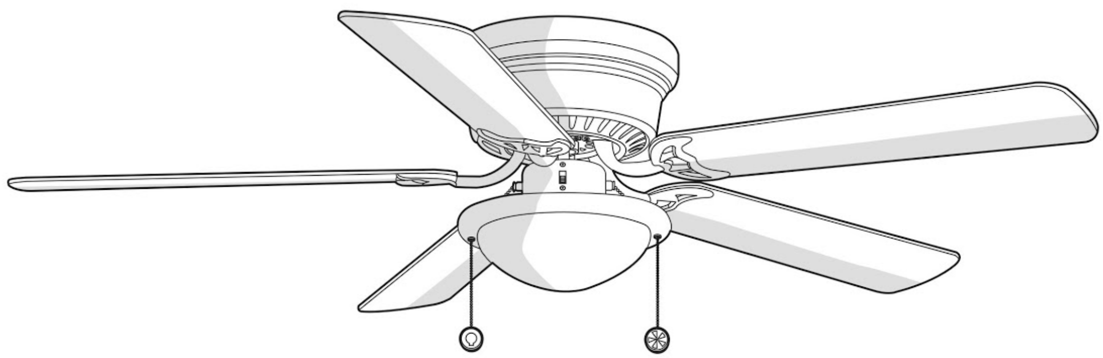
Notes

D. Fan

Item #1002269802
Model #AL383LED-BN

USE AND CARE GUIDE

HUGGER 52 IN. CEILING FAN



Questions, problems, missing parts? Before returning to the store call
Home Depot Customer Service
8 a.m. - 7 p.m., EST, Monday-Friday, 9 a.m. - 6 p.m., EST Saturday

1-877-527-0313

HOMEDEPOT.COM

THANK YOU

We appreciate the trust and confidence you have placed in Home Depot through the purchase of this ceiling fan. We strive to continually create quality products designed to enhance your home. Visit us online to see our full line of products available for your home improvement needs. Thank you for choosing Home Depot!

Table of Contents

Safety Information

1. To reduce the risk of electric shock, ensure electricity has been turned off at the circuit breaker or fuse box before beginning.

2. All wiring must be in accordance with the National Electrical Code "ANSI/NFPA 70-1999" and local electrical codes. Electrical installation should be performed by a qualified licensed electrician.

3. The outlet box and support structure must be securely mounted and capable of reliably supporting a minimum of 35 lbs (15.9 kg) or less. Use only UL-listed outlet boxes marked "FOR FAN SUPPORT."

4. The fan must be mounted with a minimum of 7 ft (2.1m) clearance from the trailing edge of the blades to the floor.

5. Avoid placing objects in the path of the blades.

6. To avoid personal injury or damage to the fan and other items, be cautious when working around or cleaning the fan.

7. Do not use water or detergents when cleaning the fan or fan blades. A dry dust cloth or lightly dampened cloth will be suitable for most cleaning.

8. After making electrical connections, spliced conductors should be turned upward and pushed carefully up into the outlet box. The wires should be spread apart with the grounded conductor and the equipment-grounding conductor on one side of the outlet box and ungrounded conductor on the other side of the outlet box.

9. All setscrews must be checked and retightened where necessary before installation.

10. This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

    Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

    NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

WARNING: To reduce the risk of electrical shock or fire, do not use this fan with any solid-state fan speed control device. It will permanently damage the electronic circuitry.

WARNING: To reduce the risk of personal injury, do not bend the blade arms (also referred to as flanges), when installing the brackets, balancing the blades or cleaning the fan.

WARNING: Do not insert foreign objects between rotating fan blades.

WARNING: To reduce the risk of fire, electric shock or personal injury, mount the fan to the outlet box marked acceptable for fan support with the screws provided with the outlet box.

CAUTION: To reduce the risk of personal injury, use only the screws provided with the outlet box.

Warranty

We warrant the fan motor to be free from defects in workmanship and material present at time of shipment from the factory for a period of lifetime after the date of purchase by the original purchaser. We also warrant that all other fan parts, excluding any glass or acrylic blades, to be free from defects in workmanship and material at the time of shipment from the factory for a period of one year after the date of purchase by the original purchaser. We agree to correct such defects without charge or at our option replace with a comparable or superior model if the product is returned. To obtain warranty service, you must present a copy of the receipt as proof of purchase. All costs of removing and reinstalling the product are your responsibility. Damage to any part such as by accident, misuse, improper installation or by affixing any accessories, is not covered by this warranty. Because of varying climatic conditions this warranty does not cover any changes in brass finish, including rusting, pitting, corroding, tarnishing or peeling. Brass finishes of this type give their longest useful life when protected from varying weather conditions. A certain amount of “wobble” is normal and should not be considered a defect. Servicing performed by unauthorized persons shall render the warranty invalid. There is no other express warranty. We hereby disclaim any and all warranties, including but not limited to those of merchantability and fitness for a particular purpose to the extent permitted by law. The duration of any implied warranty which cannot be disclaimed is limited to the time period as specified in the express warranty. Some states do not allow limitation on how long an implied warranty lasts, so the above limitation may not apply to you. The retailer shall not be liable for incidental, consequential, or special damages arising out of or in connection with product use or performance except as may otherwise be accorded by law. Some states do not allow the exclusion of incidental or consequential damages, so the above exclusion or limitation may not apply to you. This warranty gives specific legal rights, and you may also have other rights which vary from state to state. This warranty supersedes all prior warranties. Shipping costs for any return of product as part of a claim on the warranty must be paid by the customer.

Contact the Customer Service Team at 1-877-527-0313 or visit www.homedepot.com

Pre-Installation

SPECIFICATIONS

Fan size	Speed	Volts	Amps	Watts	RPM	CFM	N.W.	G.W.	C.F.
52 in.	Low	120	0.21	9.42	61	928	6.22 kg (13.68 lb)	7.32 kg (16.10 lb)	1.87 cu. ft.
	Medium		0.36	28.34	106	2202			
	High		0.49	58.12	145	3256			

NOTE: These are approximate measures. They do not include amps and wattage used by the light kit.

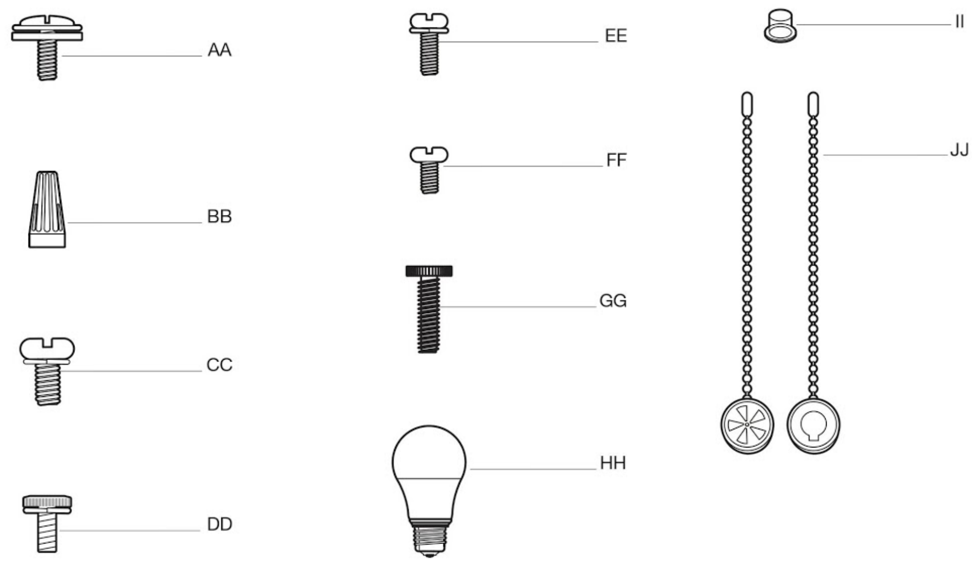
LISTED

TOOLS REQUIRED

Pre-Installation (continued)

HARDWARE INCLUDED

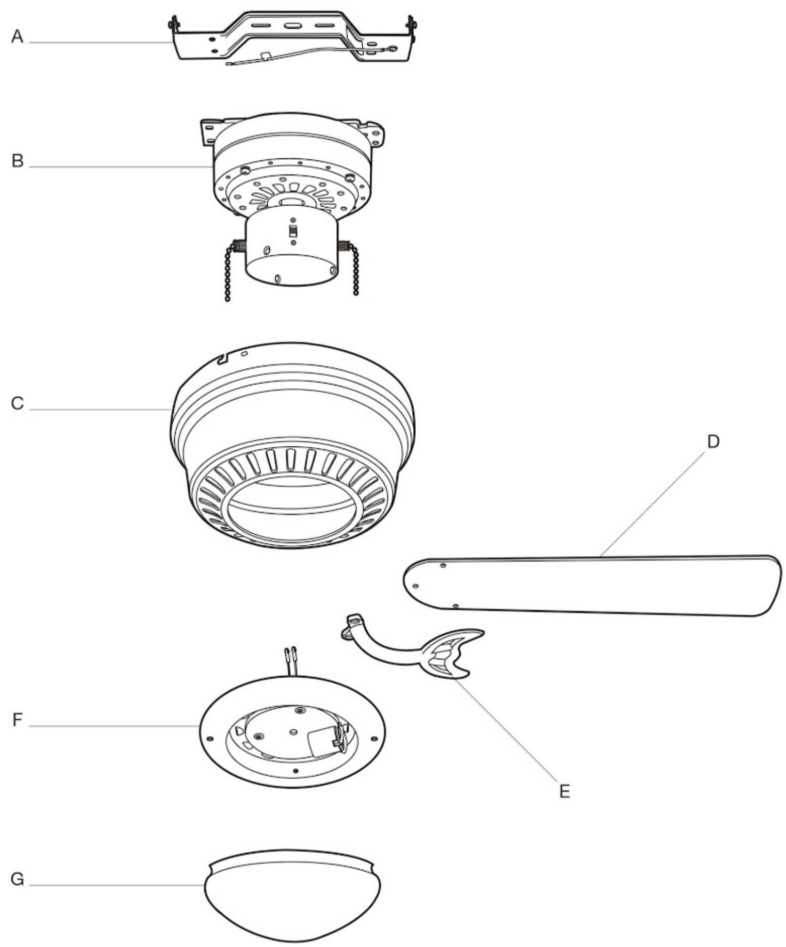
NOTE: Hardware shown to actual size unless noted otherwise in the table below.



Part	Description	Quantity
AA	Blade attachment screw and fiber washer	16
BB	Plastic wire nut (not to scale)	3
CC	Mounting plate screw and lock washer (not to scale)	5
DD	Motor housing screw and lock washer (preassembled)	4
EE	Blade arm screw and lock washer	11
FF	Light kit mounting screw (preassembled)	3
GG	Light holder thumbscrew (preassembled)	4
HH	9.5 watt LED bulb (not to scale)	1
II	Plastic plug (not to scale)	1
JJ	Pull chain and fob (not to scale)	2

Pre-Installation (continued)

PACKAGE CONTENTS



Part	Description	Quantity
A	Mounting plate	1
B	Fan motor assembly	1
C	Motor housing	1
D	Blade	5

Part	Description	Quantity
E	Blade arm	5
F	Light kit	1
G	Glass shade	1

Installation

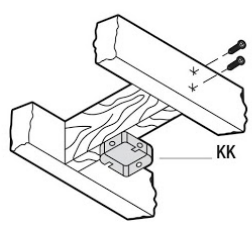
MOUNTING OPTIONS

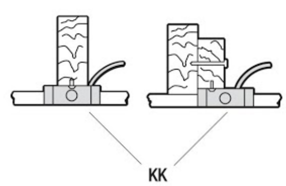
> ⚠ **WARNING:** To reduce the risk of fire, electric shock, or personal injury, mount the fan to an outlet box marked acceptable for fan support using the screws provided with the outlet box. An outlet box commonly used for the support of lighting fixtures may not be acceptable for fan support and may need to be replaced. If in doubt, consult a qualified electrician.

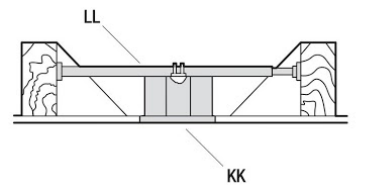
If your ceiling fan does not have an existing UL-listed mounting box, then install one using the following instructions:

- □ Disconnect the power by removing the fuses or turning off the circuit breakers.
- □ Secure the outlet box (KK) (not included) directly to the building structure. Use appropriate fasteners and materials (not included). The outlet box and its bracing must be able to fully support the weight of the moving fan (at least 35 lbs.). Do not use a plastic outlet box.

The illustrations below show two different ways to mount the outlet box (KK) (not included).







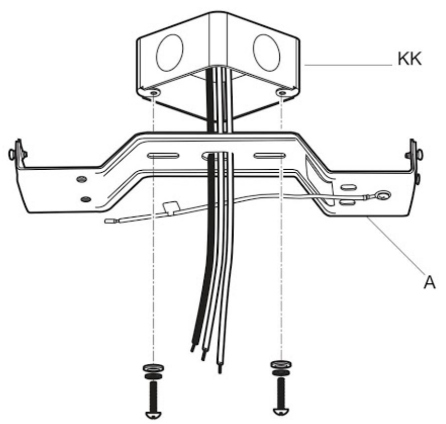
To hang your fan where there is an existing fixture but no ceiling joist, you may need an installation hanger bar (LL) (not included) as shown above.

Assembly — Hanging the Fan

1 Attaching the mounting plate to the electrical box

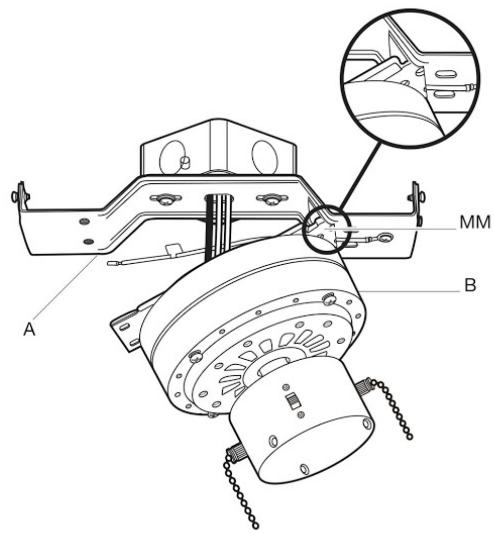
⚠ **WARNING:** To reduce the risk of fire, electric shock or other personal injury, mount the fan only to an outlet box or supporting system marked acceptable for fan support and use the mounting screws provided with the outlet box.

- ☐ Attach the mounting plate (A) to the outlet box (KK) (not included) with two screws and washers provided with the outlet box (KK). Ensure the mounting plate (A) is tight and secured.



2 Hanging the fan from the mounting bracket

- ☐ Carefully lift the fan motor assembly (B) and insert the T section of the motor mounting plate (MM) into the slot in the mounting plate (A).



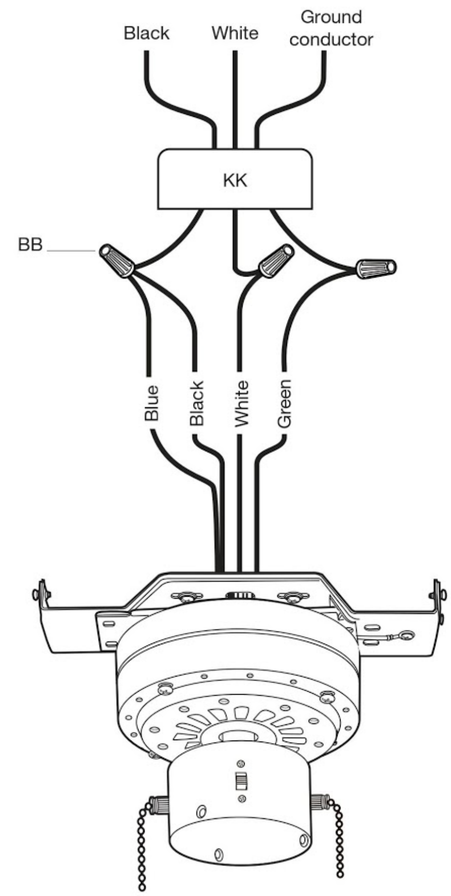
Assembly — Hanging the Fan (continued)

3 Making the electrical connections

WARNING: To avoid possible electrical shock, be sure electricity is turned off at the main fuse box before wiring.

WARNING: Check to see that all connections are tight, including ground, and that no bare wire is visible at the wire nuts (except for the ground wire).

WARNING: To reduce the risk of fire or electric shock, do not use this fan with any solid-state speed control device.



If you feel you do not have enough electrical wiring knowledge or experience, have your fan installed by a licensed electrician.

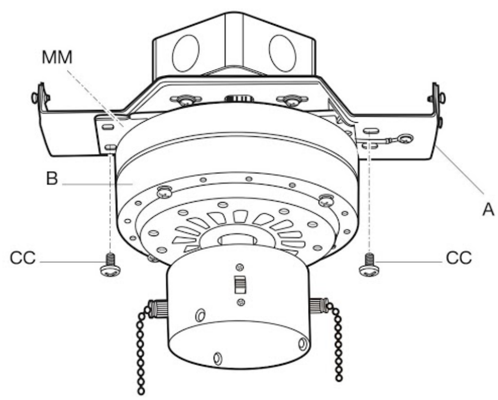
Follow the steps below to connect the fan to your household wiring. Use the plastic wire nuts (BB) with your fan. Secure the wire nuts (BB) with electrical tape. Make sure there are no loose strands or connections.

- ☐ Connect the ground conductor of the 120V supply (this may be a bare wire or a wire with green colored insulation) to the green ground lead(s) of the fan.
- ☐ Connect the fan motor white wire to the supply white (neutral) wire using a plastic wire nut (BB).
- ☐ Connect the fan motor black wire and the blue wire to the supply black (hot) wire using a plastic wire nut (BB).
- ☐ Turn the wire nut connections upward, spreading them apart so the green (ground) wire and the white wire will be on one side of the outlet box (KK), the black and blue wires will be on the other side, and push carefully up into the outlet box (KK).

Assembly — Hanging the Fan (continued)

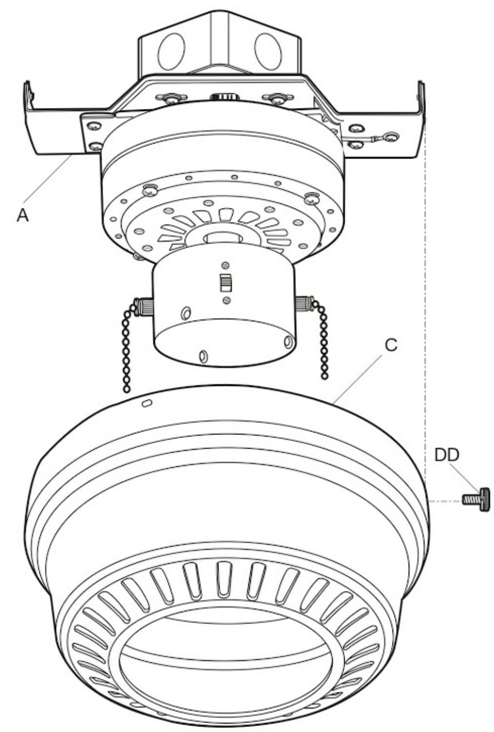
4 Finishing the fan installation

- Swing the motor assembly (B) up into position under the motor mounting plate (MM). Secure the motor mounting plate (MM) to the mounting plate (A) with the screws and lock washer (CC) provided.



5 Attaching the motor housing to the mounting plate

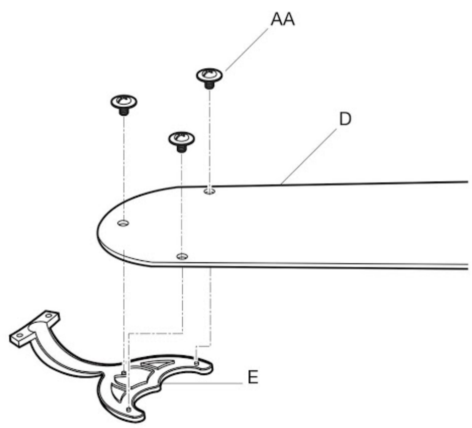
- Carefully lift the motor housing (C) onto the mounting plate (A), properly align the holes and tighten the motor housing (C) with the four screws and lock washer (DD) supplied.



Assembly — Attaching the Fan Blades

6 Attaching the blades to the blade arms

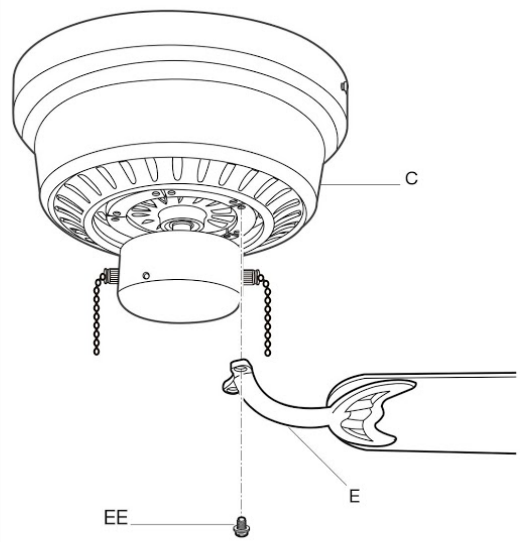
- ☐ Attach the blades (D) to the blade arms (E) using the three blade attachment screws and fiber washers (AA). Start a screw and fiber washer (AA) into the blade arm (E), but do not tighten.
- ☐ Repeat for the two remaining blade attachment screws and fiber washers (AA).
- ☐ Tighten each screw securely starting with the center screw. Make sure the blade (D) is straight.
- ☐ Repeat these steps for the remaining blades (D).



7 Fastening the blade assemblies to the motor

> **WARNING:** To reduce the risk of personal injury, do not bend the blade arms (E) while installing, balancing the blades (D), or cleaning the fan. Do not insert foreign objects between rotating fan blades (D).

- ☐ Align motor holes to blade arms (E) and secure with screws and lock washer (EE) provided; tighten screws securely.
- ☐ Repeat this procedure for the remaining blade arms (E).



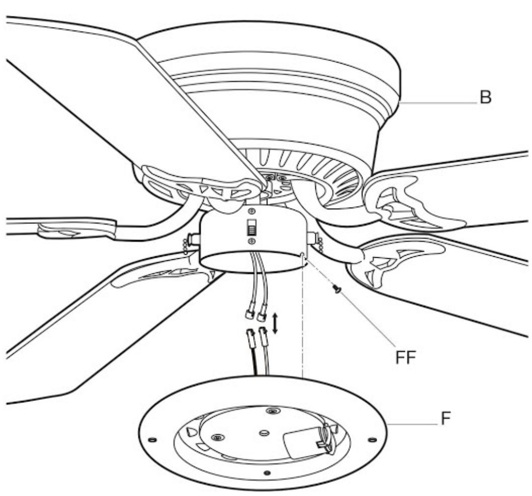
Assembly — Installing the Light Kit

8 Attaching the light kit to the switch housing

CAUTION: Before starting installation, disconnect the power by turning off the circuit breaker or removing the fuse at the fuse box. Turning power off using the fan switch is not sufficient to prevent electric shock.

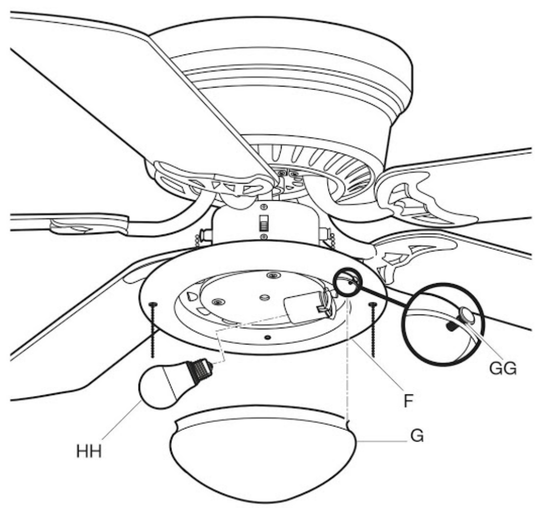
NOTE: If you do not wish to install the light kit, skip steps 8 through 9 and proceed to step 10.

- ☐ Remove the three light kit mounting screws (FF) from the light kit (F) and keep these screws.
- ☐ While holding the light kit (F) under your fan motor assembly (B), locate two single white and blue wires in the switch housing labeled "FOR LIGHT". Make the polarized plug connections:
  - White to white
  - Blue to black
- ☐ Carefully push all wires back into the switch housing. Install the light kit (F) onto the switch housing with the three light kit mounting screws (FF) provided. Be sure to tighten all screws.



9 Installing the light bulb and glass shade

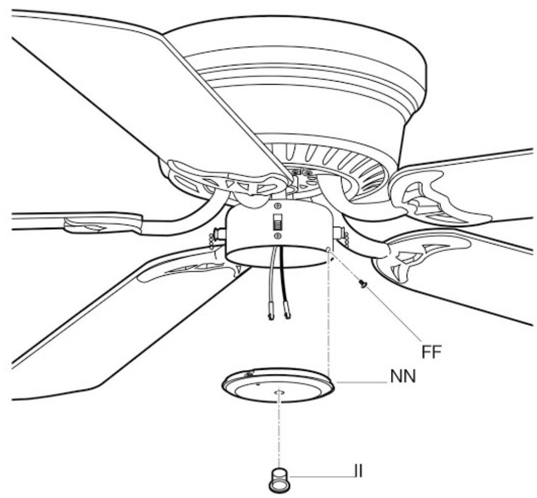
- ☐ Install 1 x 9.5W Medium base LED bulb (HH) (included).
- ☐ Mount the glass shade (G) to the light kit (F) by unscrewing partially the thumbscrews (GG) on the light kit (F). Then insert the glass (G) and gently tighten the thumbscrews (GG) by hand evenly to the glass (G). Do not overtighten.



Assembly — Installing the Light Kit (continued)

10 Installing the fan without the light kit (optional)

- ☐ Disassemble the switch housing cover (NN) from the light kit (F). You can keep the light kit (F) for future use.
- ☐ Attach the plastic plug (II) to the switch housing cover (NN).
- ☐ Install the switch housing cover (NN) to the switch housing with light kit mounting screws (FF) provided.



Operation

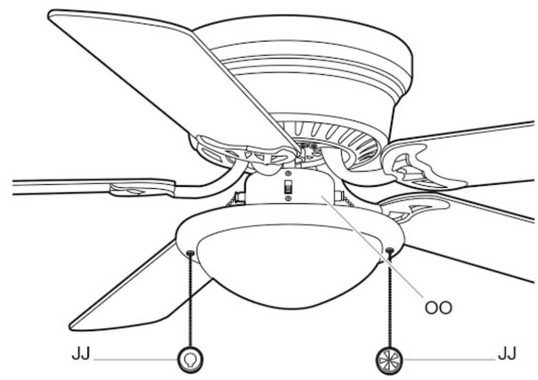
PULL CHAIN OPERATING INSTRUCTIONS

Attach the two pull chains and fobs (JJ) to the pull chains located on the switch housing (OO). Turn on the power and check the operation of the fan.

The pull chain controls the fan speed as follows:
1 pull - High, 2 pulls - Medium, 3 pulls - Low and 4 pulls - Off.

Speed settings for warm or cool weather depend on factors such as the room size, ceiling height, number of fans, and so on.

To turn the light kit on or off, pull the chain (JJ) that is attached to the switch housing (OO).



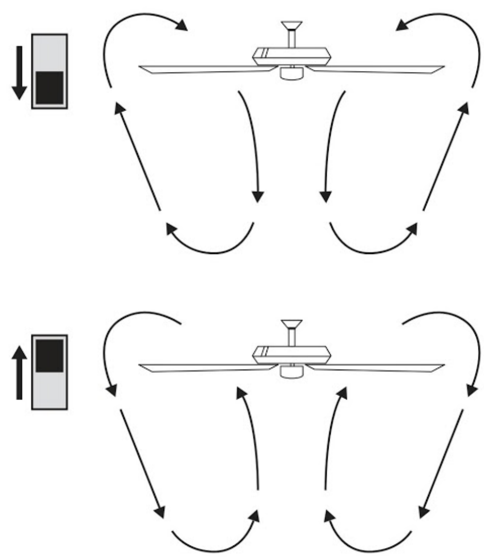
REVERSE SWITCH OPERATING INSTRUCTIONS

The reverse switch is located on the surface of the switch housing. This switch controls directions: forward (switch down) or reverse (switch up).

NOTE: Wait for the fan to stop before reversing the direction of the blade rotation.

Warm weather - (Counterclockwise Direction) A downward air flow creates a cooling effect. This allows you to set your air conditioner on a warmer setting without affecting your comfort.

Cool weather - (Clockwise Direction) An upward air flow moves warm air off the ceiling. This allows you to set your heating unit on a cooler setting without affecting your comfort.



Care and Cleaning

Do
□ Check the support connections, brackets, and blade attachments twice a year. Make sure they are secure. Because of the fan's natural movement, some connections may become loose over time. It is not necessary to remove the fan from the ceiling.
□ Clean your fan periodically. Use only a soft brush or lint-free cloth to avoid scratching the finish. The plating is sealed with a lacquer to minimize discoloration or tarnishing.
□ (Optional) Apply a light coat of furniture polish to the wood blades.
□ (Optional) Cover small scratches with a light application of shoe polish.

Do not
□ Use water when cleaning. Water could damage the motor, or the wood, or possibly cause an electrical shock.
□ Apply oil to your fan or motor. The motor has permanently-lubricated sealed ball bearings.

Troubleshooting

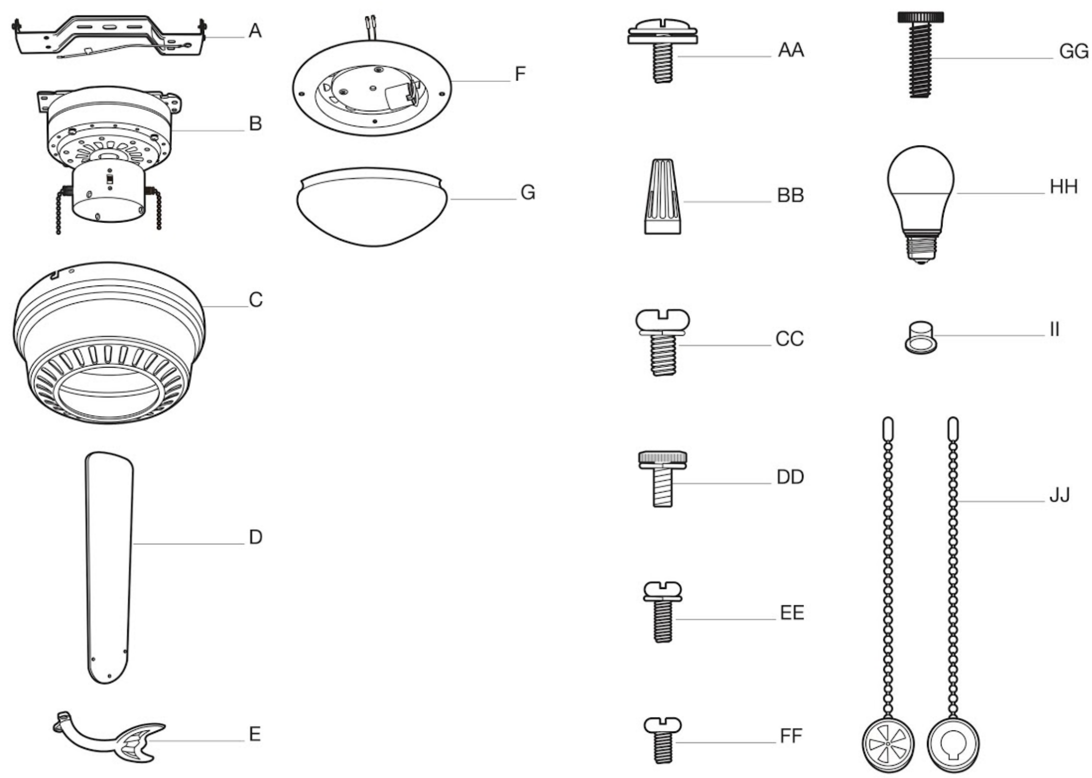
WARNING: Make sure the power is off at the electrical panel box before you attempt any repairs. Refer to step 3 "Making the electrical connections" on page 9.

Problem	Solution
The fan will not start.	□ Check the main and branch circuit fuses or breakers.
	□ Check the line wire connections to the fan and switch wire connections in the switch housing.
The fan sounds noisy.	□ Make sure all motor housing screws are snug.
	□ Make sure the screws that attach the fan blade arm to the motor hub are tight.
	□ Make sure the wire nut connections are not rattling against each other or the interior wall of the switch housing.
	□ Allow a 24-hour "breaking-in" period. Most noises associated with a new fan disappear during this time.
	□ If using the ceiling light kit, make sure the screws securing the glassware are tight. Check that the light bulbs are also secure.
	□ Make sure there is a short distance from the ceiling to the canopy. It should not touch the ceiling.
	□ Make sure your ceiling box is secure and that rubber isolator pads are used between the mounting bracket and outlet box.

Troubleshooting (continued)

Problem	Solution
The fan wobbles.	☐ Verify that all blades and blade bracket screws are secure (most fan wobble problems are caused by loose parts). Once the fan is properly installed, run the ceiling fan for 10 minutes to let the fan self-adjust. If wobble occurs after running the fan for 10 minutes, verify blade level using the following process: - Select a point on the ceiling above the tip of one of the blades, then select any fan blade and measure from the center of the selected blade to the point on the ceiling. Rotate the fan until the next blade is positioned and repeat the measurement using the same point from the ceiling for every blade. Measurement deviations should be within 1/8 in. - If all deviations are less than 1/8 in. and the fan continues to wobble, please call Customer Service (1-877-527-0313) to order a complimentary Blade Balancing Kit. - If deviation is greater than 1/8 in., please call Customer Service (1-877-527-0313) to order complimentary replacements of your brackets.

Service Parts



Part	Description
A	Mounting plate
B	Fan motor assembly
C	Motor housing
D	Blade
E	Blade arm
F	Light kit
G	Glass shade

Part	Description
AA	Blade attachment screw and fiber washer
BB	Plastic wire nut
CC	Mounting plate screw and lock washer
DD	Motor housing screw and lock washer (preassembled)
EE	Blade arm screw and lock washer
FF	Light kit mounting screw (preassembled)
GG	Light holder thumbscrew (preassembled)
HH	9.5 watt LED bulb
II	Plastic plug
JJ	Pull chain and fob

E. Fridge

(https://sundanzer.com/app/uploads/2017/08/225L-open-v02.jpg)

Translate »

A patented low-frost system reduces frost and moisture build-up for low maintenance. These chest-style refrigerators and freezers are easy to clean using the drain hole at the bottom of the unit. With thick insulation and a refrigeration system optimized for solar, SunDanzer refrigerators and freezers provide outstanding economical and reliable operation.

Low energy consumption is the key that allows SunDanzer refrigerators and freezers to be cost effectively powered from solar, wind, fuel cells or batteries. This technology allows refrigeration in remote locations where it was previously unavailable or prohibitively expensive.

Features

- Refrigerators run on a single 75W module in most climates!
- 12 or 24 VDC with low voltage disconnect for battery protection
- Environmentally friendly CFC free refrigerant (R-134a)
- Rugged scratch resistant galvanized steel exterior
- Easy to clean aluminum interior
- Interior light
- Patented low-frost system
- Automatic control with adjustable thermostat
- Baskets for food organization

Specifications Dimensions Loading Quantities

Specifications

Voltage	10.4-17 VDC

Translate »

Average Energy Use: DCR225 Refrigerator-	198 Watt-hrs/day at 32°C 17 Amp-hrs/day at 12V, 32°C
Average Energy Use: DCF225 Freezer-	532 Watt-hrs/day at 32°C 44 Amp-hrs/day at 12V, 32°C
Gross Capacity	223 L 7.9 ft3

Sundanzer

SunDanzer's goal is to build the most energy-efficient solar powered refrigerators in the market using high quality, durable long-life components.

Products

Household (/product-category/household/)
Medical (/product-category/medical/)
Commercial (/product-category/commercial/)
Military (/product-category/military/)

Company

About Us (/about)
Our Team (/about/our-team/)
Certifications (/about/certifications/)
Survey (/about/survey/)

Contact Us

Translate »

F. Inverter

AIMS Operating Corp., Inc. dba AIMS Power Warranty Instructions:

This product is designed using the most modern digital technology and under very strict quality control and testing guide lines. If however you feel this product is not performing as it should, please contact us:

techsupport@aimscorp.net or (775)359-6703

We will do our best to resolve your concerns. If the product needs repair or replacement, make sure to keep your receipt/invoice, as that will need to be sent back along with the package and RA# prepaid to AIMS. You have a full 1 year from date of purchase warranty.

This warranty is valid world wide with the exception that freight and duty charges incurred outside the contiguous 48 United States will be prepaid by customer.

Except as provided above, AIMS makes no warranty of any kind, express or implied, including without limitation the implied warranties of merchantability and fitness for a particular purpose. In no event shall AIMS be liable for indirect, special or consequential damages. This warranty only applies to AIMS Power branded products. All other name brand products are warranted by and according to their respective manufacturer. Please do not attempt to return non-AIMS Power branded products to AIMS Power.

For additional products such as:
-Modified sine wave inverters
-Pure sine wave inverters
-Low Frequency Inverters
-Solar Charge Controllers
- On Grid Inverters
-Inverter Chargers and Automatic transfer switches
-Custom cut cables
-Batteries
-Solar Panels
Please visit our web site: www.aimscorp.net

To find out where to buy any of our products, you may also e-mail: sales@aimscorp.net or call (775)359-6703.

AIMS POWER INVERTER

2500 WATT / 5000 WATT PEAK

Model PWRINV 250012W

Model PWRINV 250024W

ASSEMBLY AND OPERATING INSTRUCTIONS

TO PREVENT SERIOUS INJURY, READ AND UNDERSTAND ALL WARNINGS AND INSTRUCTIONS BEFORE USE.

PLEASE READ THE FOLLOWING CAREFULLY

THE MANUFACTURER AND/OR DISTRIBUTOR HAS PROVIDED THE PARTS DIAGRAM IN THIS MANUAL AS A REFERENCE TOOL ONLY. NEITHER THE MANUFACTURER NOR DISTRIBUTOR MAKES ANY REPRESENTATION OR WARRANTY OF ANY KIND TO THE BUYER THAT HE OR SHE IS QUALIFIED TO MAKE ANY REPAIRS TO THE PRODUCT OR THAT HE OR SHE IS QUALIFIED TO REPLACE ANY PARTS OF THE PRODUCT. IN FACT, THE MANUFACTURER AND/OR DISTRIBUTOR EXPRESSLY STATES THAT ALL REPAIRS AND PARTS REPLACEMENTS SHOULD BE UNDERTAKEN BY CERTIFIED AND LICENSED TECHNICIANS AND NOT BY THE BUYER. THE BUYER ASSUMES ALL RISK AND LIABILITY ARISING OUT OF HIS OR HER REPAIRS TO THE ORIGINAL PRODUCT OR REPLACEMENT PARTS THERETO, OR ARISING OUT OF HIS OR HER INSTALLATION OF REPLACEMENT PARTS THERETO.

Page 9

Specifications

ITEM	DESCRIPTION
Continuous Power	2500 Watts
Peak Power	5000 Watts
Input Voltage	12 Volts DC (17V over voltage protection) 24 Volts DC (34V over voltage protection)
Output Voltage	120 Volts AC at 60 Hz
AC Receptacles	(2) Two 3-Prong, Polarized Outlets
Fuse	12V: 40Amp x 8Pcs; 24V: 20Amp x 8Pcs
Dimensions	15 1/2"L x 9 1/3"W x 3 3/5" H
Weight	10,4lbs
Indicators	Volt and Amp LED bar graph
Switch	Rocker type, On / Off
Operating Temperature	30-150° F (Automatic shutdown)
Recommended Input Cord	Battery cable (not included; 1 / 0 AWG(1 / 0) recommended)
Features	- Modified sine wave with overload protection - Low voltage alarm[1] and shutdown[2] - Overvoltage shutoff[3] [1] at 10.5 V; [2] at about 10 V; [3] at about 17Vdc (12V version) [1] at 21V; [2] at about 20 V; [3] at about 34Vdc (24V version)

Save This Manual

You will need the manual for the safety warnings and precautions, assembly instructions, operating and maintenance procedures, parts list and diagram. Keep your invoice with this manual. Write the invoice number on the inside of the front cover. Keep the manual and invoice in a safe and dry place for future reference.

Safety Warnings and Precautions

WARNING: When using this device, basic safety precautions should always be followed to reduce the risk of personal injury and damage to equipment.

Read all instructions before using this tool!

1. **Do not plug in a battery charger** if the charger has a warning that dangerous voltages are present at the battery terminals.
2. **Keep work area clean.** Cluttered areas invite injuries.
3. **Keep inverter away from any direct heat source or combustible material.**

Page2

4. **Observe work area conditions**. Do not use machines or power tools in damp or wet locations. Don't expose to rain. Keep work area well lit. Do not use electrically powered tools in the presence of flammable gases or liquids.
5. **Keep children away**. Children must never be allowed in the work area. Do not let them handle machines, tools, or extension cords.
6. **Store idle equipment**. When not in use, tools must be stored in a dry location to inhibit rust. Always lock up tools and keep out of reach of children.
7. **Use the right tool for the job**. Do not attempt to force a small tool or attachment to do the work of a larger industrial tool. There are certain applications for which this tool was designed. It will do the job better and more safely at the rate for which it was intended. Do not modify this tool and do not use this tool for a purpose for which it was not intended.
8. **Use eye protection**. Always wear ANSI approved impact safety goggles when using tools.
9. **Do not overreach**. Keep proper footing and balance at all times. Do not reach over or across running machines.
10. **Maintain tools with care**. Keep tools sharp and clean for better and safer performance. Follow instructions for changing accessories. Inspect tool cords periodically and, if damaged, have them repaired by an authorized technician.
11. **Disconnect power**. Unplug inverter when not in use.
12. **Avoid unintentional starting**. Be sure the switch is in the Off position when not in use and before plugging in any appliance.
13. **Stay alert**. Watch what you are doing, use common sense. Do not operate any tool when you are tired.
14. **Check for damaged parts**. Before using any tool, any part that appears damaged should be carefully checked to determine that it will operate properly and perform its intended function. Check for alignment and binding of moving parts; any broken parts or mounting fixtures; and any other condition that may affect proper operation. Any part that is damaged should be properly repaired or replaced by a qualified technician. Do not use the tool if any switch does not turn On and Off properly.
15. **Servicing**. This device should be serviced only by a qualified technician. This item does not have any user-replaceable parts,except for fuses.

Page 3

Troubleshooting Tips

1. If the low battery alarm sounds, this means that the input voltage is below the necessary 10.5 V. The battery needs recharging. You should stop using the appliance and then recharge the battery. If this is not done, the Inverter will shut off automatically at around 10 V.
2. If you are unsure if the inverter will have the proper amount of current to run the device, use this rough guideline: Take the power consumption of the load in watts and divide it by 12 (input voltage). The result will be the approximate number of amps needed to power your device.

   Example: Load is rated at 312 watts. 312 watts / 12 V = 26 amps needed. You could use this device with the inverter.
3. If your television will not start, it is important to keep in mind that some appliances (including many televisions) may require two to six times their wattage to start up.
4. If your audio system buzzes while using this inverter, it is because some sound systems can not filter out the modified sine wave produced by the inverter. Use a sound system that incorporates a higher quality power supply.
5. This inverter is made to minimize the interference with TV signals. However, especially with weak TV signals, some interference may still be visible. To correct this, place the inverter as far away as possible from the television antenna and it's cables. Next, adjust the orientation of the inverter to the antenna cables and TV power cord to minimize the interference. Also use a shielded antenna cable.
6. If the low battery alarm is on all the time, try these corrective measures: Recharge battery if in poor condition. Next, check the battery connection. You may need to clean the connectors.
7. If you are getting a low output voltage, try reducing the load to minimize watts. You may have overloaded the inverter. Reduce your load to 2400 watts. Also, keep input voltage above 10.5 volts to maintain a constant flow of power.
8. If you are not getting any power output, turn the power switch Off and On again, until the green power light comes on. Your devices may draw too much power to operate them. The inverter may be in thermal shutdown. Let it cool down and make sure there is adequate ventilation around the unit.
9. If the green light turns red one of the following has happened:
   A. Input voltage is too low. B. input voltage too high C. Short circuit D. Inverter is near overload.

Page 8

5. **Display:**

DC Input Voltage Indicator :

- 7 Green LED : indicate 11-15V Range step: 0.5V (12V version); indicate 22-30V Range step:1V (24V version)
- 1 Orange LED : indicating lower than 11V (12V version); indicating lower than 22V (24V version)
- 1 Red(Bottom) LED: indicating lower than 10.5V (12V version); indicating lower than 21V (24V version)
- 1 Red(Top) LED: indicating above 15V(12V version); indicating above 30V (24V version)

Output Power Indicator :

- 8 Green LED indicate,step 250 Watts, up to 2000 Watts
- 1 orange LED indicate,step 2000 Watts, up to 2250 Watts
- 1 red LED indicating,The output load is more than 2250 Watts

6. Remote On/Off Switch

A **Remote On/Off Switch** can be connected to the **Remote Jack** allowing you to turn the inverter On or Off from a convenient location when the inverter is installed in an out-of-reach location. Be sure to have your power inverter and Remote On/Off Switch properly installed before attempting to turn the unit On(see "Installation" page 6). Before connecting the remote switch you should ensure the inverter is turned OFF (O). The plug the remote switch into the jack. The main power switch of the inverter must be turned ON (I) for the remote switch to function properly. You may now use the remote switch to turn the inverter ON (I) and OFF (O).

BOTTOM

Maintenance

1. Keep this unit clean and dry. Unplug the unit before cleaning. Clean only the outside of this unit with a soft, dry cloth; never clean this unit with water or harsh cleaners.
2. This device does not contain any other user replaceable parts.If it needs service,contact your retailer or AIMS Power(see warranty page for details).

16. **Guard against electric shock.**
Do not open the metal case; risk of electric shock.
Prevent body contact with grounded surfaces such as pipes, radiators, ranges, and refrigerator enclosures during installation.
Connect all wires securely and cover the connections with insulating rubber boots (not included).
Store tools and metal objects away from the inverter.
17. **Do not operate tool if under the influence of alcohol or drugs**. Read warning labels on prescriptions to determine if your judgement or reflexes are impaired while taking drugs. If there is any doubt, do not operate the tool.
18. **People with pacemakers should consult their physician(s) before using this product.** Electromagnetic fields in close proximity to a heart pacemaker could cause interference to or failure of the pacemaker.
19. **Keep the Inverter well-ventilated.** Do not place any objects on top of or next to the Inverter or allow anything to cover the cooling fans; doing so can cause the Inverter to overheat, causing a potential fire hazard and/or damage to the Inverter. Leave adequate ventilation space underneath the Inverter as well; thick carpets or rugs can obstruct air flow, causing the Inverter to overheat.
20. **Read and adhere to all warnings and safety precautions in the owner's manual for the device that this inverter is used to power.**
21. **A vehicle's engine must never be used in any sealed structure.** Carbon **monoxide is produced during operation and is DEADLY in a closed environment.** Early signs of carbon monoxide poisoning resemble the flu, with headaches, dizziness, or nausea. If you have these signs, get fresh air immediately.

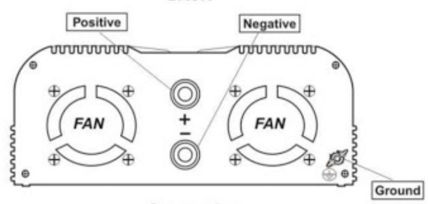
Note: Performance of this unit may vary depending on the available battery power or appliance wattage.

Warning: The warnings, cautions, and instructions discussed in this instruction manual cannot cover all possible conditions and situations that may occur. It must be understood by the operator that common sense and caution are factors which cannot be built into this product, but must be supplied by the operator.

Unpacking

When unpacking, check to make sure that the Inverter is in good condition. If any parts are missing or broken, please call AIMS Power,Inc. at the number found on the warranty card.

BACK



Connection

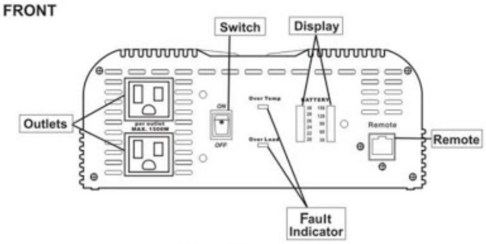
For the power inverter to work properly, your power source must provide 12 (24) volts DC, and the power source must provide enough current (i.e., 46 (23) amps to operate the load of 560 Watts or under).

Caution: This inverter must only be connected to batteries with a nominal output voltage of 12 (24) volts. Lower voltage will not operate the inverter properly, and more voltage could damage the inverter or the device being powered. If more than one 12 (24) volt battery is to be used, the batteries must be connected in a parallel circuit; 12 (24) volt batteries connected in a series circuit will produce too much voltage.

1. Place the Power Inverter on a flat surface. Make sure it has adequate ventilation and is not in direct sunlight. Fasten the inverter securely to the surface, using screws or some other means. If holes are to be drilled, follow safe, proper installation techniques.
2. Connect the Battery Cable(not included; 1 / 0AWG (1 / 0) recommended) lugs to the (Positive) red and (Negative) black terminals on the back of the Inverter, see *BACK* above. Connect the Ground Cable (not included; #2 AWG or larger cable recommended) lug to the Ground terminal, see *BACK* above. Securely tighten For 24Vdc model it is ok to use 4 Awg wire to the batteries.
3. The Power Inverter can be used either while the engine is running or off. Connect the Battery Cables (not included) to the Negative (black) and Positive (red) terminals of the battery.
4. Connect the Ground Cable to an earth ground, such as a metal water pipe or to the vehicle's ground when used in a vehicle.

Page 5

FRONT



Operation

Warning: NEVER operate this inverter unless it is properly grounded.

1. Plug the 115 VAC device(s) you wish to power into the 3-prong AC Receptacles. See *FRONT* above. The appliance(s) must not use more than 2500 (total) watts during continuous operation, otherwise it may overload the Inverter.

Caution: Some rechargeable appliances may damage the Power Inverter or the appliance. When first using a rechargeable device, check the inverter's temperature for the first 10 minutes. If it becomes abnormally hot, do not use this device with the Inverter. You should consider using a Pure Sine Wave Inverter instead.

2. Flip the Power Switch to the On (I) position to turn on. Do not use the appliance until the Display LED indicator is on.
3. Turn on appliance. If an alarm sound is heard, turn off the appliance.

Caution: It is recommended that the vehicle be started every hour to recharge the battery system. Doing this will help prevent any unexpected shutdown of the equipment. This will also help ensure that there will be enough battery power to start the vehicle. Due to the risk of carbon monoxide inhalation (see *Warning* # 21 on page 4), do not run the vehicle's engine within an enclosed area.

4. After use, disconnect the appliances, flip the Power Switch to the Off (O) position.

Page 6

G. MPPT

MAGNUM ENERGY

PT-100 CHARGE CONTROLLER

Maximize Energy Harvest and Improve Battery Life

Model Numbers

- PT-100

Available For

- Renewable Energy Systems
  - Off-grid Power
  - Back-up Power

Works With

- ME Series
- MM-AE Series
- MM-E Series
- MMS Series
- MMS-E Series
- MS Series
- MS-AEJ Series
- MS-E Series
- MSH Series
- MS-PAE Series
- MS-PE Series
- MMP Panel System
- MMP-E Panel System
- MP Panel System
- MP-E Panel System
- RD Series
- RD-E Series

Available Configurations

- Works as a stand-alone controller using internal settings
- Works with a Magnum-Dimensions Inverter/Charger and Magnum-Dimensions Remote. Menu settings for the PT-100 are currently only available via the ME-ARC Remote

The PT-100 is a Maximum Power Point Tracker (MPPT) charge controller designed to harvest the maximum available energy from the PV array and deliver it to the batteries. The PT-100's MPPT algorithm finds the maximum power point of the array and operates at this point while regulating the output current to 100 amps and battery voltage to fully charge the battery.

Features

- **High Efficiency:** The PT-100 provides typical 99% conversion efficiency and uses less than four watts of power in nighttime mode.
- **MPPT:** Maximum Power Point Tracking technology for increased PV power output efficiency.
- **Voltage Options:** Compatible with 12, 24, or 48V battery systems with automatic detection of system voltage. The PT-100 will produce up to 100 amps regardless of battery voltage.
- **Supports a Large PV Array:** A single controller supports a large PV array up to 6600W. Larger PV arrays may be used because the PT-100 is current limited to 100 amps for maximum harvest.
- **Optimal Battery Charging:** Automatic battery temperature compensation using an included external temperature sensor for optimum battery charging, even during extreme temperature changes.
- **Multi-stage Charging:** Maximizes system performance and improves battery life.
- **GFDI:** Integrated PV Ground-Fault Detection and Interruption/ Indication, with pre-fault leakage/ diagnostic metering.
- **LED Indicators and Screen:** Multiple LED indicators and large digital LED screen on front panel for easy-to-read system information.
- **On-site Updates:** The PT-100's software can be updated on site.
- **Extensive Electronic Protection:** Over-temperature protection, power derating when temperature is high, PV short circuit and high PV input shutdown, output overcurrent protection and night-time back-feed (reverse current) protection.
- **AFCI:** An integrated PV Arc-Fault Circuit Interrupter detects, indicates, and extinguishes series arcs.
- **Convenient Installation:** Run all of the wiring to the unique, remain-in-place wiring box with ease prior to installing the full PT-100 unit.
- **Easy MP and MMP integration:** The PT-100 is designed to work with a Magnum Panel (MP) or Mini-Magnum Panel (MMP). It provides room and access to PV and battery disconnect breakers.

Even More Functionality with the Optional Remote

- Built-in programmable auxiliary relay for device control.
- Internal data logging functionality keeps energy harvest information and battery Ahr/Whr data up to 255 days. Use the optional remote to display this information.

PT-100 CHARGE CONTROLLER SPECIFICATIONS

	PT-100
ELECTRICAL SPECIFICATIONS	
Maximum PV input voltage (any condition)	200 VDC + battery voltage or 240 VDC - whichever is lower
Maximum PV operating voltage	187 VDC
Maximum PV array short circuit current	100 ADC
Nominal battery voltage range	12, 24, or 48 VDC
Battery charger output voltage range	10 to 66 VDC
Continuous charger output current	100 ADC (from -20 °C to +40 °C) with proportional power reduction up to 60 °C ambient
Maximum output power	6600 watts
Efficiency	99% typical
Tare loss / nighttime power consumption	<4 watts (fan off, display/LEDs off)
Charger regulation method	Automatic three-stage (bulk, absorption, float) charge with manual equalization
GENERAL FEATURES AND CAPABILITIES	
Battery temperature compensation	With Battery Temperature Sensor (BTS) connected (battery temperature -20 °C to +55 °C)
Internal cooling	Using dual ball-bearing fans for long life
Overcurrent protection	With two overlapping circuits
Over-temperature protection	On transformer and MOSFETS
Listings	ETL Listed to UL/cUL 1741, CSA C22.2 #107.1-01, CE
Warranty	Five years parts and labor
ENVIRONMENTAL SPECIFICATIONS	
Operating temperature	-20° C to +60° C (-4° F to 140° F)
Nonoperating temperature	-40° C to +70° C (-40° F to 158° F)
Operating humidity	0 to 95% RH non condensing
PHYSICAL SPECIFICATIONS	
Enclosure type	Indoor, ventilated, with removable powder-coated conduit box
Unit dimensions (w x h x d)	8.5″ x 15.5″ x 4.0″ (21.6 cm x 39.4 cm x 10.2 cm)
Shipping dimensions (w x h x d)	11.5″ x 19.5″ x 8.125″ (29.2 cm x 49.5 cm x 20.6 cm)
Mounting	Mounted on a vertical surface (wall) or installed on MP or MMP enclosure
Weight	13.6 lb (6.2 kg)
Shipping weight	18 lb (8.2 kg)
Max operating altitude	15,000′ (4570 m)

Sensata Technologies

The World Depends on Sensors and Controls

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Everett, Washington 98204 USA

425-353-8833

4467 White Bear Pkwy
St. Paul, MN 55110 USA

800-553-6418

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Testing for specifications at 25° C.
Specifications subject to change without notice.

August 2015 Rev C Part #64-0660

D: Project Management

DI: Client Wants and Needs Table

#	*Demand/ Wish*	*Need Statement*	*Accomplished (Y/N)*
1	D	Electronic prototype of final project to display on website to create awareness	Y
2	D	Three cottages to accommodate guest, with space for two more in the future	Y
3	D	Queen size beds, sink, and mirror in each cottage	Y
4	D	Protection from insects	Y
5	W	Climate control in guest cottages ie ceiling fan	Y
6	W	Gardens with sacred geometry and attention to medicinal properties of plants	N
7	D	Improve current structures to have improved roofing but match/maintain current cultural purposes	N
8	D	Evaluate water system design to eliminate need for trucking in water	Y
9	D	Analysis of wastewater system in place and potential improvement	Y
10	D	Raised walkways between cottages	Y
11	D	Power to light walkways and power for lights in rooms potentially using solar lanterns	Y
12	W	Team members to visit site at least once	Y
13	D	Security for power system	Y
14	D	Disguise for power system to make sure they blend in and are not vandalized or stolen	N
15	W	Furnishing for cottages	N
16	D	Team contact via email with contacts at reserve	Y
17	D	Keep structures for an authentic experience and with the ideals of a sustainable “Eco-Tourism”	Y
18	D	Community oriented set up	Y
19	D	Give community members and rangers choices and options for how they might want to add to the tourist site	Y
20	D	Capacity to add a fridge in the future	Y
21	D	Preservation of environment in construction	Y
22	W	Add flushing toilets	Y
23	W	Update common kitchen to utilize open fire pits for cooking	N
24	D	Use of Renewables as primary source of power generation	Y

DII: Final Budget

Team Name	Eco Engineering Group
Team ID	F18-16
Treasurer e-mai	rajewell@mymail.mines.edu

	Date	Source	Total
500	10/9/2018	Client	500
3000	10/11/2018	HE Department	2667
1500	1/17/2019	Capstone	1881.84
		Total Funds	$ 5,048.84
		Total Spent	$ 4,370.67
		Remaining Funds	$ 678.17

* purchase request out-of-pocket, client directly paid, faculty onecard, etc
** If none, put $0; if unknown, put "unknown" - do not estimate

Date	Company	Item	*Payment Method	Item cost	*Shipping cos	Total cost	Reimburseme nt Request	Return Date	Refund Amount	Notes:
January										
1/22/2019	Travelocity	4 Student flights to Belize City	Capstone Faculty	$ 1,881.84	$ -	$ 1,881.84				
1/22/2019	Travelocity	2 student flights to Belize City	HE Faculty onecar	$ 1,008.40	$ -	$ 1,008.40				
					Total:	$ 2,890.24				
February										
2/14/2019	Office Max	Drawing Set Prints	Out of Pocket	$ 27.93	$ -	$ 27.93				
2/15/2019	Mike Hormell	Travel to Guatemala	HE Faculty onecar	$ 1,330.00		$ 1,330.00				
					Total:	$ 1,357.93				
March										
					Total:	$ -				
April										
4/4/2019	Hobby Lobby	Model Materials	Out of Pocket	$ 84.29		$ 84.29				
4/19/2019	Capstone Printing	Poster Printing	Out of Pocket	$ 20.00		$ 20.00				
4/24/2019	Printing Center	Report printing	Out of Pocket	$ 18.21		$ 18.21				
					Total:	$ 122.50				

DIII: Schedule

1	**Project Setup**				-			-
1	Broader Impacts Essay	Team		Wed 1/23/19	Thu 1/31/19	9	100%	7
1.1	Intermediate Design Review	Team		Wed 1/23/19	Thu 2/07/19	16	100%	12
1.4	Intermediate Design Report	Team		Wed 1/23/19	Thu 2/14/19	23	100%	17
1.5	Travel to Guatemala	Team		Thu 2/14/19	Wed 2/20/19	7	100%	5
1.6	Next Steps Letter	Team		Thu 2/28/19	Tue 3/05/19	6	50%	4
1.7	Detailed Design Critique	Team		Sun 2/24/19	Thu 2/28/19	5	100%	4
1.8	Spring Break	Team		Sat 3/23/19	Sun 3/31/19	9	0%	5
1.9	Project Synopsis for Design Showcase	Team		Mon 3/04/19	Thu 3/14/19	11	100%	9
1.1	Capstone Poster Draft	Team		Thu 3/14/19	Tue 4/02/19	20	0%	14
1.11	Final Design Review	Team		Tue 2/26/19	Tue 4/09/19	43	0%	31
1.12	Final Design Report	Team		Tue 2/26/19	Tue 4/30/19	64	0%	46
1.13	Capstone Showcase	Team		Sun 4/07/19	Thu 4/18/19	12	0%	9
1.14	Next Steps Letter	Team		Tue 4/09/19	Tue 4/30/19	22	0%	16
2	**Sprint Meetings**				-			-

2.1	Sprint 1 Meeting/ Sprint Backlog	Team		Tue 1/22/19	Tue 1/22/19	1	100%	1
2.2	Sprint 2 Meeting	Team		Mon 2/04/19	Mon 2/04/19	1	100%	1
2.3	Sprint 3 Meeting	Team		Mon 2/18/19	Mon 2/18/19	1	100%	1
2.4	Sprint 4 Meeting	Team		Thu 3/07/19	Thu 3/07/19	1	70%	1
2.5	Sprint 5 Meeting	Team		Tue 3/19/19	Tue 3/19/19	1	0%	1
2.6	Sprint 6 Meeting	Team		Tue 4/02/19	Tue 4/02/19	1	0%	1
2.7	Sprint 7 Meeting	Team		Tue 4/16/19	Tue 4/16/19	1	0%	1
4	**Intermediate Design**				-			-
4	Draft Concepts	Team		Tue 1/29/19	Fri 2/01/19	4	100%	4
4.1	Design Narrative	Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.1.1		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.1.2		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.2	Path Forward and Risk Mitigation	Team		Tue 1/29/19	Mon 2/04/19	7	100%	5
4.2.1		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.2.2		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.3	Engineering Calculations and Analysis	Team		Tue 1/29/19	Mon 2/04/19	7	100%	5
4.3.1		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.3.2		Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.4	Preliminary Drawings	Team		Tue 1/29/19	Fri 2/01/19	4	100%	4
4.5	Review Drawings/Calcs with Advisors	Team		Tue 1/29/19	Fri 2/01/19	4	100%	4
4.6	Preparation of Review Presentation	Team		Tue 1/29/19	Mon 2/04/19	7	100%	5
4.7	Invite Clients/ Panel	Team		Tue 1/29/19	Fri 2/01/19	4	100%	4
4.8	Dry run	Team		Tue 1/29/19	Tue 2/05/19	8	100%	6
4.9	Present	Team		Tue 1/29/19	Thu 2/07/19	10	100%	8
5	**Travel to site**				-			-
5.1	Travel to site	Team		Fri 2/15/19	Thu 2/21/19	7	100%	5
5.1.1	Fundraise $2700	Team		Tue 1/15/19	Fri 2/08/19	25	100%	19
5.1.2	Fill out paper work	Team		Tue 1/22/19	Thu 1/24/19	3	100%	3
5.2	Community Engagement Plan	Team		Tue 1/22/19	Fri 2/15/19	25	100%	19
5.2.1	Meet with Beth	Team		Wed 1/23/19	Wed 1/23/19	1	100%	1

5.2.2	Design Workshop	Team		Wed 1/23/19	Tue 2/05/19	14	100%	10
5.2.3	Create List of Questions to ask community	Team		Wed 1/23/19	Tue 2/05/19	14	100%	10
5.2.4	Create team strategy	Team		Tue 2/05/19	Thu 2/14/19	10	100%	8
5.2.5	Reach out to contacts to meet	Team		Thu 2/07/19	Thu 2/14/19	8	100%	6
5.3	Prepare Site Investigation	Team		Thu 2/07/19	Thu 2/14/19	8	100%	6
5.3.1	Rent equipment	Team		Thu 2/07/19	Thu 2/14/19	8	100%	6
5.3.2	Learn how to use equipment	Team		Tue 2/05/19	Sun 2/24/19	20	100%	14
5.3.3	Make specific list of data to be collected	Team		Tue 2/05/19	Sun 2/24/19		100%	14
5.4								
5	Final Design And Report				-			-
5.1	Environmental			Tue 3/05/19	Thu 3/21/19	17	0%	13
5.1.1	Redesign catchment system: Find needed catchment/storage	Maggie		Tue 3/05/19	Wed 3/06/19	2	0%	2
5.1.1.a	Incorporate each system use in model	Maggie		Tue 3/05/19	Tue 3/05/19	1	0%	1
5.1.1.b	Add dry season limit in model	Maggie		Wed 3/06/19	Wed 3/06/19	1	0%	1
5.1.2.a	Update Utilities sheet to show lines, grey water call out, pumps, tanks, treatment	Maggie		Wed 3/06/19	Tue 3/12/19	7	0%	5
51.2.b	Add septic tank to sheet and add lines from all drains	Maggie		Wed 3/06/19	Tue 3/12/19	7	0%	5
5.1.3.a	Septic System Recommendations: Calculate max use of septic tank	Maggie		Tue 3/12/19	Tue 3/19/19	8		6
5.1.3.b	Get biodigester informatin from Gerson	Maggie		Thu 3/07/19	Thu 3/07/19	1		1
5.1.3c	Call out biodigester in plan	Maggie		Thu 3/07/19	Tue 3/12/19	6		4
5.1.4a	Greywater: Call out where greywater will tie in	Maggie		Thu 3/07/19	Tue 3/12/19	6		4
5.1.4.b	Write a paragraph detailing how it could be tied into existing system	Maggie		Tue 3/12/19	Tue 3/19/19	8		6

5.1.5.a	Solidwaste: Write recommendation for composting and segregating waste streams	Maggie		Fri 3/15/19	Tue 3/19/19	5		3
5.2	Civil System							
5.2.1	Cottages	Spencer		Tue 3/12/19	Thu 4/04/19	24		18
	Foundation Calcs	Dot		Tue 3/12/19	Tue 3/19/19	8		6
5.2.2	Walkway	Spencer		Tue 3/12/19	Thu 4/04/19	24		18
5.2.3	Retrofit existing structures					1		-
5.2.4	Utility Shed	Spencer		Mon 3/18/19	Tue 4/02/19	16		12
5.2.5	Pavillion	Dot		Mon 3/18/19	Tue 4/02/19	16		12
5.2.6	Site Plan	Spencer		Tue 3/12/19	Tue 3/19/19	8		6
5.2.6.a	Incorporate survey data	Dot		Mon 2/25/19	Thu 2/28/19	4	100%	3
5.2.6.b	Call out area for garden	Spencer		Tue 3/12/19	Sun 3/17/19	6		4
5.2.6.c	Email Don Reginaldo and ask for preliminary garden design	Dot		Tue 3/19/19	Tue 3/19/19	1		1
5.2.7.d	Create strategy for drainage					1		-
5.3	Power System							
5.3.1	Batteries	Blake		Tue 3/12/19	Sun 3/17/19	6		4
5.3.2	Electrical lines	Meghan		Tue 3/19/19	Thu 4/04/19	17		13
5.3.3	Solar Panels	Meghan		Tue 3/12/19	Sun 3/17/19	6		4
5.3.4	Appliances	Meghan		Tue 3/12/19	Thu 3/14/19	3		3
5.4	Final Report							
5.4.1	Maintenance Section	Becca		Thu 3/07/19	Mon 3/18/19	12		8
5.4.2	Calculation - Appendix	Meghan, Spencer, Maggie		Thu 3/07/19	Mon 3/18/19	12		8
5.4.3	Bill of Materials - Appendix	Noah		Tue 3/19/19	Thu 4/04/19	17		13
5.4.3.a	Building Materials	Dot		Thu 3/07/19	Tue 3/19/19	13		9
5.4.3.b	Major Appliances	Meghan		Thu 3/07/19	Mon 3/18/19	12		8
5.4.3.c	Power System	Meghan		Thu 3/07/19	Mon 3/18/19	12		8

5.4.3.d	Water System	Maggie		Thu 3/07/19	Mon 3/18/19	12		8
5.4.4	Final Report Draft	Team		Thu 3/07/19	Tue 3/19/19	13		9
5.4.5	Polish Final Report	Lukas		Tue 3/19/19	Tue 4/09/19	22		16
5.3	Final Design Review			Tue 2/05/19	Tue 2/26/19	22	0%	16
5.4	Trade Fair			Tue 4/02/19	Tue 4/30/19	29	0%	21
1	[Level 1 Task or Phase]				-			-
.1	. [Level 2 Task]				-			-
.1	. . [Level 3 Task]				-			-
.1	. . . [Level 4 Task]				-			-
6	CAD Files				-			-
6.1	Model Space			Tue 3/12/19	Thu 4/11/19	31	0%	23
6.2	Cover Sheet			Tue 3/12/19	Thu 4/11/19			23
6.3	Note			Tue 3/12/19	Thu 4/11/19	31	0%	23
6.4	Detail			Tue 3/12/19	Thu 4/11/19	31	0%	23
6.5	Existing Site			Tue 3/12/19	Thu 4/11/19			23
6.6	Site Plan			Tue 3/12/19	Thu 4/11/19			23
6.7	Utilities			Tue 3/12/19	Thu 4/11/19			23
6.7.1	Water System Update			Tue 3/12/19	Thu 4/11/19			23
6.7.2	Power System Update			Tue 3/12/19	Thu 4/11/19			23
6.8	Grading and Erosion Control			Tue 3/12/19	Thu 4/11/19			23
6.9	Foundation Plan			Tue 3/12/19	Thu 4/11/19			23
6.10	Preliminary Timber Framing Plan			Tue 3/12/19	Thu 4/11/19			23
7	3D Model				-			-
7.1	Create CAD File				Thu 4/11/19	43567	0%	-
7.2	Physical Model					1	0%	
7.2.1	3D Print Model			Mon 3/04/19	Tue 4/02/19			22
7.2.2	Buy Materials for Model			Tue 3/19/19	Thu 4/04/19			13
7.2.3	3D print or build cottages			Tue 3/19/19	Tue 4/16/19			21
7.2.4	build power system model			Tue 3/19/19	Tue 4/23/19			26

7.2.5	**Build water system model**			**Tue 3/19/19**	**Tue 4/23/19**			**26**
7.2.6	**Add all systems to model**			**Tue 3/19/19**	**Tue 4/23/19**			**26**
7.2.7	**Add landscaping to model**			**Tue 3/19/19**	**Tue 4/23/19**			**26**

E: Cost Estimates

EI: Civil

Cottage (cost per cottage)					
Material	Quantity	Unit	Cost per unit	Cost	Source
Timber - 2x4	1607.06	BF	$0.35	$566.49	The Home Depot
Timber - 2x6	1629.67	BF	$0.75	$1,215.73	The Home Depot
Timber - 2x8	28	BF	$0.91	$25.56	The Home Depot
Concrete Mix	12,600	lbs	$0.04	$518.18	The Home Depot
Corrugated Steel	396	SF	$1.04	$409.86	The Home Depot
Timber Siding	1743.03	SF	$3.64	$6,346.37	The Home Depot
Screen	244.17	SF	$0.32	$77.50	The Home Depot
Flooring	621.11	SF	$3.99	$2,478.23	The Home Depot
Subfloor	621.11	SF	$0.89	$554.53	The Home Depot
			Total Cost =	**$12,192.46**	
Walkway (cost per foot)					
Material	Quantity	Unit	Cost per unit	Cost	Source
Timber - 2x4	4.23	BF	$0.35	$1.49	The Home Depot
Timber - 2x6	7.38	BF	$0.75	$5.51	The Home Depot

Timber - 4x4	0.92	BF	$1.10	$1.02	The Home Depot
			Cost per foot =	**$8.02**	
			Total Cost=	**$2,686.25**	
Pavilion					
Material	Quantity	Unit	Cost per unit	Cost	Source
Concrete Mix	119040	lbs	$0.04	$4,895.52	The Home Depot
Timber - 2x6	1071.22	BF	$0.75	$799.13	The Home Depot
Timber - 2x8	261	BF	$0.91	$238.29	The Home Depot
Timber - 6x6	126	BF	$3.28	$413.75	The Home Depot
			Total Cost =	**$6,346.70**	

EII: Water

Table EII.1: Water and Wastewater Cost Estimate

System	**Item**	**Unit Cost**	**Unit**	**Quantity**	**Total Price**	**Source**
Water System Total:						**$18,791.30**
Catchment				**Subtotal:**	**$2,191.03**	
	Wood Pavilion and cottages - Civil Cost	**$0.00**	**-**	**1.00**	**$0.00**	
	Corrugated Steel roofs - Civil Cost	**$0.00**	**-**	**1.00**	**$0.00**	
	Gutters, 5" PVC		**LF**	**276.00**	**$0.00**	**cottages and new structure**
	Downspout, 2"	**$3.73**	**Each**	**4.00**	**$14.92**	**cottages and new structure**
	2" PVC Pipe	**$3.24**	**LF**	**110.70**	**$358.67**	**cottages and new structure**
	3" PVC Pipe	**$3.33**	**LF**	**316.70**	**$1,054.61**	**Main**

	2" PVC Elbows	$2.28	Each	5.00	$11.40	cottages and new structure
	2" PVC tees	$1.74	Each	5.00	$8.70	cottages and new structure
	2" PVC Gate Valve	$27.69	Each	4.00	$110.76	cottages and new structure
	3" PVC Gate Valve	$38.17	Each	1.00	$38.17	Main
	Leaf Guard	$33.81	Lump Sum	5.00	$169.05	cottages and new structure
	Diverter and Filter	$84.95	Each	5.00	$424.75	cottages and new structure
Storage				Subtotal:	$11,439.90	
	Concrete	$108.00	CY	105.00	$11,340.00	Tank
	3" PVC Pipe	$3.33	Each	30.00	$99.90	Overflow
Pump					$343.64	
	1 1/4" PVC Pipe	$1.51	LF	17.50	$26.43	From tank to pump and pump to filter
	1 1/4" PVC Elbows	$1.65	Each	3.00	$4.95	
	1 1/4" PVC Gate Valve	$8.06	Each	1.00	$8.06	
	3/4 HP centrifugal pump	$279.99	Each	1.00	$279.99	
	Pressure Switch and Gauge	$24.21	Each	1.00	$24.21	
Treatment				Subtotal:	$1,205.87	
	1 1/4" PVC Pipe	$1.51	LF	16.41	$24.77	From Filter to Main connection
	1 1/4" PVC Elbows	$1.65	Each	8.00	$13.20	
	1 1/4" PVC tees	$2.58	Each	7.00	$18.06	
	1 1/4" PVC Gate Valve	$8.06	Each	4.00	$32.24	
	UV System	$969.00	Each	1.00	$969.00	
	Pre-treatment Filter	$110.16	Each	1.00	$110.16	
	1 1/4" PVC Sampling Taps	$9.61	Each	4.00	$38.44	
Distribution				Subtotal:	$761.55	
	1 1/4" PVC Pipe	$1.51	Each	297.70	$449.53	Main
	1 1/4" PVC Gate Valve	$8.06	Each	1.00	$8.06	

	3/4" PVC Pipe	$1.13	LF	109.63	$123.88	To cottage
	3/4" PVC Elbows	$0.48	Each	3.00	$1.44	
	3/4" PVC Tees	$0.61	Each	3.00	$1.83	
	3/4" PVC Gate Valve	$13.23	Each	3.00	$39.69	
	1" PVC Pipe	$1.19	LF	16.96	$20.18	To bathoom
	1" PVC Elbows	$1.14	Each	2.00	$2.28	
	1" PVC Tees	$1.34	Each	1.00	$1.34	
	1" PVC Gate Valve	$5.42	Each	1.00	$5.42	
	1/2" PVC Pipe	$0.84	LF	122.25	$102.69	To kitchen
	1/2" PVC Elbows	$0.39	Each	5.00	$1.95	
	1/2" PVC Tees	$0.46	Each	1.00	$0.46	
	1/2" PVC Gate Valve	$2.80	Each	1.00	$2.80	
Fixtures				Subtotal:	$2,849.31	
	American Standard Dual Flush Toilet	$343.61	Each	3.00	$1,030.83	In cottages
	3/4" PVC Pipe	$1.13	LF	30.00	$33.90	
	Kohler Low-Flow Faucet	$198.00	Each	4.00	$792.00	In cottages and kitchen
	3/4" to 3/8" PVC reducer	$1.79	Each	3.00	$5.37	
	3/8" PVC Pipe	$4.94	LF	36.00	$177.84	
	1/2" to 3/8" PVC reducer	$39.00	Each	1.00	$39.00	
	Grohe Low-Flow Shower Head	$49.00	Each	3.00	$147.00	In Cottages
	3/4" to 1/2" PVC Reducer	$0.39	Each	3.00	$1.17	
	1/2" PVC Pipe	$0.84	LF	30.00	$25.20	
	Solar Water Heater	$199.00	Each	3.00	$597.00	On Cottage Roofs
Wastewater System Total:						$1,532.48
Septic System				Subtotal:	$1,532.48	
	4" PVC Pipe	$4.62	LF	250.5	$1,157.31	New Main
	4" PVC Gate Valve	$71.99	Each	1	$71.99	
	1 1/4" PVC Pipe	$0.55	LF	30	$16.50	From sinks
	2" PVC Pipe	$3.24	LF	81.5	$264.06	From Cottages
	2" PVC Tee	$1.74	Each	13	$22.62	

EIII: Power

Appliance	Number of appliances	Cost of One	Total cost for appliances
Ceiling Fan	12	49.97	599.64
Freezer	1	1449	1449
LED lights	50	1.5	75
Solar Walkway Lights	89	5.88	523.32
2500W 24VDC-120VAC inverter	1	250	250
2500W 12VDC-120VAC inverter	1	237	237
2000W 12VDC-120VAC inverter	1	800	800
Solar Panel	10	275	2750
MPPT Charge Controller	1	895	895
Batteries	19	350	6650
Panel Board	1	76.69	76.69
Trip Unit	9	3.04	27.36
Total Cost for Appliances			14333.01

Wire Size	Length in Feet	Cost Per Foot	Total Cost of Wire
#12 AWG	3376	0.1	337.6
#10 AWG	2025	0.18	364.5
350 KCMIL	585	5.92	3463.2
Total Cost for Wire			4165.3

Total Electrical Cost			18498.31