April 2013

Sustainable Development of Treasure Valley Scout Reservation

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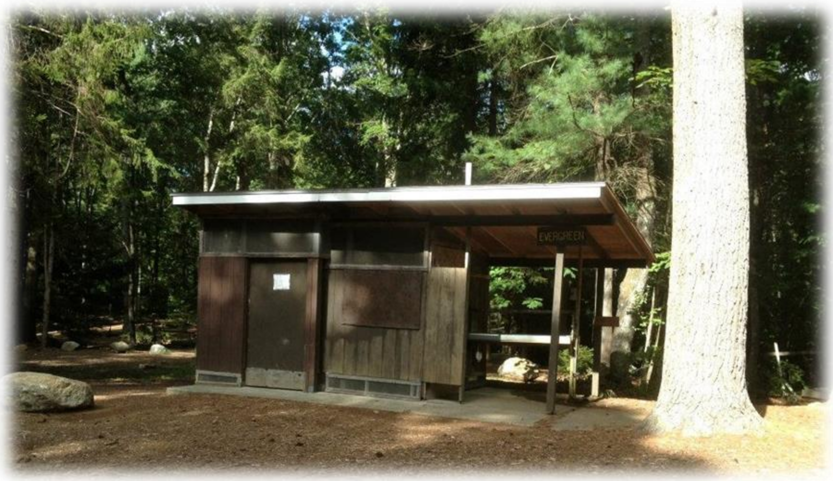

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In cooperation with:
Treasure Valley Boy Scout Reservation

April 24, 13

This project report is submitted in partial fulfillment with the major degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or options of the Treasure Valley Boy Scout Reservation or Worcester Polytechnic Institute.

Abstract

This project worked towards the development of a comprehensive sustainability plan for Treasure Valley Scout Reservation that included the framework of a large scale sustainability plan with focuses in solar energy development, future land use planning, and educational development. The solar energy component created a design and prototype of an off-grid solar powered lighting system for night time use on the campsites. The land use component of the project consisted of a constraints analysis to produce land use zoning recommendations along with three conceptual designs for specific program development. The education piece was focused on creating a learning tool to facilitate STEM learning using solar power as a medium. The hope is that future projects will endeavor to develop and update the sustainability plan, ensuring that it remains a living document that Treasure Valley and future projects can utilize.

Acknowledgements

The successful completion of this project would not be possible without the support of the following people. We would like to thank our advisors, Professor Suzanne LePage and Professor Fred Looft, for their guidance at every stage of the project. Also, we would like to thank Raymond Griffin from Treasure Valley Scout Reservation for being a dedicated and involved liaison and project coordinator. And to the other stakeholders at Treasure Valley, Ted Coghlin, Thomas Chamberlin, Ron Marsh, Jeff Hotchkiss, Warren Bock, Joe Marengo, Michael DiPierro, and Paul Sweeny, thanks for the enthusiasm, support, and input.

Capstone Design Statement

Civil Engineering

This project meets the requirements of the Accreditation Board for Engineering and Technology (ABET) for capstone design experience in Civil Engineering. ABET requires that engineering design be incorporated with "realistic constraints" to demonstrate a comprehensive engineering design. The project addresses the constraints of economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political concerns.

Economic
One of the main constraints of developing renewable energy and other sustainable technologies on the Treasure Valley Scout Reservation is the cost of the implementation of the recommendations. The plans and proposals take into account the resulting initial and operational costs. Each stormwater management option considered was evaluated in terms of economic cost versus the corresponding water quality benefits. The fact that Treasure Valley had a limited budget drove the need for finding the most cost effective options. These considerations were important to make a viable plan.

Environmental
The plan developed is aimed at reducing the reservation's impact on the surrounding environment. All proposed construction will be in compliance with the local, state, and federal environmental regulations including the wetlands protection act, watershed protection efforts and others. Given the Boy Scout's value for preservation of the environment, all tree cutting, land moving, or other processes that involve alteration of the natural environment were minimized.

Sustainability
The development of a plan for Treasure Valley is mostly in an aim to ensure successful and sustainable development of the reservation. The deliverable includes sustainable solutions for future building development and renewable energy.

On a local level, these recommendations are designed to be durable and replaceable so that many generations of Boy Scouts can benefit from the benefits of the system and the education they bring. In addition, the plan was developed for the reservation's long term future developments with recommendations for maintaining minimal environmental impact through renewable energy and sustainable building siting.

Manufacturability

The ability of our plans and recommendations to be executed and constructed is important for our objective to be met. The end product is a plan that will be usable by the Boy Scouts. Recommendations are included for implementation in phases to make execution feasible.

Ethical

In the execution of this project, each group member followed the guidelines of the American Society of Civil Engineers' Code of Ethics. We upheld the fundamental principles and canons by being honest in our presentation of information and working towards a product that best met the needs of our client.

Health and Safety

The health and safety of those who will be affected by any aspect of the project were held paramount. With the majority of users being younger children, all safety risks were assessed and minimized with cooperation of the Treasure Valley staff.

Social

The benefits of this project do not only provide practical benefits such as lighting and conceptual development plans. The design of the renewable energy system will be used as an education tool for the Boy Scouts. In addition, the expansion of programs will engage a higher amount and wider variety of community members. All of the recommendations were designed to be user friendly with knowledge of the demographic of the users of the facility.

Political

Given that the Treasure Valley Scout Reservation spans the borders of four towns, we catered our designs to any needs and restrictions that each town may have.

Electrical and Computer Engineering

This project meets the requirements of the Accreditation Board for Engineering and Technology (ABET) for capstone design experience in Electrical and Computer Engineering. This project addresses the constraints described below.

Economic Considerations

This project must be able to meet the client's financial needs. These needs are demonstrated by presenting estimates of the total cost of the product, producing a capital plan, optimizing cost vs. performance, and computing life cycle costs.

Safety Considerations

With the constraint that this project deliverable will be used around children, safety is a major concern. We have strived to make sure that there is limited operator risk that would affect both the technicians and end-users as well as making sure that risks are properly assessed and presented.

Reliability Considerations

Reliability must be integrated well into the design because our device will be a safety device. We demonstrated the ability to integrate safety into our design by testing (quality assurance, quality control) and analysis (reliability, availability, component tolerance).

Aesthetic Aspects

This project displays aspects such as power dissipation, weight, volume, form factor, and user interface were taken into consideration into the design process and implemented into the final design.

Analysis

This project supports design decisions with appropriate mathematical analysis and simulations.

Syntheses

This project describes how the design was created from top-level system description into lower level specifications until component level specifications are reached.

Integration of Previous Course Work

This MQP demonstrates our ability to integrate concepts from completed courses into a solution of an engineering problem.

Experimental Work

In this project, analytical results, computer simulations, and compliance with specifications are verified by experimental measurements.

Environmental and Sustainability Studies

The Environmental and Sustainability Studies (ESS) major at WPI does not require a capstone design experience. However, the project is being completed in partial completion of the degree requirement. The project will show an understanding of the social impacts of engineering design and highlight the importance of the human component in the environment. The development of an educational tool regarding renewable energy provides a link between sustainable technology and how humans can affect the way we get our energy and develop the world. Providing this perspective for the younger generation will ideally stimulate interest for the young people who will be future engineers and scientists making decisions regarding environmental development.

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Executive Summary

This project took a multidisciplinary approach to focus on the development of a sustainability plan for the Treasure Valley Scout Reservation of the Mohegan Council Boy Scouts of America. Treasure Valley is a 1600 acre camp ground and program area utilized by the cub scouts, boy scouts, and venturing scouts of 22 surrounding communities. As the future progresses, the decision makers within Treasure Valley have a desire to advance and expand the development of the reservation to ensure its continued use. The stakeholders also have a desire to be an example for sustainable development and practices as they move forward.

Based on these needs, this project group worked towards the development of a comprehensive sustainability plan that included the framework of a large scale sustainability plan with focuses in solar energy development, future land use planning, and educational development. The entire project was guided by input from stakeholders through a variety of meetings held over the course of the project. The final product included a vision statement with guiding principles to direct development into the future.

The focus on development of solar energy included the design of an off-grid solar powered lighting system for night time use on the campsites. The system design consisted of a solar panel charging multiple 12V batteries which would be transported to the multiple campsites on the property by the scouts. Once plugged in to the campsite, the batteries would power a modular motion sensitive lighting system around the latrine, a USB charging station, power monitor, and pavilion lights. The batteries would return to the charging station every morning and charge during the day.

The land use component of the project consisted of a constraints analysis to produce land use zoning recommendations along with three conceptual designs for specific program development. Recommendations were created for the development of a venturing program, a nature's classroom program, and expanded parking infrastructure. For each of these recommendations the necessary facilities were identified and sited based on needs of the program and users and constraints of the land. The final recommendations include considerations for stormwater management and future incorporation of solar energy.

The education piece was focused on creating a learning tool to facilitate STEM learning using solar power as a medium. The tool was designed in the form of a website to make the tool dynamic and adaptable. The site should be able to be used for solar power education, regardless of its application including the Nova Program, Energy Badge, or Natures Classroom. It should also be updated by future users to make sure it remains relevant and useable.

The groundwork for a longstanding working relationship between Treasure Valley and WPI has been reestablished. This MQP was a starting point that will provide a number of additional projects that will follow the direction of the sustainability plan framework created in this project. Future projects will endeavor to develop and update the sustainability plan, ensuring that it remains a living document that Treasure Valley and future projects can utilize.

1.0 Introduction

The Treasure Valley Scout Reservation (TVSR) in Rutland, MA, the primary camp for the Mohegan Council of the Boy Scouts of America (BSA), has identified a desire to pursue alternative forms of energy generation for the reservation and a need for a long term sustainable development plan. More specifically, the stakeholders of Treasure Valley have indicated an interest in renewable energy development and feel that "technology has a dynamic place in the Boy Scouts," (Griffin).

In fulfillment of the Major Qualifying Project (MQP) for the areas of Civil Engineering, Electrical and Computer Engineering, and Environmental Studies, this group completed a project in collaboration with the stakeholders at Treasure Valley. In an effort to meet the needs of the client, the team created a sustainability plan framework to direct the future development of Treasure Valley. Within the areas of the sustainability plan, this project focused in the areas of renewable energy generation and land use planning. Concerning land use, the project group analyzed the current state and future plans of Treasure Valley to develop a set of future development recommendations. The group also developed a renewable solar-electric generation system independent from the grid which includes smart lighting systems and charging stations at various campsites for the safety, security, and peace of mind of camp goers without spoiling the camping experience.

2.0 Background

This section details the background knowledge that was necessary to develop a base understanding to complete the objectives of the project. The information includes the existing condition of Treasure Valley Scout Reservation, the needs of the client, and concepts that were relevant to the project.

2.1 Treasure Valley

The Treasure Valley Scout Reservation is the Boy Scout camp used by the Mohegan Council BSA. The reservation land covers approximately 1600 acres and spans the towns of Rutland, Paxton, Oakham, and Spencer located in the center of Massachusetts (www.doubleknot.com). The location of the reservation within Massachusetts can be seen in Figure 2. Given that TVSR spans four towns, regulations vary on different sides of the borders. The zoning bylaws for each town make the development of buildings difficult and mandate different approval processes in each town. Most of the facilities used on the property are located in Paxton and the major pond, Browning Pond, is located in Oakham. A map of the developed area of Treasure Valley that is widely utilized is shown in Figure 1.

The reservation is divided by Browning Pond into Treasure Valley East and Treasure Valley West. Treasure Valley West is mostly used by the younger boys (7 to 10 years in age) who are enrolled in the Cub Scout program. Treasure Valley East is most often used by the older boys (11 to 17 years in age) who are Boy Scouts. The facilities consist of 24 designated camping areas, various buildings, activity areas, and established roads to navigate the reservation (Figure 1).

Treasure Valley was established in 1925. The reservation has never had a master plan to guide development in any area (Griffin). There is currently no organized budget for expected improvements or development of the reservation. Many of the minor improvements done on the reservation are done by volunteers or through donations. The main road running through the reservation was recently paved by donations with a “price per foot” of asphalt. Those interested in helping out with improvements could pay $50 and receive a ruler with the text, “I own this much from Pleasantdale Road to Pine Point - TVSR.” Additionally, the TVSR website currently has an entire page dedicated to materials they would like to see donated. A few things on the list are pressure treated wood, concrete mix, and paint. Treasure Valley relies mostly on generosity for basic improvements and upkeep of the facilities (www.doubleknot.com/).

In Massachusetts, there are ten Boy Scout Councils. The Mohegan Council is the regional division of the Boy Scouts of America in which Treasure Valley falls. It encompasses 30 towns in Central Massachusetts including the Massasoit District, Hassanamisco District, and Quinsigamond District. It is expected that in the future, these districts will be restructured in an effort to consolidate. In this process, should it happen, Treasure Valley is expected to stay active as a majorly used reservation for Scouts given its extensive facilities and central location (www.doubleknot.com/).

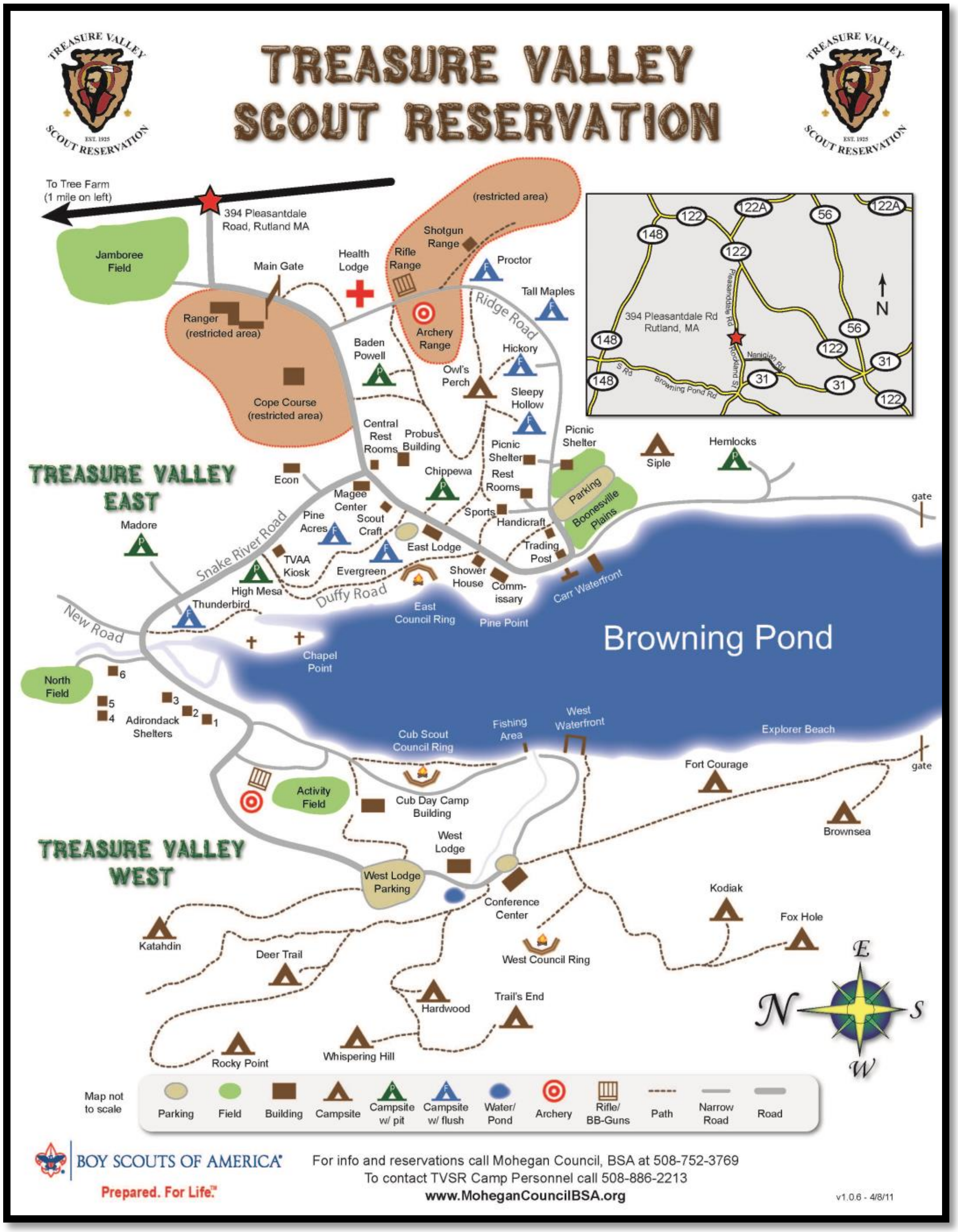


Figure 1: Boy Scouts of America's map of Treasure Valley Scout Reservation

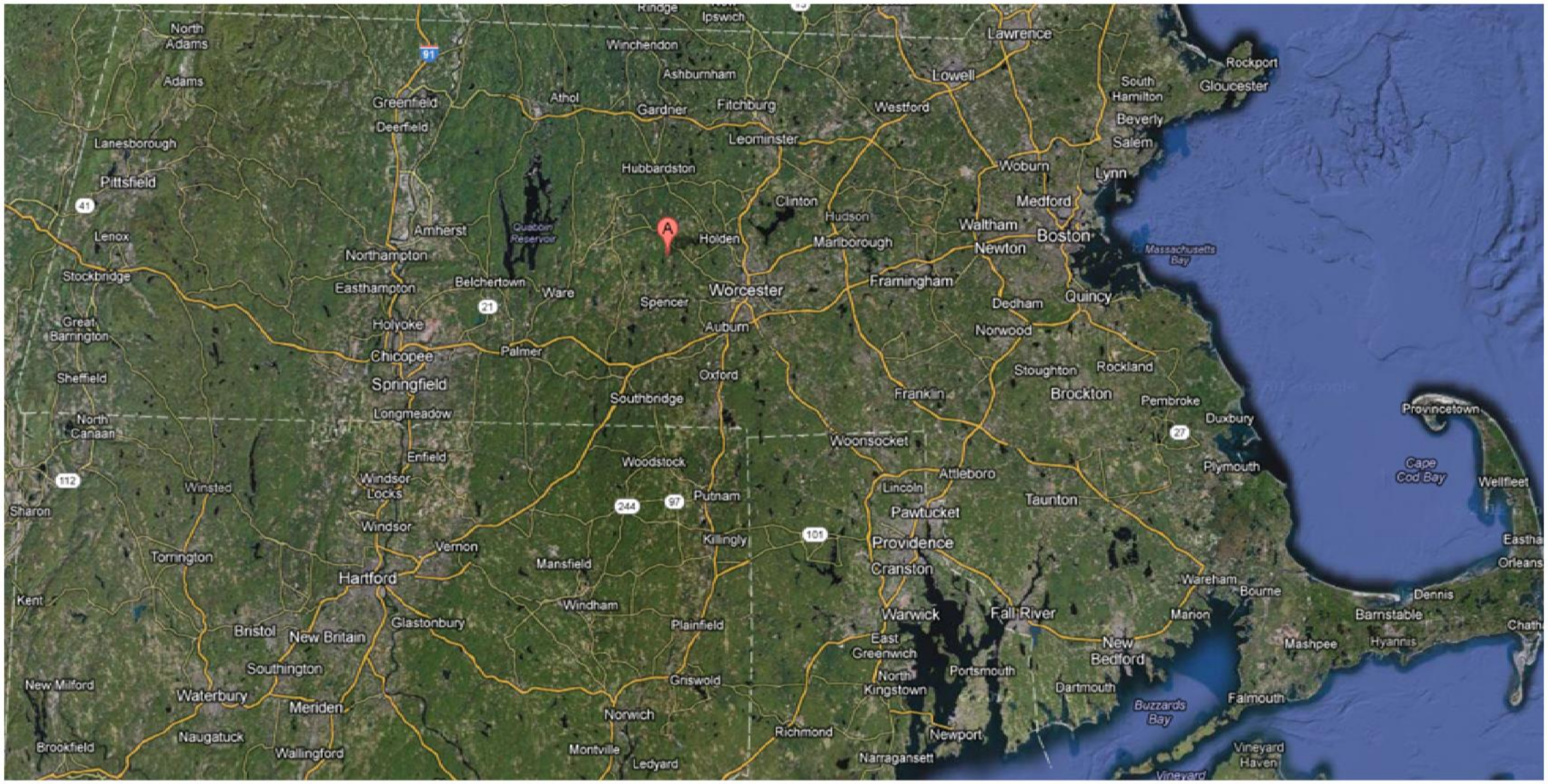


Figure 2 : Location of Treasure Valley (A) – Google Maps

2.2 Stakeholders

The key decision makers that control operations of the reservation are:

- Treasure Valley Organizations
  - Board of Trustees
  - Executive board
  - Board of Directors
  - Camping Committee
  - Treasure Valley Alumni Association
  - Friends of Treasure Valley
- Boy Scouts of America
  - Mohegan Council

2.2.1 Treasure Valley Organizations

The land on which Treasure Valley is located is in a trust. The owners of the land are the Board of Trustees of Treasure Valley. All decisions made regarding the Treasure Valley Scout Reservation and its facilities must be cleared by the Trustees. The Trustees focus on the preservation of TVSR for future generations, which includes long-term visions for development (Griffin).

Other organizations that are a part of the decision making process in Treasure Valley are the Executive Board, Executive Committee, Board of Directors, and the Camping Committee. The first three are part of the formal process for getting things approved. The camping committee is a group that is primary concerned with the day to day functioning of the activities and the safety and wellbeing of the children on the reservation (Griffin).

The Treasure Valley Alumni Association (TVAA) is a subsidiary of the Mohegan Council. This group is composed of members of any age who are or were at one point eligible to be Boy Scouts. The responsibility of the Association is to manage business matters to promote the experience and learning of the Boy Scouts at Treasure Valley (www.tvaa.us). Though the TVAA have some influence, they are not the major authority in large-scale decision-making regarding Treasure Valley (Griffin).

The Friends of Treasure Valley is a group of retirees, scouts and non-scouts, who have a particular interest in assisting with the operations of the reservation. From year to year, they manage improvement projects focused on the reservation’s buildings and grounds (www.doubleknot.com).

Worcester Polytechnic Institute used to be heavily involved with Treasure Valley. Students worked on projects with the reservations. Many people who are involved with TV are WPI alumni. Reservation leaders are interested in rekindling this historic relationship with WPI (Griffin).

2.2.2 Boy Scouts of America

Boy Scouts of America is a nationwide organization founded more than a century ago in 1910. Since their founding, the Boy Scouts have been an organization that encourages values and moral growth for the promotion of young boys to be the future leaders of the nation. Over their history, more than two million Boy Scouts have advanced through the program to the advanced level of Eagle Scout. The organization firmly believes in building character through community service, outdoor activities, and learning by doing (www.scouting.org).

The Mohegan Council is a regional division of the Boy Scouts of America. It encompasses 30 towns in Central Massachusetts. Their community contains about 5,000 children under the age of 18 and 1700 volunteer adults all-engaging in Scouting activities (www.doubleknot.com). It is estimated that on a yearly basis 15,000 people make use of the facilities at Treasure Valley. The main period of usage is in the summer months. During the winter months, the reservation sees little to no usage (Griffin).

2.3 Renewable Energy

Renewable energy is increasingly becoming a significant part of electricity generation all over the world. In the right location, energy from renewable sources can be very useful in locations where large scale, non-renewable energy production cannot be used or accessed. In the case of Treasure Valley, renewable energy can also be used to teach the concepts of energy generation and demonstrate the importance of energy conservation to children and young adults.

2.3.1 The Advantages of Solar

There are numerous types of renewable energy technologies available. These include ways to harness wind, solar, geothermal, tidal, and biomass. Treasure Valley is familiar with solar energy because there is currently a large-scale solar development being planned for TVSR land. This close relationship with solar power generation has piqued the Trustee’s interest in finding a way to utilize solar power on a small scale for use in the reservation.

Solar systems are attractive because of their simplicity. There are no moving parts. They are noise free and potentially have low maintenance requirements. They are also easily integrated in a multitude of electric systems (Tester).

From an ecological perspective, an off-grid power system for Treasure Valley would allow the reservation to be independent from the electrical grid and would be an example for other businesses and educational facilities to follow. The power system would also allow for the integration of an educational element that would fit the style of learning that the Boy Scouts of America strive for. A potential drawback of an off-grid solar power system for Treasure Valley would be lack of financial incentives specifically the large upfront capital cost and low return on investment.

2.3.2 Solar Technology

Instead of mechanical power generation, solar panels use photovoltaic (PV) cells to harness the sun's energy and convert it directly to electricity via the photoelectric effect. When a photon strikes a certain semi conductive material, the material's electrons are able to capture the photon's quantized energy. Under the right conditions, the striking of the photons releases electrons in the material creating voltage difference. The most common material used in PV cells is silicone (Tester). An illustrative example can be seen in Figure 3. Currently, solar powered devices are widely used in both small-scale applications (such as a calculator) and large-scale power generation. Because of the versatility of both high and low power needs, solar energy can fit solar effectively into a variety of site locations and power situation.

The most important advancements in solar power production technology are the efficiency of the cells and the cost effectiveness. As shown in Figure 4, even the most popular consumer panels are between around 12-17% efficient (www.sroeco.com).

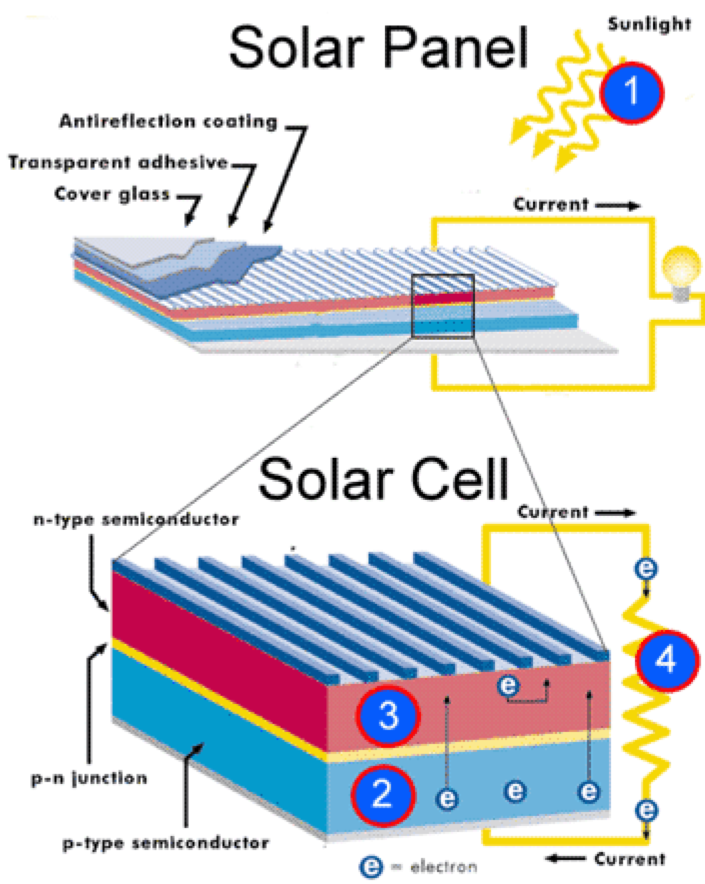


Figure 3: Operation of a solar cell (www.solarcell.net.in)

Manufacturer	ID	STC	Density	Eff.	Tier
Sanyo Electric	HIP-200BA19	200	14.89	17.24%	1
SunPower	SPR-200-WHT-U	200	13.55	16.08%	1
Canadian Solar	CS5A-200M	200	13.29	15.66%	2
Suntech Power	PLUTO200-Ada	200	13.28	15.66%	2
Trina Solar	TSM-200DA01A	200	13.12	15.64%	2
Kyocera Solar	KC200GT	200	12.03	14.74%	3
Schuco USA	SPV 200 SMAU-1	200	11.82	14.21%	3
BP Solar	SX3200B	200	11.52	14.17%	3
Yingli Green Energy	YL200P-26b	200	11.26	13.65%	4
ET Solar Industry	ET-P654200	200	11.18	13.61%	4
Evergreen Solar	ES-200-RL	200	10.69	13.40%	4
Sharp	ND-200U1	200	9.86	12.27%	5

Figure 4: Most popular consumer solar panels (www.sroeco.com)

2.3.3 Solar Incentives in Massachusetts

Currently, there are a variety of different incentives for Massachusetts residents and businesses to install solar power systems. The following information is from solarpowerrocks.com, a database of solar incentives based on each specific state as of October 2012. The solar power rebate program developed by the state of Massachusetts started in 2007 with a budget of $68 million and a goal of having 27MW of solar power installed on consumer and business property in 2010. So far the program has been successful and the budget has already been depleted. Massachusetts' incentive program is not the only one in the country with heavy usage. Most states have an incentive program coupled with a federal tax rebate to stimulate the growth of solar and other renewable power systems. The incentive program is expected to continue and grow in the amount of money that will be able to be used by Massachusetts residents. If Treasure Valley was to implement solar energy into their electrical system, they could be eligible for these benefits.

Government subsidies are important in the implementation of solar power because of the high initial costs that is incurred by a new system. For example, a 5kW solar system in the Boston area would cost around $26,000 but with the subsidies from both the state and federal governments, the cost can be reduced to about $12,000 including the tax credits. Though $26,000 is still a substantial amount to have to pay upfront for an energy system, it is best to think of the system as an investment. Typically, a system would take 5 years to pay for itself once the reduced costs of electricity and the solar renewable energy credits (SRECs) are accounted for.

In order for solar power systems to become more pervasive in the current power system, two things must happen. First, solar panels must become cheaper to produce. By advancing the technology to be more cost effective, it will become easier to implement by consumers and more attractive as an investment. Secondly, the efficiency of widely available solar cells must increase. With the currently available efficiencies, a large surface area of panels is necessary to produce electricity. In the previous example (solarpowerrocks.com), a 5kW system is 625 square feet. In places where space is limited, this can be a constraint that prohibits the effectiveness of solar. By increasing efficiency, the space necessary per kW will decrease, which will help eliminate some space constraints.

3.0 Problem Statement

The Treasure Valley Scout Reservation leadership has a desire to expand their scouting programs. The driving force is the ambition to grow their capacity and attract more scouts. Further, as the Boy Scout Councils in Massachusetts consolidate, Treasure Valley wants to maintain its standing as a prominent and attractive camp for use by the community. One aspiration of the Treasure Valley stakeholders is to incorporate modern technology and apply best practices with current and future development.

In addition to the desire to expand future developments, Treasure Valley has a lack of current planning for sustainability, a particular interest in solar energy, and a mission to engage youth through practical learning. Treasure Valley currently does not have a development plan. The creation of a plan to guide future development in a sustainable way will help Treasure Valley be able to provide a haven for Boy Scouts for many years in the future.

Additionally, an outside contractor is developing and constructing a 6-megawatt solar array on leased Treasure Valley lands. This development has sparked Treasure Valley's interest in pursuing renewable initiatives. None of the electricity from this array will be used directly on site before entering the grid, which leaves a potential for the development of small scale solar power generation systems to satisfy some of the power needs of the reservation while displaying the process and results to Boy Scouts for learning purposes.

Treasure Valley leadership believes that everything that happens within the reservation is an opportunity for learning. Future development and pursuit of renewable energy can naturally be tied with learning initiatives. Looking comprehensively at each of these areas of potential and combining different future plans with one cohesive product will help meet the needs of the users to teach, grow, and be sustainable. This integration will require collaboration of multiple disciplines.

3.1 Objectives

Based on the identified problems statement, the objectives of the project are as follows:

- Identify and understand the stakeholders' specific needs and constraints
- Develop a general sustainability plan for the reservation based on existing infrastructure, future plans, and sustainable goals
- Determine feasible sites on a reservation-wide level for off grid solar power applications for use throughout Treasure Valley
- Design a flexible solar power prototype that can be used to power a lighting system throughout the reservation at different locations

- Create a conceptual future land use plan for the expanded future development of programs within the reservation
- Develop a dynamic and adaptable tool to facilitate STEM learning within the programs of the reservation

4.0 Project Approach

This project was completed over the course of four terms during the 2012-2013 school year by four students. The students were two civil engineering majors, Joseph Szafarowicz and Lindsey Machamer, and two Electrical and Computer Engineering majors, Chris Girouard and Peter Aspinwall. The project demanded specialized work from each group (CE and ECE). Specifically, the CEs required the technical expertise and knowledge of the ECEs to properly plan and design any necessary infrastructure and provide insight for the development of the sustainability plan regarding solar electric power. Conversely, the ECEs consulted with the CE's to determine if their plans were feasible for the given location, what the impact to the environment would be, and how any ECE recommendations could fit into the overarching sustainability plan.

The project began with the four students working together to gather data and to understand the needs of the stakeholders. Chapter 5 of this report details this portion of the project, which was mainly completed in A-Term. The methods of this section were aimed at establishing a scope of work that would meet the identified needs of the stakeholder while satisfying the capstone requirements for Civil Engineering, Electrical and Computer Engineering, and Environmental Studies. Before the scope of the project was finalized by the two student groups, the early phases of the project involved both groups closely working with each other. Dialog and brainstorming between the students groups helped set the tone and scope for the rest of the project. The scope of this project was a sustainability plan framework with focus in three areas that were completed as part of this MQP. The rest of the sustainability plan is intended to be completed as part of future projects.

Following the work in A-Term, the ECE students and CE students divided into their respective majors to work on their specialized portion of the projects on parallel tracks to accomplish the goals defined in Section 3. Recommendations and interaction between the project groups were, however, common throughout the project. Suggestions concerning the look, feel, layout, and purpose of the campsite light were given and evaluated between members of both disciplines. Chapter 6 of this report details the portion of this project completed in satisfaction of the capstone requirement for the ECE students. For this portion of the project, the students designed an off-grid solar powered lighting system prototype for a campsite. The system was designed with input from Treasure Valley stakeholders and siting input from the CE students.

Chapter 7 of this report details the parts of this project completed in satisfaction of the capstone requirement for the CE students. This portion of the project focused on creating sustainable building development recommendations on a reservation-wide scale through an iterative design process. Again, this section was approached with input from Treasure Valley stakeholders and guided with input from the ECE students.

While developing future development recommendations, the CE students considered the designs and recommendations of the ECE students in their own design process. New development was sited with solar electric power generation in mind. In addition, the ECE students kept in mind the applicability of their single site design in terms of other campsites and other areas of Treasure Valley for the potential integration of solar power. For instance, when siting buildings, care was given to place the slope of the room in a southerly direction with minimal tree cover.

A final portion of this project was completed in D-Term in satisfaction of the Environmental and Sustainability Studies (ESS) requirement for Lindsey Machamer's double major. This portion was aimed at development of an environmental education program.

A Gantt chart with a schedule showing the distribution of the work completed in this project can be seen in Figure 5. This chart contains the length, start, and end times of the different tasks of the project. Important dates such as stakeholder meetings and beginnings of academic terms are also displayed. The "background research" and "early TV visits" sections represent the early portion of the project where the initial data was gathered, the solar study was conducted, and initial stakeholder contact was made.

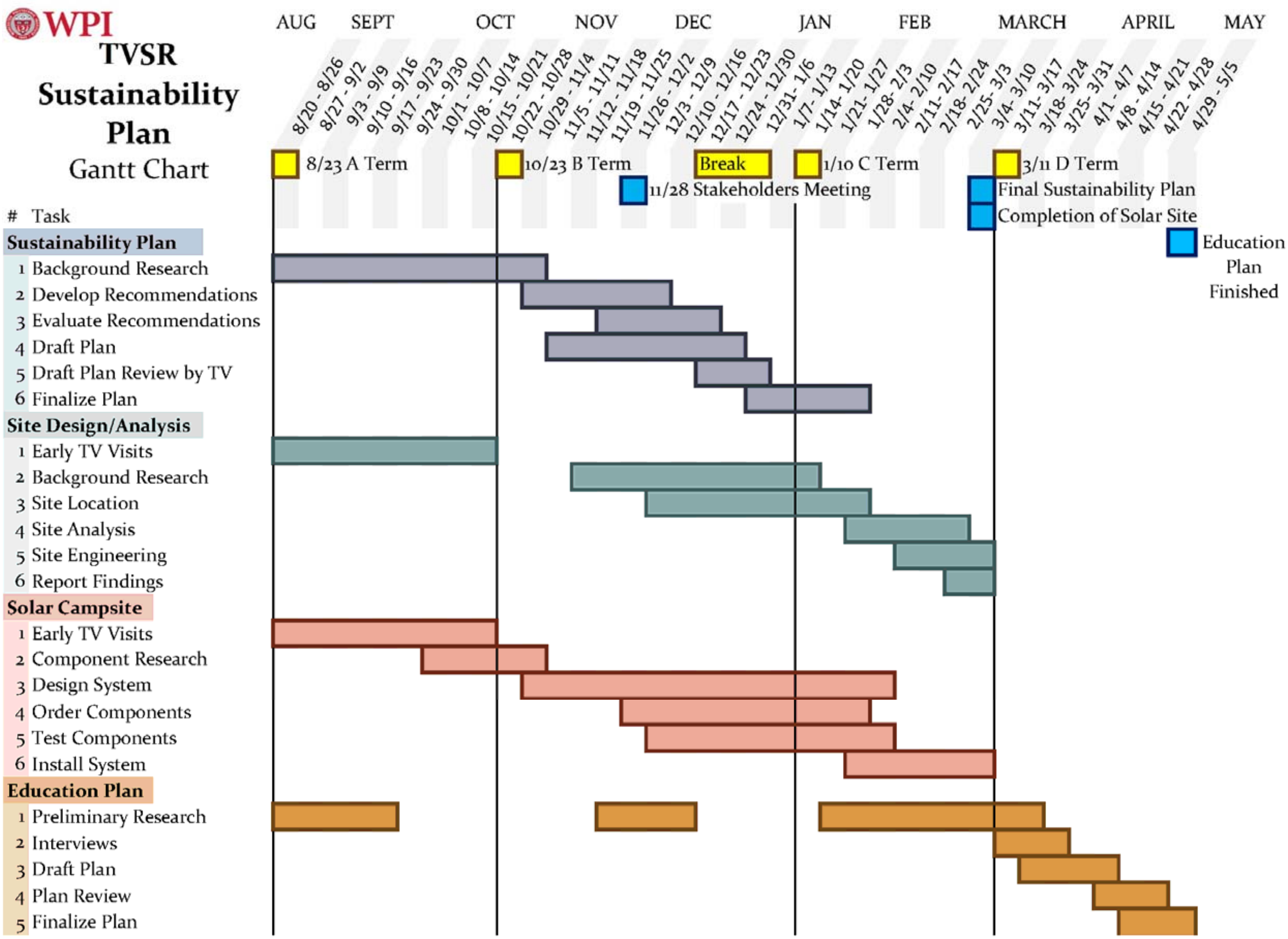


Figure 5 : Project Breakdown Gantt Chart

5.0 Planning for Sustainability

The purpose of this section is to explain and organize the techniques, methods, and data used in the process of defining the scope of the MQP. This section also includes the methodology and results of the planning portions of the project. Basic principles and guidelines were created to direct the rest of this project as well as future projects.

5.1 Background: The Planning Process

This section of the report details the background information required to effectively develop specific goals and objectives of this MQP. This includes the background of the process and history of sustainability planning. This research helped to form the project direction.

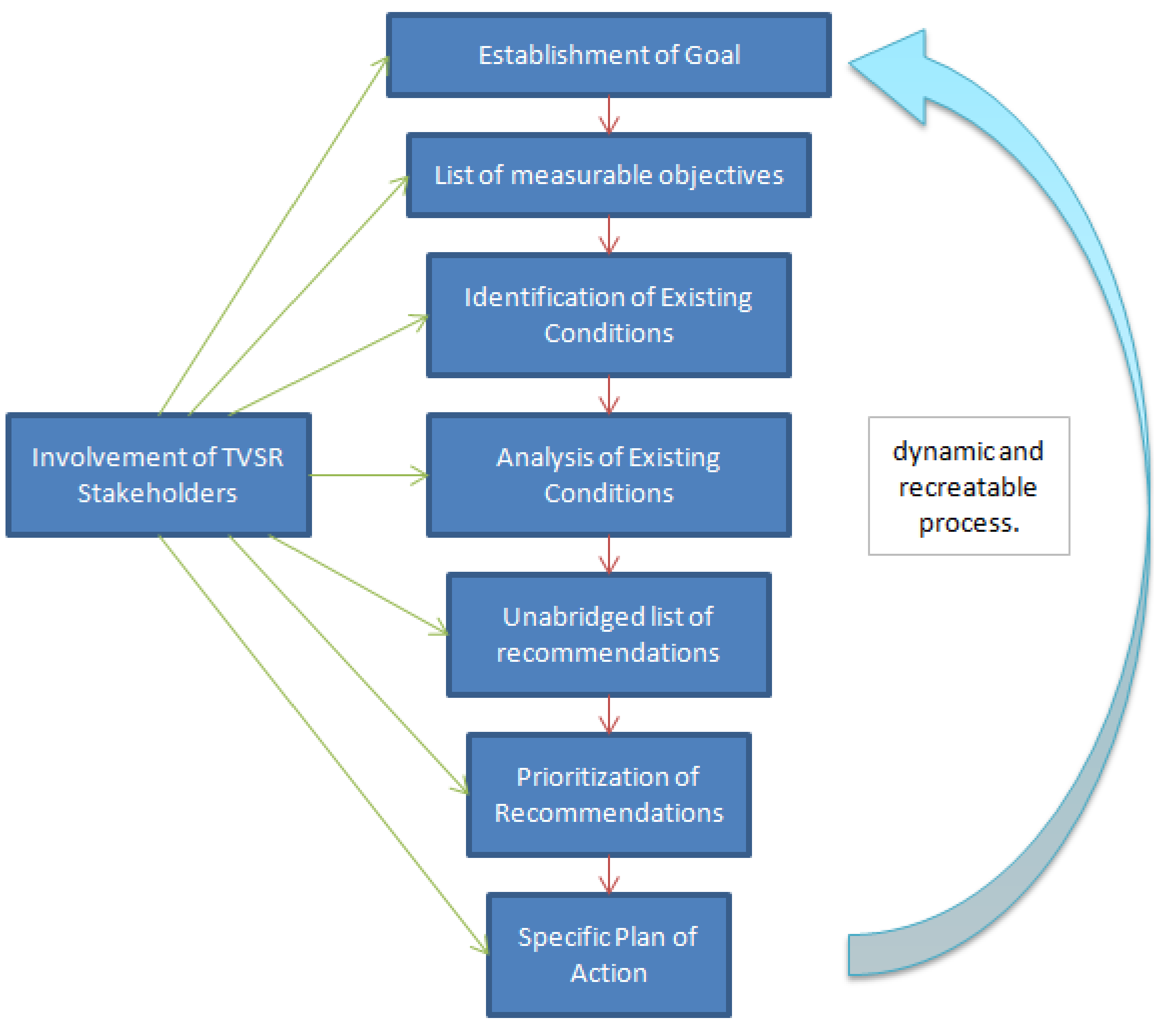


Figure 6: The planning process

In order to effectively accomplish goals and tasks, a plan was needed to organize the work progress and identify milestones and important dates. Many different organizations, such as private and government entities, follow a formal planning process. Local governments typically have planning departments to manage the direction of the community through development approvals and restrictions. Private organizations also plan to ensure their investments are managed and utilized properly. Figure 6 shows the particular parts of the planning process used. This process is comprised of a series of steps that dynamically repeat to create, evaluate, and define individual goals that will satisfy different needs of the stakeholder. The role of the stakeholder is important in this process and should be involved throughout the process.

There are many different types of sustainability plans. Typically, sustainability plans are directed at controlling the human impact on the environment in an effort to support sustainability.

5.1.1 Defining Sustainability

Sustainability is defined in a variety of different ways depending on the individual or organization defining it. From the Merriam Webster dictionary, sustainable is defined in two ways as, “1. Capable of being sustained,” and, “2. of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.” Sustainable development was defined at the Brundtland Convention in 2007 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This is the definition that is generally utilized on a global scale. In 1789, Thomas Jefferson discussed sustainable practices during his presidency.

> *Then I say the earth belongs to each...generation during its course, fully and in its own right. The second generation receives it clear of the debts and encumbrances, the third of the second, and so on. For if the first could charge it with a debt, then the earth would belong to the dead and not to the living generation. Then, no generation can contract debts greater than may be paid during the course of its own existence.*

This quote was not about environmental sustainability; rather, it was a discussion of the nation’s economic state at the time. Although he is referring to financial matters, the theme of Jefferson’s quote is aptly relevant to the contemporary day environment and Earth. Additionally, the International Association of Public Transport, another international planning organization, defines sustainable development as “balancing the fulfillment of human needs with the protection of the natural environment.”

The common focus of these different quotes about sustainability involves balancing resources of the earth with human practices, with the intent of ensuring the success of the system into the future.

5.1.2 Planning Guidelines

It is important to plan for sustainability for a variety of reasons. These include reducing the impact of pollution, protection of human health, preservation of scarce resources, improving economic conditions, and many more specific objectives. Different organizations have different motivations for planning for sustainability.

The American Planning Association has put together a policy guide for sustainability planning in order to encourage and direct successful planning efforts. These guidelines are directed at municipalities to mitigate the negative impacts of human development on the environment. The objectives of the guidelines are to reduce the use of fossil fuels, reduce dependence on chemicals or manufactured substances, reduce activities that impact ecosystems (i.e. water), and improve the ability to meet present and future needs (APA). The guidelines are accompanied with a sample action plan to show how planning efforts can be put into action. Particularly, the APA stresses the importance of public participation in successful plans.

Other organizations with different goals have also developed guidelines for crafting sustainability plans. The Axis (Advice and eXpertise In Sustainability) Performance Advisors is a consulting organization for improving sustainability of business operations. The process they outline includes defining sustainability for company purposes, identify the rationale for sustainability planning, defining a vision, and analyzing the key impacts. These guidelines are aimed at holistically analyzing the business operation in order to reduce expenses and negative impacts on the environment. The Center for Disease Control (CDC) also published their own version of sustainability guidelines entitled “A Sustainability Planning Guide for Healthy Communities”. This comprehensive write-up is aimed at improving health through environmental sustainability initiatives.

Regardless of the type of plan these guidelines are directed towards, there are some messages that resonate through all of them. First, it is important to define sustainability to fit the needs of the particular institution. Also, each of the guidelines stresses the importance of stakeholder participation in the development of the plan. Another aspect that is crucial to the success of a sustainability plan is having an action plan to monitor progress over time.

5.1.2 Existing Planning Initiatives

The state of Massachusetts is involved in sustainability planning. The department heading most of the planning initiatives is the Executive Office of Energy and Environmental Affairs (EEA) which was established in 1975. The mission statement of the Executive Office is to “safeguard public health from environmental threats and to preserve, protect, and enhance the natural resources of the Commonwealth.” This umbrella organization is in charge of a variety of smaller departments that have specific domains. These areas include forest management, ocean protection, global warming solutions, agriculture, renewable energy, and other more particular areas. Planning in these areas resulted in a series of statewide goals including reduction of greenhouse gases by 80% by 2050 and accomplishments like 100,000 acres of new conservation land in the last five years (EEA). These goals and many of the resources, which have been compiled at the state level, should be utilized on smaller scale planning within the Commonwealth.

The city of Northampton, Massachusetts is an example of a community that has taken initiative to develop a comprehensive sustainability plan. The process that began in 2005 produced a plan that was adopted by the community in 2007. The structure of the Northampton plan is descriptive and easy to follow. The report begins with logistical information including how the plan was developed and who was involved. Then, as the headings clearly indicate, the “Vision” is stated, followed by the more specific “Guiding Principles,” and eventually the “Elements, Actions, and Measures of Success.” Under the Elements, Actions, and Measures of Success heading, each of the areas of focus are listed and separated into their own subsections. These areas of focus include land use and development, open space and recreation, transportation, housing, and eight others. Although the areas within the Northampton plan are appropriate for the scale of a town rather than a campground, the structure of the plan’s use of guiding principles and specific areas of focus is applicable.

Many college campuses have sustainability plans. WPI is currently in the process of developing a long term sustainability plan and has just completed phase one of the project. The working vision statement for the plan incorporates WPI’s motto of theory and practice and applies it to the principles of sustainability. The plan is comprised of sustainable solutions in four areas including campus operations, academic program, institutional policies and practices, and community engagement. The recognition that the institution has a multifaceted interaction with the environment is important for achieving holistic sustainability. The development process involves input through a thorough participation plan from a broad array of individuals including faculty, staff, and students. Being an institution smaller than a town, the goals of a university will be more similar to those of a multi-program site like Treasure Valley.

The Lake Tully campground in Royalston, Massachusetts is an example of a campground that has developed a sustainability plan. Lake Tully was created by the U.S. Army Corps of Engineers (USACE) in 1942 as a flood control strategy. The campground is still owned by the USACE and operated by the Trustees of the Reservation. This sustainability plan was developed in 2010 with four goals: Site new structures, redesign the common area, address shoreline and forest health issues, and develop a list of sustainable best management practices (Kaigle, Scott, & Thomas). The report does a comprehensive job of documenting and analyzing current conditions of the camp grounds in order to best accomplish the goals. All of the information and recommendations are accompanied with interesting visuals and maps to aid help people understand the process. The final product is a usable and accessible deliverable fitting for use in a reservation.

5.2 Sustainability Plan Methodology

5.2.1 Stakeholder Participation Efforts

Along with any plan for an organization, town, region, state, etc., one of the fundamental requirements in creating a plan involves gathering input from the people and groups that your plan will affect. The best way to accomplish this is to develop a stakeholder input plan.

The first step in this process was to identify the key stakeholders who have a say or influence in any direction or steps Treasure Valley might take in the future. These groups will be the primary parties the students will be interacting with and addressing. In the first few meetings with representatives from the reservation, the key groups that govern Treasure Valley were identified as:

- Ray Griffin – WPI-TVSR Liaison
- Treasure Valley Trustees
- Executive Board
- Executive Committee
- Board of Directors
- Camping Committee
- Friends of Treasure Valley

It is also important to identify secondary stakeholders. These are the groups, individuals, and even the non-human local organisms that do not have direct influence on the operations of Treasure Valley. They will, however, be affected (directly and/or indirectly) by the decisions of the stakeholders and the repercussions of this project's recommendations. It is responsible to understand these groups to ensure any recommendations acknowledge these groups' needs. These secondary stakeholders include:

- Boy Scouts, Cub Scouts, Venturing Scouts
- Troop leaders
- Parents of scouts
- Former scouts
- People who may use the reservation outside of scouting (business retreats, Sober in the Sun, etc)
- The native fauna and flora

A comprehensive list of the information needed from each party and what information each party needed from the group was created from the stakeholders identified as major players. In this process, the interests of the secondary stakeholders are represented by the major stakeholders.

The information needed from the stakeholders in creation of a plan included approval, monetary information, information regarding existing conditions, personal priorities, and responsibilities of key players. Given that the stakeholders were the main decision makers for Treasure Valley, particularly the board of Trustees and the Board of Directors, the team would need approval of the plans in order for them to be implemented. To make sure they plans have approval, the team needed to have an understanding of the budget constraints and priorities of those making the decisions. Additionally, the stakeholders were a resource for providing the project team with information about the current state of the reservation. All of this information was vital in providing a quality product to Treasure Valley.

Information that the project team needed to provide to the stakeholders include descriptions of the details of this report including how they work, what is required to make them work, the cost and timeline, effects on the Scouts, and the reasons for the decisions. In order for these recommendations to be successful, the stakeholders needed to understand and support all of the presented information. In addition, they needed to see that the health and safety of the Scouts was kept in mind.

Information the stakeholders need from the project team:

- How will the recommendations work
- What is the maintenance and storage procedure for various recommendations
- Life cycle of each recommendations
- Cost and timeline of plans
- How will the campers be affected
- Will safety be addressed
- What will they need to do/change

Based on the list of information needed to be exchanged throughout the project, it was decided that a series of meetings with the key players would be the best method to ensure proper stakeholder participation. Given the large number of stakeholders, a meeting with everyone present would yield more concise results and more feasible than individual interviews.

A meeting at the beginning stages of the planning process allowed for preliminary input on the direction and scope of the project. This meeting took place November 28, 2012. Seven Treasure Valley representatives (from various stakeholder groups) were present. The group gave an overview on the progress of the project so far. The sustainability plan draft created by the project group was reviewed by the stakeholders, advisors, and students. The vision statement was discussed in depth. The positive aspects and the areas that need improvement were identified. The needed information (for and from the students) were discusses and tasked to individual stakeholders to gather and send to the project group. Concerning the site selection portion of the project, a list of suggestions composed of different future development was presented by the stakeholders to the students. An overview of the solar powered lighting system was presented and discussed. The initial ideas were well received. The inclusion of more usb charging hubs and the safety of the scouts were the focus of the discussion. The detailed minutes as well as the handouts used during the meeting (the agenda, the MQP Gantt Chart, the list of questions for the stakeholders, and the vision statement) can be seen in Appendix A.

All the requested information (water/electric infrastructure, etc.) was not able to send digitally to the project group. Another follow-up meeting was held on December 12, 2012. This meeting would be devoted to the acquisition of physical copies of the requested data from the stakeholders to the project group. This was not a formal meeting. Therefore, an agenda and minutes were not created.

In the intermediary stages of the project, contact was maintained with the appropriate parties via email in order to gather information regarding existing conditions on the reservation and to clarify any small questions in regards to the direction of the project.

A final meeting was held on February 27, 2013 for the project group to present the findings and results of the project to the stakeholders. The solar light system prototype was presented, demonstrated, and discussed. Future development recommendations were also presented and reviewed. An update on the environmental portion of the project as well as future projects was discussed. The minutes of this meeting can be found in Appendix A.

5.2.2 Development of Vision

The first step was to develop a vision that includes a statement of purpose and a set of guiding principles. These guiding principles were designed to create a starting ground from which to begin planning and as a reference for the formulation of specific goals. The list was compiled with input from the stakeholders of Treasure Valley. The development of a vision serves to establish a scope of a plan for Treasure Valley off of which the rest of the plan is to be based. The process of developing the vision included defining sustainability and identifying guiding principles.

5.2.2.1 Defining Sustainability

The goal was to develop a definition of sustainability that fit the context of Treasure Valley while not necessarily focusing on the large scale, but keeping it in mind. The starting point was to compile a variety of existing definitions of sustainability for review and to compare to a list of needs concerns and future and present issues of the Boy Scouts. The project group attempted to draw parallels between the values instilled by the boy scouts and those promoted by the concept of environmental sustainability. A variety of definitions of sustainability were evaluated and adapted to determine the best definition that met the needs of Treasure Valley.

The idea of creating “guiding principles” as part of the vision statement was adapted from the Northampton, MA sustainability plan. In the Northampton plan, the guiding principles are goals that the plan aims to meet. These goals are slightly more specific than the general vision statement in order to apply more directly to the community.

After the project team created an initial version of a vision statement, it was brought to the stakeholders for review. During a meeting, hard copies of the vision were handed to each person in attendance. With this document, each member present was asked to read it over silently and circle language they liked and underline language they disliked. This was able to spark a discussion about the positives and negatives of the vision in order to edit it. The final version of the vision statement is found in the results section of this chapter.

5.2.3 Inventory

The next phase of the planning process was to compile a record of the existing conditions on the reservation. The current infrastructure was identified. This includes buildings, roads, septic systems, water infrastructure, activity areas, and all other constructed facilities. These features were recorded in a GIS map for reference. Additionally, for each of the features identified, it was determined how much energy it draws and the source of that energy. It was also necessary to accumulate a centralized list of all plans that the stakeholders at TVSR have for the foreseeable future.

All of these existing conditions were compiled in a database for access by future project teams so they will not have to start the compilation process from scratch. Treasure Valley also has a need for a centralized information database. This project team created a dynamic digital database for easy access and use by Treasure Valley in the form of PDF files and a GIS database.

The use of ArcGIS is for two reasons. GIS will be a way to digitize information for inclusion in a Treasure Valley Scout Reservation database. GIS will also use all of the data compiled to perform a constraints analysis to determine the ideal locations for future developments. The creation of the GIS map file began with the creation a base map. The files that were imported to create the base map are detailed in the chart below. This basic data included aerial photographs, town boundaries, and property lines. This data allowed the establishment of a geospatial reference for the area of concern to which data would be added for archival and analysis.

Table 1 : Used GIS data information

Data Description	File Name	Source	Year
Property Lines	Level 3 Assessors' Parcel Mapping (Oakham, Spencer, and Paxton) TVSR Property Map (Rutland)	MassGIS and TVSR	2013
Aerial Photograph	USGS Color Ortho Imagery	MassGIS	2009
Town Boundaries	Community Boundaries (Towns) from Survey Points	MassGIS	2012
Buildings	Buildings	TVSR	2012
Campsites	Campsites	TVSR	2011

5.3 Plan Results

This section of the report details the results of the efforts to identify the scope of a sustainable development plan for Treasure Valley Scout Reservation. The results include a vision statement of a sustainability plan, a review of the existing conditions and planning initiatives, and an identification of focus areas for a complete sustainability plan.

5.3.1 The Vision

This section contains the final vision statement as developed by the project group with guidance from the Treasure Valley stakeholders. The definition of sustainability that resulted for use by Treasure Valley is "balancing the fulfillment of present and future human needs while ensuring the conservation and protection of the natural environment." A list of the various definitions evaluated in the process of defining sustainability is included in Appendix B. The main inspiration from this definition came from the World Bank's definition of sustainability. That definition included language "...balancing the fulfillment of human needs with the protection of the natural environment.” To this basic concept of balancing “future human needs” was added from the United Nations definition because Treasure Valley plans on being around for many generations. The term “conservation” was also added to the definition to emphasize one of the main ways that Treasure Valley will be contributing to sustainability which is by reducing their consumption.

In developing the guiding principles for Treasure Valley the team attempted to draw parallels between boy scouting principles and environmental sustainability. Based on conversation with stakeholders and an understanding of the organizations general goals, the major categories of guiding principles were identified as Operational, Behavioral, and Collaborative. Operational was included because the stakeholders of Treasure Valley want the reservation to be around for a long time. Behavioral was included because a main goal of the national organization of Boy Scouts is to educate young men. Collaborative was included because one of the major concerns of the stakeholders is establishing relationships with various organizations in order to further advance themselves into the future.

The final version of the vision is as follows:

There are not many places where one can enjoy and experience nature or, at least, get away from the hustle and bustle of modern society. Treasure Valley is one of these exceptional places where someone can enjoy a different perspective of nature. The reservation also fosters an environment based upon Scouting principles where a young person can learn and develop in a way that is unique.

The Boy Scouts of America have been advocates for sustainable lifestyles since their inception more than 100 years ago. Currently, the Boy Scouts are making a national effort to take their sustainable principles to the next level. “From stewardship to sustainability, and from "leave no trace" to leaving the world a better place. We're going from green to deep green,” (BSA). This desire to advance the influence of their actions combined with a desire to maintain Treasure Valley for future generations provides an impetus to develop a plan for sustainability.

This plan defines sustainability as:

> *balancing the fulfillment of present and future human needs while ensuring the conservation and protection of the natural environment.*

This is the working definition that influences the general decisions presented in this plan. These decisions are embodied in a set of guiding principles developed for the context of sustainable development within Treasure Valley.

Guiding principles of sustainable development of Treasure Valley Scout Reservation include:

- Ensure the operation and continued expansion of the reservation into the future
    - Maintain fiscal and operational sustainability of the reservation
    - Mitigate the environmental and resource demand in order to become better stewards of the earth
    - Retain the relevance of programs by finding a dynamic place for technology in scouting
- Foster environmental attitudes that the users will carry with them through life (attitudes)
    - Provide education to help with making the right decisions beyond the confines of the reservation
    - Prepare users to be future leaders in their community to further promote sustainable ideals
    - Foster interest in the science, technology, engineering, and math (STEM)
- Cultivate relationships and collaborations to improve future success of TVSR
    - Establish an environment for WPI-TVSR collaboration that is independent of people
    - Initiate and build relationships with other institutions to open other avenues for development and in order to qualify for and obtain more grants

5.3.2 Inventory

This section includes a presentation of the information that was gathered throughout the methods of this chapter. This includes a review of existing planning efforts for the Treasure Valley Scout Reservation, a base map of Treasure Valley created in GIS, and the data regarding use of various facilities.

5.3.2.1 Existing Site and Use Conditions

The base map created as part of the inventory of existing conditions is shown in Figure 7. This map provided the basis for which future analysis can be conducted and to organize future spatial data collected. The buildings and campsites files were digitized in GIS from Treasure Valley maps and information accompanying each was collected and added in the form of attributes to the data. The data tables are show in Appendix D. The next section details the existing environmental planning initiatives at Treasure Valley.

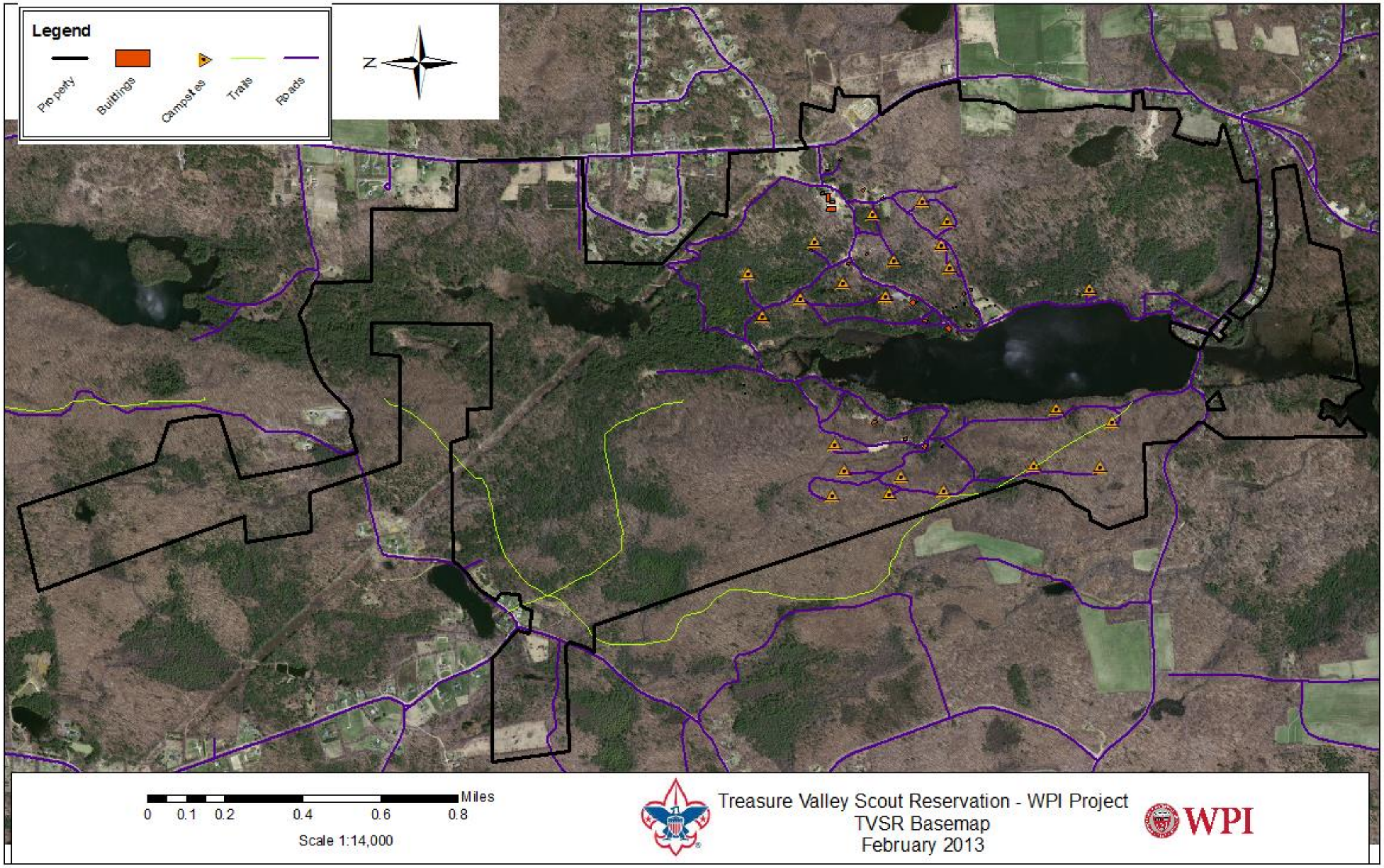


Figure 7: TVSR Base Map

5.3.2.2 Existing Plan Conditions

TVSR Conservation plan

The Treasure Valley Scout Reservation Conservation plan is a plan designed for use in 2012-2015. It was created primarily as a response to the Asian longhorn beetle problem that had been plaguing the area and an ice storm in December of 2008 that significantly affected the reservation. The plan's initiatives are broken up in to East Camp, West Camp, and Overall with numbered actions by year. East Camp initiatives include tree clean-up, replenish soil, plant seedlings, improve nature trails, maintain roads, fix disturbed areas with loam or mulch, improve environmental education, and improve campsites. West Camp initiatives include an emphasis of leave no trace and efforts to monitor erosion. The Overall initiatives include forest management plan, monitor beavers, mow annually, mosquito control plan, year round toilets, invasive plants, encourage service for improvements, no importing firewood, maintain trail system, resource storage, browning pond quality, and solar.

The positive of this planning effort is that it identifies and addresses areas of interest specific to Treasure Valley. Unfortunately, there are no action items filled in beyond 2012, only a few items for West Camp, and no budget associated with the plan.

TVSR Forest Management Plan

The Treasure Valley Forest Management Plan was created in 2004 by Gerrish Forestland Management as a 10 year plan for 2005-2015. The creators of the plan had TV leaders rank the importance of typical forest management goals. Treasure Valley marked the items "generate long term income," "enhance habitats," and "promote biological diversity" with high importance. The plan also addresses stewardship issues including biodiversity, rare species, riparian and wetland areas, soil and water quality, forest health, fire, wildlife management, wood products, cultural resources, recreation and aesthetics. A majority of the document is taken up with tree stand descriptions and management practices listed for each tree stand with a range of years given as a timeline.

The positives of this planning effort are that it includes very detailed action steps and details regarding best areas for development. The negatives are that there are no specific tasks with dates laid out or party designated as responsible for the tasks.

Council Conservation Committee Guidebook

This guidebook was created for BSA on a national level by the national council conservation committee that emphasizes the importance of conservation to scouts and scouting. The guidebook encourages the creation of a council conservation committee that will help by providing experts and decision makers regarding management of resources and promoting conservation programs. It also focuses on promoting distributed conservation initiatives, conservation education and advancement, and revenue opportunities through conservation.

The positives of this guidebook are that it encourages initiatives that are made to be adaptable to local needs and encourages creativity, includes samples of a local council conservation plans, and includes resources and references to draw from. The negatives are that it includes a section inapplicable to TV focused on cultural resources, and that it is not an actual plan, only a guideline for creating a plan.

5.3.3 Future Projects

To accompany the vision statement for a sustainability plan, the team created a series of focus areas that are comprehensive in achieving the guiding principles of the vision.

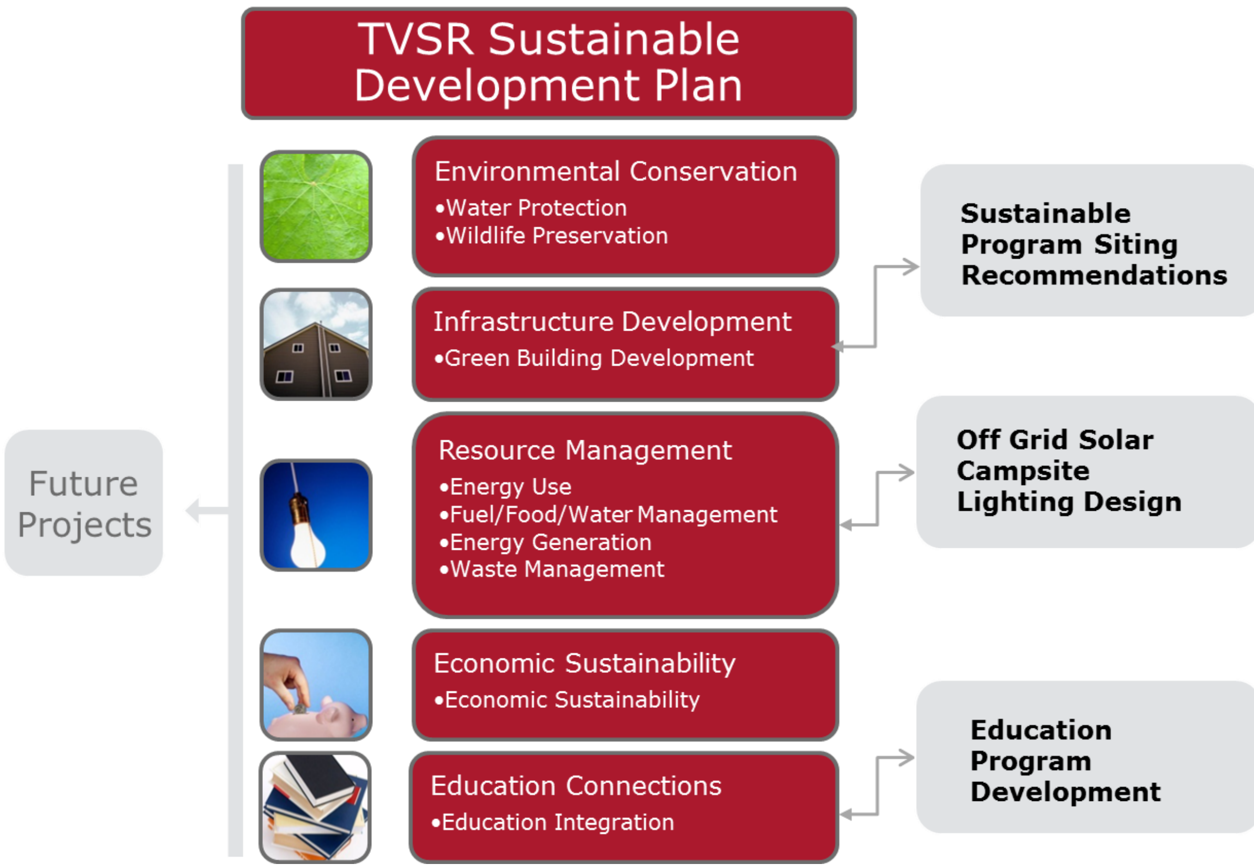


Figure 8: Focus areas within the sustainability plan

These areas are Environmental Conservation, Resource Management, Economic Sustainability, Infrastructure Development, and Education Connections. In terms of this project, the areas for which to focus this project were identified. These include the renewable energy generation portion of environmental conservation and the green building development portion of infrastructure development. The other areas were identified as areas for future project. The major project areas are summarized below. The identification of these areas for future projects will help to ensure continued participation between WPI students and Treasure Valley in years to come. The list of future projects is organized in Figure 9.

Current MQP

Energy Management

- Design and prototype solar lighting system
- General solar power recommendations

Infrastructure Development

- Inventory existing conditions
- Reservation-wide constraints analysis
- Develop general building recommendations

Education and connections

- Organize and future projects
- Outreach to other institutions
- Collaborate with government organizations
- Develop scout education programs

ECE MQP

CE Capstone Design

ENV Requirement

Potential Future CEE MQPs

WATER RESOURCES

- Water Conservation
- Drinking water
- Waste Water
- Browning Pond water quality

ECONOMIC OPPORTUNITIES

- Inventory TVSR's current budget
- Organize TVSR's past money flow
- Recommend new means of generating new incomes
- Identify new programs that TVSR can offer

Potential Future IQPs

HABITAT

ENVIRONMENTAL CONSERVATION

- Wildlife research
- Study on the impacts on scouting
- Forrest management
- organizations
- Develop scout education programs

Potential Future ENV MQP

Potential Future CEE MQP

MILFOIL STUDY

- Field research on the milfoil problem in Browning pond
- Report findings
- Develop solutions to problem
- Recommendations going forward

RESOURCE MANAGEMENT

- Inventory existing resources
  - Food, fuel, waste management
- Evaluate TVSR's current resource consumption
- Develop 5-yr capital equipment schedule
- Develop maintenance schedule
- Develop resource use recommendations

Potential Future IQPs

Potential Future IQP

DATABASE MANAGEMENT

- Update current database
- Improve database
- Identify future projects

Figure 9 : Future Projects

6.0 Solar Lighting System Development

The purpose of this section is to outline the methods of analysis used to develop the design of a solar powered lighting system for campsite integration at Treasure Valley Boy Scout Reservation. Included is an analysis of the needs of the stakeholders, technical and overall system design, and component level measurement and analysis.

6.0.1 Project Background

The solar lighting system project was a spin-off from the Treasure Valley Solar Reservation (TVSR) project involving the installation of a 6-megawatt solar system for on-grid power generation. The project sparked interest in additional off-grid solar systems to support safer and more reliable campsite lighting for Boy Scouts at night. A specific camp-site solar lighting project objective was established after several meetings with Treasure Valley representatives to create a safe, reliable, durable, sensor activated lighting system powered entirely by renewable energy.

6.1 Methodology

In the following sections information and details are provide on the steps taken to develop the final design of the solar lighting system. The information provided will include the details of the analysis, design, construction and testing of an off-grid lighting system. In general, a basic systems engineering approach that was used to develop the project will serve as the framework for this presentation.

6.1.1 Stakeholders

Stakeholders provide key system requirement and needs input when establishing a design for any project. At TVSR, the Board of Trustees and the Friends of Treasure Valley oversee the policies and finances of the reservation and form the long term plans for the camps future. As the key stakeholders for this project, their input, coupled with the feedback from the scoutmasters who bring their troops to the camp during the summer, as well as the scouts themselves, were the primary stakeholders and sources of data for needs assessments and requirements when designing the prototype.

The TVSR stakeholders were involved for a number of reasons. The main reasons were to ensure safety and cost of the system. They were also important in the design of the system in regards to durability, reliability and serviceability of the system. Similarly, the scouts, who would benefit from the system installation were stakeholders because of the safety provided by additional area lighting and because they were the ultimate users of the system. They also needed to be able to operate it with minimal training and, because of their direct contact with the system, the system would have to be safe for them to manage and operate. Throughout the project, the stakeholders were consulted multiple times to gauge their interest and change this design based on their input.

6.1.2 Needs

The needs for the lighting system were based on the needs of the two principle stakeholders. The needs of each are listed below.

TVSR Board of Directors and Scout Leader Needs

1. Increase the level of lighting in the campsite for the safety of the campers
2. Increase the level of lighting in the shelter area for evening merit badge work
3. Make sure the system is safe and manageable by the scouts
4. Make sure the system is affordable, durable, reliable, adaptable, and easily serviceable

Scout and Scout Master Needs

1. Be able to work at night on merit badges
2. Safely walk from tent to latrine with adequate lighting
3. Lighting available inside the latrine.
4. Be able to easily use the lighting system
5. Be able to carry the battery from the charging station to the lighting system
6. Learn about the energy requirements and help gain knowledge for the energy or environmental science merit badge
7. Provide some capability for cell phone and pad type device charging.

Aggregating these needs and adding a few more from the designer's perspective resulted in the system needs shown in Table 2.

Table 2: Lighting System Needs

Need	Title	Stakeholder	Description
N01	Shelter Lighting	Scouts, Scout Masters (SM)	Provide sufficient area lighting for scouts to work on merit badge activities on the picnic tables in the shelter area
N02	Safety	Scouts, SM, TVSR	Operating voltage should be low enough to not pose a shock risk under any circumstances - no sharp edges or design issues that would result in a scout being injured
N03	Operations	Scouts	The system should be operable with minimal instruction by any scout camper - if instructions are provided, they should be primarily via pictures or similar
N04	Maintenance	TVSR	The system should need minimal maintenance and not be a burden on the operator – battery replacement will be needed every few years
N05	Education	Scouts	The design should incorporate educational elements in order to help scouts pursue their energy or environmental science merit badges
N06	Cost	TVSR	The cost should be minimal so that TVSR can install these lights and sensors throughout the entire camp – no specialized parts

6.2 Gap Analysis

Currently there is very limited lighting throughout the camp sites and, in general, area lighting is provided only on buildings that are attached to the grid. This limits the time that events can be held throughout the operation of the camp. Lighting at campsites is currently provided by flashlights, gas lanterns and other systems that are not based on renewable resources.

By increasing the lighting throughout the campsite, the hours of activity can be extended because it would be safer to walk around the campsite. Because of the location of the property, there is very little ambient light from manmade sources and most of the ambient light comes from the moon and stars.

Similarly, there is no mechanism by which cell phones or other laptop computer or “pad” type devices, becoming more common among scouts who are working on merit badges, to be recharged. If a recharging system were available, this would increase the educational value of the camp if other media, such as iPads or tablets, can be used and integrated into camp programs. Communication can also be ensured to be more readily available if device can be charged at night.

6.2.1 Overall System Design

The concept system design is shown in the context diagram in Figure 10 and includes the following parts:

- A power system
  - Power generation
  - Electrical storage
- A lighting system
  - With appropriate enclosures
  - Ample ability to connect to other components of the system
  - Ability to switch on and off
- A peripheral system
  - Device charger
  - Educational component
  - Monitoring component

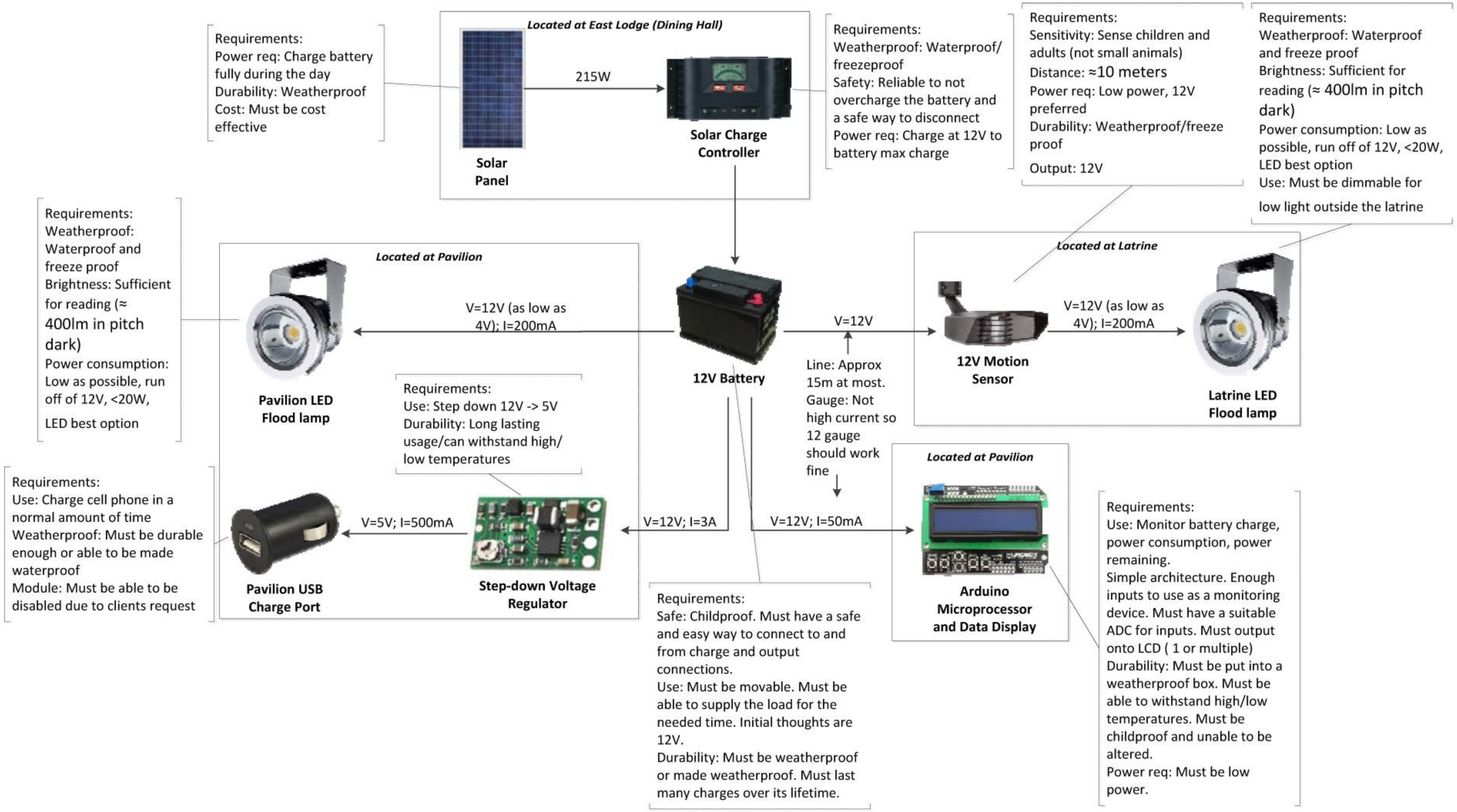


Figure 10: Solar Lighting System Diagram

The next step was to determine the best way to implement the concept system as a working prototype. To do this, the team first needed to look at the needs of the stakeholders and to translate those needs into requirements.

6.2.2 System Requirements

The requirements of this system are divided into functional requirements and non-functional requirements. Functional requirements include all requirements that need to be implemented in order for the system to function properly. Non-functional requirements include all other requirements such as color of the lights, safety, reliability, and usability. In general, functional needs included:

- Provide lighting for the entire night
- Be safe and enclosed
- Weatherproof
- Expandable

While non-functional needs included;

- Aesthetically pleasing
- Easy to use
- Easy to transport
- Inexpensive
- Long life span
- Back-up capability
- Educational

The requirements that were derived from these functional and non-functional needs are summarized and listed in Table 3. The priority rankings were developed through discussion with the stakeholders.

Table 3: Requirements derived from needs

Req.	Title	Description	Priority	Trace-ability
F01	Power Safety	The system shall use 12 V or lower voltage for all components in the camp site areas	high	N02
F02	Power Safety	The solar charging system shall use 36V or lower when connected to charge batteries	high	N02
F03	Operational	The system shall operate for at least 9 hours with at least 10 lights (4W each minimum)	high	N01
F04	Weatherproof	The system shall be waterproof, windproof, and childproof.	high	N03
F05	Expandable	The system shall be able to attach additional lights or sensors.	medium	N04
NF01	Ease of use	Any scout shall be able to use the system easily and transport the battery with minimal instructions	medium	N03
NF02	Maintenance	There shall not be lengthy or reoccurring repair of any of the modules by the stake holders	low	N04
NF03	Aesthetics	The system shall not take away from the natural aspects of its surroundings and should blend in or be minimal in nature	low	N05
NF04	Environment	The system shall not pollute the environment - including light pollution	low	N05
NF05	Educational	The system shall be able to integrate into the future energy educational plans that will be developed in the future for the stakeholders	low	N05
NF06	Cost	The system shall be able to fit within TVSR's budget and be able to be installed inexpensively on all campsites – do not use expensive components	medium	N06

6.2.3 System Concepts

A variety of concepts were brainstormed for the lighting system design. As noted earlier, the system was partitioned into three sub-system components:

- *Power generation:* providing adequate energy for usage needs
- *Lighting technology:* bright enough for night usage and still within power budget
- *System implementation:* functional, interchangeable, and expandable

For each of these sub-systems an analysis was conducted to choose the best method of implementation.

6.2.4 Power Generation

The stakeholders at Treasure Valley had a particular request to incorporate solar power into their daily operations. This interest stems mainly from the fact that there is a six megawatt ground mounted solar array being constructed on land that Treasure Valley has leased. The stakeholders are proud of the fact that they are going to be home to one of the largest solar developments in the state of Massachusetts. They want to share this excitement by pursuing solar in other areas to showcase their interest and involve the scouts and the community. Though the stakeholders made this request, the project team wanted to provide the best recommendations possible. Therefore, the process of choosing a source of power for the lighting system included a consideration of other generation options.

In order to produce power for the lighting system, different generation technologies that could be implemented at the TVSR campsites were investigated. Because the goal was to keep the system off the electrical grid, localized power generation had to be provided. Also, because this project needed to be amenable to environmental education, non-renewable sources were eliminated for the prototype.

The main sources of renewable energy that are used today are solar, wind, hydroelectric, biomass, and geothermal. The most important factor considered in analysis is the ease of small-scale implementation. Many of these technologies are used in large facilities; however, only a relatively small amount of power was needed for these purposes. The only sources that can be compact and implemented easily on a small-scale level are solar and to some extent, wind energy. All of the other sources require complex construction and maintenance as well as have a much higher capital cost and would be difficult to implement. Also, due to stakeholder requirements, an inexpensive and simple solution was needed if this project was going to be installed on-site.

Solar and wind power were evaluated for how the technology could be integrated with the campsite. Because of how heavily wooded the area is, solar or wind power would only be able to be implemented in a clearing. One aspect that also needed consideration was the aesthetic impact that each will have on the campsite. Because the Boy Scouts are environmentally conscious, the system needed to be unobtrusive to the camp.

It was decided that solar would be the focus because of the expandability, simplistic installation, and flexibility of application. To verify the use of solar, a solar site analysis of different areas of the property was conducted and found that there were many places that solar panels could be implemented. Because the system would also be used at night, the solar power needed to charge a portable battery during the day to power the lights.

6.2.5 Lighting Technology

Different types of lights were investigated for use in the appropriate environment and application. Because solar panels were used, it would be very easy to have a DC system rather than an AC system. There are 3 main types of light bulbs could be used: fluorescent, incandescent, and LED as shown in Figure 11. The system needed to have a high efficiency, so the best lights for the system are LEDs. The right bulb also had to be chosen based on an adequate amount of lumens for the application. LED bulbs are also easier to direct light compared to 360-degree illumination fluorescent and incandescent bulbs give off.

Figure 11: Three different types of bulbs (qriquality.com)

6.2.6 Solar Feasibility Study

A solar feasibility study was conducted by testing the solar exposure of six specific locations within the developed areas of the reservation. These areas were determined through a site walk of the reservation. The sites chosen were all determined to be feasible locations for implementation of a charging station. The variety of these included the options for centralized and decentralized and Boy Scout and Cub Scout areas. An identification and description of each site tested is shown in Table 4.

Table 4: Solar Test Site Locations and Descriptions

Site Name	Description	Coordinates
Health Lodge	*Across the road (to the West) of the Lodge, center of the open space*	N 42.32027º W 71.98964º Elev 904’
Hickory (camp site)	*Near the fire pit*	N 42.31771º W 71.99185º Elev 917’
Evergreen (camp site)	*Center of opening (open campsite)*	N 42.31952º W 71.99185º Elev 833’
East Lodge	*Grassy spot near parking lots*	N 42.31898º W 71.99463º Elev 827’
Carr Waterfront/ Boonsville Plains	*center of the field for ceremonies, nearest to the water*	N 42.31555º W 71.99538º Elev 743’
Cub Day Camp Building	*Roof of the Cub Day Camp building*	N 42.31990º W 72.00053º Elev 858’

The results of the pathfinder tests are shown in Table 4. Each site is shown with the interpreted solar exposure data. The total column shows the test year average percentage for each location. The totals are color coded for performance potential. The additional data gathered, including images of the solar pathfinder recordings, are shown in Appendix E.

Based on these findings it was determined that the best location for solar panels to power an off-grid system for use of the power within the reservation is East Lodge. This area has a high exposure to sunlight throughout the year and it is a central location, accessible to most areas of the Boy Scout camp. This area also sees high traffic given that the Scouts dine there on a daily basis. It also seems that a centralized array for charging rather than distributed on individual campsites will be feasible based on the tree cover on most camp sites.

Figure 12: Aerial view of East Lodge solar site

Conclusions were also drawn about the reservation wide potential for future solar development. Though this study was mainly focused on the already developed areas of camp, certain aspects of this study are applicable to future developed areas.

The best areas for solar are those clear of trees and with solar access to the south. Depending on the application for which solar is desired, the ideal location varies. For a small scale application that is being applied to multiple areas (such as campsite lighting), a centralized charging station located at a central and accessible location is best. For power within a building, a flat, south facing rooftop is ideal. At this stage, development can be designed to create the best spaces with the most potential for implementation of solar in the future.

In order to determine the potential for off grid solar within Treasure Valley, the first step was to conduct a feasibility study within the reservation to determine the proper location to site a solar power system.

6.2.6.1 Data Gathering

Data for collection includes visual identification of potential sites, solar access testing, GPS locations of test sites and other landmarks. The equipment used for these visits includes cameras, solar pathfinder, handheld GPS, notebooks, maps, tape measure, and angle measurer. A detailed record of data and observations were kept of each site visit for effective compilation of all information.

The Solar Pathfinder is an instrument used to determine the shading considerations of a specific location when siting solar. The instrument is used to determine the effects the surrounding shading will have on power output of a solar system. The solar pathfinder is shown in Figure 15. The tool consists of a tripod topped with a plastic dome. Once leveled and oriented to true south, the plastic dome reflects an image of the surrounding environment, including shade-causing barriers. The outline of the horizon where it meets the sky is then traced onto a ‘sun path diagram’ that, when interpreted, details the amount of ‘solar hours’ that the given site will receive throughout the year. Two examples are in Figure 13 and Figure 14 below that how the data was transcribed and read. Also, Figure 14 shows it being used on one of the recorded sites.

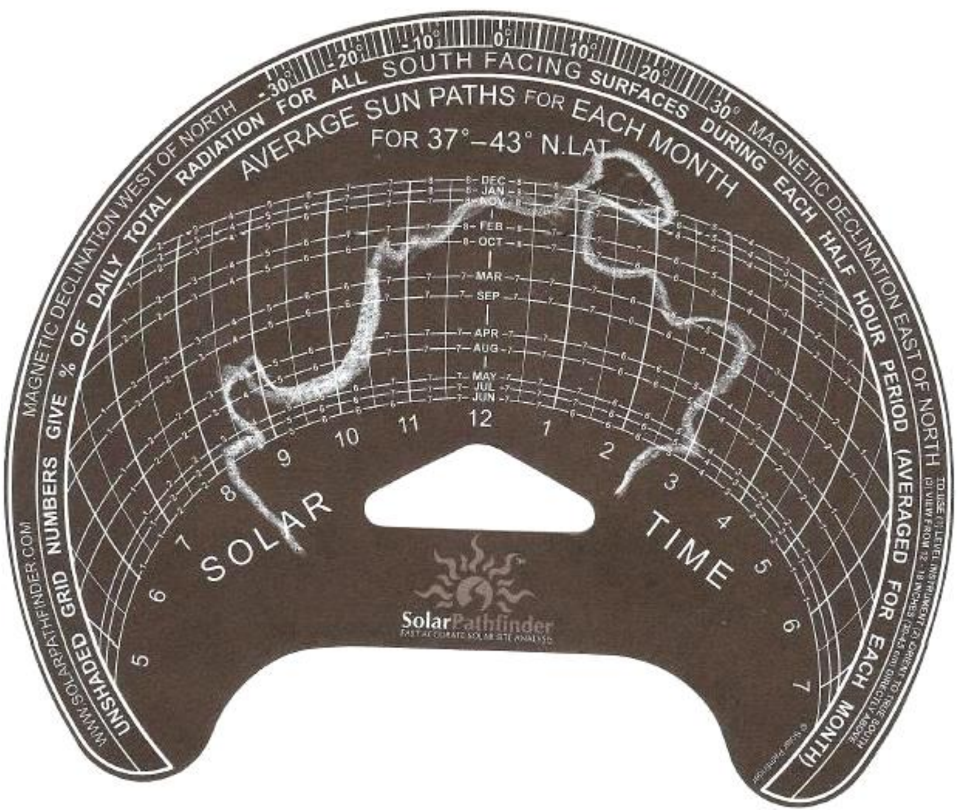


Figure 13: Campsite diagram

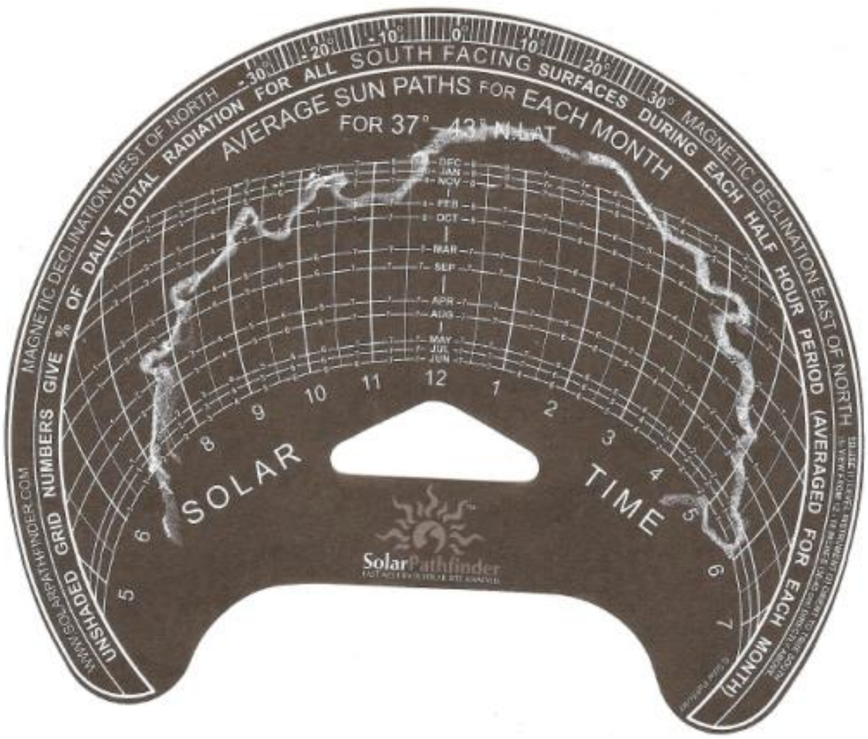


Figure 14: East Lodge diagram

Figure 15: Solar Pathfinder with a sun-path diagram adjusted for declination

To track location of test sites and other landmarks and to aid with GIS mapping, the team used a GPS device. The model of the device is Garmin eTrex Venture HC. This GPS was selected based on its availability and its level of accuracy. The altimeter in the device is accurate to 10 feet and has the potential to be accurate to one foot when calibrated by the user. The general GPS accuracy is less than 33 ft. In North America, the device has Wide Area Augmentation (WAAS) accuracy which means it is accurate within 10 ft. Both of the GPS accuracies are 95% typical (Garmin). Being in North America, the coordinates gathered in Treasure Valley utilized WAAS accuracy. Each waypoint used to specify a solar test site or other landmark was marked digitally on the GPS for mapping and physically in a data log notebook.

Figure 16: Garmin eTrex Venture HC (http://blog.discoveryeducation.com/msvmaher/)

Additional equipment was used. A camera was used to record visual information about the sites. Additionally, qualitative site descriptions were recorded in the data log notebook. A tape measure was used to determine rough dimensions of a site for comparison to potential system size. During the feasibility study, the group archived the data in the GIS database. Each waypoint was included to geographically map the testing progress.

6.2.6.2 Preliminary Calculations

Part of the feasibility study included preliminary calculations of electricity demand, panel area, and system efficiency. These calculations were done through a comparison of alternative equipment available including panels, lighting fixtures, inverters, and storage devices. Categorical determinations were made at this stage of the planning based on efficiency, cost, availability, and siting feasibility. A decision matrix was utilized to facilitate and detail the decision making process.

Using the data gathered from the Solar Pathfinder, analysis was done on a location basis. Once solar hours are determined, the information can be used with available weather data through the National Renewable Energies Laboratory (NREL) and typical system data to estimate expected production. An application such as PVWatts, which is also available through NREL, was helpful in calculating production.

Locations were analyzed based on the solar exposure in a systematic method. A list was kept of each site to be tested including a qualitative description and the GPS coordinates. The testing locations included a number of sites including campsites, open fields, waterfront, and rooftops. The group also tested a wide range of sites to ensure the inclusion of a variety of options for comparison.

The results meant that a centralized area was necessary to locate the solar panels site rather than having solar panels at each camp site. If the design were to be implemented there would need to be a way to distribute power throughout the entire camp. Because of how widespread each campsite is relative to a central location, power line transmission would not be feasible for this small-scale prototype. The solution was to have a battery that can be charged at one location then moved to the campsite at night. This idea was further justified after meeting with Treasure Valley representatives who supported the idea that the batteries could be charged near the dining hall so scouts could bring the batteries to be charged in the morning and then picked up at night. Figure 17 shows the distance in feet of each campsite from East Lodge.

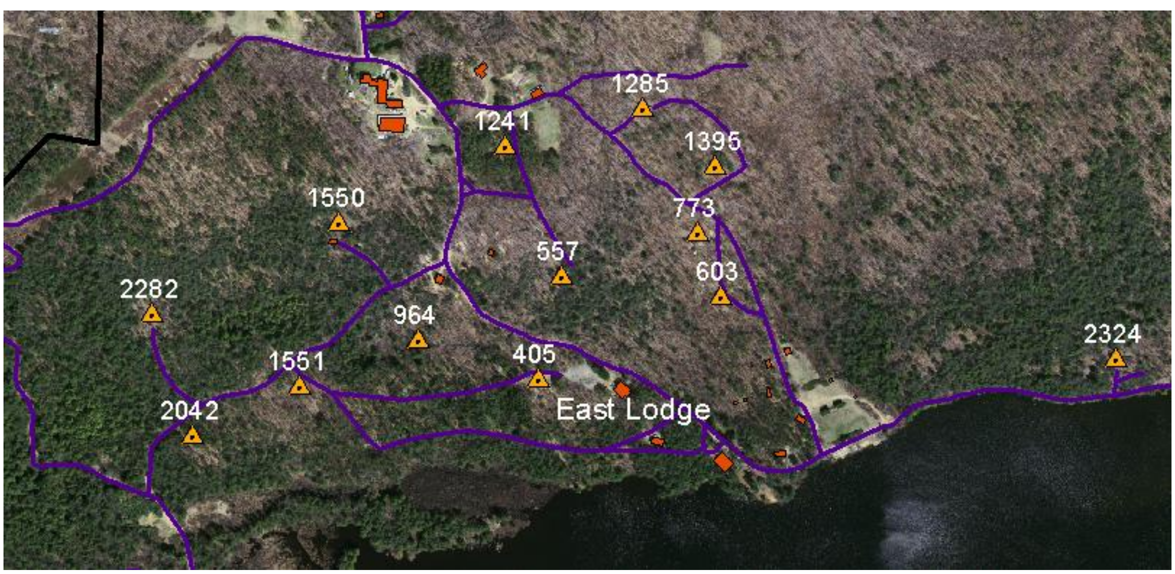


Figure 17: Map showing distance in feet of campsites from East Lodge

The next design challenge was how to implement a lighting system. If a battery was used, the easiest system would be direct current (DC). Prior to doing a full power analysis, battery types were investigated and the most commonly available type was 12V. It was decided that 12V would be assumed for the entire system and find the correct battery capacity depending on the energy requirements. Also, since the lights did not need to be on all the time, it was decided to implement a motion sensor. The physical implementation of the system would be a network of modules, each with either a light circuit or a sensor circuit. This way, modules could be added or removed if needed and each module would be able to be placed where it would work best. For example, the motion sensors would be placed around the latrine so that scouts would activate the lights if they came close to the area.

With a modular approach, all the lights could be put into the pavilion area in a campsite. This is also where the battery will be plugged in. In this part of the system, there would be a USB charging circuit in which electronic devices such as cell phones and tablets can be plugged in. Finally, there would also be an energy use, battery capacity meter, and voltage and current level meter for load analysis. This would be implemented with a microprocessor with an LCD display.

In figures 18-21 below, a mockup was drawn as well as diagrams of how the system would look at a campsite. As shown in Figure 18, lights and sensors were placed along a layout of the buildings. In Figure 19 and Figure 20, the latrine and pavilion, respectively, are shown with both lights and sensors. In Figure 21, a pavilion is shown with the USB charging station and the display modules.

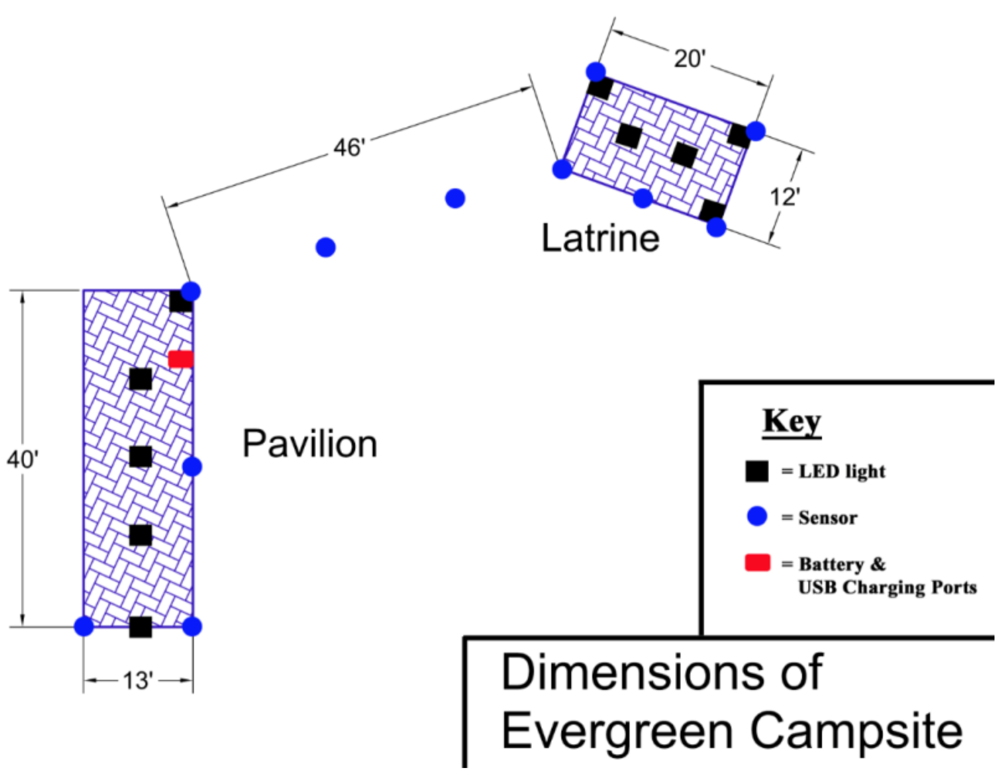


Figure 18: Dimensions of Evergreen Campsite

Figure 19: Latrine Mock-up

Figure 20: Pavilion Mock-up

Figure 21: Charging Station Mock-up

6.2.7 Safety and Risk Assessment

Working with younger children requires a much higher level of safety precautions than working with adults or older students. Since the goal of this project was also to address safety, every portion the system needed to be made child proof to eliminate risks of injury.

Initial risks that identified included the following:

- Possibility of a battery malfunction and resulting acid release or explosion
- Injury sustained from dropping battery
- Incorrect plug connection resulting in short circuit or circuit failure
- Accidental electric shock
- Tripping over wiring or modules
- Light malfunction (i.e. turning off when needing to be on)

The International Electrotechnical Commission (IEC) defines anything below 120V DC (or 50V AC) as extra-low voltage with limited risk. Because the system will be operating well below anything with electrical shock risk, the most dangerous risk is virtually eliminated.

6.3 Prototype Analysis

The first step in designing the lighting system was to analyze the different aspects of each module. The most important analysis performed was the maximum energy needed for the entire system. This analysis would later determine the battery type and the number of solar panels needed to charge the battery after each use.

The battery analysis was the next step after determining the power consumption. This analysis was key in the systems power efficiency. The solar charging module was later calculated in order to fully charge the battery every day.

6.3.1 Energy analysis breakdown

The energy analysis was conducted for each module component that would consume power. The largest consumers of energy are the 10 LED lights. Other power consuming components are the sensors, the Arduino microprocessor, and the USB charge ports. In this analysis, there were several assumptions made about the operation of the system that were taken into account when calculating the overall energy consumption.

These assumptions included;

- The battery is 12V Sealed Lead Acid
- USB charging does not exceed full charging of 2 phones at 2500 mAh or 1 tablets at 11000 mAh (4 hours of charging total): Phone total = 5 Ah and Tablet total = 11 Ah
- There are minimum power line losses
- The summer (July) light hours are between 5:30am and 8:30pm (15 hours of sunlight with only 10 hours of full solar charging)
- The camp operates during July and August (2 months of operation)

Component		Power	Number of Components	Total Component Power	Max Hours of Use	Total Power
Lights		4 W	10	40 W	6 hrs	240 Watt hrs
IR Motion Sensor		0.07 W	10	0.70 W	9 hrs	6.3 Watt hrs
Arduino Microprocessor		1 W	1	1 W	9 hrs	9 Watt hrs
USB Charger	2 Smartphones	2.5 W	1	2.5 W	2 hrs per device = 4hrs	9 Watt hrs
	2 Tablets	5 W	1	5 W	2 hrs per device = 4hrs	20 Watt hrs
					Total System Power	= 284 Watt hrs
					Totall System Amp hrs @ 12V	= 24 Amp hrs

Figure 22: Energy Analysis Breakdown

The maximum usage time was approximated based on summer light hours and the operation of the camp. With summer light hours being between 5:30am and 8:30pm (15 hrs), the maximum use for the system at night will be 9 hours. The LED lights however, will not be running on full power for the entire 9 hours due to the motion-sensing switch. The LED lights were approximated to be in use for a maximum of 6 hours. This is shown in Figure 22.

The USB charging is based on average USB charging behavior and charge times of the iPhone and iPad devices (apple.com/batteries). The iPhone is reported to charge at 500mA at 5V through USB charging. This charging takes approximately 2 hours to completely charge. The iPad charging is very similar to iPhone. It takes approximately the same amount of time (2 hours) at 1A to charge an iPad. These charging periods would only be possible using a charger that operates at 2A. The most suitable USB chargers would be 12V car chargers that operate at 5V and output 2A of current. This would be most suitable for multi-device charging.

After careful analysis of the total energy of the system (Figure 10), if it is running at its full potential should not exceed 284.3Watt hours or 24 Amp hours. Based on the total Amp hour consumption of the lighting system, it was determined that the type of battery needed to sustain the system was a 12V, 24 Amp hours, deep discharge battery.

6.4 Motion sensing board

Once finished analyzing the system power consumption the design of each component began as well as the design of the overall rail system implementation. The sensor was the most important aspect of the design. There were two challenges when designing the sensor. First the output current of the sensor is not enough to drive the LED light. Second, the sensor chosen does not stay 'ON' for very long, meaning that the LED lights would only be switched 'ON' for a few seconds. These problems were solved using a current amplifier to drive the LED lights and a

CMOS timer to increase the time that the sensor is 'ON'. The design of the he functional aspect of each component was started after the sensor was designed. This step consisted of making sure each part was waterproof and could withstand the elements.

6.4.1 Rail System Design

For the system to be easily applied to other campsites at TVSR, it would need to be designed so that every module could be replicable. To do this, a power rail system was implemented to allow varying lengths of cable to be placed around the campsite where needed. Figure 23 shows how each module is connected to the rails as well as the battery. The goal was to have all the lights turn on whenever any sensor is triggered. This design makes it easy for us to add on other sensors or lights as needed.

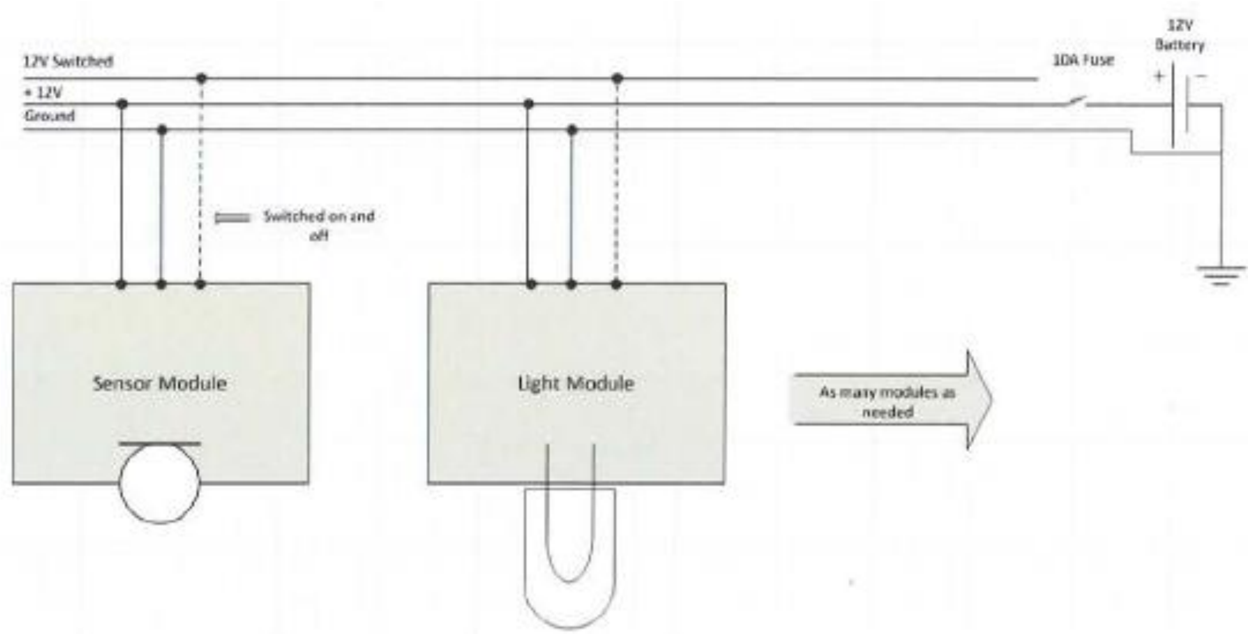


Figure 23: Rail Design

6.4.2 PIR Sensor

The sensor circuit is used for the latrine and flood lighting. It detects motion and turns the switched rail 'ON,' turning the lights on for a certain amount of time. With the system running at 12V, it would be easiest to have a sensor that can operate at 12V. This design decision eliminated the need to use a step-down converter to drop the 12V voltage to a lower sensor operating voltage. In addition to operating at 12V the sensor must also meet the range specifications.

To choose the type of sensor, the most common types of motion sensors that are used were researched: passive infrared, ultrasonic, and microwave. Of these sensor types, a passive infrared sensor was chosen due to its low price and effective range of approximately 20 feet for this system. When the sensor was tested, it was successfully able to turn ‘ON’ at a range of approximately 5 meters. For the needs, that range will suffice as an adequate distance to detect motion. There were; however, two design challenges with the sensor upon testing.

The sensor outputs 0V when the sensor turns ‘ON’ and outputs 12V when ‘OFF’. This feature worked normally; however a problem arose then time that the circuit would stay ‘ON’ was too short. When the sensor is tripped, the lights would need to activate for a certain amount of time. In order for this to happen, a CMOS Timer was implemented into the sensor circuit. By adjusting the resistances of the timer circuit, the team would be able to control how long the sensor would be ‘ON’ and thus the LED lighting would be on. In order to have more capabilities for the end product, a SPDT (single pole, double throw) switch was applied to modify the output from a short time (about 11 seconds) to a longer time period (about 165 seconds). The equation used to calculate this time was T= 1.1RC. The short time R and C values were calculated as 10MΩ and 1µF respectively. The long time values were calculated as 15MΩ and 10µF. The schematic is shown in Figure 24

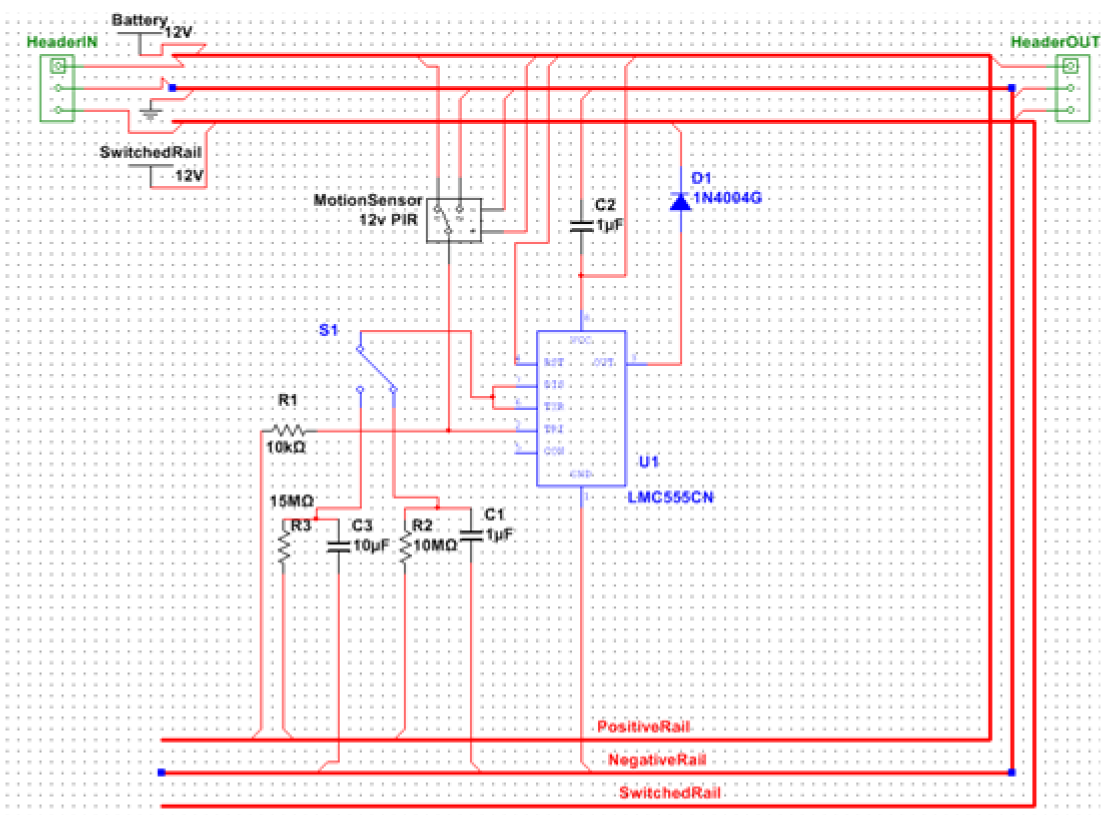


Figure 24: Sensor and Timing Circuit

The second design challenge was that the sensor could not adequately supply the current needed by the LED light to be at full power. The decision was to a apply solid state relay to the sensor circuit that would buffer and switch the current to the LED lights.

6.4.3 LMC 555 Timer

The timing problem can easily be solved with a CMOS 555 timer. Because the chosen sensor outputs low, inverting the voltage prior was needed to using it as the trigger for the timer. A LMC555 timer was chosen because it inverts the signal at the input so extra components were not needed. CMOS is used because it can be used at a higher voltage and no alteration will be needed to connect with the 12V rail. The second issue that arose was that the sensor only turns ‘on’ for a short period of time and not long enough to turn on the lights. This problem is solved with a timer that can be adjusted for any time the stakeholder would like the lights to stay on for. The timer that was chosen is also CMOS so it can be directly attached to the sensor and will work correctly. The concept is proven in simulation as shown below in Figure 25 Figure 26.

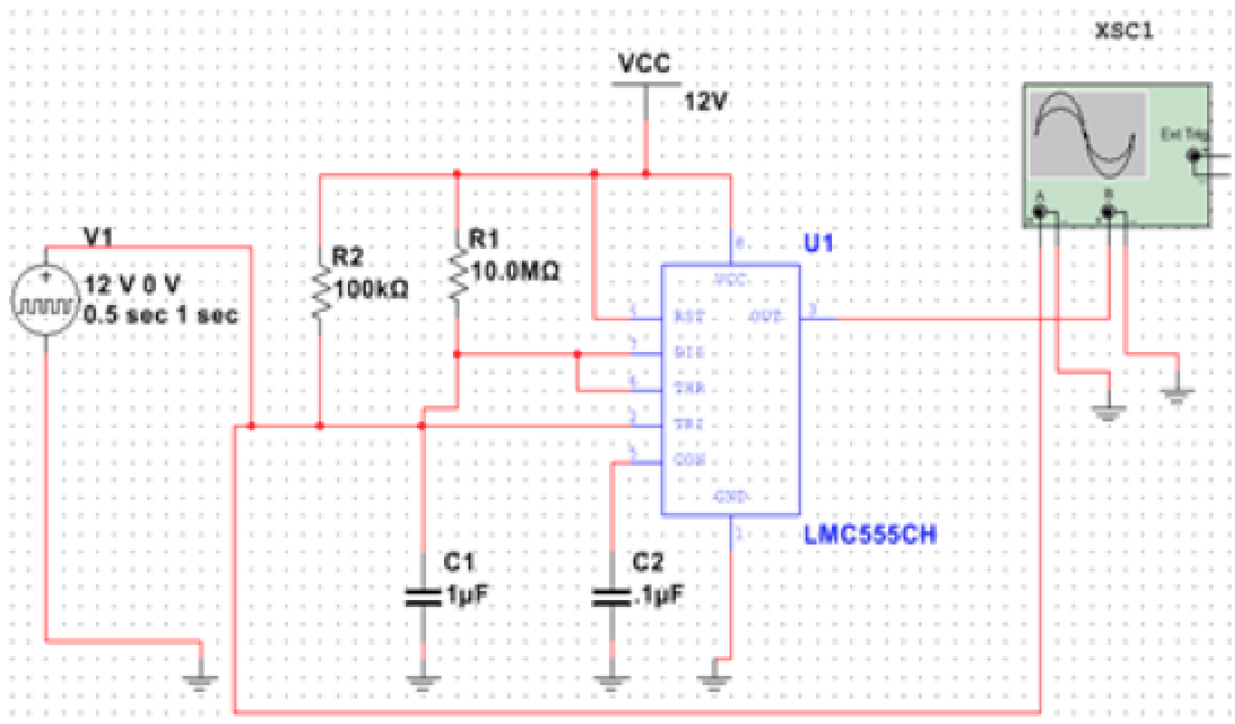


Figure 25: Multisim Circuit Schematic

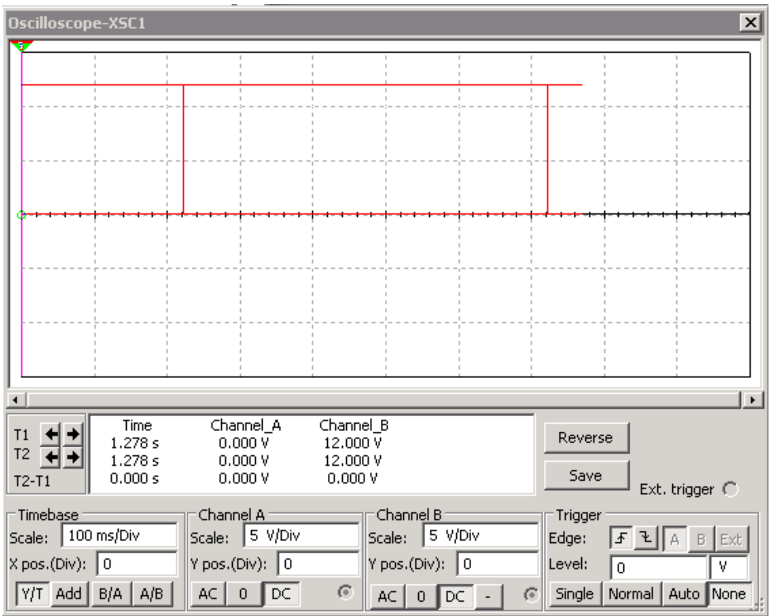


Figure 26: Multisim Oscilloscope Simulation

Finally, Figure 27 shows the function of the timer output (purple) and the input from the sensor (green). The sensor is tripped, seen by the oscillations of the green square wave. When this occurs, the timer output in purple is switched on for the set time, which is 10 seconds in this instance.

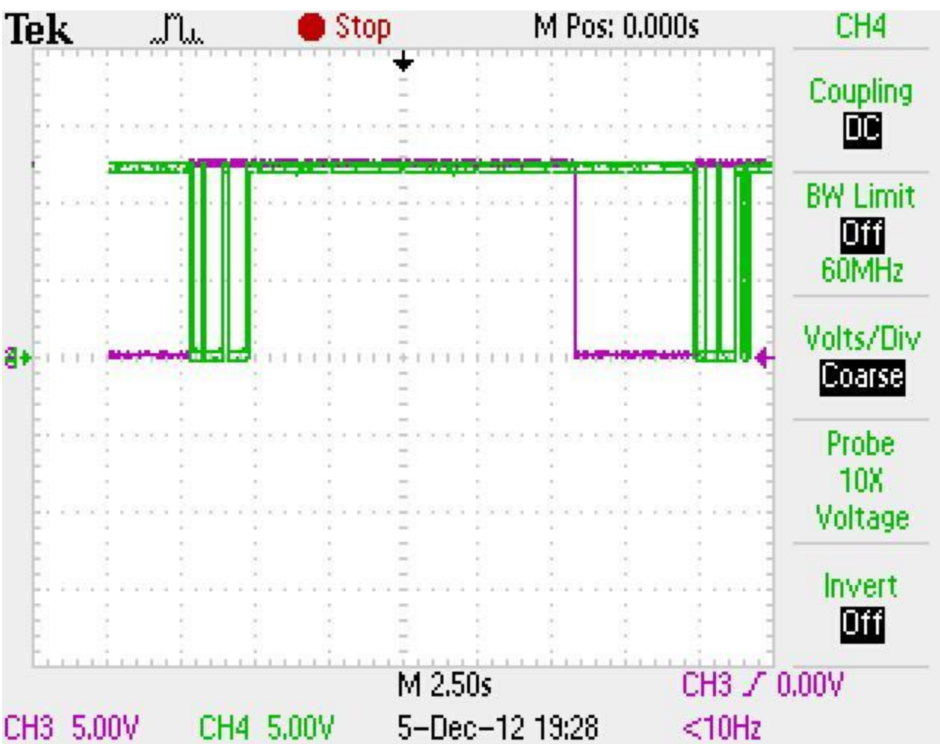


Figure 27: Timer Output Reading

6.4.4 Lighting Board

In order to provide the LED's with sufficient current, the design of a switch system was needed. Rather than trying power the entire rail of LED's with the output of the timer, the system needed a device that would isolate the output signal from the timer and switch on the LED with the power rail. Implementing a relay was the best solution.

The main decisions were what type of relay that should be used. The two types primarily available is either a mechanical or solid state relay. A solid state relay was chosen because of its low input current, long life, and its reliability. The specific component chosen was the CLA717 made by Clare. This was because it has a low on-state resistance (150mΩ) and a high DC load current (4A when configured in DC mode). Through testing, the minimum voltage needed to turn on the relay is 1.1V. This is easily supplied by the timer output rail. The schematic is shown in Figure 28.

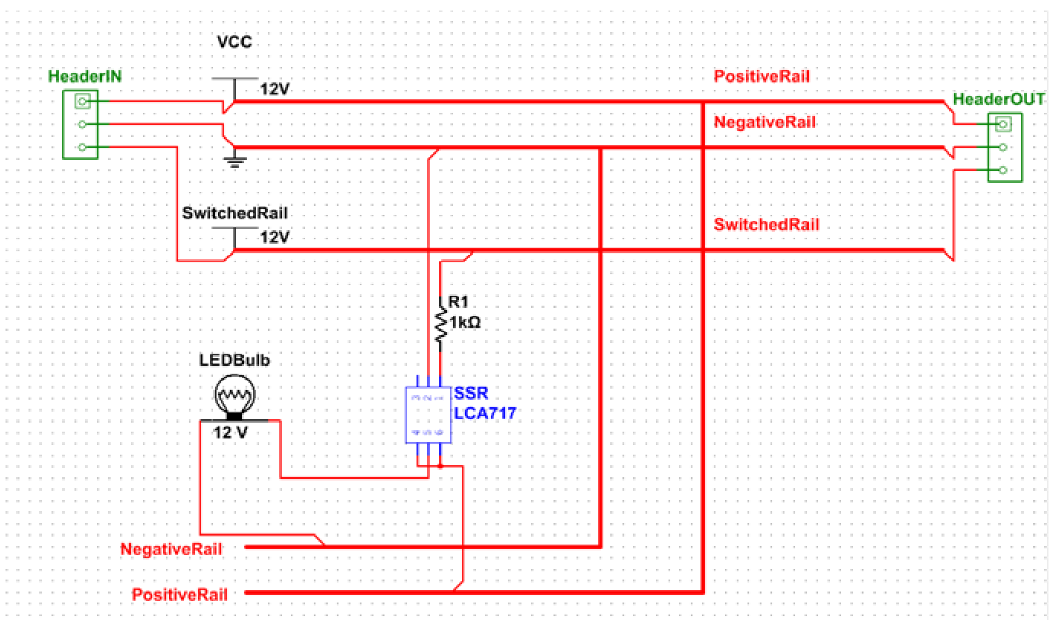


Figure 28: Overall lighting schematic

Initially, problems occurred when LMC555 timers burned out by allowing too much current to flow on the switched line. Originally there were no issues when only 1 or 2 lights were connected; however, on a full system test, the current was too high and would burn out the timer, which was only protected by a current limiting resistor of 100Ω. The following calculation proved the problem:

$$12\text{V} = \text{I} * 100\Omega \rightarrow \text{I} = 120\text{mA}$$

$$4\ \text{lights} * 120\text{mA} = 480\text{mA}$$

To solve this problem, the 100Ω resistor was switched with a 1kΩ resistor. This changed the current from the 480mA to 48mA, which is well under the limit for the timer. The resistor change did not affect the luminosity of the LEDs.

6.4.5 Battery

There are a variety of battery types that needed to be analyzed to choose the correct type of technology. An assumption was that the battery must be rechargeable. The most common types are shown in Table 5.

Table 5: Common Battery Types

Nickel Cadmium	• Older technology and mostly replaced by NiMH. Larger cells were used in UPS's and standby power.
Nickel Metal Hydride	• Commonly used in small AA package. Small capacities. High self-discharge.
Lithium Ion	• High energy density. Used in most electronics today.
Sealed Lead Acid	• High capacities. Commonly used in vehicles. • Inexpensive and reliable.

The aspects that were analyzed at in order to determine the technology were:

- Capacity
- Safety
- Depth of discharge
- Life Cycle
- Ease of use

To sustain the maximum system power usage, the battery would need to supply 24 Amp hours of power. The system is designed to function at 12V so the battery would essentially be a high capacity 12V "car" battery. Researching what type of battery to use led us to compare starter batteries and deep cycle batteries. The main difference was the depth of discharge compared to amount of cycles as shown in the Table 6. Deep-cycle batteries are more expensive than starter batteries but are more appropriate for this system.

Table 6: Starter vs. Deep-cycle Batteries

Depth of Discharge	Starter Battery	Deep-cycle battery
100%	12-15 cycles	150-200 cycles
50%	100-120 cycles	400-500 cycles
30%	130-150 cycles	> 1,000 cycles

Because the LED lighting system is subject to varied use each night, depending on how long the LEDs are used and how often the motion sensors are tripped, the battery could potentially be fully discharged. Starter batteries such as a standard a car battery, are not designed to be fully discharged. The number of cycles or lifetime of a starter battery would be greatly diminished if fully discharged too many times. Deep-cycle batteries on the other hand, are designed to withstand frequent discharging. While the number of cycles still decreases the more the battery is fully discharged (Table 6), it will still last longer than a starter battery. By choosing deep-cycle over standard starter batteries, the battery will be able to manage the varying power consumption of the lighting system as well as allow the battery to last longer.

6.5 Charge Circuit

The charge circuit was built with pre-made devices; a charge controller and a solar panel. These devices were both donated to this team and can be used in the onsite prototype. For the single battery, only a single charge controller is needed. However, if the need arose to expand the charge system so that more batteries could be charged at each time, more controllers (or an investment in larger, more expensive controllers that can independently monitor more batteries) would be required.

6.5.1 Solar Panels

For the energy analysis the maximum capacity of the battery that will be used is 24 A/hrs. If the battery will be charging for a maximum of 15 hours a day, the lowest wattage rating for a solar panel that could still charge the battery would be about 20W. This is for one battery so for every battery added to this charging circuit, it would need adequate capacity to support the charge.

For this project, 215-Watt solar panels were used. This prototype only needs to charge one battery. However, if the system is meant to be expandable, it would need to account for additional batteries being added to the system. The system would need every battery to be fully charged during daylight hours. So, it was assumed that the solar panels needed to charge four 12V batteries at 24 Amp hours each.

6.6 USB Charging

In addition to the lighting system, another system that the stakeholders were interested in implementing was charging devices through USB. There is a need for devices such as iPads, phones, and even laptops to be charged both by the scouts and the adults. Though the system does not have enough power to support charging a laptop, a 4 port USB hub and converter was used to charge smaller peripherals. This is shown in Figure 29.

Figure 29: 4 Port USB Charging Hub

6.6.0.1 Step down converter

Because a USB charger uses 5V to charge the devices attached, the voltage must be dropped from the 12V from the battery. A commercially available converter from Powerwerx rated up to 3 amps was purchased. This is shown in Figure 30.

Figure 30: Powerwerx 3A Converter

Upon testing, the device works fine with a USB hub to charge up to 4 devices.

6.6.1 Power Monitoring

To both create a system that is educationally valuable as well as user friendly, the team wanted to create a way to show the power usage of the whole system. A device was needed that could calculate the power consumption, voltage of the battery, and percent drained of the battery. A micro controller was used with a display for this task. When comparing different hardware architectures, the best fit was the Arduino hardware due to its wide availability of example code and its ability to use 12V directly to power itself. The Arduino also had add-ons that would suit the needs such as a display that integrates directly on top of the base unit. The Arduino Uno and the serial display shield that connects on top were used.

6.7 System Enclosures

While the lighting system would only be used during the summer months, the LED lights and Sensors would be set up outside year round. In order for the system to stand up to adverse New England weather conditions, standardized prototype enclosures that would be mounted at each campsite must be designed and created. Acrylic was chosen because it was the easiest plastic to manufacture with the lowest cost.

The design was created the enclosures using Solid Works, a computer aided design (CAD) software program. To do this, an initial design would need to be determined that would allow for the LED's to be freely positioned and for all the enclosures to be opened easily in the case of a malfunction. Figure 31 through Figure 34 show the CAD drawing of the enclosures.

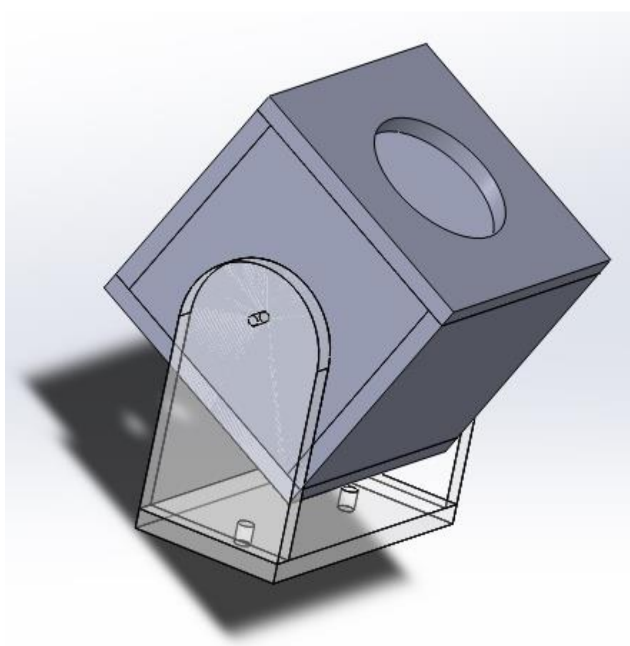


Figure 31: LED Light enclosure (front)

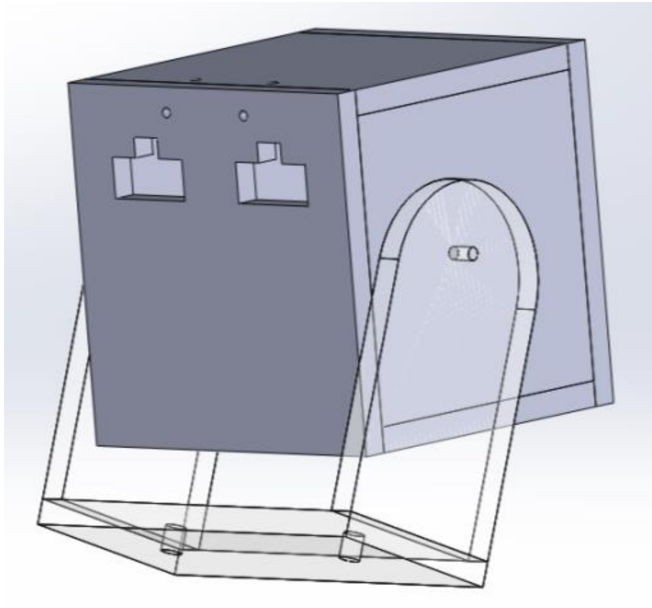


Figure 32: LED Light enclosure (back)

Next, using a precision laser cutting machine, the designs were cut from 1/4 in acrylic and assembled using watertight acrylic cement.

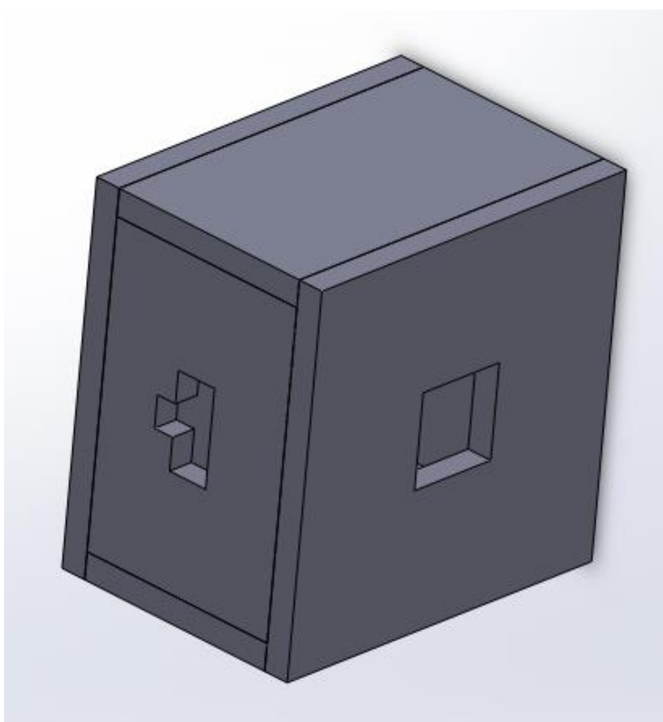


Figure 33: Sensor enclosure (front)

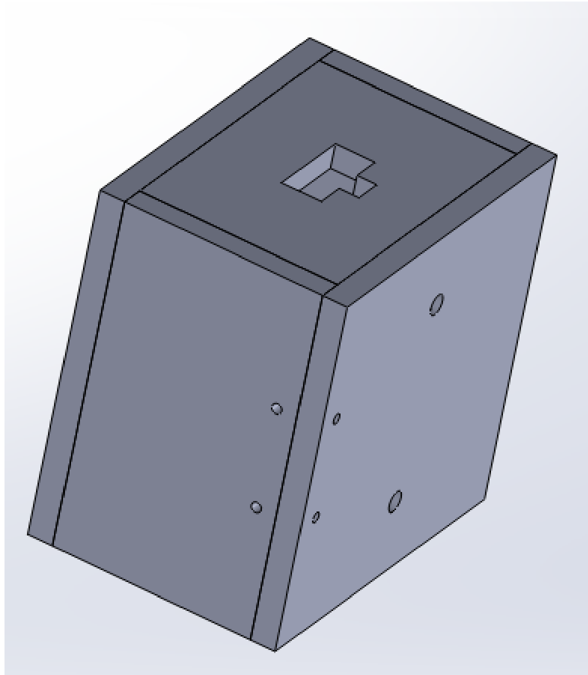


Figure 34: Sensor enclosure (back)

6.7.1 Connectors

Because connectors for the wires must be universal, easy to plug, and safe for scouts to use, a 3 pin socket connector was chosen that can only be plugged in one way. This is very important for making sure all of the rails are connected properly.

6.7.2 Wires

In design of the enclosures, determining the type of cable that would be used to connect the sensor and light modules was important. For this selection the most important choice was the gauge of the wire. To calculate the gauge the chart shown by Table 7 was used.

AMPS	3'	5'	7'	10'	15'	20'	25'
0 to 5	18	18	18	18	18	18	18
6	18	18	18	18	18	18	18
7	18	18	18	18	18	18	18
8	18	18	18	18	18	16	16
10	18	18	18	18	16	16	16
11	18	18	18	18	16	16	14
12	18	18	18	18	16	16	14
15	18	18	18	18	14	14	12
18	18	18	16	16	14	14	12
20	18	18	16	16	14	12	10
22	18	18	16	16	12	12	10
24	18	18	16	16	12	12	10
30	18	16	16	14	10	10	10
40	18	16	14	12	10	10	8
50	16	14	12	12	10	10	8
100	12	12	10	10	6	6	4
150	10	10	8	8	4	4	2
200	10	8	8	6	4	4	2

Table 7: Wire Gauge Table 12 Volt Circuit

Because a 3-wire rail system was chosen, a cable system with at least 3 conductors as well as being 18 gauge was needed. The easiest and cheapest solution found was a 5 conductor cable made for underground sprinkler systems.

6.7.3 Prototype

For the demonstration and prototype of this project, the pictures below show an accurate representation of how the system would be implemented on a site. In this case, the Evergreen campsite was used as the demonstration.

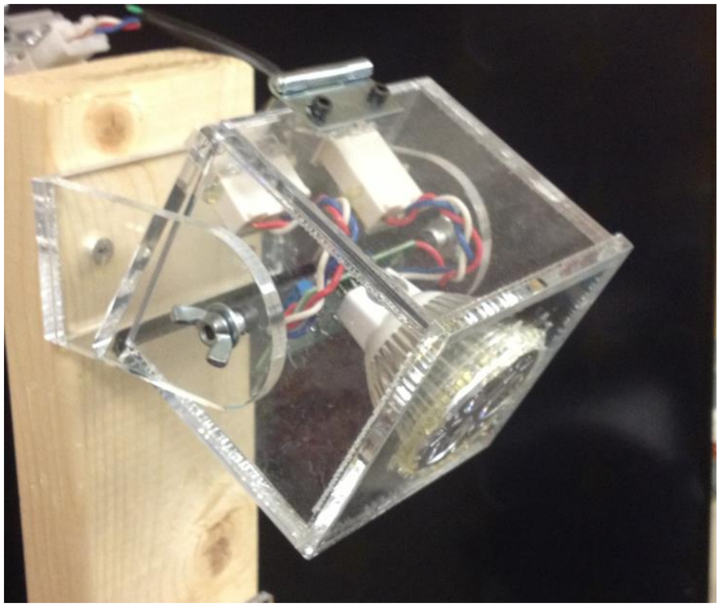


Figure 35: Light Module Mounted

The light module and enclosure is easily mounted anywhere and the light is adjustable and rotatable around the mount (Figure 35). The back of the module can be opened to reveal the LED circuit board for easy accessibility in case of a malfunction.

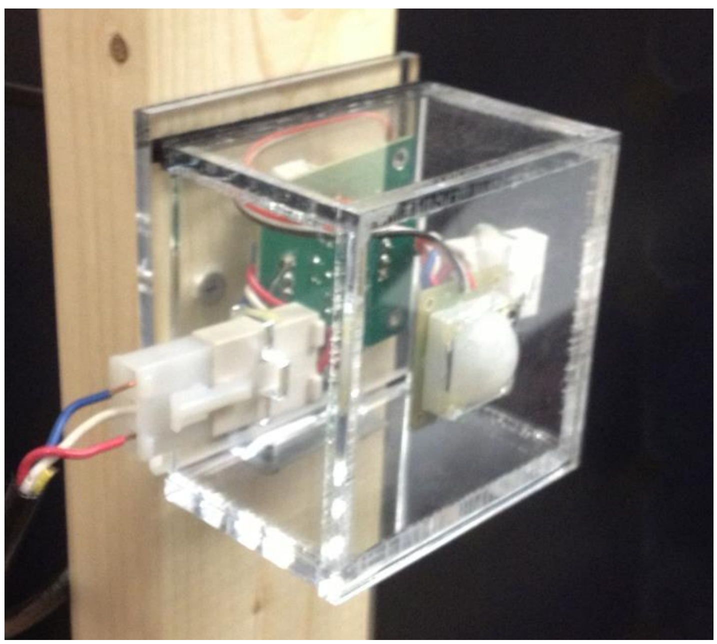


Figure 36: Sensor Module Mounted

The sensor module is also capable of being mounted anywhere (Figure 36). Similar to the light module, the enclosure can be opened to reveal the sensor circuit board in case a malfunction as well as to switch the sensor timing.

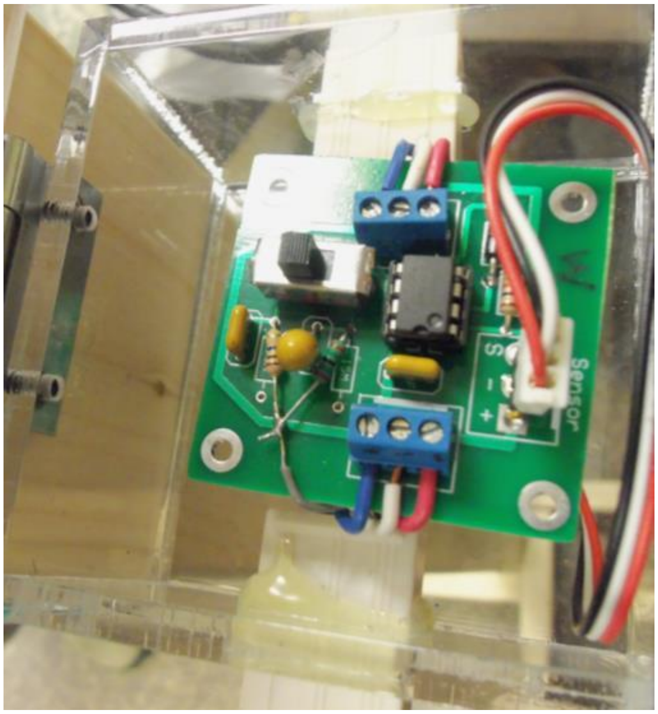


Figure 37: Inside Motion Sensor Module

Inside the sensor enclosure, the sensor circuit can be accessed (Figure 37). The LMC 555 Timer chip can easily be replaced and the switch can be turned to change the timing of the LED light.

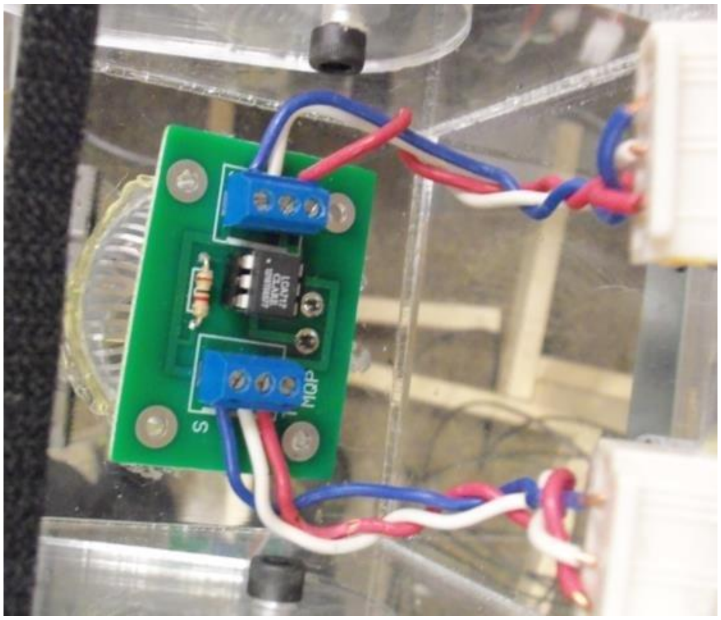


Figure 38: Inside Light Module

The LED circuit board is also accessible if in need of repair and the solid state relay chip can be changed as necessary.

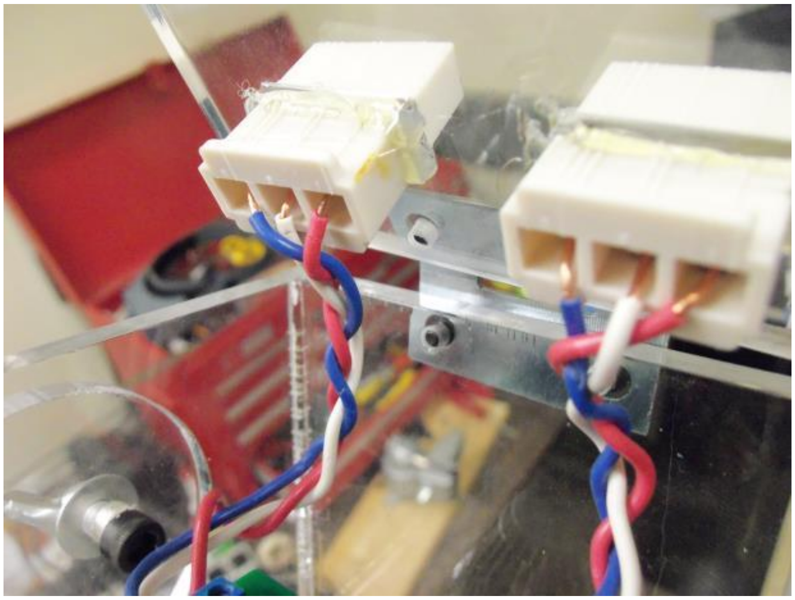


Figure 39: Inner Plug

The plugs are mounted on the inside of the enclosures for both the LED and sensor modules

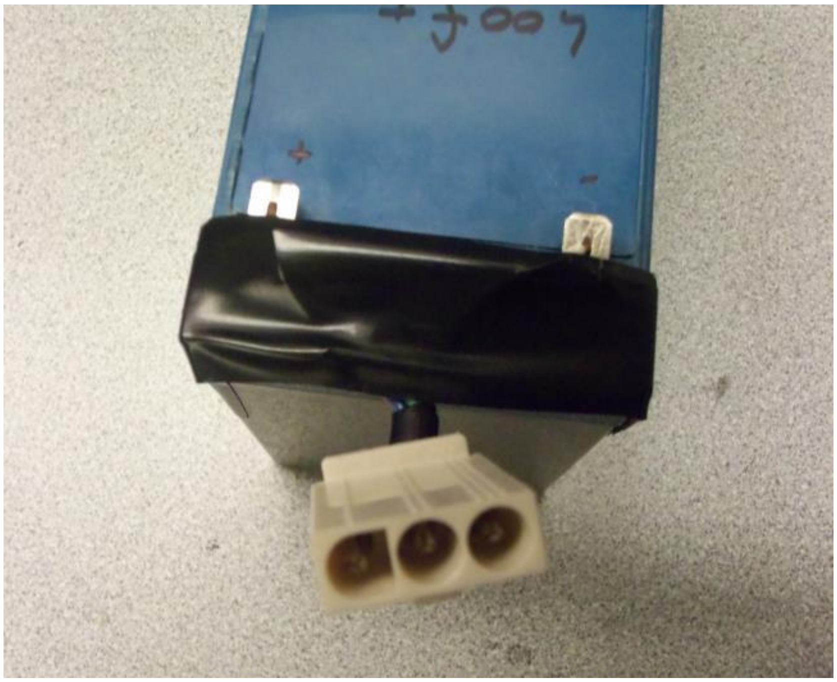


Figure 40: Battery Plug

The prototype uses a small capacity 12V battery with the plug attached directly to the battery terminals (Figure 40).

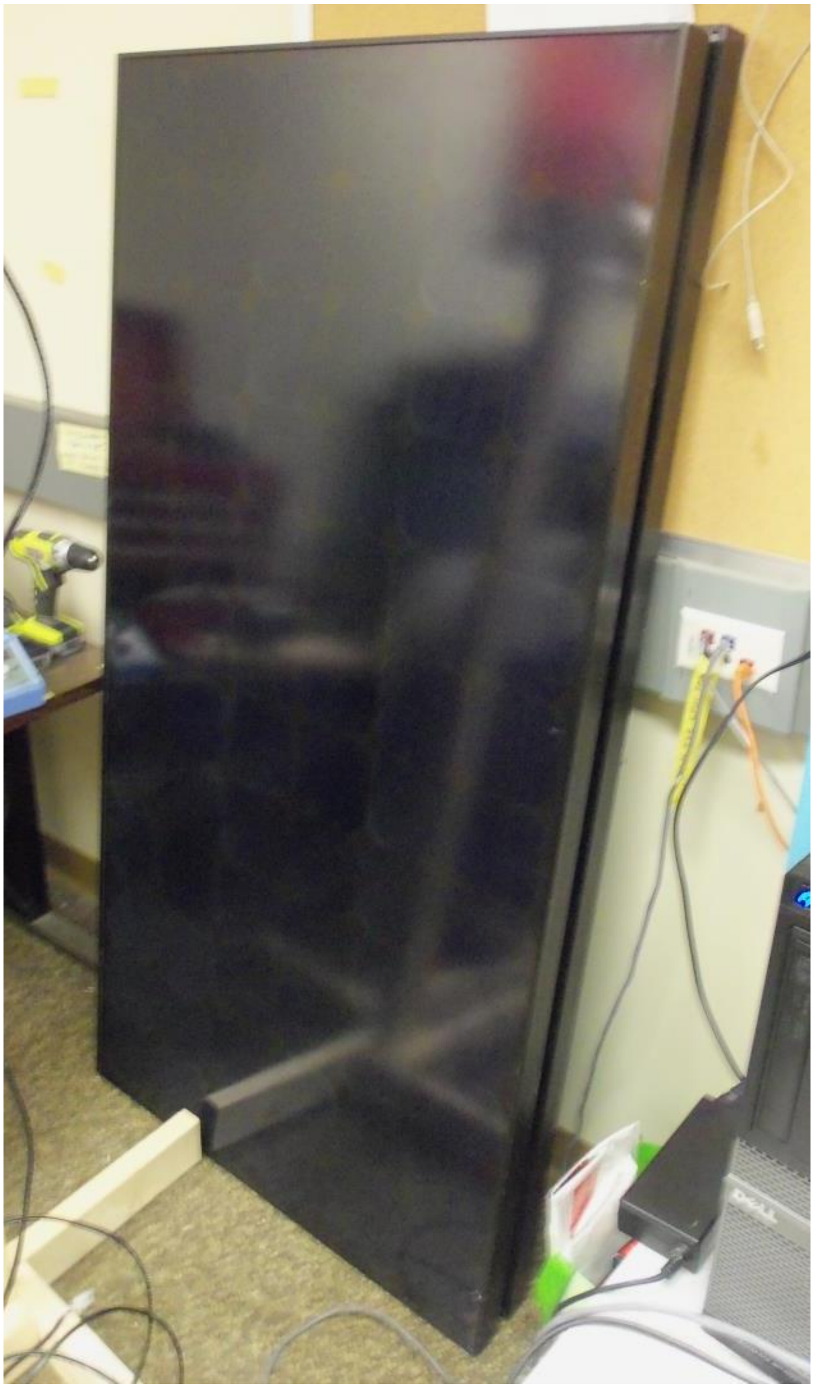


Figure 41: 215W Solar Panels

The solar panels would be mounted at a centralized location with capabilities of charging multiple batteries at one time (Figure 41).

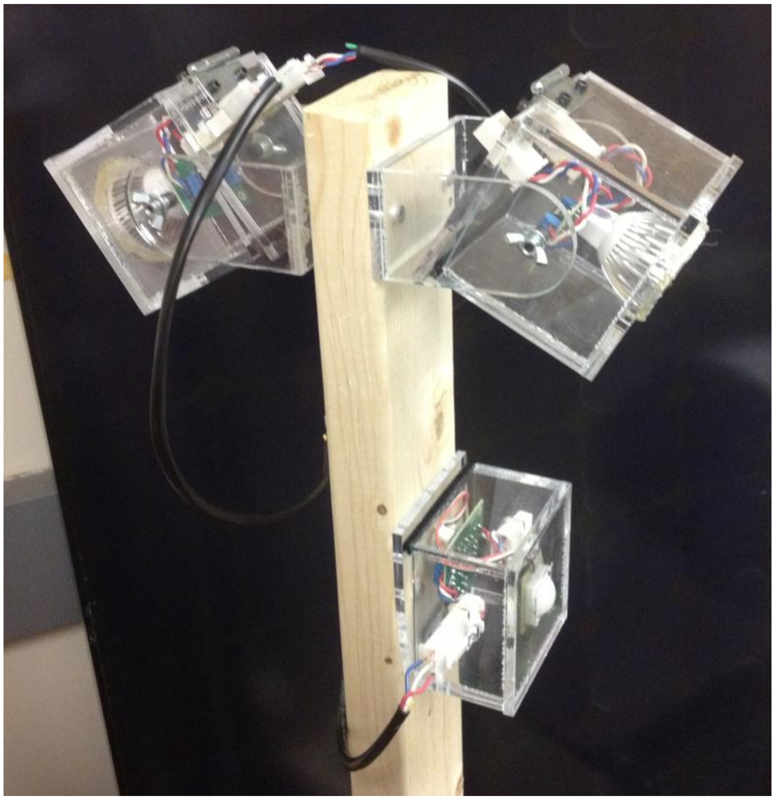


Figure 42: Lighting and Sensor Modules Mounted

The prototype demonstrates all the necessary modules, mounted on a post, and capable of managing multiple LEDs and sensors. The enclosures allow for easy installation and maneuverability.

6.8 Costs

Our prototype costs differ from the full implementation costs by only a few components.

Key additions would include;

- Cable lengths
- Waterproof connectors
- Battery enclosure
- Larger battery
- Switches and lights for the pavilion
- Power rail components

Table 8 below shows the approximate cost for each site.

Table 8: Cost Per Site

Unit	Parts	Cost ($)
Motion Sensor		**$22.95**
	PCB	$5.00
	Passive Components	$4.00
	Motion sensor	$9.95
	Enclosure	$4.00
Light Module		**$13.00**
	PCB	$5.00
	LED Bulb	$1.00
	Passive Components	$3.00
	Enclosure	$4.00
USB Charging		**$26.98**
	12V Converter	$19.99
	USB Hub	$6.99
Status Display		**$54.90**
	Arduino microcontroller	$29.95
	Display	$24.95
	Enclosure	
Battery		**$100.00**
	SLA	
Solar Charging		**$0.00**
	Solar panels	N/A (donated)
	Charge controller	N/A (donated)
	Mounting hardware	N/A (donated)
Wires and Connectors		**$62.15**
	3 Pin connectors	$28.40
	Multi conductor cable (100')	$33.75
Total Cost per campsite (w/ 4 sensors and 8 lights)		**$439.83**

6.9 On-site Testing

After the prototype was completed, the design was tested on the campsite in the evening. The information below shows the lux measurements at the latrine and pavilion.

- Latrine
  - With light = 440 lux
  - Without light = 190 lux
- Pavilion
  - With light = 169 lux
  - Without light = 17 lux

The lighting system was very successful in creating enough light to effectively illuminate both a path to the latrine as well as enough light to read in the evening in the pavilion. Figure 43 and Figure 44 shows how the system may look like installed.

Figure 43: Sensor and light installation at latrine

Figure 44: Light installation in pavilion

6.10 Next Steps

The most important next step would be a full installation on the site. A demo installation was completed in the spring, pictured in the previous section, to show the functionality of the system, as it would be on site. For a permanent system, some parts discussed in the costs would have to be changed.

As for portions of the project that were not completely completed, the Arduino system was not working by the end of the project. Through testing the cause of the issues was not found. With that, the enclosure was not built that would house the display and Arduino, the USB charge system, and the pavilion light switches.

Ideally a test of operation in the camp would be the best way to analyze whether this system would be both effective and viable in a permanent and camp-wide setup. The most important impact of the system is in the interaction with the campers themselves. How they use the system and how useful, effective, and user friendly it is will drive the use of the project.

Near the end of the project Pat McGarrah, from LED manufacturing company LightEngines, came to talk about the possibility of donating sets of LEDs to the project. Figure 45 shows one of the LEDs that has a built in voltage regulator and figure 46 shows one that does not. The LEDs run on a higher voltage (between 18-24 volts) so a boost converter will be required. These particular models are very efficient and are mostly weatherproof so it will take minimal effort to fully install them.

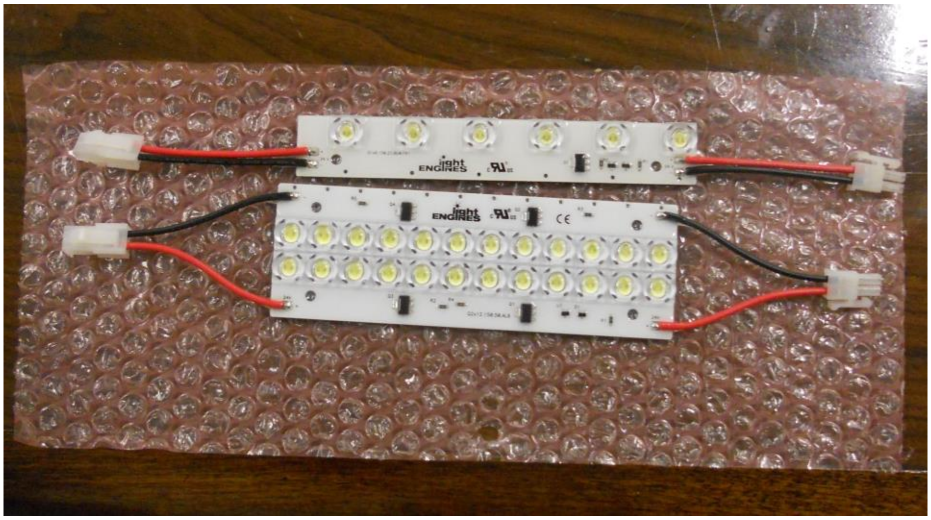


Figure 45: LED with Voltage Regulator

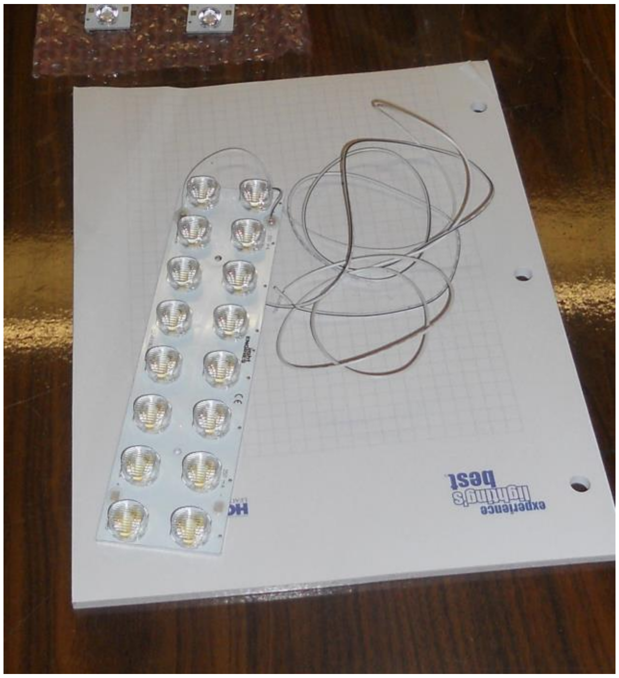


Figure 46: LED without Voltage Regulator

7.0 Future Land Use Development

The purpose of this section is to detail the process and results of the creation of a future land use plan for the Treasure Valley Scout Reservation. The background includes factors considered during the sustainable land use planning. The methods include large scale and site specific constraints analyses to determine desirable and appropriate areas for development. The results include recommendations for land use zoning and conceptual program development plans. The entire process was guided by input from the Treasure Valley stakeholders.

7.1 Sustainable Development Background

7.1.1 Constraints Analysis

In land use planning, practiced often by municipalities, leaders make decisions on how to structure the future development of an area. An effective way of doing this is to look at the entire area in order to make comprehensive decisions. A method for this is to perform a constraints analysis. A development constraints analysis involves the overlay of various spatial constraints to inform which areas are best and least suited for certain types of development.

According to the Northwest Vermont Regional Planning Commission, the development constraints can be broken down into the categories of geographic constraints, natural resources constraints, absolute constraints, and zoning constraints. Geographic Constraints are factors such as distance from roads, waterlines, and other infrastructure. Natural Resources Constraints are natural features such as wetlands, steep slopes, or wildlife habitats that impact the suitability of building on that land. Absolute Constraints are constraints that simply cannot be built on, such as water bodies, existing facilities, and conserved land. Finally, zoning constraints are regulatory restrictions on development of certain types.

Treasure Valley contains a few constraints that are absolute in preventing development. The primary ones are water bodies. Browning Pond and Sevenmile River are both within the reservation property. Details about the surface water can be found in section 7.1.3. The other categories of constrains are described in the following sections.

7.1.1.1 Geographic Constraints

Geographic constraints are based on relatively location to existing facilities. Leadership in Energy and Environmental Design (LEED) is a certification program through the US Green Building Council design to increase the sustainability of various types of development. LEED is discussed further in section 7.1.2. One of LEED's siting criteria for new construction is for consideration for is in the area of Density and Connectivity. Considering proximity to existing infrastructure allows developers to consider higher density developments with easier access to existing developments. Maintaining the density of development in the reservation and access to the centralized facilities and infrastructure can decrease the environmental impacts of new developments. Treasure Valley, comprised of 1600 acres, has developed facilities that use approximately 350 acres.

In terms of use by the community Treasure Valley Scout Reservation sees its highest capacity in the summer months. The reservation houses as much as 950 people at one time during the summer camping season. The level use depends on the time of year. Table 9 and Figure 47 show the typical numbers of people using the reservation throughout the year.

Table 9: TVSR use throughout the year (Griffin)

Event	Scouts	Adults
5 Weeks of Summer Camp	850	125
Week before summer camp	75	12
Non summer season (weekend)	30	5
District Events (three winter weekends)	60	20
Spring Event (one weekend in May)	200	80
Sober in the Sun (Early Fall)	0	500
Two weekends after Sober in the Sun	50	5

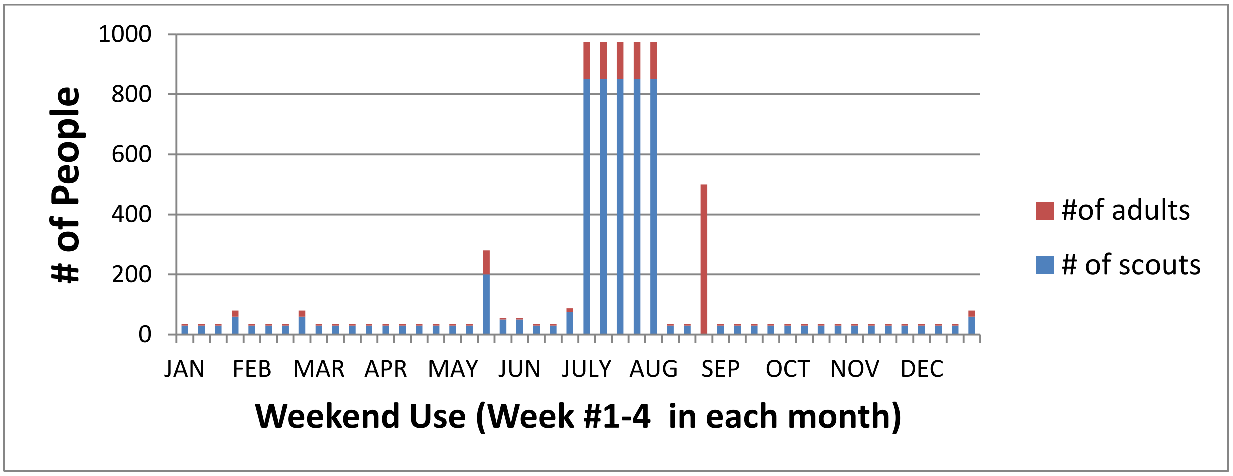


Figure 47: Typical average number of people using TVSR throughout the year (weekends)

Currently, parking is mainly decentralized. For a specific building or area of Treasure Valley, there is a certain amount of small capacity, on-site parking. People using the specific facility are not forced to walk from a central parking lot near the entrance to a lodge across Treasure Valley, but this increases traffic through the reservation. The parking capacity of these decentralized lots has enough space to accommodate the current expected number of people who might use a facility such as East Lodge or Boonesville Plains. In addition to scouting activities throughout the year, TVSR provides venues for a variety of non-scouting events and activities. Table 10 shows the capacity of several of its facilities.

Table 10: Sleeping capacity of the main TVSR buildings

Building	Capacity (sleep)
Adirondack Shelters	6-8 (each)
Conference Center	28
East Lodge	200
Probus Building	10
West Lodge	22
Commissary	26

The Reservation currently uses the Jamboree field for centralized parking. This is usually only temporarily used during large events like Sober in the Sun – a weekend-long annual alcohol and drug free festival which features live music, camping, fireside meetings, workshops, dances, and other activities that make use of nearly the entire Reservation (Sober in the Sun).

Transportation of users within the reservation is a concern in addressing community connectivity. A simple way to reduce the amount of energy needed is to use a fuel efficient or alternative fuel vehicle to traverse the 1600 acres. At times when upfront costs for new vehicles are too much, changing habits of vehicle use can be helpful. One example of this is to reduce idling. Idling results in zero miles/gallon. When a vehicle sits and idles, it is only using fuel and not producing any benefit. If the vehicle sits for more than 10 seconds, it is better for the vehicle to be turned off then restarted when needed. This way, it saves fuel. Constantly restarting a vehicle does not result in a large amount of wear and tear on the starter/motor. Vehicles also do not need to idle for long to “warm up.” This issue of transportation fuel use can be addressed when designing developments to ensure community connectivity. Considering connectivity and access to existing developments when siting can reduce the amount of driving necessary.

7.1.1.2 Natural Resource Constraints

Natural Resources Constraints are natural features such as wetlands, steep slopes, or wildlife habitats that impact the suitability of building on that land.

Water

In addition to surface water, Treasure Valley also contains wetlands. On a state level, wetlands are protected under the Wetlands Protection Act. Wetlands are a vital resource based on their ability to support a wide variety of wildlife, protect water quality, and store water to manage stormwater and flooding. The Wetlands Protection Act establishes a buffer zone of 100 feet surrounding a wetland in which development is prohibited or controlled. The legislation also requires a management of stormwater and other effects of nearby developments so that they do not negatively affect the wetland (MassDEP).

Slopes

Development is best avoided in areas with steep slopes. Steep slopes are not ideal for development because of the increased risk of structural failure, increased design complication, and drainage concerns. The ideal maximum slope for siting a residential house is a slope of 20-25%. Slope stability is also determined by the type of soil present. Grainier soils like sand will generally fail at lower slopes than finer soils like clay (Marsh).

When building on slopes, it is important to minimize the alteration to the landscape. The presence and maintenance of vegetation on soils helps to physically root the soil in place. Additionally, the infiltration and absorption of runoff in plants reduces the water that would otherwise work to destabilize the soil (Marsh).

Wildlife Habitats

In 2005, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) responded to federal requirement by adopting a Wildlife Action Plan. This plan identifies 257 species in Massachusetts that are in the Greatest Need of Conservation and details their habitats. The plan also details actions and monitoring programs to ensure adequate conservation for these species and their habitats.

Included with the plan is an interactive map called BioMap2 produced in 2010 by Natural Heritage and Endangered Species Preservation (NHESP). This database is a map of Massachusetts that shows the spatial locations of Core Habitats and Critical Natural Landscapes.

Core Habitats are the areas that are best suited for rare species. Treasure Valley is home to an Aquatic Core which accounts for Browning Pond and its tributaries. Aquatic Core areas are identified to protect fish and other wildlife that spends part of its life in the water. It also contains a Vernal Pool Core which provides a special kind of habitat by providing seasonal wetlands to species that need it.

Critical Natural Landscapes are undamaged areas of landscape that are able to support a variety of wildlife in the long term. Treasure Valley is home to a Critical Natural Landscape that functions as a Landscape Block. A landscape block provides a refuge for animals that move a lot throughout the day and provides isolation from development disturbances (NHESP). Treasure Valley contains a significant landscape block.

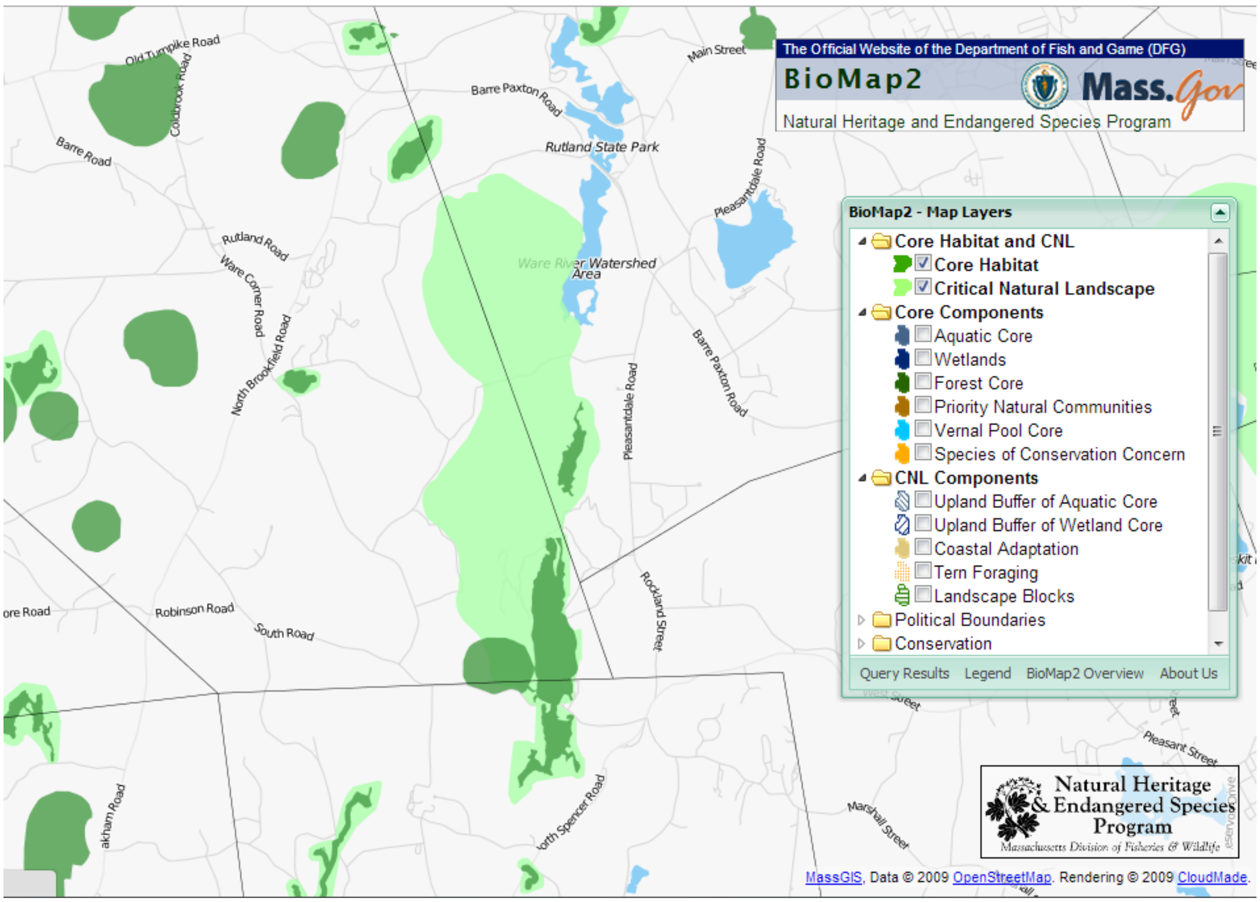


Figure 48. Core Habitats and Critical Natural Landscapes in Treasure Valley

Strategies for conservation of wildlife include identification of critical habitats, preservation of these habitats, education and increasing awareness about the issue, and remediation of any harm previously done (MassWildlife). In Treasure Valley, the identification process has been done on a state level in the Action Plan. The areas that are in need of protection have been mapped and are regulated to minimize development.

7.1.1.3 Zoning Constraints

Three out of the four towns that Treasure Valley is located in have zoning bylaws. These towns include Spencer, Oakham, and Paxton which can be seen in Figure 49. Rutland does not have zoning bylaws. Care was given to these town documents to ensure that potential recommendations would be allowed in these towns. The bylaws of these towns do not explicitly regulate an entity like Treasure Valley (a large recreation reservation). There are, however, general guidelines like setbacks that any development would have to conform to. There are also several restrictions on the type of development depending on the zone type.

Table 11 lists and organizes all the applicable restrictions established in the towns' bylaws.

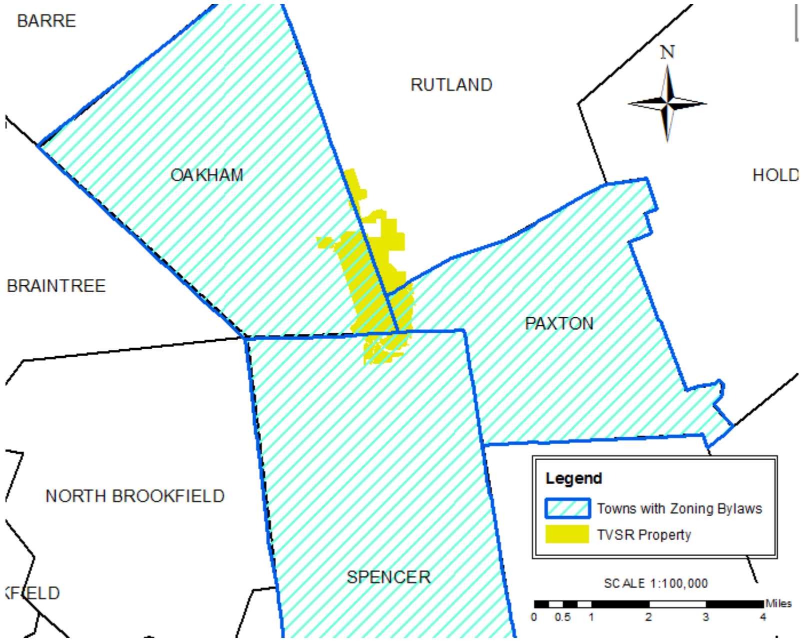


Figure 49 : Towns with Zoning Bylaws that Treasure Valley is located in

Table 11 : Applicable Town Zoning Regulations

	Paxton	Spencer	Oakham
Zone Type	General Residence B	Rural Residential (Lake Resident, on Browning Pond)	Agricultural and Rural Residential
Max Building Height (stories)	30’ (2)	35’ (2.5)	35’
Front Setback	30’	55’	50’
Side Setback	25’	25’	30’
Rear Setback	30’	25’	50’
Misc. applicable regulations	Day Camp – SP, Building mounted Solar energy collector – Y, Alternative Energy systems - SP	Camp – SP (SP), Private nonprofit community center building or adult education/adult day care center SP (N)	-na-

Y – Permitted use, SP – Special Permitted Required, N – use not allowed

When developing recommendations for development, one must ensure that the building design or recommended land use does not go again any law or regulation. If it is not in compliance, then the recommendation would not be legal, feasible, or it would require extra resources to receive a variance or an exemption. It is not likely that development in Treasure Valley would entail an exception use or building (such as a building over 3 stories tall, a parking garage, etc.), but being mindful of the zoning regulations will ensure a friendly relation with the towns and its residents.

7.1.2 Green Building Development and Siting

Another method of reducing the impact of development on the environment it though Green Building practices. Green building is a process for building development that minimizes the impact of the development from its inception throughout its useful life. According to the US EPA, the “aspects of the built environment” include siting, design, construction, operation, maintenance, renovation, and demolition.

The building sector is responsible for nearly half of energy use and greenhouse gas emissions throughout the world. 43% of the energy use and emissions within building sector is operations and maintenance, the rest comes from the building materials and construction. The operations of a building are impacted by HVAC systems, lighting, and other utilities. The construction and building materials factor in the extraction of the resources, transportation to the site and construction processes and equipment (Architecture 2030).

One of the leading organizations for sustainable building operations is the United States Green Building Council. Leadership in Energy and Environmental Design (LEED) certification is a program offered by the US Green Building Council established in 2000. The certification is internationally recognized and recognizes building design in the areas of sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. In order to become certified, a building must meet a certain number of requirements in each category, dictated by a list of potential innovations (www.usgbc.org). Since achieving LEED certification costs the sponsoring organization money, it can be more economically feasible to make a building LEED certified, meaning it meets the standards of the LEED rating system without the official certificate. The benefits of this include a guideline for sustainable building development without the added cost of certification.

There are LEED rating systems for a variety of different types of developments including new developments, operation and development, neighborhood development, or buildings in different sectors including education, healthcare, etc. Once the category is identified, the development is evaluated using a checklist for the various categories of green development. The checklist represents a scale of possible points earned and in order to earn certification, the development must meet certain prerequisites and achieve 40 out of 110 points. Figure 50 shows the checklist for a new commercial development.

LEED 2009 for New Construction and Major Renovations

Project Checklist

Y	?	N	Sustainable Sites		Possible Points: 26
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1

			Water Efficiency		Possible Points: 10
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4

			Energy and Atmosphere		Possible Points: 35
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	2
			Credit 5	Measurement and Verification	3
			Credit 6	Green Power	2

			Materials and Resources		Possible Points: 14
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2

Project Name

Date

Materials and Resources, Continued

Y	?	N			
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y	?	N			
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

Y	?	N			
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

Y	?	N			
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Certified 40 to 49 points   Silver 50 to 59 points   Gold 60 to 79 points   Platinum 80 to 110

Figure 50 : LEED checklist for New Construction and Major Renovations

The categories included in the New Construction checklist are Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. In addition to the categories that the LEED checklist, there is an Innovation and Design Process category that allows for additional green innovations. This allows for creativity and innovation in sustainable design.

Within the Sustainable Site category, the aspects of siting a building or other development that need to be considered are development density and community connectivity, alternative transportation, protecting habitats and preservation of open space, stormwater quality and quantity control, and light pollution reduction

Within the Energy and Atmosphere category, points are given for developments that utilize green energy and improve energy efficiency. The ideal siting design would include potential for the development to be entirely self-sufficient in terms of energy. In an effort to become entirely off grid, various combinations of energy generation and conservation can be pursued. As discovered previously in this report, solar power has a great potential to provide clean power to developments within Treasure Valley in working towards becoming completely off grid. In addition, harnessing geothermal temperature regulation can help to reduce the energy needed for heating and cooling. The considerations for utilization for these methods should be considered in the siting phase of development.

Solar power’s two most common forms are photovoltaic and thermal. With both of these methods, the energy collector should be facing south to receive the maximum amount of solar energy. It is also important that the area where the collector is situated to have the maximum exposure to direct sunlight. The path of the sun should be taken into consideration over the course of a year. Trees and buildings nearby can easily block the path of direct light and dramatically reduce the amount of energy generated.

In central Massachusetts, there is fairly good potential for solar energy compared to the rest of the country. The map in Figure 51 shows the average daily total available solar potential. Treasure Valley’s solar resource average of about 4.5 kWh/m^2/Day. Buildings with flat roofs that are south facing are best able to capture solar energy.

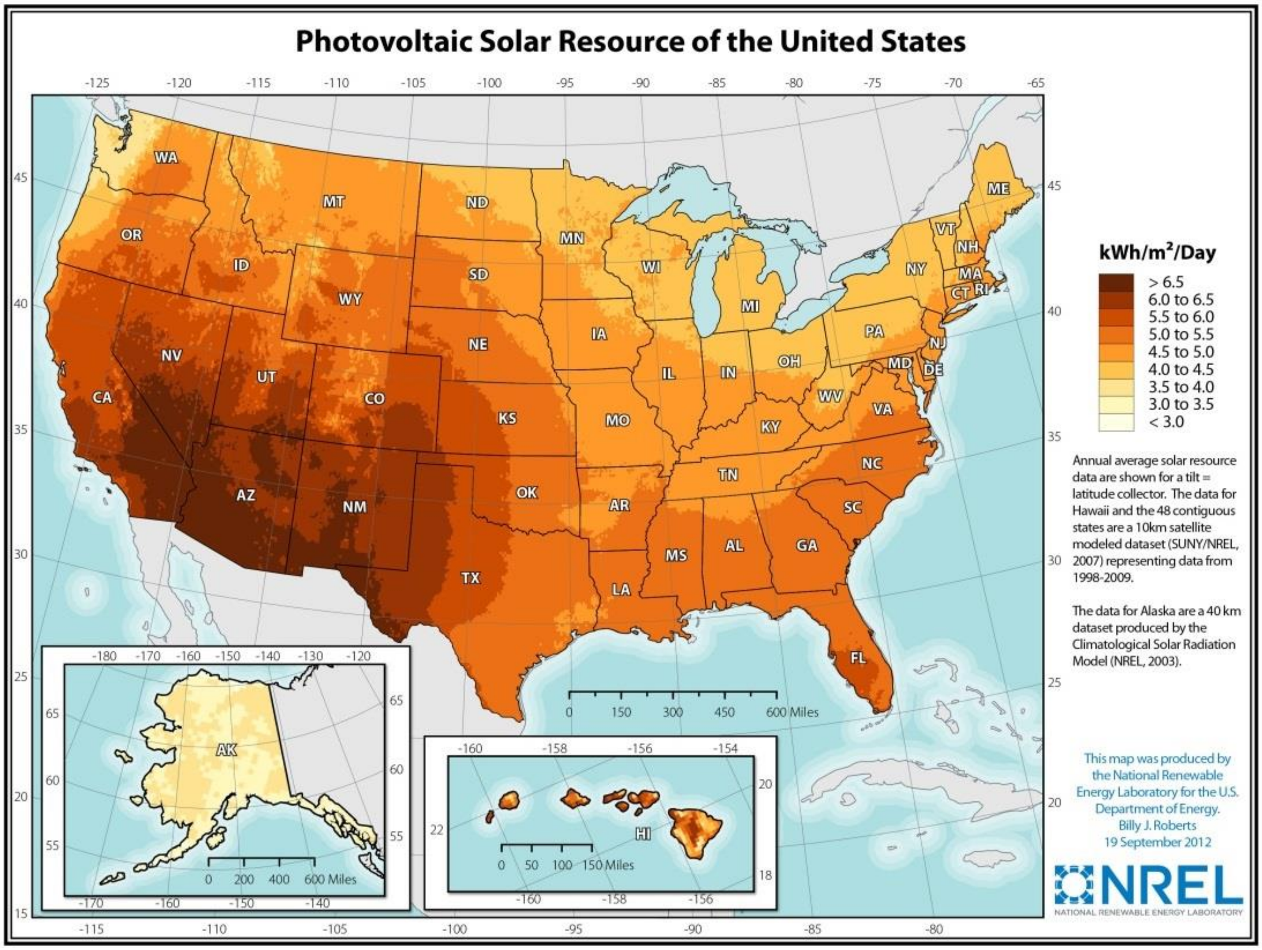


Figure 51: Solar Resource Map of the US

Geothermal Energy makes use of the internal temperature of the Earth. In Massachusetts, there is not enough energy (heat) to directly create a viable source of energy. However, even without a high temperature geothermal source, one can take advantage of the advantage of the fact that not too far below the surface (few feet) there is a constant temperature of around 52°F. This constant temperature is enough to create a usable heat pump for heating and cooling of buildings.

A series of pipes underground at the depth, where the temperature is constant, carries a fluid that absorbs heat (for heating) or dissipates heat (for cooling). After the exchange of heat, this fluid is brought into the building and exchanged with the ambient air. In addition, the natural temperature regulation of the Earth can be utilized with the way a building is built into a slope or below the ground. This then has a cooling or heating effect which can reduce the loads of an Air Conditioner or heater.

7.1.3 Stormwater BMPs

Treasure Valley lies within the Chicopee watershed, which is the largest watershed in Massachusetts, located centrally within the state. More specifically, the reservation is within the Quaboag River sub-basin. The Chicopee Watershed spans 721 square miles and ultimately leads to the Connecticut River. The annual flow into the Connecticut River is 909 cubic feet per second (Chicopee River Watershed Council). The Quaboag River sub-basin is 212 square miles (EEA). Within the watershed, Treasure Valley contains the Sevenmile River that flows into and out of Browning Pond. This watershed is protected by a local advocacy group called the Chicopee River Watershed Council. This Council's mission is to advocate for protection of the watershed by being a part of long term planning efforts.

Figure 52. Major sub-basins of the Chicopee River Watershed

In 2003, the EPA updated their standards for state's Watershed plans, causing Massachusetts to update their Watershed-Based Plan to in order to protect non affected water bodies. In 2003, a Water Quality Assessment Report was conducted by the state in order to begin the state's watershed management program (EEA). This report gives water quality data for the entirety of the Chicopee drainage basin in order to update the Surface Water Quality Standards (SWQS). The data is broken down into specific segments. The Sevenmile River segment and Browning Pond are both classified as water bodies that are limited by a Total Maximum Daily Load (TMDL) of certain contaminants.

Sevenmile River is a Class B water body that flows for 7.3 miles. In Sevenmile River, there are two withdrawals and discharges controlled by permits. In the areas of aquatic life, primary contact, secondary contact, and aesthetics, this segment is support. There are some issues with data for bacteria content so it was recommended that monitoring of bacteria levels continue.

Browning pond is a class B water body that takes up 106 acres. In Browning Pond, there are no withdrawals or discharges. In Browning Pond, the designated use of Aquatic Life was deemed impaired because of non-native aquatic plants. The total maximum daily load of phosphorus for Browning Pond is .015 mg/L (EEA).

Water quality protection of all types of water bodies is often implemented at the watershed level. Watershed management is done by monitoring and controlling the pollution from point and nonpoint sources. Point sources are specific discharges into the environment from wastewater treatment or any other factory or commercial process that uses water in their operations. Non-point sources are sources of pollution that is not directly emitted from a source. In this case, pollutants are collected as stormwater runs over and through the ground and into water bodies (EPA). Mitigation of negative impact of both can be implemented.

Stormwater management is particularly important in urban environments where impervious surfaces and increase the incidence of runoff becoming contaminated before it reenters the natural system. Anywhere there is human development, it is important to manage stormwater to prevent any negative environmental impacts. Stormwater management processes that may be applicable to Treasure Valley are green roofs, permeable pavement, rainwater collection barrels, and maintaining trees.

Blue roofs are roofs that retain water during rain storms to restrict the runoff of water. The roofs are typically made up of gravel and the rainwater is stored in the voids. When the water reaches the maximum capacity of retention, the rainwater flows off as usual, and over time gradually releases the flow, ultimately reducing the peak flow rate during the storm. The cost of a blue roof is an extra $4 per square foot in comparison to a standard roof. This system is suited for flat roofs that must be designed specially to be waterproof and hold significant weight. On average, the implementation of this system can reduce the peak flow of water by 85%.

Green roofs are roofs of buildings with plants growing from soil atop the roof. The way this helps to manage stormwater is that it acts as a retention area where water is stored in the soil and greenery. These roofs can reduce the volume of stormwater leaving the roof anywhere from 29-90%. They also naturally filter pollutants out of the water. An additional benefit of green roofs is that they typically reduce the temperature of the roof surface, which allows for less heat loss through the roof during the summer months. This ultimately leads to a reduction of energy bills due to a reduced need to cool the building. Simple green roofs can cost from around $10 per square foot and more complex green roofs can cost anywhere from $15-$70 per square foot. There is a maintenance cost associated with green roofs at about $0.75-$1.50 per square foot per year (City of New York, EPA).

Permeable pavements are pavements that are porous to allow for water to seep through the material. Porous pavements come in a variety of different designs including permeable paver, porous asphalt, or porous concrete. Impervious surfaces are a negative impact on stormwater because they do not allow for water to infiltrate the subsurface. Instead, the water runs off, collecting pollutants on the surface, and increasing the volume in another location. Permeable pavements allow for infiltration of water into the subsurface, thereby reducing runoff significantly. Depending on the type, permeable pavement can cost between $10 and $15 per square foot (City of New York, Center for Watershed Protection).

Rain barrels are barrels that are used to harvest rainwater via the downspouts of buildings. The water collected can be reused. Typical applications are for onsite irrigation. Rainwater barrels generally hold about 50 gallons of water and the larger alternative that serves the same purpose, cisterns, hold upwards of 500 gallons. Benefits of these systems include reduction of stormwater by storage during rainfall events and a reduced need for water from the tap from the reuse. Rainwater barrels are relatively easy to install and cost about $3-$9 per gallon of capacity. The larger cisterns cost around $0.50-$2 per gallon of capacity (City of New York). Sustainable stormwater management practices typically provide multiple benefits, including overall cost reduction based on increased efficiency.

A non-technical solution to stormwater management is the presence of trees. Trees can provide storage of water in their biomass and in the leaves in the canopy to reduce stormwater volumes. Trees also provide air quality improvements, provide habitats for wildlife, and can provide cooling cost reduction in nearby building. In urban environments the re-addition of trees should be encouraged and in areas such as Treasure Valley, tree clearing should be minimized (Center for Watershed Protection).

7.2 Land Use Planning Methodology

This section will detail the methods used to determine the recommendations for future building and facility development. The process includes two main parts. The first is a constraints analysis that results in the zoning of the reservation into designated uses. The second is a smaller scale look at three specific zones within the reservation to identify and site future developments. The resulting recommendations are designed to fit the needs to the stakeholders in a way that considers the environmental impacts.

7.2.1 Treasure Valley Constraints Analysis

As discussed in section 7.1.1, the first step towards conducting a constraints analysis is to determine the development constraints. In the context of Treasure Valley, the constraints categorized Northwest Vermont Regional Planning Commission were rearranged into the categories of absolute constraints, limiting development factors, and limiting access factors. For the Treasure Valley site, the data associated with each of these categories was determined and is listed below:

- Absolute Constraints: Areas, that in their given condition, cannot be developed such as water bodies, roads, utility rights-of-way, conserved lands, and existing buildings.
- Limiting Factors: a collection of natural resource and regulatory constraints that deter development such as such as wetlands, steep slopes, floodplains, quality of soils, protected habitats, and zoning regulation.
- Limiting access factors: Geographic constraints based on access to existing resources that would require extra money and resources to develop. These include access to roads, parking, access to infrastructure (water, electric, sewer), solar access (indoor and outdoor comfort), tree clearing, proximity to existing developments (buildings, campsites) … etc.

Once the development factors were identified, they were added into the base map created in GIS. The creation of the base map is detailed in section 5.3.1 of this report as part of the inventory process. A list of layers and their sources is shown below. The layers that were statewide layers taken from the MassGIS database were clipped by the four towns of Rutland, Paxton, Oakham, and Spencer to make the data more manageable in terms of file size. The layers taken from maps provided by Treasure Valley were digitized visually from printed maps.

Table 12 : Constraints GIS data and details

Data Description	File Name	Source	Year
Roads	CENSUS2010TIGERROADS_ARC	MassGIS	2010
Built Water Infrastructure	Waterlines	TVSR	2012
Powerlines	Powerlines	TVSR	2012
Solar Exposure	SiteVisit	GPS Coordinates	2012
Parking areas	Parking	TVSR	2011
Tree Stands	TreeStands	TVSR Forest Management Plan	2004
Buildings	Buildings	TVSR	2012
Campsites	Campsites	TVSR	2011
Floodplains	FEMA Q3 Flood	MassGIS	1997
Slopes	NRCS SSURGO-Certified Soils	MassGIS	2012
Habitats and protected species	Biomap10	MassGIS	2010
Wetlands, Streams, Lakes	MassDEP Hydrography (1:25,000)	MassGIS	2010
Buildings	Buildings	TVSR	2012

7.2.1.1 Objective Analysis

In the GIS map, the added data was group into layers based on the established groups. Once the groups were created, it was easy to turn on and off the layers in each group simultaneously. The process began by viewing the map with only absolute constraints. The first group of absolute constraints is comprised of factors that are absolute in preventing development and are therefore weighted the highest. After visual inspection, the limiting factors group was turned on. The second group of limiting development factors is made up of the regulatory and physical factors that would be hard to overcome and are weighted second in importance. The visual inspection of these two groups of constraints yielded a list of general areas that have potential for development. Each general area was detailed with a descriptive title based on location and a list of pros and cons for development. For these results see section 7.4.1.

7.2.1.2 TVSR Zoning

Following the completion of Part 1 of the constraints analysis, the results of Part 1 were brought to the Treasure Valley Stakeholders for evaluation and input. See Stakeholder input section of the report for the methodology and results of this process. Part 2 of the constraints analysis process included an incorporation of stakeholder inputs and access constraints in order to produce more specific development recommendations, including zoning recommendations.

An additional constraints category of stakeholder input was added for consideration. It was incorporated into the GIS map through the creation of a polygon shapefile to characterize designated areas. Each polygon was included with an attribute for purpose. The various purposes were: solar development land, desired natural buffer areas, and land planned to be traded.

Additionally, access constraints were factored in by displaying the infrastructure shapefiles, including water infrastructure, electric infrastructure, roads, and parking areas. The result of the visual analysis that followed was a zoning map for development of the reservation. A zoning map was created from visual analysis of all displayed constraints, knowledge of natural and infrastructure delineations, and stakeholder development preferences. In the GIS map, a new shapefile, TVZones, was created with the attribute of Zone that included the following zones: Boy Scout Camp, Venturing Program, Cub Scout Camp, Nature Education, Buffer, Solar, Conservation, and Land for Trade.

7.2.2 Site Selection

In order to create a list of developments to plan for, information from stakeholders was compiled and interpreted it into a concrete list. The discussion from stakeholders included a list of programs that they wished to develop, infrastructure that would simultaneously need expanding, and a desire for certain types of facilities. In order to narrow down this list and translate it into physical facilities, research and follow-up meetings were conducted to finalize a list of developments.

The initial list of programs gleaned from the stakeholder meetings was inclusive of all suggestions received from various stakeholder communications. The areas that were eliminated first were those that did not fall into the scope of this project. These were identified as future projects as part of the effort for continued relationship between TVSR and WPI (See Section 5.3.3). The resulting list can be seen in Figure 53.

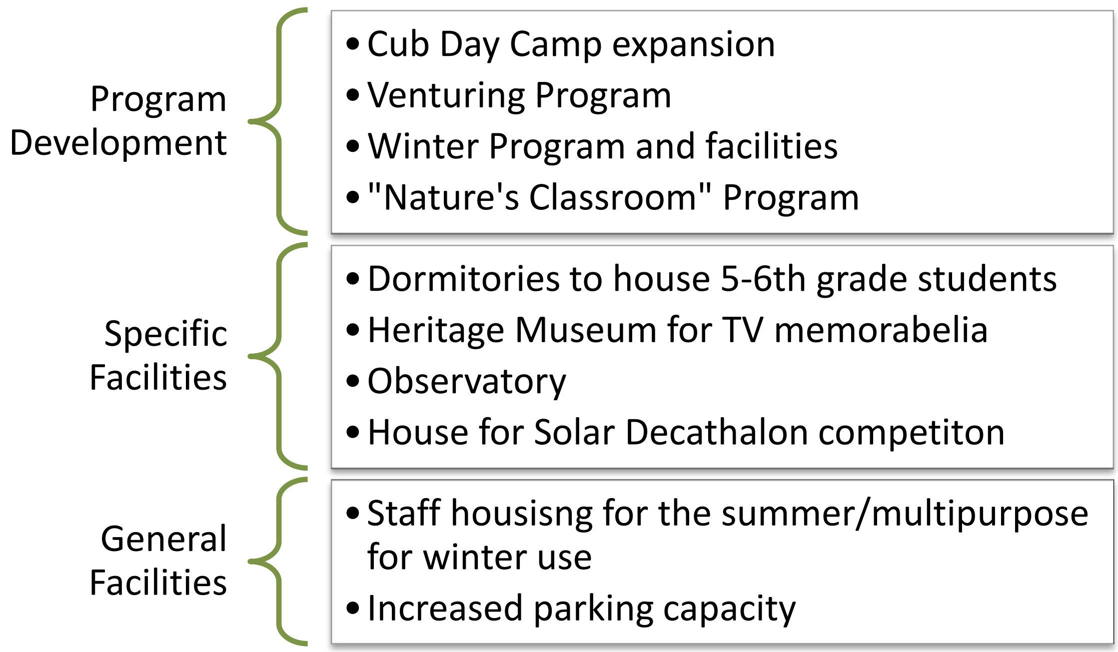


Figure 53: Initial desired development ideas

Certain factors narrowed the focus away from certain developments on the initial potential development list. The Cub Day Camp expansion was eliminated from the scope because Treasure Valley has recently contracted a civil engineering company to redesign the program. Their goal is to double the capacity of the program. Additionally, the siting of the house for the Solar Decathlon competition was eliminated because of the uncertainty of this development. The Solar Decathlon house is an energy efficient house being designed by WPI and other partners for a competition in China. The ultimate destination of this house following the competition is currently undetermined and can be considered when a decision is more imminent.

The revised list of developments to be sited is as follows:

1. Venturing program
2. Nature Education
3. Parking

The research focused on translating program development initiatives into building and facility requirements. Once the buildings and facilities were determined, they were sited on the reservation.

7.2.2.1 Venturing Program

Program Research

The Venturing Program is offered for youth ages 13-18, which is the highest age level of scouting. The program is co-ed and provides a less structured environment for the participants. These scouts often have a say in the types of activities that they plan to do and are allowed more leisure time through the day in comparison to boy scouts or cub scouts.

Certain activities that are unique to the venturing program include climbing/rappelling, caving, sailing, boardsailing, scuba diving, orienteering, fishing, wilderness survival, mountain biking, cycling, water skiing, navigation, hunter education, backpacking, horseback riding, Leave No Trace, Project COPE, and Venturing Leader Skills Course. Venturing programs in terms of facilities, are typically equipped for the scouts to stay overnight for 3 consecutive nights.

Specific to the Mohegan Council, there are 10 Venturing crews each with approximately 5-10 scouts per crew with relatively even ratio of males to females.

Determination of Facilities

Based on the needs of the venturing program, the facilities to be sited were determined. The developments to be sited are 6 new campsites, a program building, a pistol range, and a centralized restroom facility. Details of each type of facility are detailed below.

Campsites

Design considerations for siting campsites can be found in the 2012 National Standards for Cub Scout/Boy Scout/Venturing Resident Camps. The criteria from the standards are listed below:

- 1 toilet for every 15 campers
- 30 square feet of shelter space to sleep and store belongings
- 5 shower heads for 100 campers
- contain a shelter with tables and seating, a program bulletin board, and a fire pit

In the Treasure Valley Scout reservation, the average area of the currently developed campsites is about 15000 square feet per camp site. Therefore this area will be the guideline for siting new campsites in the venturing program area. Due to the size of the program, 6 new campsites were sited.

Program Building

Treasure Valley Scout Reservation contains approximately 20 program buildings. With the addition of a venturing program, a program building is desired for use by those that participate and run the program. The needs that a program building in the Venturing Program area must meet are bunking capabilities, a common indoor space, and water facilities including drinking water, toilets, and showers. The existing program building whose use most nearly matches the needs of this new building is the West Conference Center. The West Conference Center contains two conference rooms, room to bunk 28, and shower facilities. Given that that the venturing program contains youth between the ages 13-18 and the program is geared to include more independence for the participants, the area per participant for bunking increases. The footprint of the West Conference Center is approximately 3000 square feet. Therefore, the approximate footprint of the program building for siting purposes to be 4000 square feet.

Pistol Range

The venturing program is characteristic of offering many programs that are not offered at the Boy Scout and Cub Scout level, one of those being pistol shooting. This unique privilege comes with many restrictions such as requiring no more than 3 scouts for one NRA certified supervisor. There are, however, no special regulations for a pistol shooting range. A rifle or shotgun range may be used for pistol shooting. Therefore, the rifle or shotgun range must follow the guidelines in the *Camp Program & Property Management* document written and maintained by the Boy Scouts of America.

A Rifle Range must be a permanent facility which includes a well-defined backstop with adequate fencing combined with natural barriers to protect any stray people that may be near or around the shooting range. A covered shelter with platform and locked storage is a mandatory part of a rifle range's permanent facilities. For .22 caliber ammunition, a 50-foot target range is recommended.

A shotgun range has similar requirements to a rifle range, but it requires a canvas, carpet, or backstop to absorb the shot from shotgun rounds. The range is 600 feet deep for number 8 shot size or 750 feet deep for number 6 shot size. The width at the ready line and firing line is 75 feet. Shooting stations must be clearly marked. The width at range end is 700 feet. The distance from the ready line to the firing line is at least 15 to 20 feet. Boundaries should be roped or fenced off with only one entrance. The range is usually away from unit campsites and heavily used areas.

In general, a range should have a north to northwesterly direction to minimize sun shining into the eyes of a shooter or range officer to permit firing at any time of the day. The target frames should be placed on the same horizontal plane as the firing line. Trees should be cleared so that no tree is within either flank or in front of the firing line. The area between the firing line and the targets will be cleared of downed timber, underbrush, trailing vines and trash. Grass must be kept short to prevent interference for shooters aiming from the prone position. Shooting may not take place within 500 feet of a residence.

The backstop is integral for the safety of the range since this is the area a majority of all shots are fired at. Many different kinds of backstops may be used. Natural backstops must satisfy one of the following requirements:

- Hillcrest 30 feet or more above the firing point, brush must be cleared away 30 feet above the target line and 60 feet beyond the flanks of the target frame, can cut away the soil from the face of the hill with a height of at least 10 feet above the shooting line, all rocks must be cleared from the hillside or buried under at least 6 inches of soil to prevent ricochets
- Open flat country, where visibility extends for at least 3,000 feet behind the targets with no buildings, trails, roads, rivers, or any other structure or land characteristic that may endanger people or damage property

For most ranges, an artificial backstop is used. Below are three examples of artificial backstops:

- An earthen embankment at least 10 feet above the firing line, 3 feet thick at the top, and is well sodded to prevent erosion
- An earthen embankment at least 5 feet above the firing line, topped by cribbing (to retain earth) to a total height of 10 feet
- Cribbing 2 feet thick and 10 feet high, with wing walls, filled with dry, screened dirt or sand. Ends and rear faces may be of rough timber. The face of the crib should be of rough lumber, using vertical studding and planking. This planking is held in place by inserting each piece from the top. The planks are held in place by horizontal framing. The planks immediately behind the targets should be removable since they will soon be shot full of holes.

In the Venturing zone, a shotgun range currently exists and a rifle range is also nearby. For each range, it must be determined if the ranges are up to BSA standards. Ranges must be safe and operational. The range must also be able to accommodate a standard group of Venturing students with the appropriate number of shooting officers. The addition of pistols must not interfere with or hinder the current use of current facilities (e.g. a modification that renders the shotgun range not compliant with BSA standards).

Siting Process

The steps for siting the proposed developments within the venturing program followed a similar approach to the constraints analysis previously described. The Venturing Program zone was overlaid with the absolute constraints and limiting factors from the previous methods. Based on the specific needs of the program and facilities detailed above, the following additional pieces of information in shape files were included.

Table 13. Additional Constraints data and details for the Venturing Program

Data Description	File Name	Source	Year
Woods Roads used as walking paths	woods_road	TVSR Forest Management Plan	2004
450' buffer from the Solar Phase II zone	SolarIIBuffer	National Standards for Cub Scout/Boy Scout/Venturing Resident Camps	2012
Contour Lines	Elevation Contours (1:5,000)	MassGIS	2003

ArcGIS was used to create a map with constraints and to identify points with labels for each type of potential site (campsite, program building, and shooting range). Based on the initial options identified, the options for each facility were compared qualitatively using a list of pros and cons for each. The location of the shooting range was determined first, followed by the program building, and then the campsites. This order was used because the location of the shooting range and the program building influenced the location selection of the campsites, and therefore needed to be identified first.

Based on the selection of sites, a shape file was added with polygons that show the existing developments. The program building was sited as a rectangle with area of 4000 square feet. The shooting range is represented as a point, given that a new area for development need not be established. The campsites were sited as circles with area of 15000 square feet, based on the average area of existing campsites.

In addition to these developments, a few additional considerations needed to be made. These include additional water distribution infrastructure, electric power line extensions, bathroom facilities to accommodate the additional campsite capacity, and service roads to ensure access to all facilities.

7.2.2.2 Nature Education Program

Program Research

The purpose of the Nature's Classroom program is to provide an opportunity for students and teachers to experience education outside the walls of a classroom. This program offers up to 5-day overnight stays for students. A typical day has students learn outside by exploring different outdoor sites during the morning after breakfast and cleanup. After lunch and recreation/rest time, the students choose different special interest classes to take with a variety of evening activities after dinner (such as a campfire, a folkdance, or night hike). There are 13 Nature Classroom locations in New England and New York. The closest Nature's Classroom to Treasure Valley is in Charlton, Massachusetts.

Morning field group activities focus on giving students better understanding of the dynamic interactions in the natural worlds and social situations. Examples of field group activities may include learning about predator/prey relationships in the natural environment or focus on changes through time or investigate the ways producers, consumers, and decomposers are dependent on each other.

The afternoon special interest classes emphasize motivating students and helping them appreciate the value of education. Science, Math, Social Studies, and Humanities lessons are all offered as types of interest classes. For example, a science class may study the life in a pond, a math class may involve the students constructing a geodesic dome, a social studies class may have the students play Native American games, and a humanities class might have students compose "woodland music."

The TVSR stakeholders have expressed a strong desire to open a Nature's Classroom facility on their land. The stakeholders have a specific capacity in mind and expect to site the program near the to-be-constructed Nexamp solar farm. This area presents ample space and access to accommodate a new building and to the natural features such as wetlands and forests to host trails and sites for outdoor education.

The capacity of the program as projected by the stakeholders include dorm space for 150-200 5th-6th grade student including boys and girls, and apartment space for adult chaperones. There are a variety of ways that these facilities can be established. The Nature's Classroom at Sargent Center, Hancock, New Hampshire has more decentralized facilities, including a variety of cabins which house 4- 10 people each and dormitories that house 30-50 people each which in aggregate can accommodate 150 people year round. This setup also includes separate program buildings and a dining hall. The Natures Classroom at the Hilltop in Charlton, MA takes a more centralized approach. Their facilities consist of two dormitories that together house 164 students and 12 adults. Their setup also includes a separate function building that contains a dining hall, indoor program space, and meeting rooms.

Determination of Facilities

The size of the available and accessible space in the Nature Education zone lends itself to more centralized development of building such as the Charlton, MA example. Based on the needs of a Nature's Classroom program, the facilities that were selected to site in Treasure Valley are two dormitory buildings, and a program building to house dining and program space. The outdoor education spaces were sited at this point of development. The nature of the wetland/beaver pond area near within the Nature Education zone is currently dynamic. As the permanent facilities are being developed, the outdoor spaces and programs should be determined using similar constraints analysis and planning in combination with site walks and evaluations.

Housing Facilities

The housing facilities to be sited were based on the configuration in the example of the Hilltop configuration of the Charlton, MA Nature's Classroom. As described in the previous section, the capacity of the Charlton program is comparable to the needs of a Treasure Valley's Nature Program. The two story dormitories together house 164 children and 12 adults, and the program building can handle the same capacity. To determine the dimensions the ruler tool was used in Google Earth over the aerial photograph of these facilities located at 73 Pumpkin Lane, Charlton, MA. The two identical dorm buildings in Charlton have dimensions of approximately 130 ft by 45 ft. The separate program building is roughly 90 ft by 73 ft. Figure 54 shows the aerial image of the facilities in Charlton.

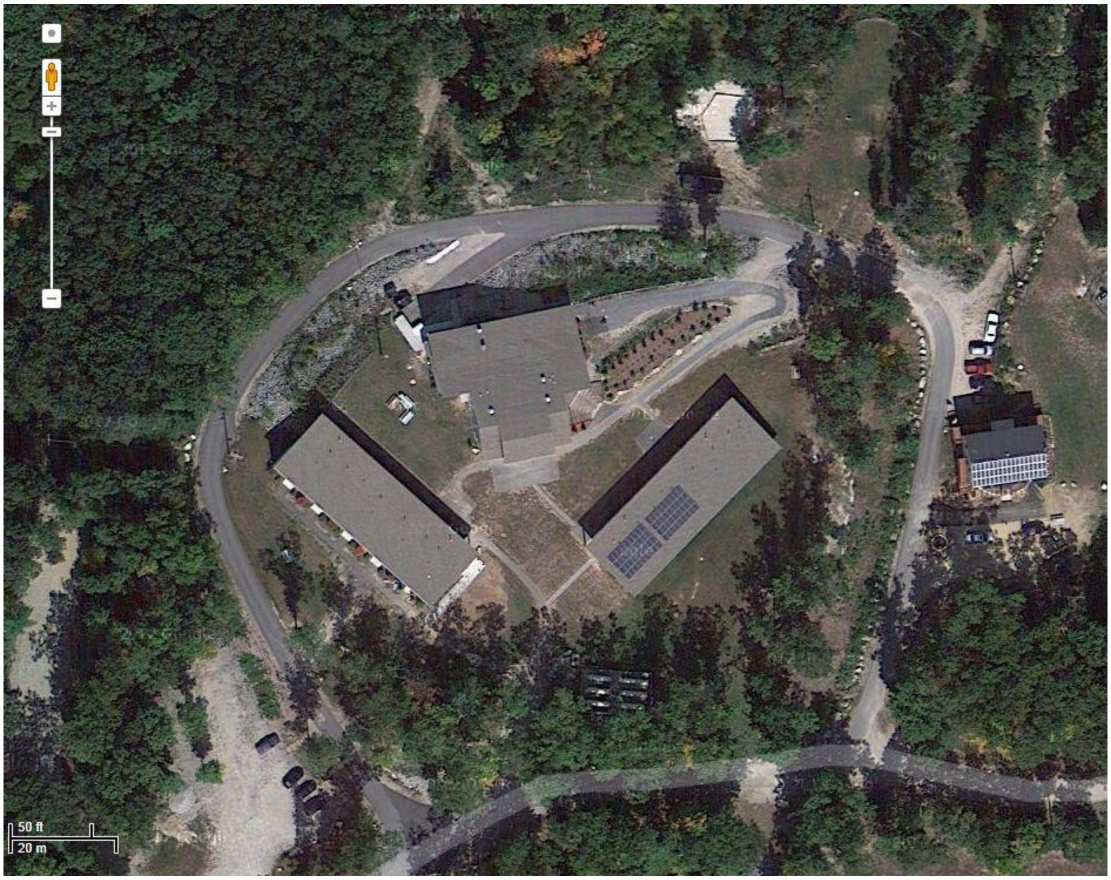


Figure 54 : Hilltop, Charlton, MA Nature's Classroom buildings

Siting Process

The siting process within the Nature Education zone began with a smaller scale look at the constraints analysis within the confines of the established zone. This analysis included all data layers included in the absolute constraints and limiting factors in the initial constraints analysis with the addition of contours.

The next step for siting the facilities was to create a new shape file of polygons with the established approximate dimensions of the dorm buildings and program building. With this layer, the project group was able to use the edit mode to rotate, move, and reconfigure the buildings to various orientations. Each potential configuration was compared qualitatively with an evaluation of the respective pros and cons. Based on this analysis, a configuration was chosen as the conceptual design recommendations.

In order to minimize the environmental impact of the buildings, green building design concepts were incorporated into the design. Based on these calculations, stormwater best management practices (BMPs) should be pursued to accompany the building. According to the MassDEP's Stormwater Management Handbook, management practices should be implemented in order to ensure that the post development runoff from the site should not exceed the pre-development conditions (source). The risk of high volumes of stormwater runoff is that pollutants are collected as stormwater runs over and through the ground and into water bodies (EPA).

The change in stormwater runoff before and after development can be estimated by calculating the total volume of runoff for varying degrees of storms in the before and after cases. A basic method for estimating stormwater runoff flow and volume is the Rational Method. The equation used in the rational method for volume calculations is $Q_v = cRA$, where Q_v is the volume of discharge in cubic feet, c is the runoff coefficient, R is the total rainfall in inches, and A is the watershed area (Marsh). For these purposes, the rational equation was used to evaluate the variables that would vary in the pre- and post-development cases.

Each of the variables in this equation were determined for this specific development in Treasure Valley. The analysis was considered for a one-year and 100-year storm to have a rough estimate of a more typical rain event and a rarer (more intense) rain event to be able to plan for each. The results of these considerations were used to evaluate various stormwater management techniques that would be successful in this application. The methods were compared qualitatively for their positives and negative in order to select the appropriate management methods.

7.2.2.3 Parking

System Research

The Treasure Valley stakeholders have stated that they wish to greatly expand their capacity for their scouting programs. Specifically, they plan to at least double the size of the Cub Scout program, being able to host larger jamborees, and develop a Venturing program. All these expansions will bring significantly more scouts, faculty, and other people to the reservation resulting in a greater demand for parking. The Treasure Valley stakeholders have expressed a desire to create an established centralized parking area. The reservation currently uses the existing Jamboree Field as a temporary parking area for large events. When this field is taken up by cars, it is unusable as a field. The creation of a designated centralized parking area will preserve the immediate use of the jamboree field, preserve the quality of the field by reducing driving over the area, and account for existing and future need for a large capacity parking area.

It is also the desire of the TVSR leadership to minimize and regulate the amount of traffic going through the reservation for safety, nuisance, cost, and environmental issues. Therefore, some manner of centralized shuttle service (bus, van, etc.) must be used to transport people to and from a central location to the individual reservation locations. This will entail having a primary parking area near the entrance of the reservation and having adequate infrastructure at potential destinations to accommodate the periodic dropping off and picking up of people.

Determination of facilities

Based on the anticipated expansion and increased need for parking within the reservation a centralized parking area was sited. In addition, recommendations were made for an inter-reservation transportation system to make centralized parking a feasible option for all programs.

Parking Lot

Parking is a large scale infrastructural issue. Attention must be given on a Reservation-wide level. The constraints from the previous siting (specifically zoning) are relevant to any parking development recommendations.

Potential parking areas need to be clear of any natural or man-made obstacles such as water bodies and existing buildings. Care must also be given to the proximity of a potential parking area to any existing development. Parking lot should not be cited near (within 450ft - the recommended buffer for a campsite per the BSA) a campground since the constant use of the lot can be distracting and dangerous to campers. There are natural restrictions as well. It is not recommended (in fact restricted) to building near a wetland (100ft in Massachusetts). Not only will the development potentially impact the wetland or water body, but the associated increase in storm water runoff coupled with the oils and such produced from cars have the potential to impact the water even further.

The purpose of the lot is to have people store their vehicles so they are able to be driven to a specific location. This poses two more criteria for a parking area: the proximity to the desired area and the proximity to roads. The parking lot must be reasonably close to the location the lot was built for. For Treasure Valley a parking lot for the Reservation should, ideally, be located near the entrance and a parking lot for East Lodge should be sited near East Lodge. People will have to be able to drive their vehicles to the parking area. There will have to be access from the nearest main road. Therefore, it would be easier and more cost effect to site a parking lot on or near existing roads.

Another important constraint is the condition of the proposed parking area. The current state of the site (vegetation, use, etc.) directly affects the difficulty, cost, and impact of construction. An empty field will offer an easier site to grade and construct over a heavily forested location.

For a rough estimate, the average land area per parking spot is around 600 square feet. This number is quite conservative and takes into account the parking space, lines, walking areas, driving area, and other needed infrastructural space. Each lot will have to be large enough to accommodate the specific need of the location. For this project, the focus is on a central parking location. To determine the capacity needed for future development, the current capacity was calculated.

In order to determine the best location for future implementation of parking lots, the existing "main" (labeled as parking lots in the official TVSR site map) were modeled in the GIS map. Here, the areas of the parking lot polygons were measured. To determine the capacity, the area of each lot was divided by 600 square feet/parking lot. The resulting capacity for each lot can be seen in Table 14.

Table 14 : Current Parking Capacity

Parking lot #	Name	Area (ft^2)	Capacity (spaces)
1	East Lodge parking	12529	21
2	Boonesville Plains	17679	29
3	West Lodge Parking	4045	7
4	Cub Day Camp Parking	27806	46
5	Jamboree Field	244654	407

Inter-Reservation Transportation

It would not be practical to have large parking lots throughout Treasure Valley. Not only would it would be quite unsightly to replace large tracts of natural landscapes with flat fields of parking, but it would also pose potential safety issues. Cars driving to and from parking areas (especially during peak Scouting use) will increase the likelihood of possible accidents involving TVSR users. Traffic will also distract Scouts from the natural environment and require better road infrastructure. Programs like Cub Day Care cause Cub Scouts to be dropped off and picked up daily. Since Treasure Valley leadership plans to greatly expand this program, this rise in future traffic will need to be addressed. A large volume of people will need to be transported from a location away from the populated areas of the Reservation to individual locations.

Siting Process

There are two peak times during the year at TV –Summer Camp and Sober in the Sun. These highest use times will be the design capacity. To translate these numbers into usable figures, assumptions were made. Looking at the summer camp time, there are two different users of the reservation – scouts, cub scouts, and adults. Scouts do not drive there themselves (for the most part). They are more likely dropped off by a parent or guardian. Cub scouts also do not drive, but they usually do not stay overnight and sometimes their parents might accompany them to TV. To be on the conservative side, 1 parking space per 10 scouts is a reasonable assumption. Adults include scout masters, troop leaders, Reservation employees, and others. Some people may carpool, but it is safe to assume that for every adult there needs to be 1 parking space available. Therefore, during the Summer Camp weeks, 210 parking spaces will be needed. With the use of the jamboree field, this capacity is easily achievable as shown in Table 14.

For events like Sober in the Sun, scouts are not using the Reservation. The whole Reservation is rented out by a private organization. It is estimated that 500 people are in Treasure Valley at one time. It is safe to assume that not everyone will be driving to the event separately since families do attend and friends may drive together. Being conservative and assuming that each person attending this event assuming that 50% of the attendees would carpool with another person (which is a reasonable estimate, since friends and family members could drive together) a reasonable estimate would be that each person would need .75 parking spaces. Therefore, an event like Sober in the Sun would require 375 parking spaces, which, like the Summing Camping time, is easily achievable with the use of the jamboree field.

Treasure Valley Leaderships plans to greatly expand their size and scope of their scouting program in the future. The current parking capacity is adequate, but it will be stretched when this expansion takes place. The use of the Jamboree field for parking is required to allow for a large amount of centralized parking. There is no other central parking area and the Jamboree field cannot be utilized for anything other than parking during these peak times. To compete with growing use, new parking is needed.

Using GIS, the potential parking lots in different areas of the reservation were modeled. Existing structures and vegetation, proximity to a site or the reservation entrance, and development constraints (such as wetlands) were looked at to determine where parking lots can be sited. The sites were evaluated to determine potential parking capacity.

The purpose of the new parking lots was to create a centralized parking area to minimize people driving through the Reservation. In some cases, visitors and staff could park in the central location and walk to their destination. With groups of young children, high volumes of people, or locations far from the parking lot, there would be issues for people getting to their destinations. Therefore, an inter-reservation transportation system (IRTS) was considered to resolve this issue. This system would utilize some manner of shuttle (like a van, bus, etc.) to ferry a number of people from point to point. This would not have to be a permanent operation. Shuttles could be rented during the times of peak use (i.e. during Summer Camp or during a large event like Sober in the Sun).

7.3.2.4 Phases

The recommendations for development of each program were broken into phases. The purpose of the phases is to establish a relative timeline for the implementation of each piece and to make implementation more practical. The two major factors that influenced the delineation of phases are steps that chronologically must precede each other based on the use of the program and physical expansion. In other words, developments sited close to existing development are slated to be completed first and developments, such as roads that reach a certain site, must be developed before the sites themselves. The phases are detailed in the results section of this report with accompanying maps.

7.2.3 Stakeholder Participation

Another meeting was needed to verify the accuracy and validity of the Treasure Valley data gathered by the project group. The meeting was held on January 30, 2013. The ranger of Treasure Valley, Joe Marengo, was present along with several other stakeholders. At this stage, the CE students started to compile and organize pertinent information about the reservation (infrastructure, etc.). Preliminary map showing general constraints were reviewed by both groups. Future development priorities and constraints were also discussed. The agenda and the detailed minutes of the meeting can be found in Appendix A.

To create an adequate database in order to perform the necessary analysis to develop recommendations, a complete inventory of all the buildings was needed in order to go forward. Ray Griffin was contact via email by the project group. The group requested that Griffin would compile and send the names, uses, and other information about each building at Treasure Valley.

7.3 Results

7.3.1 Constraints Analysis

7.3.1.1 Objective Analysis

The objective conclusions drawn after Part 1 of the constraints analysis –the initial visual analysis of the Treasure Valley map based on mapped absolute constraints and limiting factors – are included in the following pros and cons list. Figure 55 shows the map from which the conclusions were drawn.

The overlaying of the absolute constraints did not eliminate enough acreage to make the best sites for development obvious. The absolute constraints were most helpful for eliminating bodies of water including ponds, streams, and wetlands that physically cannot be built on.

The addition of the limiting factors overlaid on the map allowed us to draw initial conclusions about general areas that might be best for development.

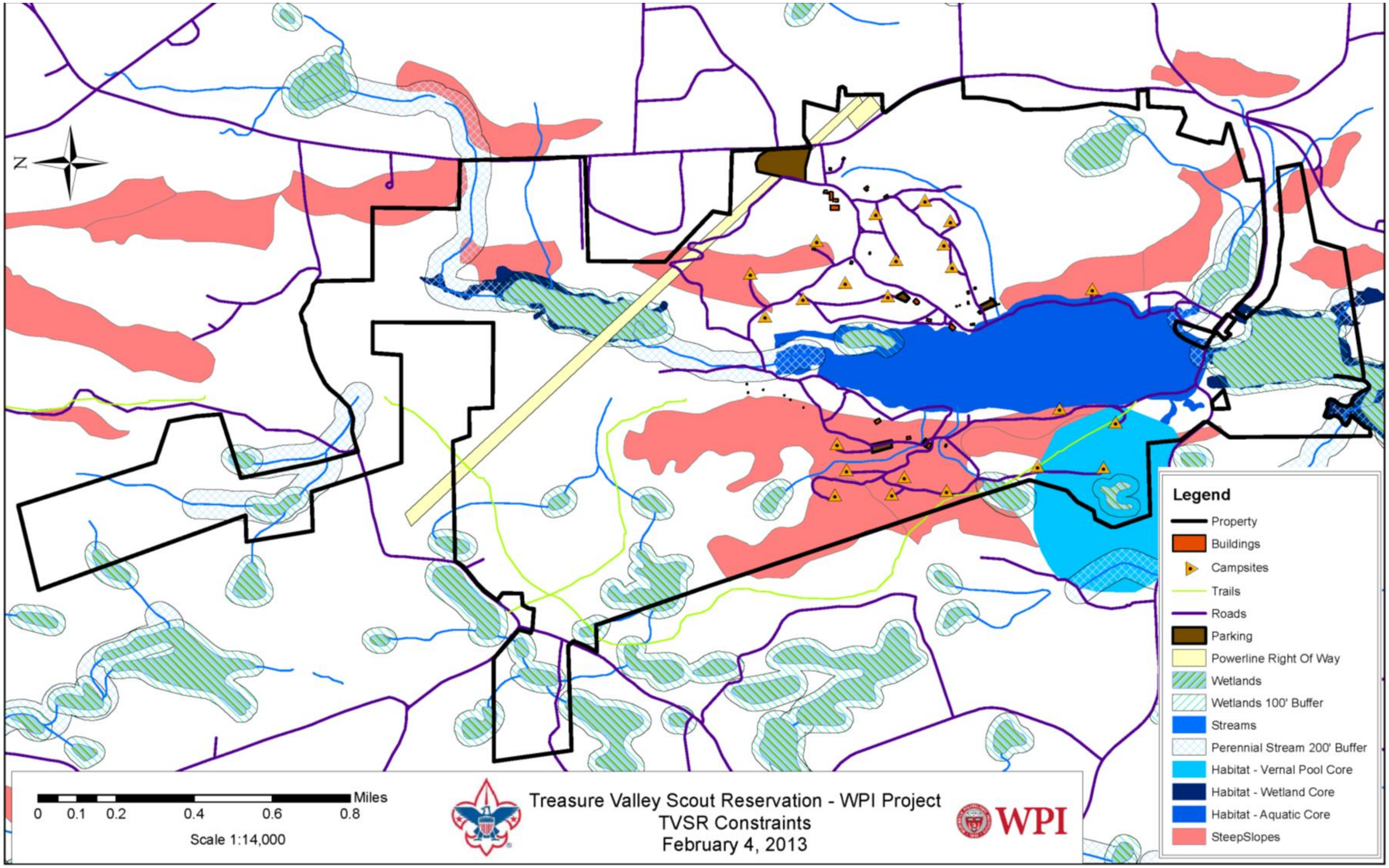


Figure 55 : Treasure Valley constraints map

The team identified four of the best potential areas for development and listed them with a name descriptive of their general location. The potential areas were Paxton East Camp, West Camp, North Camp, and Northern Rutland. The group included a list of pros and cons for each area in regards to development potential. This list was used to present the objective finding to the Treasure Valley stakeholders. Certain areas were not included in the list of pros and cons because the constraints map showed more cons than pros. For example, most of the Spencer properties are densely populated with wetlands and existing houses. This area is segregated from the rest of camp and does not contain the uninterrupted natural habitat that is so attractive to a scout camp. Pros of this area are that the established infrastructure may make a building easier to site. It might also be a good location for easier access to the public. Given this, this area should not be entirely ruled out for development. These initial objective findings were then used in combination with stakeholder feedback to proceed to Part 2 of the constraints analysis

Table 15 : Potential development regions pros and cons

PROS	CONS
Paxton East Camp	
● No steep slopes, water bodies, or protected areas ● High access to town roads and TVSR roads	● Existing campsites and facilities ● Solar Development
West Camp	
● Access via TVSR roads ● Heating benefits of building on a hillside	● Steep slopes, protected habitats, and wetlands ● No access to town roads ● Only access via dirt roads and small bridges
North Camp	
● Currently undeveloped ● Access to TVSR roads ● No steep slopes	● Possible beaver pond/ wetland issues ● Nearby campsite conflict ● Would need to expand utilities
Northern Rutland	
● Access to town roads ● No steep slopes or wetlands ● Currently undeveloped	● Not connected to rest of camp ● Requires tree clearing ● No existing water infrastructure ● Proximity to trails

7.3.1.2 TVSR Zoning

Part 2 of the constraints analysis included the incorporation of stakeholder inputs and the infrastructure access layer. The infrastructure access layer is shown in Figure 56.

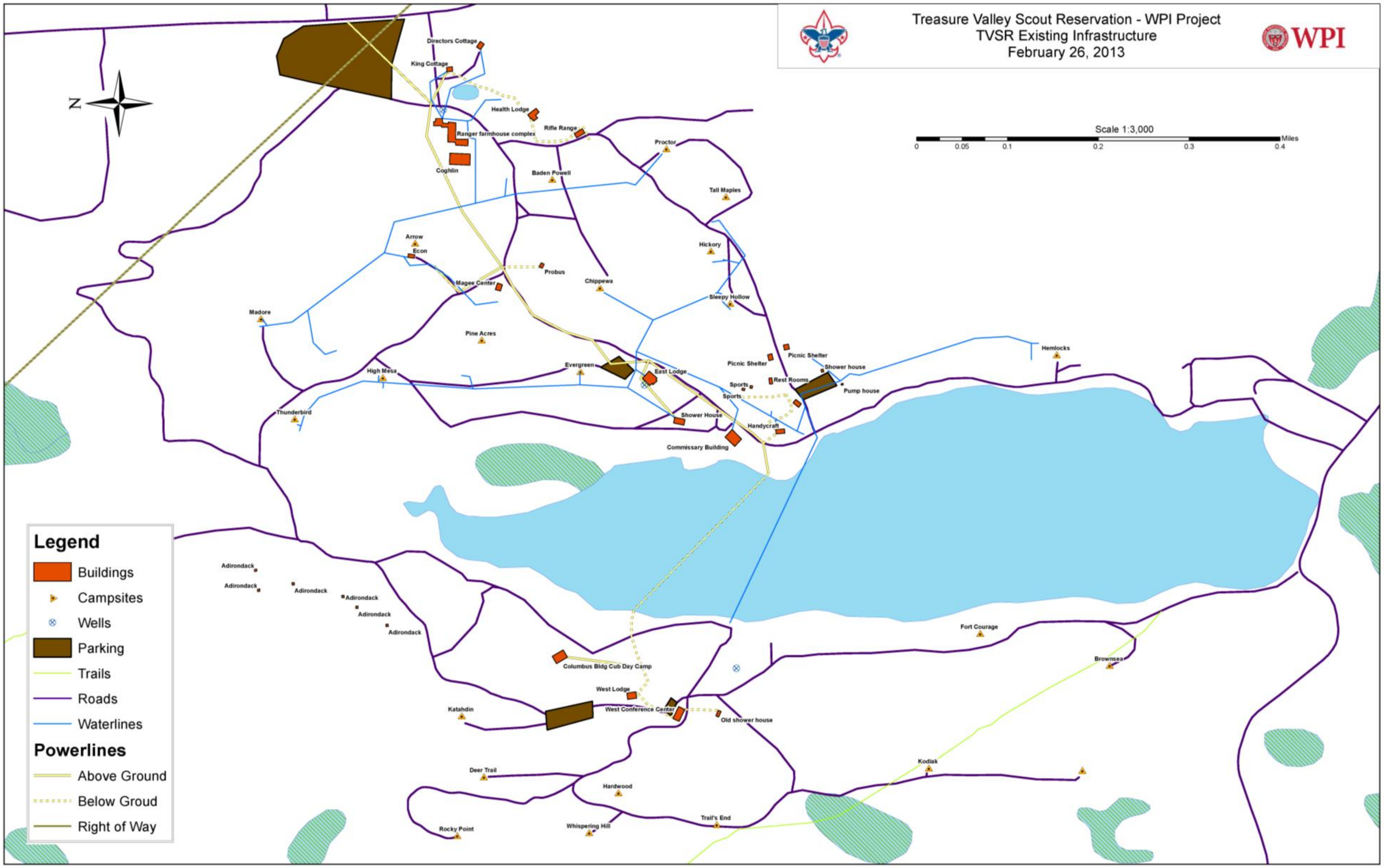


Figure 56 : TVSR infrastructure map

The zoning map developed from the analysis of the constraints included in Part 2 is shown in Figure 57. The zones are Boy Scout Camp, Venturing Program, Cub Scout Camp, Nature Education, Buffer, Solar, Conservation, and Land for Trade. Below, each zone is described with an explanation of how they were delineated.

Solar

The solar zone is designated as the zones that have been planned for development of large scale solar farm. The land is to be leased and developed by Nexamp. The northernmost solar zone is inclusive of Phase I of the development and encompasses the panels, other electric infrastructure, fences, tree buffers to be planted, and a service road to be established. This area has detailed plans for development and construction is planned to begin in March of 2013. The southernmost solar zone is designated for Phase II of the project with Nexamp. The project is in the proposal stage with basic proposal designs. These zones were delineated with input from the TV stakeholders and digitized from the stakeholder input layer.

Nature Education

The nature education zone is designated for development of the “nature’s classroom” program. Nature’s Classroom, as conceptualized by the Treasure Valley stakeholders, will be a series of outdoor education areas that allow school aged children, to learn about nature and the natural environment. The program will also include education about renewable energy, incorporating the Nexamp solar development as an example and display.

The zone was positioned for its proximity to the solar development. The eastern border abuts the solar zone and the western border extends around the beaver pond and wetland to include important natural habitats that could be included in the education program. The northern border extends to parcel borders and the southern border abuts the Boy Scout camp area for access via paths for the boy scouts to the education area.

Boy Scout Camp

The Boy Scout Camp area is generally the current area that is designated as “East Camp.” The Boy Scout camp is the most developed area of the reservation at present. Facilities contained within this area include campsites, dining building, program buildings, storage facilities, COPE area, waterfront area, developed water infrastructure including two wells and water lines, electric lines, the only paved road, and other facilities. Boy Scout camp areas are designed to house Boy Scouts ages 11-17 for five consecutive nights (scouting.org).

This zone to the East was delineated by the main town road and property border and to the West by the Browning Pond shoreline. The northern and southern borders were determined by the extent of the developed area with a buffer of roughly 300 feet. The Southern border follows an intermittent stream that surrounds the development and extends around the developed waterfront. The Northern border loops around the northernmost campsites.

Cub Scout Day Camp

The Cub Scout Day Camp zone is what is currently known as West Camp. This area is the second most developed area of the reservation. This area is connected to East camp by a dirt road and a bridge that wraps around the North of Browning Pond. Other infrastructure includes program buildings, campsites, Adirondack shelters, a well with some functional and disrepair water infrastructure, and dirt roads and paths. Characteristic of this portion of camp is the steep, east-facing slope. Treasure Valley has recently contracted a civil engineering company to redesign their Cub Scout camp area in West Camp in order to double the capacity for programs and scouts. A typical Cub Scout overnight camp is designed for cub scouts, ages 7-11, to stay for two consecutive nights. This zone was delineated by the Browning Pond shoreline to the East, the extent of the developed area in the West, the Buffer zone to the North, and the property border to the South.

Land to be Traded

The Land to be Traded zone consists of currently undeveloped land that the stakeholders of Treasure Valley have a desire to or are in conversation regarding a trade to another entity. The Northernmost Land to Trade zone is land that Treasure Valley would like to trade to the State of Massachusetts to add to Rutland State Forest land in exchange for two parcels of Oakham State Forest Land totaling a little over 200 acres. The parcels to be received are to the west of West Camp. This trade is desired due to the buffer of contiguous natural land that would result.

The Southernmost land to trade is a 100 acre parcel in Spencer that Treasure Valley would like to trade to St. Joseph’s Abbey. The land to be received is a 90 acre parcel owned by the Abbey to the Southwest of West Camp in Oakham. Again, this trade is desired to make a more continuous and central buffer around the reservation. In each zone, the delineation was determined based on the property boundaries of the parcels in question.

Buffer

The Buffer zones are areas where development is to be deterred. The zone to the North of Browning Pond currently functions as a natural buffer between East Camp and West Camp. The stakeholders of Treasure Valley have a desire to limit development in this area to maintain the natural buffer between the separate program areas of camp. This area was delineated by the East and West camp borders and to a large wetland to the North.

The Buffer zone to the south is to limit development to allow for natural land to not develop near the existing houses and other developed infrastructure not belonging to Treasure Valley. This area is approximately 500 feet thick to maintain the “backwoods” environment that is characteristic of the reservation. The Buffer zone in the Northeast of the reservation is again a natural buffer area designed to limit development between properties not owned by Treasure Valley in order to preserve the “backwoods” environment. This buffer is between 300 to 500 feet in thickness.

Conservation

The Conservation zone is comprised of lands that are to be set aside as land to be conserved and kept undeveloped. These lands are characterized by high concentration of wetlands, vernal pool habitats, large expanses of forest, and abutting State Forest land. Both Conservation zones in the West were delineated by property boundaries and intersection with other zones.

Observatory

The observatory zone located in the western most portion of Treasure Valley has been identified as an area that would be suitable (dark, quiet, remote, and accessible) to site an observatory. These plans are currently being worked on by an outside part in collaboration with Treasure Valley.

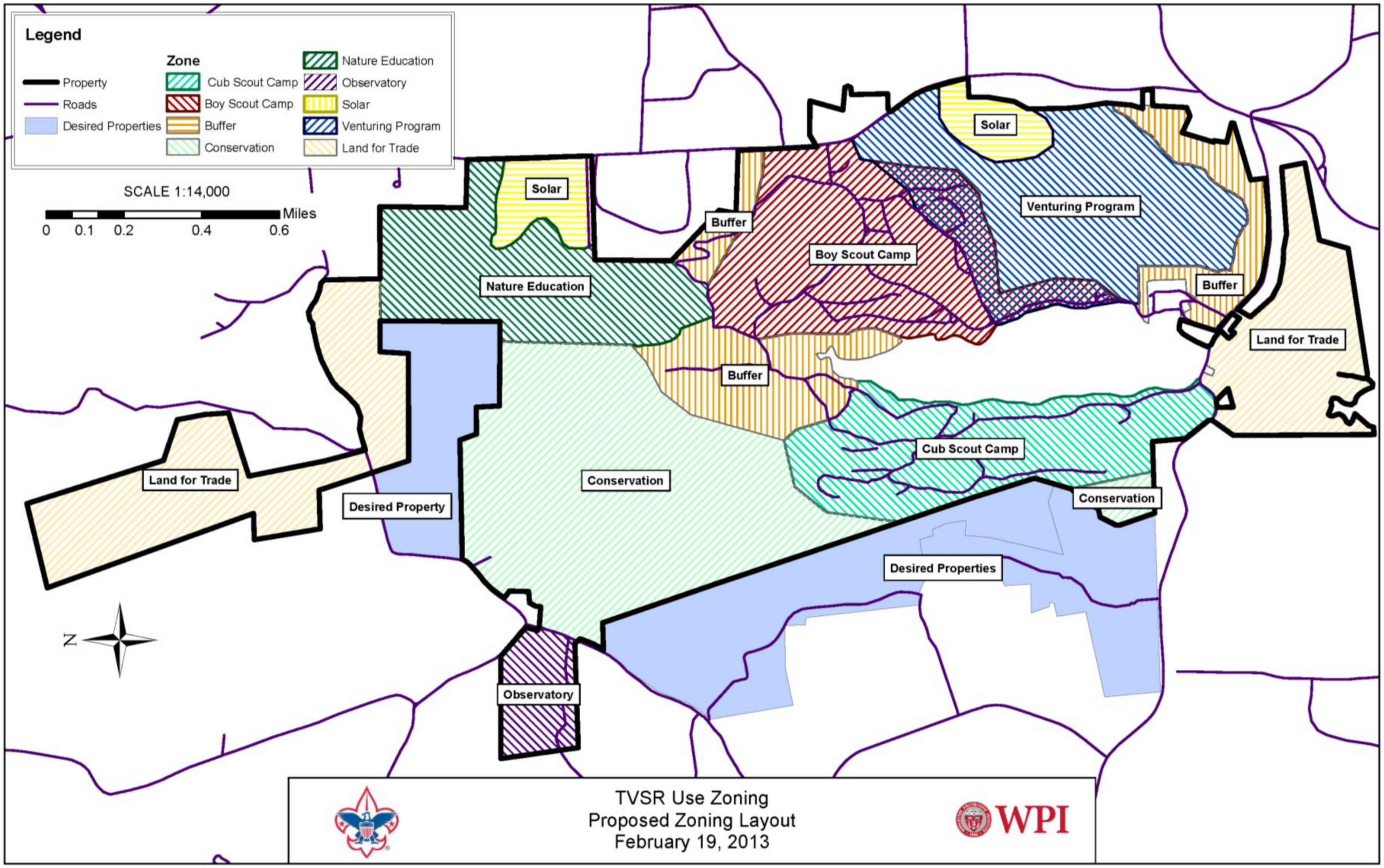


Figure 57 : Zoning Map

7.3.2 Building Site Selection

As previously discussed in Section 7.2.1.2 the final list of developments to be sited is as follows:

Venturing Program
- Campsites
- Program building (with dorm capacity)
- Pistol Range

Nature Education
- Dormitory
- Outdoor education display

Parking
- Centralized lots for increased capacity
- Inter-Reservation Transportation System

Each area's siting recommendations are detailed in the following sections. Each area was planned to be developed in phases for practical implementation.

7.3.2.1 Venturing Program

The main constraint affecting the determination of the location of potential sites was access. The woods road that exists through the forest are walking paths that can be used to access the land. Given that these paths could be widened into roads, it makes the potential expansion of access to the venturing program area more feasible. Therefore, a majority of the potential sites were positioned around the woods road. Figure 58 shows a constraints map of the Venturing Program zone. This map also includes the initial selection of potential locations of facilities. The analysis of each of these options, organized by facility type, follows.

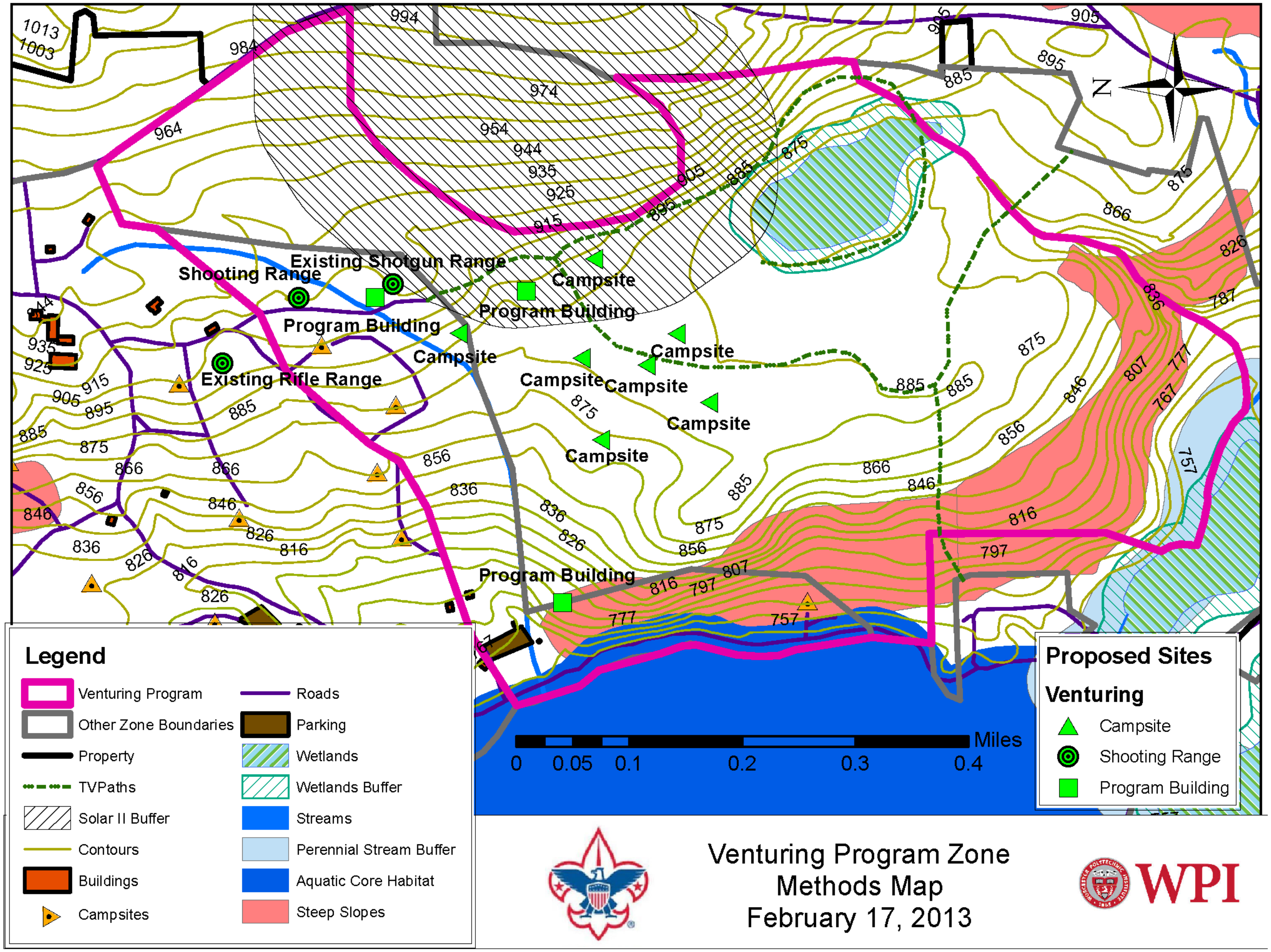


Figure 58 : Venturing Program Zone initial site selection considerations

Of the three sites selected for the siting of the pistol range, one was the existing rifle range, one was the existing shotgun range, and one was an undeveloped area. The aerial image of each is shown in Figure 59. In the figure, the orange rectangle is the existing rifle range building and the green square is a potential location for the Venturing program building.

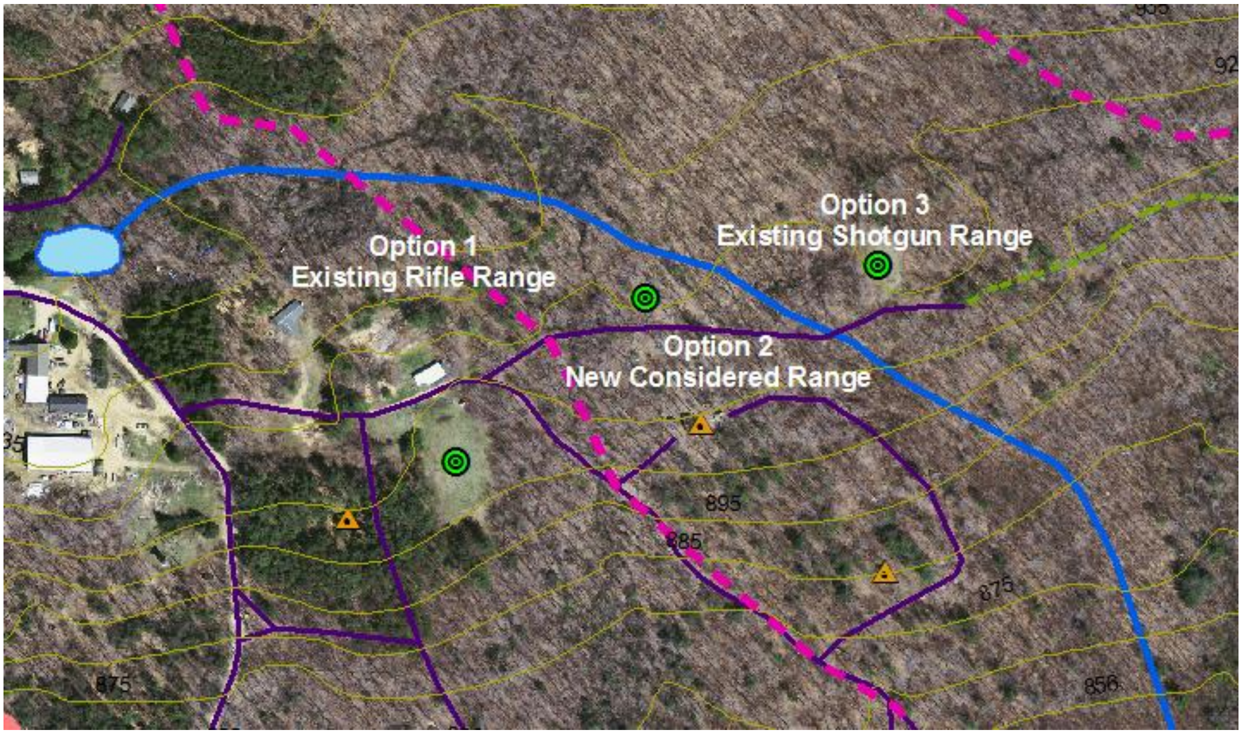


Figure 59 : Three options for the Venturing pistol range location

Table 16 : Venturing Program Pistol Range Benefits/Negatives

	Benefits	Negatives
Option 1	● Already cleared and established ● Rifle ranges are more easily converted for pistol shooting	● Not within the Venturing Program Zone
Option 2	● Not established (can be designed to meet ideal configuration)	● Proximity to stream
Option 3	● Already cleared and established	● Facing the future solar development

Based on the comparison of options, the existing rifle range was selected as the best option.

The three points used to identify sites for program buildings were analyzed further with the insertion a shape file with a sample building footprint with the ideal orientation for that site. The Northernmost site (Option 1) is positioned directly north of the existing shotgun range. The building is positioned with its entrance facing the existing service road. The site to the south of Option 1 (Option 2) is at an intersection in the woods road. This building is oriented south facing in order to maximize solar power generation potential for the roof. Additionally, it orients the view from the front of the building away from the Solar Phase II development to minimize the visual impact. The remaining westernmost site (Option 3) is positioned near the Boonesville Plains area near the waterfront of Browning Pond. The building is oriented with the contour of the building with its entrance oriented toward the existing field for ease of access. Options 1, 2 and 3 are shown in Figure 60.

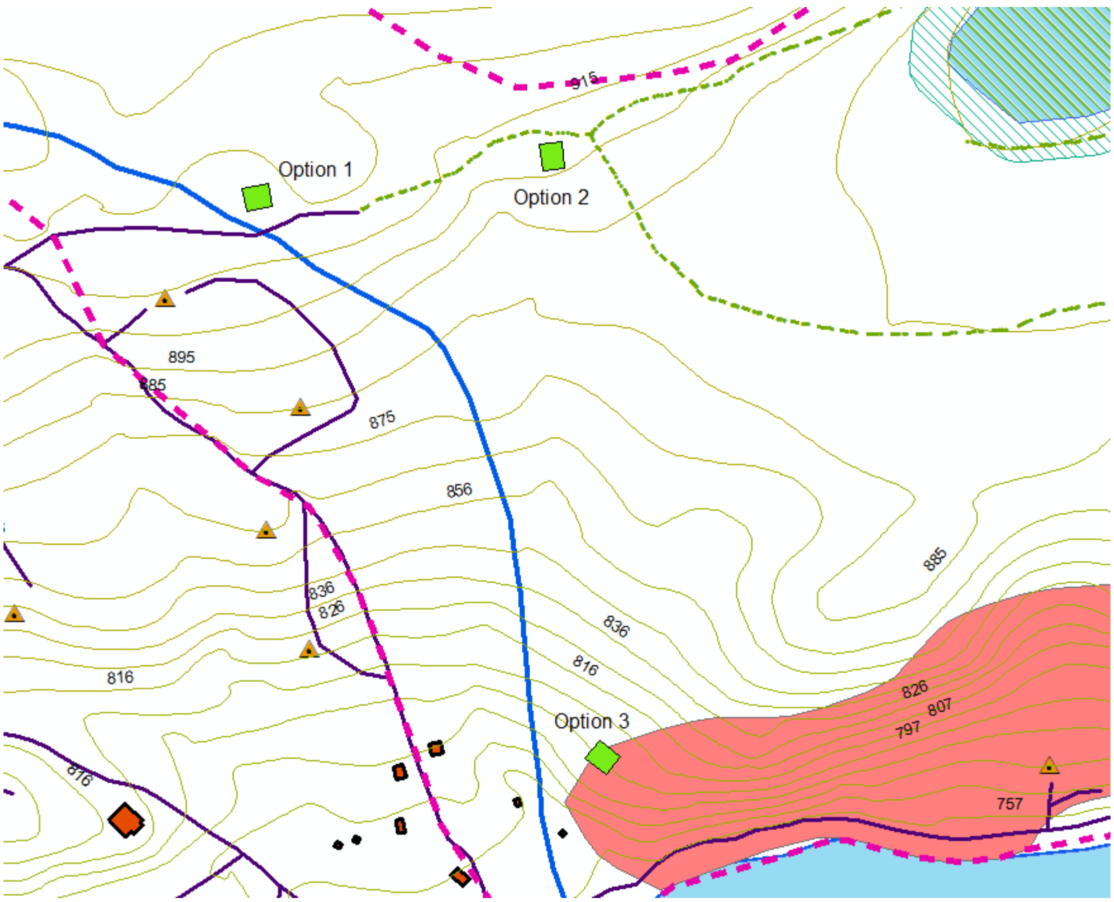


Figure 60: Three options for the program building location

Table 17 : Benefits and negatives of each program building location option

	Benefits	Negatives
Option 1	● Flat area ● Access to existing service road	● Proximity to stream ● Proximity to existing shotgun range if the range is not decommissioned
Option 2	● Establishes in new Venturing area (separate from Boy Scout area) ● Access near woods trail	● Proximity to Solar Phase II
Option 3	● Proximity to waterfront facilities ● Proximity to existing water infrastructure	● Steep slope ● Lack of established access to site

Table 17 shows a list of pros and cons for each option. Based on this table, Option 2 is the best option to be recommended for program building location.

After selection of the program building location and shooting range, the location of the campsites were determined. The seven points used to identify sites for campsites were placed with consideration for access. Simultaneously upon the consideration of campsite locations, the locations of future roads were also considered. Figure 61 shows the juxtaposition of a proposed service road to be established through the Venturing Zone. The proposed road follows the established woods road with an extension that extends the reach through the sites identified as potential campsites.

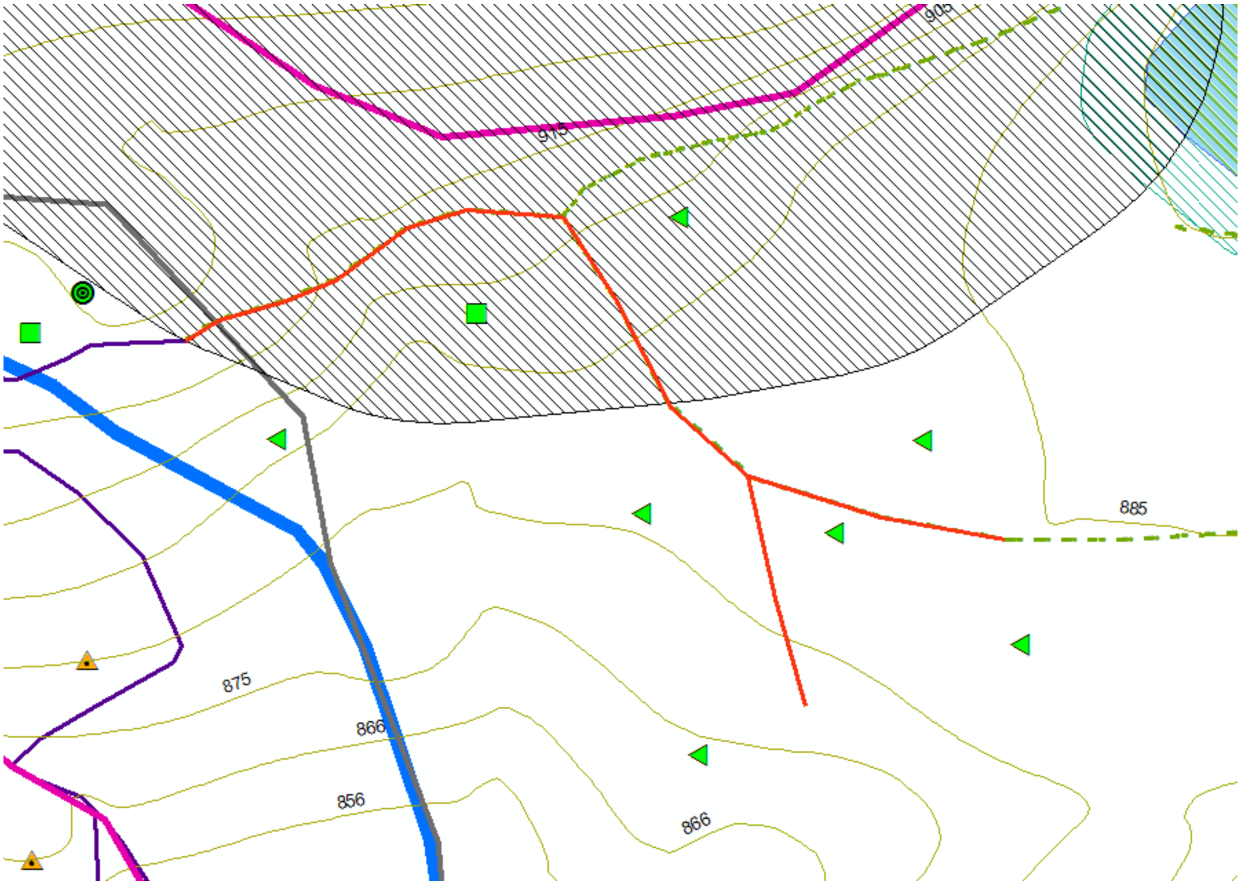


Figure 61: Potential Venturing campsite locations with proposed road

Each of the proposed campsites sites were chosen based on their access to potential roads, flat area and distance from other developments. Of the proposed campsites, the easternmost campsite was eliminated based on its proximity to the Solar Phase II development.

Figure 62 shows a map of the Venturing Program area and the recommendations for development of the program area. The configuration of the proposed development was determined based on the nature of the Venturing Program as defined by the BSA program, the location of existing developments, and natural resource constraints. The proposed siting configuration is determined to be the best and most feasible option for the program and the area.

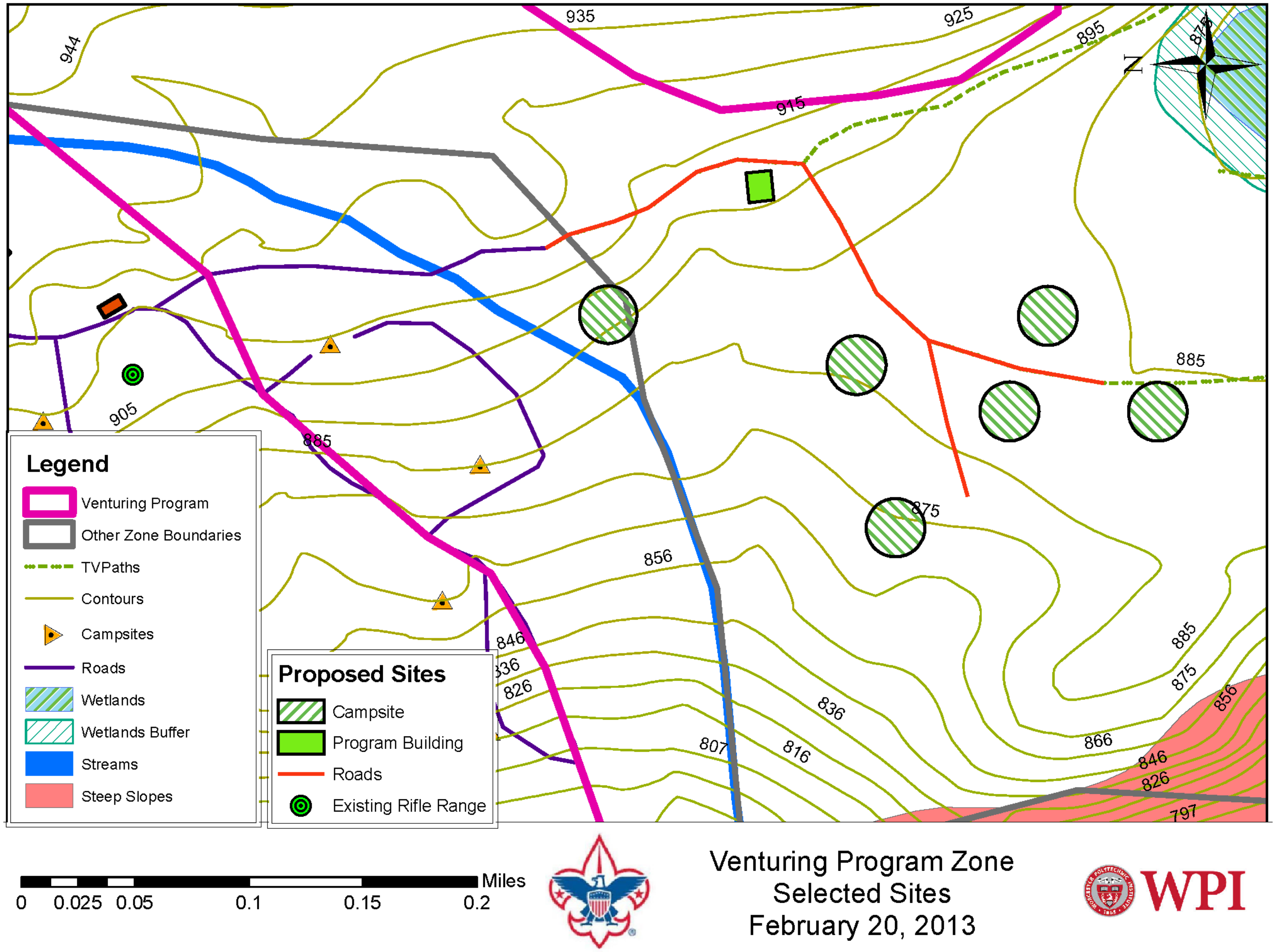


Figure 62 : Venturing Program zone showing the selected sites for program building, pistol range, and campsites

With the establishment of this new area, a new well will likely need to be established in order to reach the planned facilities. It should ideally be sited uphill from the venturing program area which is the easternmost area of the Venturing Program zone. A future project should be completed to determine the location of a new well in combination with an analysis and evaluation of the existing drinking water system within the Reservation. The same should be done for the expansion of the electric infrastructure so that the Venturing area can have power.

As stated earlier, for the addition of each 15 campers there needs to be an additional toilet. The current model for toilets and campsites is that each campsite has its own toilet. An alternative to this is to have a centralized facility with multiple toilets to accommodate the addition of the 6 new campsites. Six new campsites with an estimation of 10 campers per site is an additional 4 toilets. (6*10/15= 4). The Treasure Valley stakeholders have expressed interest in exploring the option of a centralized bathroom facility. Treasure Valley already employs the use of a clivus composting toilet within the reservation. Given that Treasure Valley is already versed in the management practices involved with a Clivus toilet and that they do not require water, this type of facility would be practical in the Venturing Program area. It is recommended that before implementation, as part of the future project regarding water resources, that it be determined that this option is truly the ideal option.

Based on these additional considerations a final configuration was produced and is shown in Figure 63. The toilet facility was sited in a central location among the campsites and bordering the proposed road for ease of access. Additional service roads were added to provide access to the individual campsites to the central road. A walking trail was added connecting the Venturing Program area directly to the Boonsville Plains and waterfront area. This will provide increased connectivity to the existing program areas within the reservation. The trail was sited based on the contours to find a relatively manageable walking path for the venturing scouts. A more in depth, on-site analysis should be performed to establish this path preceding the implementation. Additionally, a small parking area was added near the proposed program building to provide capacity for 3-6 cars to park outside the building.

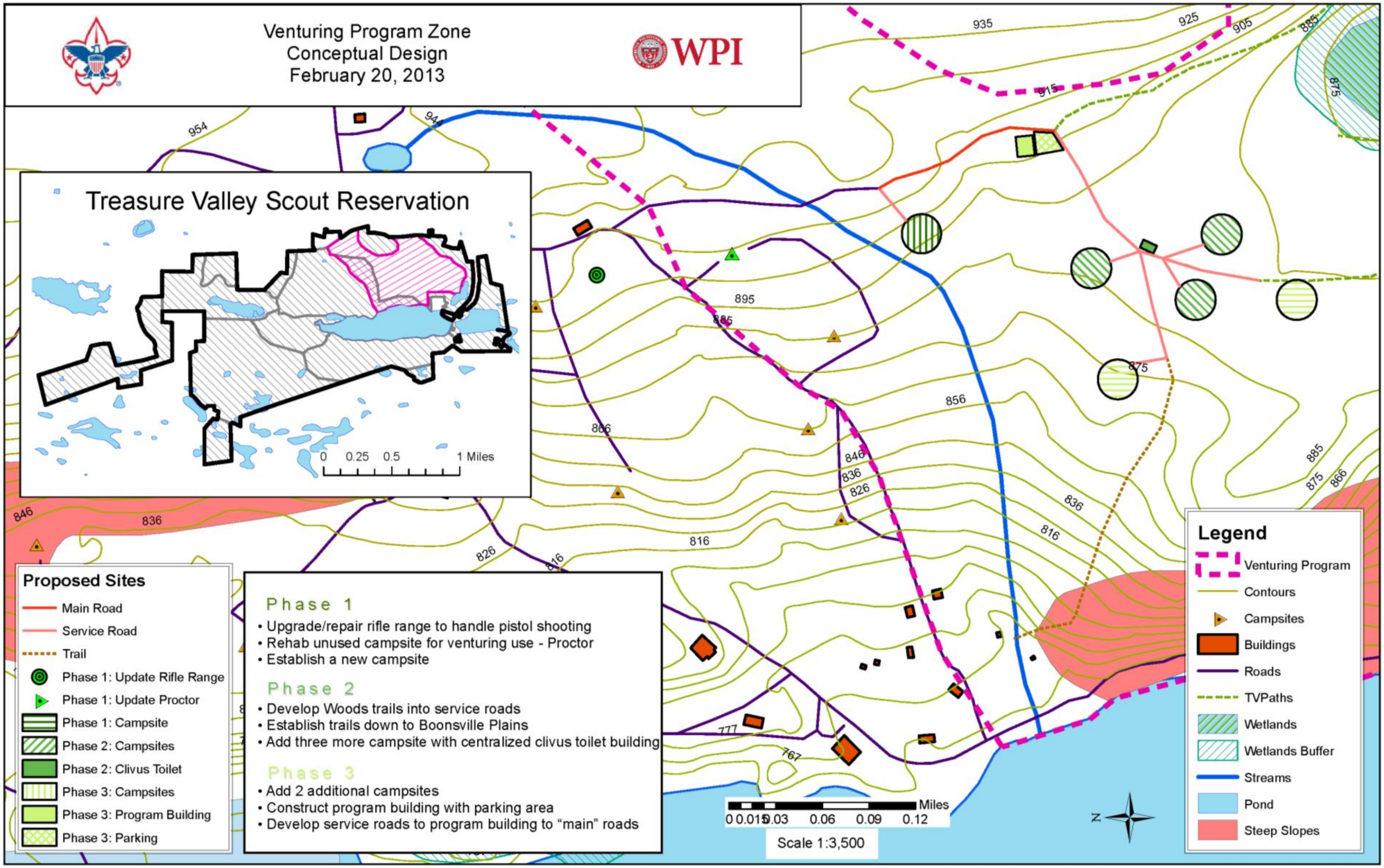


Figure 63 : Venturing Program zone final proposed developments

The phases for the development of the venturing program are determined based on a gradual distance expansion from existing facilities. Phase 1 includes an expansion of roads to improve access and establishment of new campsites that can be used by the Boy Scout camp area while the next phases of the venturing program are being implemented. Phase 2 includes the next step in expanding infrastructure, including establishing a well location for water infrastructure, creating an additional road connection to the developed waterfront area of the reservation, and the addition of two new campsites. Phase 3 will be for development of facilities that will be strictly for the venturing program, including a program building and activities that are exclusive to the venturing age scouts. Maps of each phase with descriptions are shown below.

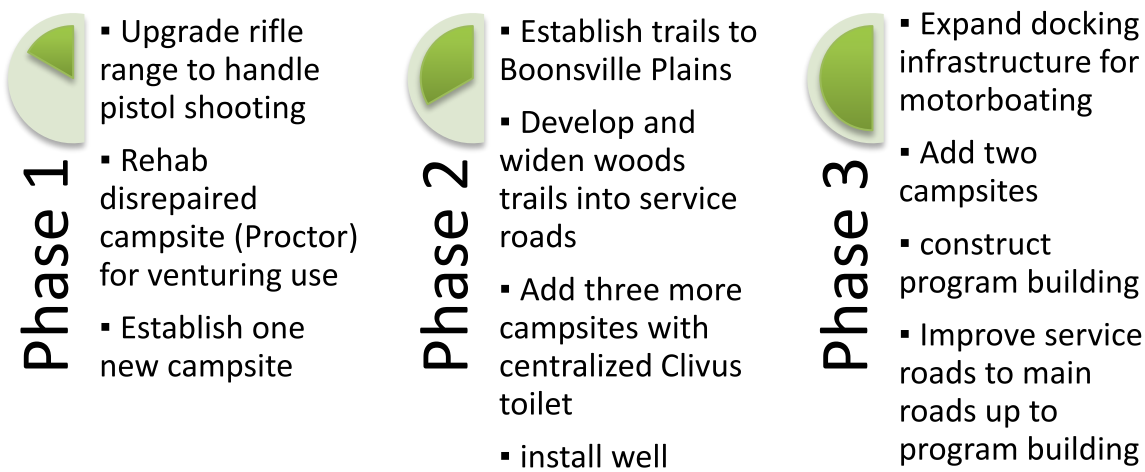


Figure 64. Descriptions of implementation phases for the Venturing Program Area

7.3.2.2 Nature Education

Based on the constraints map there is only a relatively small area that has minimal constraints and has access via main roads. The constraints map for the Nature Education Zone is shown in Figure 65. This area with the least amount of constraints is the space west of the Solar zone, south of the steep slopes, and east of the wetlands, indicated by the star. Access to this area will be available once the Solar farm is developed and the proposed service road is installed. The other relatively unconstrained areas are inaccessible due to lack of access presented by natural boundaries of streams and wetlands.

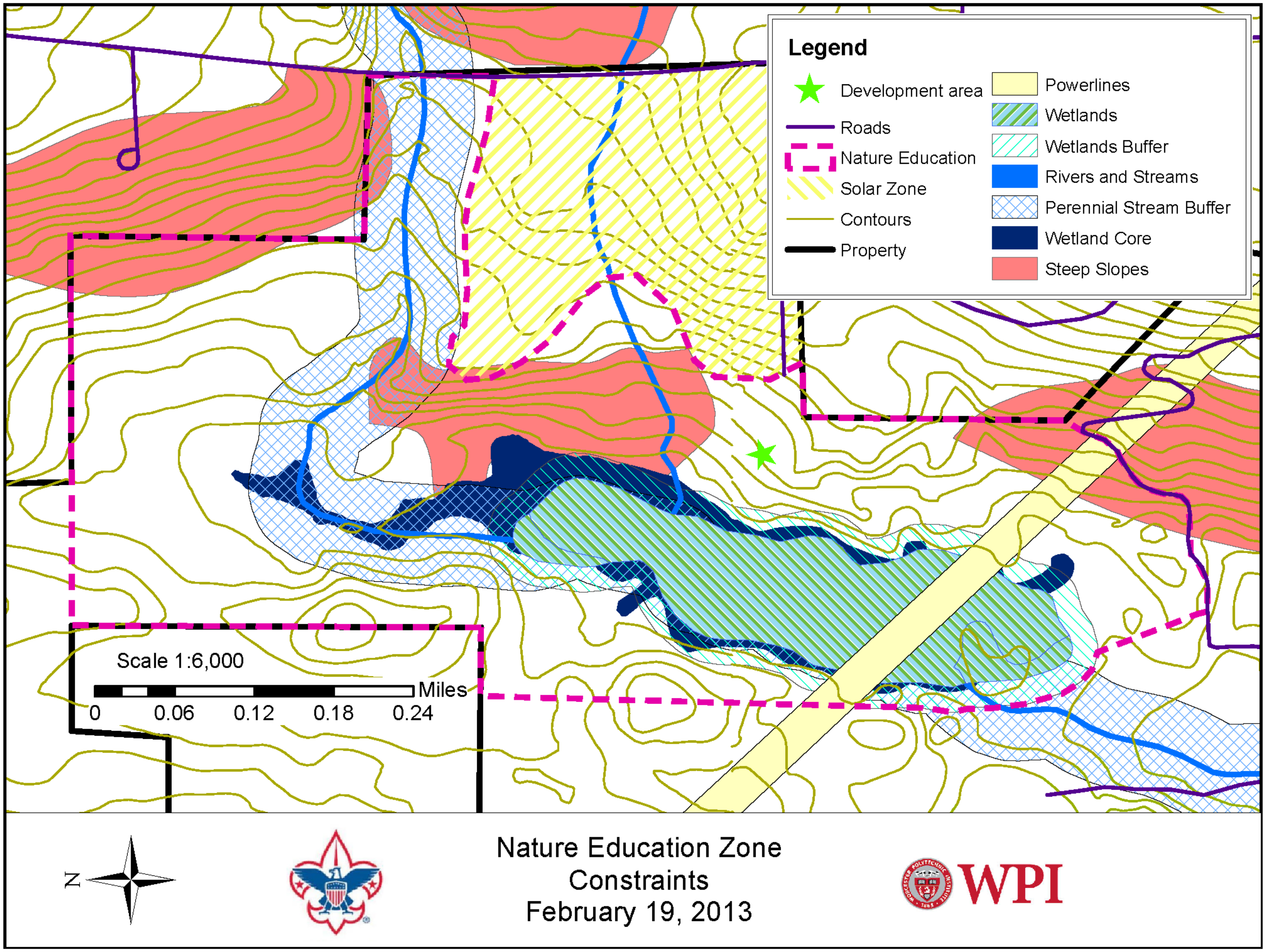


Figure 65: Nature Education Zone constraints map

The total footprint of the buildings modeled after Charlton, MA Nature's Classroom buildings is approximately 18270 feet squared. The three configurations evaluated are shown in Figure 66. Configuration 1 shows the configuration of the Charlton, MA site. Configuration 2 shows a configuration in which each building is adjacent. Configuration 3 is an additional separate building configuration that attempts to take into account the site specific constraints and needs of Treasure Valley. Based on the analysis of the three configurations, Configuration 3 was chosen.

Configuration 1   Configuration 2   Configuration 3

Figure 66 : Nature Education building configuration options

Table 18 : Benefits and Negatives for the different Nature's Classroom Building Configurations

	Benefits	Negatives
Configuration 1	● Buildings are facing each other – easy navigation between	● Does not account for site specific conditions at TV (entrance location, gradient) ● Multiple buildings need to be constructed
Configuration 2	● Need to construct only one building ● Orientation accounts for entrance location	● Eliminates need for program participants to walk outdoors
Configuration 3	● Buildings are facing each other ● Accounts for TV site conditions (configuration relative to entrance, gradient of slope, solar access)	● Multiple buildings need to be constructed

Following a selection of a building configuration, the team conducted a basic stormwater analysis in order to mitigate negative environmental impacts. For this case, the variables in the rational method were defined and considered:

The rainfall amounts should be considered in multiple cases including small storm events and large storm events. An example of a small storm event is a 1 year, 24 hour rain event. The total rainfall of this type of event in Worcester County is 2.5 inches. In terms of the Rational equation, $R = 2.5\ inches$. An example of a large storm event is a 100 year, 24 hour rain event. The total rainfall of this type of event in Worcester Country is 6.5 inches. In the context of the Rational equation, this variable would increase to $R = 6.5\ inches$ (MassDEP). This variation of rainfall intensity will lead to a variety of stormwater flow rates and volumes that need to be managed.

The runoff coefficient of a surface is a determined by the character of the surface. In the pre-development condition, the surface is in a natural wooded state with a slope between 8 and 15%. The value used for this surface can be estimated at 0.15 (Marsh). The post-development condition is an impervious rooftop. The value used for this surface can be estimated as 0.9 (Marsh). This change in runoff coefficient will significantly increase runoff and decrease infiltration.

Stormwater management processes that may be applicable to Treasure Valley are green roofs, permeable pavement, rainwater collection barrels, and maintaining trees. Details of these are found in the background section of this chapter. Table 19 lists the potential stormwater management practices with a qualitative discussion of the positives and negatives of each as applied to Treasure Valley.

Table 19 : Stormwater Management Options for the Nature Education Zone

Options	Positives	Negatives
Blue Roof	● Inexpensive ● Allows future installation of solar	● Requires special roof structural design
Green Roof	● Provides water retention and filtration	● Requires maintenance ● Requires special roof structural design ● Will limit the ability to install solar power
Rainwater Collection Barrels	● Inexpensive ● Allows for reuse of water	● Retains only 50 gallons per barrel
Cisterns	● Retains a significant amount of water	● Unattractive when placed above ground, require excavation to place underground
Permeable Pavement	● Increases infiltration	● Expensive ● Requires maintenance
Vegetation	● Natural ● Helps with infiltration and natural treatment ● Fits with the existing conditions of the area – wildlife habitats ● Reduction of nearby building cooling costs	● Best at managing water from lower intensity storm events

Based on the comparison of positives and negatives, the most significant considerations are the effectiveness at managing the stormwater, cost, and naturalness. Managing the stormwater by reducing peak flow rate and volumes and increasing infiltration will help to ensure that the wetlands and water bodies to not become impaired. Cost is important to Treasure Valley because their budget is limited, coming mostly from the lease payments for the solar development and donor participation. Naturalness of the methods is important in order to uphold Boy Scout principles of environmental stewardship in development of the reservation.

The conceptual development of the nature education area includes a significant increase of stormwater runoff within 300 feet of a wetland and 500 feet of the stream that leads into Browning Pond. Based on an evaluation of existing stormwater management options, the group recommends that the following be incorporated into the development of the nature education area.

For each of the buildings established, the team recommends the use of a blue roof. As described in section 7.1.3, a blue roof is a gravel roof that stores rainwater in the voids between rocks. The benefits of a blue roof are the relatively inexpensive cost to implement and up to 85 percent reduction of the peak flow runoff. This also leaves open the potential for the installation of solar panels on the roof in the future.

In addition to reducing the peak runoff rate, an additional method to increase infiltration before the water reaches the wetland or river is recommended. In parallel with the natural state of Treasure Valley and the goals of the nature education programs, preservation of the existing natural environment is recommended. Trees and vegetation are a natural way to reduce runoff and encourage infiltration. Ensuring that the existing trees are maintained, especially down gradient from the new development, will help to manage stormwater.

In an effort to maintain the natural buffer, the construction of the new buildings should attempt to reduce the amount of tree clearing necessary. Following construction of the new buildings in the Nature Education zone, trees should be replanted up to within 50 feet of the buildings. This distance will not only provide the maximum amount of stormwater control, it will also help ensure future solar access of the roofs. The trees planted should be native species found in the area and should ideally include evergreen trees, given that those intercept more rainfall than deciduous trees. In addition to tree re-planting, the inclusion of a forest filter strip will be applicable in increasing the management capacity of the trees for stormwater, especially in higher intensity storms.

The profile of a forest filter strip sample design is shown in Figure 67. This design includes a small gravel diaphragm adjacent to the development that filters the main sediments out of the runoff. The ponding zone is a depression where water collects during rain events and is planted with shrubs rather than trees. To allow this system capacity to handle storm events larger than 1 inch, a gravel berm with a wire mesh will allow more ponding and increased filtration (forestsforwatersheds.org). The conceptual application of this system in the Treasure Valley Nature Education zone is shown in Figure 68 along with the final building conceptual design.

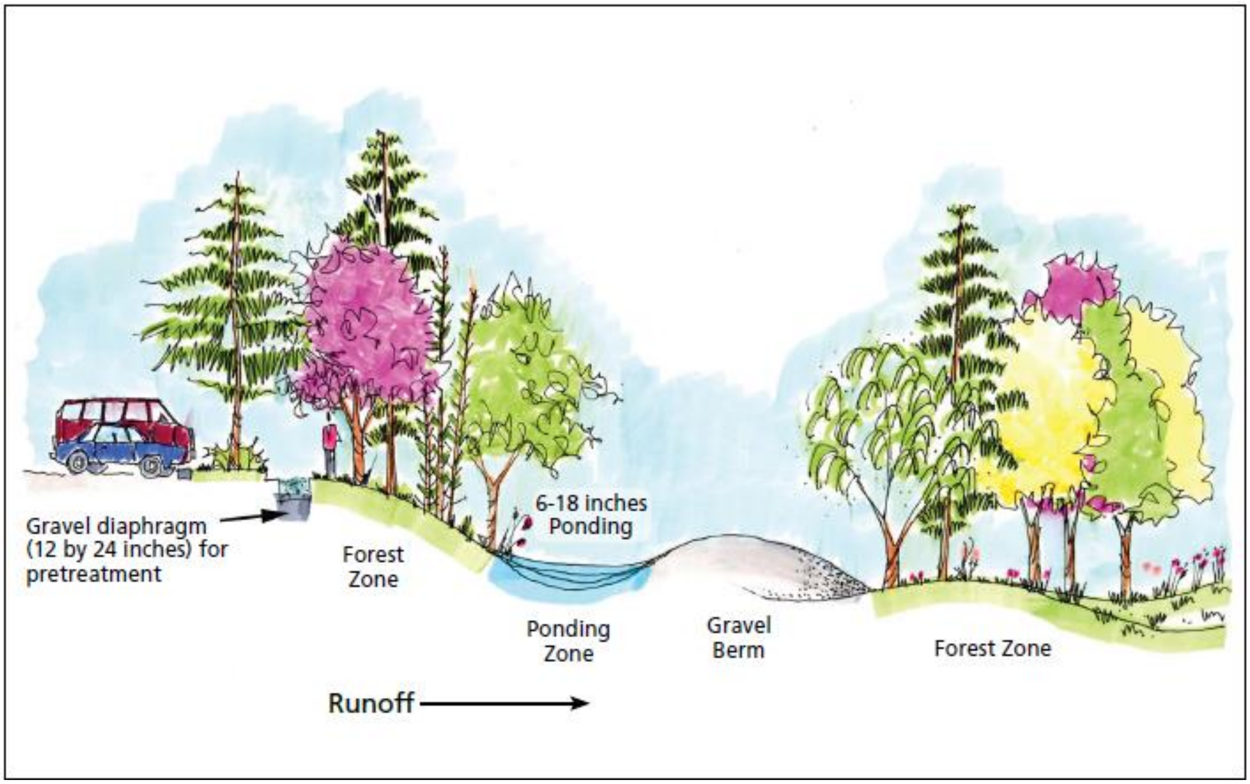


Figure 67: Forest Filter Strip system (forestsforwatersheds.org)

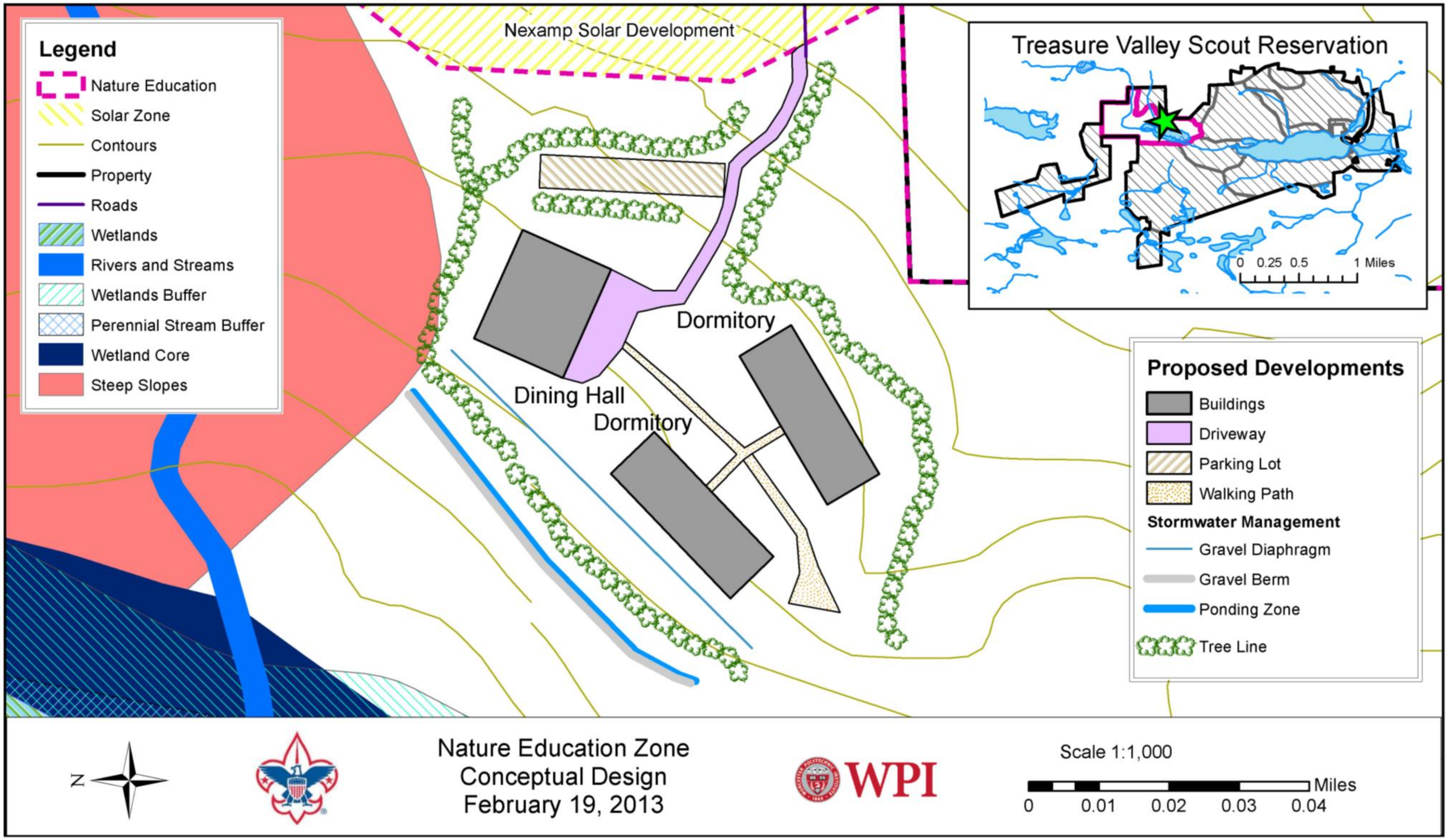


Figure 68: Nature Education zone conceptual design

The phases of development for the nature education area are established for ease of implementation. The initial phase, Phase 0, is the establishment of a road from Pleasantdale Road along the side of the solar development to the recommended development site. This road is a part of the development plan that Nexamp will execute as part of the development of the solar farm. Phase 1 of the development will be the construction of the dormitory building. This must be completed as the first step in order to have the capacity to host the nature education program. Once the construction is completed and the construction area is re-established as natural environment, the outdoor program areas should be developed along with established paths to access the areas.

Figure 69: Descriptions of implementation phases for the Nature's Classroom program

7.3.2.3 Parking

A capable central parking area is paramount to ensuring there is enough parking. Several different parking lot locations have been identified in Figure 70 based on the present constraints and existing infrastructure. A summary of the pros, cons, area, and capacity of each location is located in Table 20.

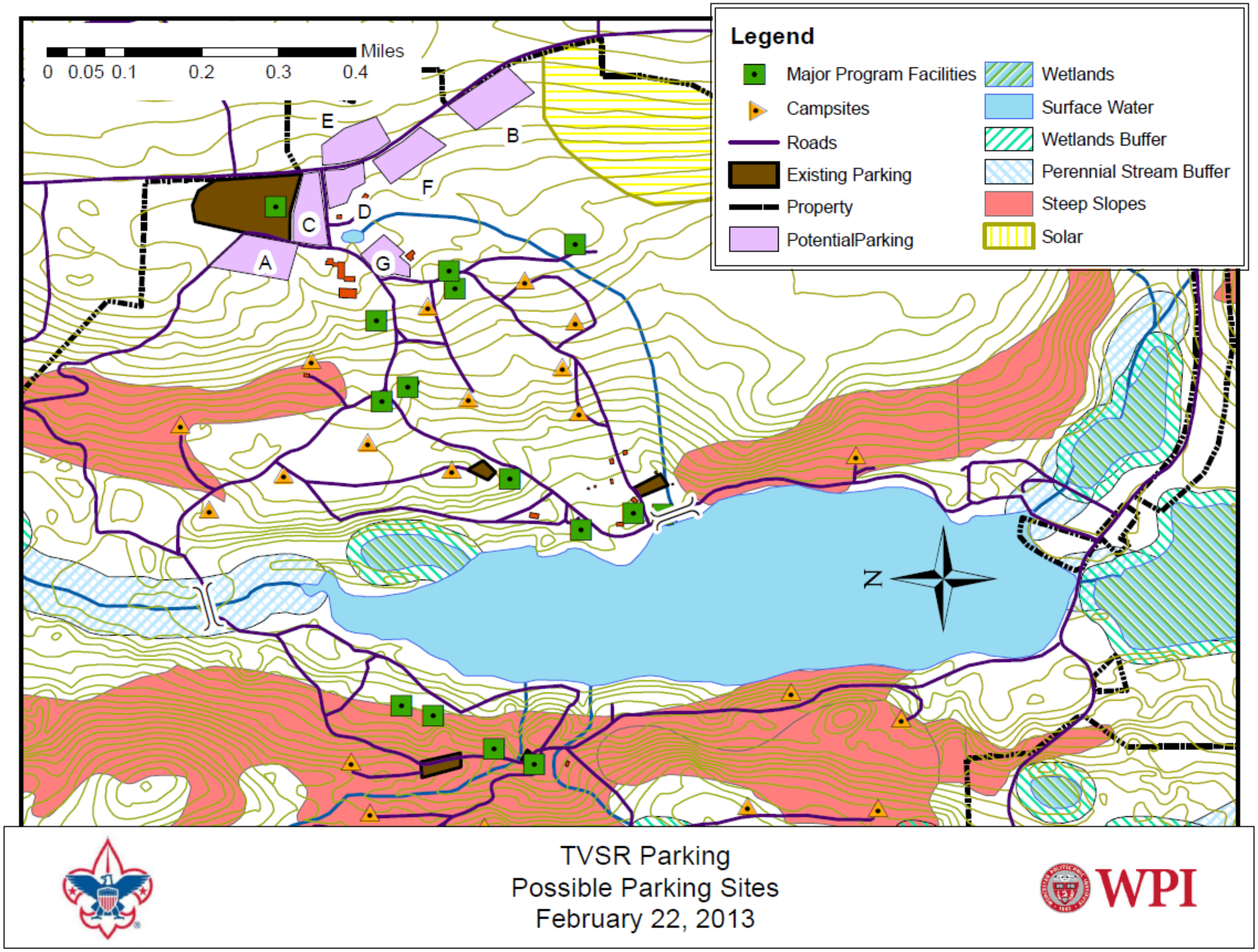


Figure 70 : Map of Potential Parking Areas

Table 20 : Proposed parking Site Information

Parking Lot	Area (ft^2)	Capacity	Increase in Runoff (ft^3)	pros	cons
A	120,296	200	17,543	Next to the Jamboree field, large capacity	relatively further into the reservation,
B	119,386	199	17,410	On the main road	would have to use main road to get to entrace (or need additional trails/roads), further away from TV
C	91,700	153	13,373	Right at the enterence, next to jamboree field, on the main road	Would replace many trees causing the entrance to TV to be less attractive
D	54,730	91	7,981	Right at the enterence, on the main road	Would replace many trees causing the entrance to TV to be less attractive
E	93,467	156	13,631	On the main road	have to cross the main road to get to the reservation
F	85,661	143	12,492	Close to the entrace of TVSR, on the main road	would have to use main road to get to entrace (or need additional trails/roads)
G	57,413	96	8,373	close to many building and sites	encroaching on the reservation (unsightly), need some driving through the reservation

The larger the lot, the more space and impact the development will have on the local environment. The two types of parking would either be a packed-dirt clearing or a paved flat area. Either type will reduce the infiltration capacity of the area and increase storm water runoff. A dirt lot will allow significantly more infiltration than a paved surface (which is nearly impervious) but it will still have a great effect due to changing of the natural characteristics of the area (i.e. eliminate or reduce vegetation, compacted soils, etc.). Preliminary calculations should be conducted to determine general storm water conditions for before and after development. Like for the educational housing facilities, the rational method is a good choice since it will present a broad sense of potential environmental impact without significant calculations or analysis since there would be many different factors affecting runoff. Using the 1 year, 24 hour rain fall event of 2.5 in and a change in the runoff coefficient of 0.70 (from 0.15 to 0.85), each increase in volumetric storm water runoff is calculated in Table 7.

For the foreseeable future, TV will not require too many extra spaces. The design number used is the Summer Camp parking demand of 210 spaces. As it expands, it can be assumed that the parking requirements will increase by 50% due to an increase in scouts and staff which translates to a parking demand of 315 spaces. The jamboree field should still be able to hold this increase in demand, but the area is starting to become quite full. These calculations are quite broad. It is reasonable to believe that additional parking will be needed especially with a new Venturing program area and doubled Cub Scout program.

The two ideal proposed parking lot locations are parking areas A and B (highlighted in Figure 71. Area A would be a good first expansion to the TV parking system. It is adjacent to the

Jamboree field (existing parking) so overflow from this lot could go into the other field. Area A is located near the entrance so visitors would not have to drive through much of the reservation and it has access to existing drivable roads. It is also away from much of the program buildings, campsite, and initial scene of the Reservation. After even more development, a parking lot could be sited in Area B. At the point where Area A is filled up, there will need to be many people using the reservation. From here, individuals or busloads of people can park/be dropped off in this lot and then either be transported by some sort of shuttle or walk to their destination. This lot is significantly removed from the rest of the Reservation, but it will not have any direct effects on any of the inter-uses of Treasure Valley. From this location, a trail or road could be constructed to the existing road network or to the proposed Venturing area. Both areas are away from steep slopes and wetlands.

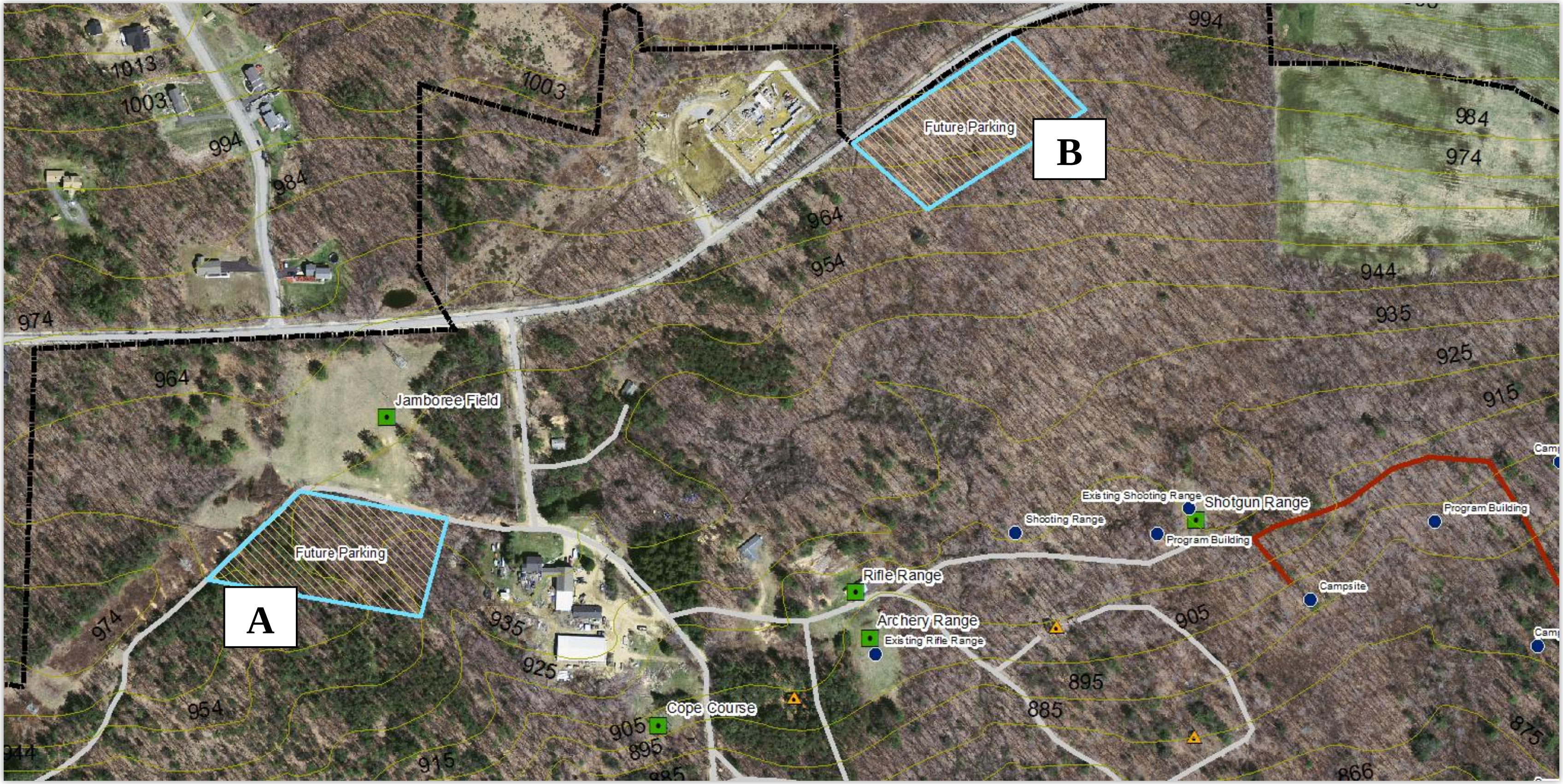


Figure 71 : Two recommended parking areas

Figure 71 shows a map of the proposed parking expansion for the reservation. The parking recommendations are based on ease of access to the entrance of the reservation, expanded capacity, and minimization of environmental impacts. The configuration shown is determined to be the most feasible option for parking expansion. The first focus would be on ensuring the parking capacity is large enough to accommodate future expansion. The proposed lot across the street from the jamboree field would the ideal location for the first parking lot

The tree clearing that would be necessary to create these two parking areas would create a significant increase in stormwater runoff of those areas and therefore create a need to manage this runoff. As discussed in section 7.3.2.2, the stormwater solutions need to be able to handle the increased capacity due to the increase in runoff coefficient of the surface for a variety of different storm event sizes.

The area of most concern is Lot A. Lot A's location is uphill from the existing farmhouse complex. This area must be protected from flooding or erosion that can result from increased runoff since equipment storage and many construction and repair projects are located at this location. In this case, two characteristics of a stormwater management system are required. First, the system must reduce the runoff rate and/or volume of stormwater to mitigate negative effects to the downhill developments. Also, the systems must provide some filtration of contaminants from vehicles to protect local wetlands and especially Browning Pond.

For this purpose, the use of a rain garden is recommended. Rain gardens are depressed soil areas with vegetation that reduce the amount of stormwater runoff. This technique makes use of bioretention and biofiltration to accomplish both necessary component of the management system. Given the slope of these areas, the system should be designed to reduce the flow rate of the runoff in order to allow for increased infiltration and stormwater storage. An example of a design technique like this is shown in Figure 72. This design allows some ponding to occur on the slope (Center for Watershed Protection). The tree clusters in combination with other natural vegetation should be positioned downhill from the parking lots. The garden design should be determined after the design of the parking lots is finalized to ensure that the system will effectively capture and manage the increased stormwater.

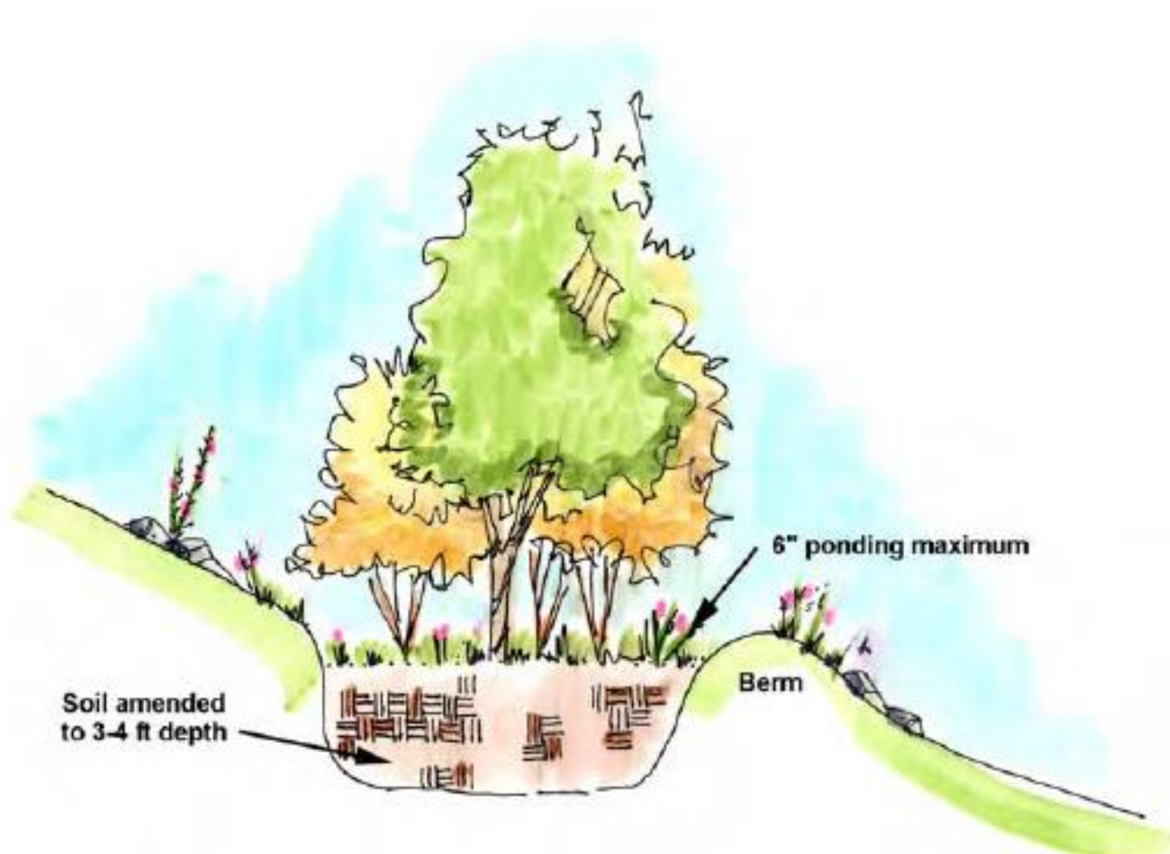


Figure 72: Tree cluster design profile

For the Inter-Reservation Transportation System recommendations, the only constraint was the need for a drivable road network throughout the reservation. With a central parking and TVSR drop-off area, this will be the starting point of any route created for the IRTS. Currently, the Jamboree field would serve as the central parking location. As TV is developed, Parking area A and B will then be the main parking areas. From these locations, the shuttles that will be transporting people will originate and return to these locations.

Figure 75 shows key locations in TVSR that would normally see high volumes of people. In addition to these main locations, other areas including campsites, future development, etc. might conditionally need a pickup/drop off shuttle stop.

At the individual Inter-Reservation drop-off/pick-up locations, there must be enough space to allow people to easily enter and exit the shuttle. These locations should be near the road and near the IRTS stop.

The Cub Day Camp is the location in Treasure Valley that will most likely see a need for this sort of system. Parents drop off their children in the morning and pick them up later in the day.

The camp is located in West Camp which is on the other side of Browning Pound from the entrance of TV. Figure 73 shows two possible pick-up/drop-off locations. The challenging issues in this area are the tight turns of the roadways and the steep slopes. The upper circle shows a spot where the shuttle could drive by and let the riders off in front of the Day Camp building. The shuttles would then be able to back-up in front of the building and drive the other way. The 2nd lower circle indicates an existing parking lot. This lot could be the pick-up/drop-off stop for the shuttle. The Scouts and other riders could walk down a path that would have to be created from the parking lot to the day camp area. The shuttle could then easily turn around in the lot and return back to the rest of the Reservation. Both of these shuttle routes can be seen in Figure 74.

Figure 73 : Potential Cub Day Camp Drop-Off/Pick-Up locations

Another challenge with the Cub Day Camp is that the future development is unknown. The area will be expanding. It is recommended that any future development would be designed incorporating an IRTS stop and other road/parking designs to facilitate the circulation of shuttle vehicles.

A final map encompassing the IRTS and the parking lot expansion recommendations can be seen in Figure 77.

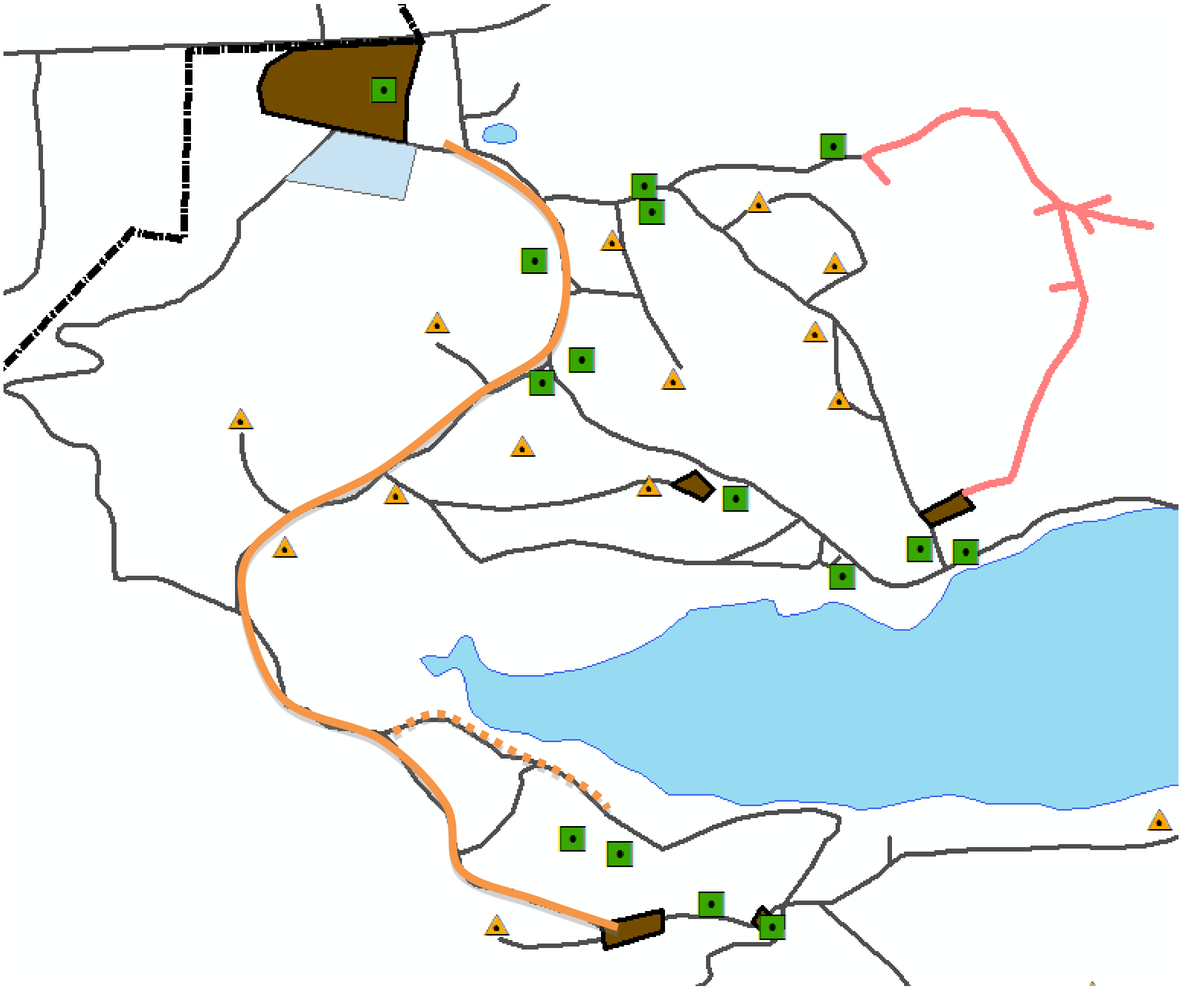


Figure 74 : Two Possible Shuttle Routes for the Day Camp

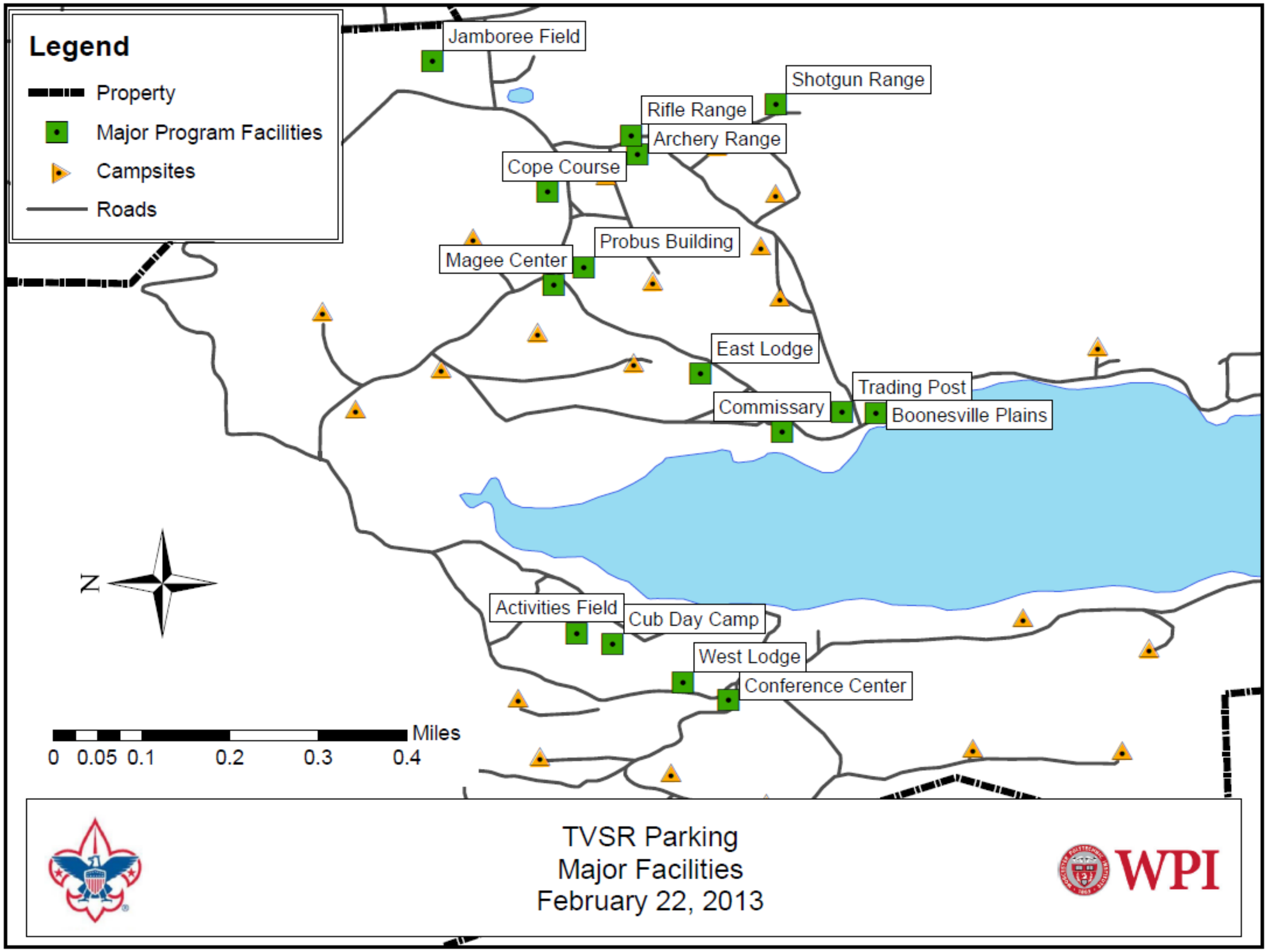


Figure 75 : Important Areas in TV

The phases for parking development:

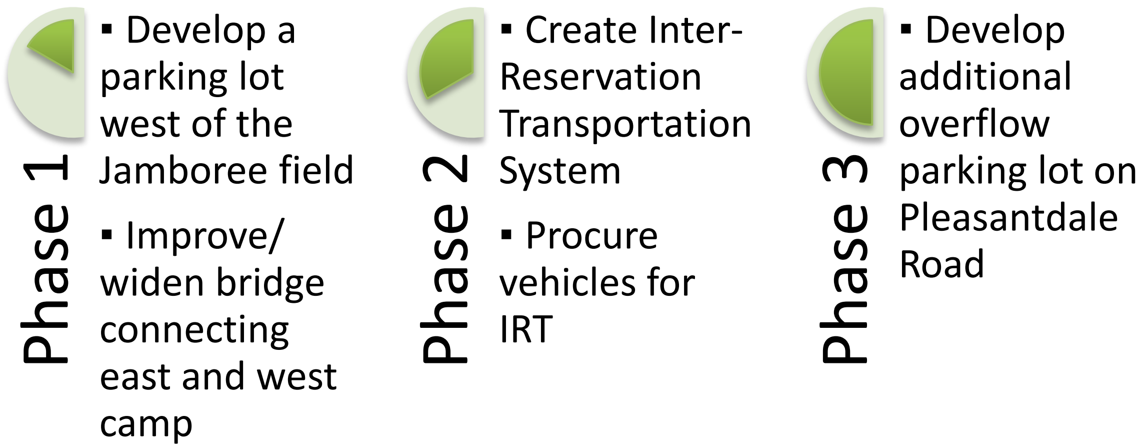


Figure 76: Descriptions of the development phases for the parking system expansion

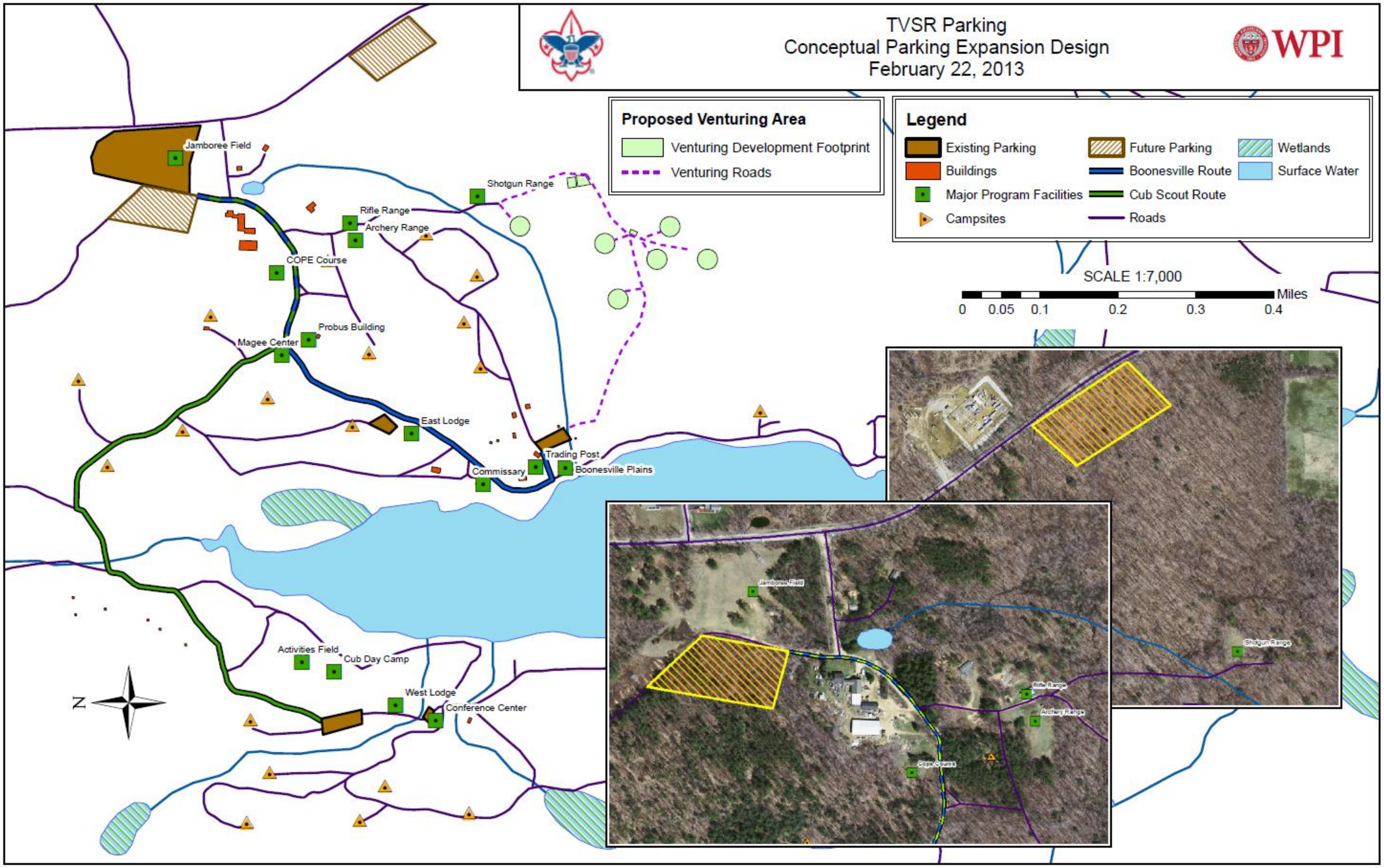


Figure 77 : Final parking system recommendations map

8.0 Solar Education

The purpose of this chapter is to detail the research and creation of a website that can be used to facilitate Science Technology Engineering and Mathematics (STEM) learning through the use of solar power as the website topic. The methods used to create this website were input from stakeholders and identification of useful educational resources. The resulting website is a centralized compilation of program information and learning activities that can be used in various STEM learning programs by the Boy Scouts.

8.1 Background: STEM Education

In the US and Massachusetts in particular, there has been recent governmental attention paid to the education in the areas of Science, Technology, Engineering, and Mathematics (STEM). The Massachusetts Department of Higher Education has developed the STEM pipeline program where they have a fund of $2.5 million to award in grants to schools and institutions. In 2003, the Economic Stimulus legislation in Massachusetts was passed which set the goals of promoting interest in STEM, increasing proficiency and graduation rates in STEM areas, and preparing students in those fields for STEM careers (www.stemedcoalition.org).

8.1.1 STEM in Scouting

Treasure Valley has a few different avenues for STEM learning. Merit Badges, the NOVA Program, and Nature's Classroom, are all programs that TVSR hosts or plans to host in the near future.

The Boy Scouts value a practice-based learning approach. To encourage this, they have a merit badge program. Boy Scouts earn merit badges by choosing from the over 100 badges that come in many different subjects. These badges range from Energy to American Business to Gardening, to Water Sports. A merit badge councilor, who is an expert in the field, helps facilitate learning in the area by following the guidelines set forth by the Boy Scouts. The guidelines require the boy scouts to gain a basic understanding of the concepts and to demonstrate that understanding. Badges can be earned by any age of scout (www.scouting.org).

The Boy Scouts have recently adopted a STEM program of their own in the form of the NOVA Awards Program. NOVA and Supernova awards are given to the scouts who complete a special project in a specific area of STEM. In each level of scouting, Cub Scouting, Boy Scouting, and Venture Scouting, there are four Nova award programs. In each program, there is a specific set of requirements that must be completed with a councilor. The Supernova Awards are awards with more "rigorous" requirements for learning within STEM disciplines.

The NOVA awards earnable by each level are as follows:

Cub Scouts: Science Everywhere, Tech Talk, Swing, 1-2-3 Go!, Dr. Luis W. Alvarez Supernova Award

Boy Scouts: Shoot, Start Your Engines!, Woosh, Designed to Crunch, Dr. Bernard Harris Supernova Award, Thomas Edison Supernova Award.

Venturing Scouts: Launch, Power up, Hang On, Numbers Don’t Lie, Dr. Sally Ride Supernova Award, Wright Brothers Supernova Award, Dr. Albert Einstein Supernova Award

These awards, though they vary in content and age level, generally have the same formula to achieve an award. For example, each program contains three parts. The first part involves the scout doing research regarding their topic. For this section, they are given suggestions for medium and resources, such as documentaries or magazine articles. The second portion involves the completion of a choice of merit badge that falls within that category. Finally, the last steps involve a project that demonstrates knowledge in the area.

As discussed in Section 7.2.2.2 of this report, Nature’s Classroom is a program that Treasure Valley desires to host on its land. Nature’s Classroom is a program for school aged kids that provides an opportunity for students and teachers to experience education outside the walls of a classroom. The facilities that were recommended by this project were based on the facilities for the program in Charlton, MA. In the Charlton, MA Nature's Classroom the director of the program made the decision to purchase a wind turbine for the facilities to supplement the energy demands of the program. The turbine not only functions to provide 10% of the energy for running the facilities, but also serves as an educational tool to assist in nature education programs. These programs include energy independence, the physics of wind, electricity, and renewable energy (Northern Power System). This shows that local renewable energy projects can be used to facilitate STEM learning, particularly in the area of energy literacy.

8.1.2 Teaching with Solar

Students are introduced to the concepts of energy and electricity for the first time in elementary school. At the elementary level, the main focus from a STEM pipeline perspective is to increase students' interest in the subject (STEM Ed Coalition). One suggestion for improving the methods of teaching energy is to use a more visual approach. Since teaching energy is quantitative by nature, teachers and students can feel confined to an explanation or description that lacks context. By ensuring that students can visualize a qualitative description of the energy will make concepts more understandable and easier to follow with relevant calculations. For example it is advantageous to include visuals of a physical system such as a circuit to demonstrate electricity and an example of a source of the energy such as solar panels or a power plant (Lawrence). A real world example can provide the context necessary to emphasize the practical applications of learning the concept of energy

The needs of STEM programs for Cub Scouts and Boy Scouts are vastly different. To understand the difference, one can consult the Department of Education in Massachusetts framework of topics that are recommended to be taught at each age level. Cub Scouts, being ages 7-11, coincide with the 3rd-5th grade level. Boy Scouts, being ages 12-18, fall in the 6th-8th grade level and high school level. The concepts that are related to solar energy within science engineering and technology are shown by grade level in Table 21.

Table 21: Solar energy learning objectives by level (adapted from DOE Learning Standards)

Broad Topic	3rd-5th Grade	6th-8th Grade	High school
Energy in the Earth's Systems	The sun's influence on weather patterns	Sun's influence on weather, climate, and seasons	Solar radiation: transfer from the source and effects on earth
Materials and Energy Resources	Properties of minerals		Renewable and nonrenewable resources
Forms of Energy	Basic energy sources and transfer	Transfer of energy (i.e. potential to kinetic, movement of heat)	Energy laws: conservation, entropy
Electrical and Magnetic Energy	Electrical circuits, conductors, and electromagnets		Laws of electricity (i.e. Ohm's, Coulomb's)
Sound and Light Energy	How light travels (i.e. reflection, refraction, absorption)		Properties of light waves

Unlike a school environment, the learning that takes place through Boy Scout programs is extramural learning, meaning that it takes place outside of the classroom. Typically extramural learning is characteristic of hands on and interactive learning which is in line with the goals of the Boy Scouts (Broman). The learning in these settings should be consistent with what is being taught in school to ensure higher understanding of the concepts.

Currently, there is a wealth of resources available for learning through solar power applications. The US Department of Energy published an Energy Literacy handbook that provides seven principles that are key in energy education. The handbook is designed to provide guiding principles on which energy education programs or curriculums should be based. The seven principles are shown in Figure 78.

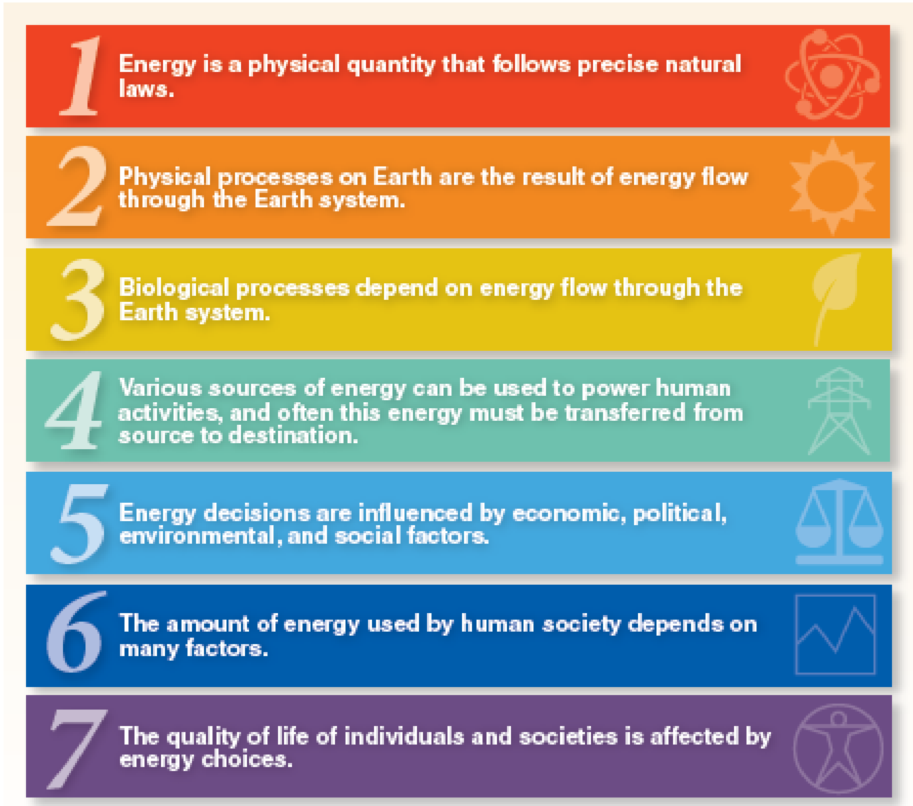


Figure 78: The Essential Principles and Fundamental Concepts of energy literacy

The US Department of Energy has a centralized resource of K-12 lesson plans and activities in a searchable database by energy topic. Each of these lesson plans are in line with the national standards. These lesson plans are categorized by age levels K-4, 5-8, and 9-12. Through research of the various lesson plans, there are currently 23 lesson plans that have been compiled from various sources around the country.

"Energy From the Sun (Seven Activities)" is a lesson plan for ages K-4 created by National Energy Education Development Project (NEED) and made available by the DOE. This lesson plan contains seven activities that are designed to present a variety of areas of solar energy. The start is a basic introduction of solar energy and proceeds to the various applications of solar energy. These include how solar energy can provide heat and motion, cause chemical reactions, and be used to create electricity. More specifically, the explanations cover the natural processes that solar influences such as weather and photosynthesis, and also human harnessed applications like photovoltaic cells. These topics are indicative of the range that can be covered to provide a comprehensive understanding of solar energy. The other lesson plans in the searchable database cover these same topics with different strategies and for different age levels. Some common activities are creating solar ovens, solar water distillers, and modeling solar photovoltaic cells.

The US Energy Information Administration has published a website titles Energy Kids with a page dedicated entirely to solar energy. This page follows a similar pattern as the NEED lesson plan described above. It begins with a discussion of the basics of energy from the sun and proceeds to the various applications of solar energy. This site focuses mostly on how solar energy can be harnessed by humans through solar thermal collectors and photovoltaic cells, rather than natural processes of weather or photosynthesis.

8.2 Methodology

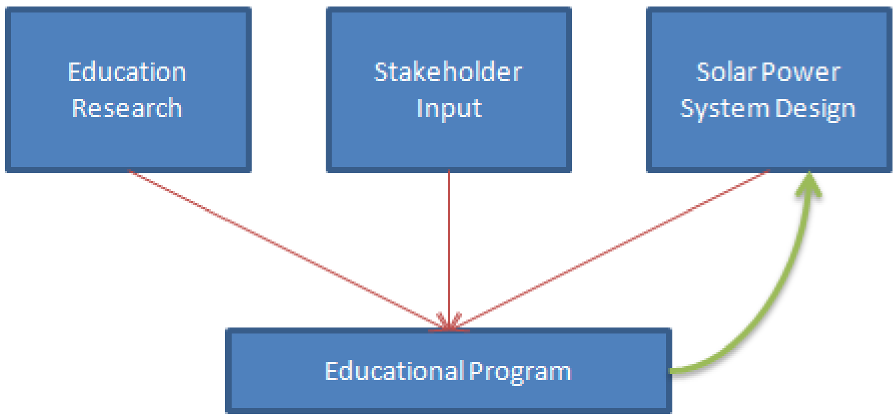


Figure 79: Educational program organizational flowchart

Throughout the design of the solar powered campsite lighting system in this MQP to be installed at Treasure Valley, considerations for presentation to the users of the Reservation were made. The presentation of the system was designed to be friendly and engaging for the Boy Scouts. This initial consideration during the design phase has allowed for integration of an education tool that will encourage interest in renewable energy in the scouts.

The process for development of the education tool involved the combination of three factors. The process included research regarding effective methods for teaching the topic of solar energy. The methods researched were utilized to develop a learning tool. Another important factor was input from the Stakeholders. The Boy Scouts are an organization that values learning by doing for the boys. Knowledge of these programs for integration into their methods was beneficial. Additionally, the solar power system that this group designed and the 6 megawatt array planned to be built on Treasure Valley land were important factors in determining the type of information that will be presented and how it will be presented for the education portion.

8.2.1 Identifying Goals and Learning Outcomes

The first step towards creation of a solar power STEM learning tool was to identify the goals. The goals were developed from the needs of the programs for which it was designed to be a part of. The next step was to itemize the learning outcomes that are desired. These were determined based on the existing resources available for teaching about solar energy.

Based on the established goals and learning outcomes, the media through which the the resources would be presented was determined. There were key features that, based on the needs of the users, must be met by the tool. In satisfaction of these criteria, a website fits the requirements. A website can be designed to present information that can be applied to various programs by providing a vast array of resources under various subheadings to meet the specific needs of programs. Additionally, a website is adaptable because it can be edited as the needs of a program changes. Those who run programs can have login information that will give them permission to change the presentation of information. Finally, a website allows all the users to have easy access to a centralized resource of information.

8.2.2 Website Design

To organize the content of the website, an outline of the data to be compiled was created. The outline was based on the needs of the stakeholders and the descriptions of the programs the tool is meant to facilitate. This list is shown in the results section of this chapter. After the creation of each page based on the established outline, the textual content for inclusion for each section was developed. The content of each page can also be found in the results section of this chapter.

8.2.3 Stakeholder Input

Stakeholder input was gathered, as it was throughout the completion of this project, through a series of meetings followed by email communications. The main participants of these efforts were Ray Griffin and Chris Paquin. Ray Griffin was able to identify the specific needs in terms of where a learning tool would be most desired. Ray is currently working on coordinating a week long program at Treasure Valley for boys to work towards achieving Nova awards. Chris Paquin is a troop leader and parent who has created his own website with resources for his troop and understands what would be helpful in the design of a website. He was able to provide insight on what the most useful structure of a learning website from a user's perspective. A meeting was held on March 22, 2013 to conceptualize the design and email communications followed with useful input at the design process progressed.

8.3 Results: Solar Website

This section of the report details the final product created for learning about solar power. This resource can be used by scouts, scout masters, parents, and any other members of the Boy Scout community to help learn about solar.

The website was created on a sub-domain of Weebly.com. This is a website creation service that allows free access to the creation of sub-domains with user friendly editing capabilities. The design options include layout selection, content creation, and page organization. This site was chosen for user friendliness and can easily be transferred to another owner.

8.3.1 Goals and Learning Outcomes

The purpose of this learning tool is to facilitate STEM learning by providing an illustrative example of solar energy. Based on the needs of the programs detailed in section 8.1.1, the goals are shown in Table 22.

Table 22: Goals established to guide creation of the solar website

Goal 1. Encourage excitement and interest in learning about solar energy
Rationale: The main design of the NOVA program through the Boy Scouts is to encourage interest in STEM fields. Therefore, it follows that this website ought to also get Scouts excited about the topic of solar energy.
Goal 2. Provide a comprehensive understanding of solar energy
Rationale: There are currently many established learning objectives for lessons involving solar power. In order to be consistent with age levels and appropriate learning objectives, this tool should convey the correct information that matches appropriate learning objectives.
Goal 3. Present tangible examples of solar power systems
Rationale: This tool will also have an advantage of being paired with two very local examples of solar photovoltaics in action. This website should showcase these examples and expand upon them to put them in context.
Goal 4. Be dynamic, adaptable, and accessible
Rationale: The tool needed to be dynamic, adaptable, and accessible. Having the tool be dynamic would mean that it would be able to be used for solar power education, regardless of its application. This includes use by the Nova Program, Energy Badge, or Natures Classroom. Each of these applications have a place where solar education can be a medium through which learning occurs. Having the tool be adaptable means that it should have the capability to be updated by future users to make sure it remains relevant and useable. In addition, in order to be applied, the resource should be accessible to all those who would use it. This way, troop leaders, parents, and scouts can all have access to the same centrally located information.

The learning outcomes were created from research of existing solar education programs. After experiencing this website, the Scouts should be able to understand the following about solar energy:

- It provides most of the planet's energy in various forms
- It has a social, political, and economic context
- It is important as an environmentally friendly source of electricity

8.3.1 Website Outline

Table 23 shows an outline of the website as it was designed. It includes the main pages and subpages, and descriptions of the content of each.

Table 23: Website Outline

Home page	
• The home page serves to describe what the site is for. It includes a description of STEM and Nova. It will also provide a brief explanation on how to navigate the site based on what one is looking for.	
Nova program details	
• This page provides a slightly more detailed description of specific Nova Awards that apply to Solar. This also includes a list of Mentors with contact information who are available for Scouts to work with to complete a Nova Award.	
Solar Energy	
• This site details the basics of solar energy and its various applications.	
	Solar for Cub Scouts
	• This page contains activities and lesson plans for Cub Scouts to facilitate learning in STEM areas through Solar Power. These activities can be used to accomplish the learning objective in various STEM programs in Scouting
	Solar for Boy Scouts
	• This page contains activities and lessons for Boy Scouts to facilitate learning in STEM areas through Solar Power. These activities can be used to accomplish the learning objective in various STEM programs in Scouting.
Solar Photovoltaics	
• This page gives an overview of solar being used to create electricity. It includes important definitions and explanations that are helpful to understand photovoltaic cells.	
	Treasure Valley 6 Megawatt Array
	• This page contains detail of the 6 megawatt solar farm being built on Treasure Valley land
	Treasure Valley Campsite Lighting
	• This page contains details of the off grid campsite lighting system designed in this MQP in chapter 6.
	Questions
	• Accompanied with the data in the Solar Photovoltaics pages are some questions that allow the viewer to delve deeper into the data and perform some basic analysis.
Solar Resources	
• This page contains resources to provide constructive avenues for further research of solar power. These include videos and websites.	

8.3.2 Content by Page

This section includes the written and visual content of each page of the website. PDFs of each page can be found in Appendix I.

Home Page

This website is for Cub Scouts and Boy Scouts learning about Solar Power. Solar power provides an excellent example for learning about energy and technology.

Treasure Valley is becoming a leader in the community for their dedication to renewable energy technology. Treasure Valley will soon be home to what is currently the largest solar array in the state of Massachusetts. Additionally, Treasure Valley has made an effort to incorporated small scale, off-grid, solar power into the daily operations of the reservation including the lighting of the entrance sign as well as campsites at night time.

The contents of this site present solar in a broad view and in the context of the solar projects on the reservation. These resources are designed to be used to help learning in Science, Technology, Engineering, and Mathematics (STEM) disciplines. These programs include the Nova program, merit badges, and a potential Nature's Classroom program (BSA, Nature's Classroom).

Nova Program

NASA and the Boy Scouts of America have teamed up to create the Nova program. Nova awards are given to scouts who have shown exemplary learning in the areas of Science, Technology, Engineering, and Mathematics (STEM). There are four awards, one for each of the STEM areas, for each level of scouting. The Supernova awards involve more in depth programs in these areas, and are awarded at each level of scouting. The aim is for scouts to get exposure to and excited about STEM fields in pursuit of these awards.

Understanding energy is a vital concept in science and technology. The concept of solar energy is an illustrative example of energy from source, through generation, to application. The Nova award that is most applicable to Solar is the "Start Your Engines!" award. For details of each award, follow the links below.

Solar Energy

Energy from the sun is the main source of energy on planet Earth! The only sources of energy that do not come from the sun are geothermal and nuclear energy. Wind power, water power, and fossil fuels are all influenced by the suns energy.

The energy from the sun stays on the earth because of the greenhouse effect. In the same way that a greenhouse lets in light and keeps in heat, our atmosphere traps some of the energy from the sun.

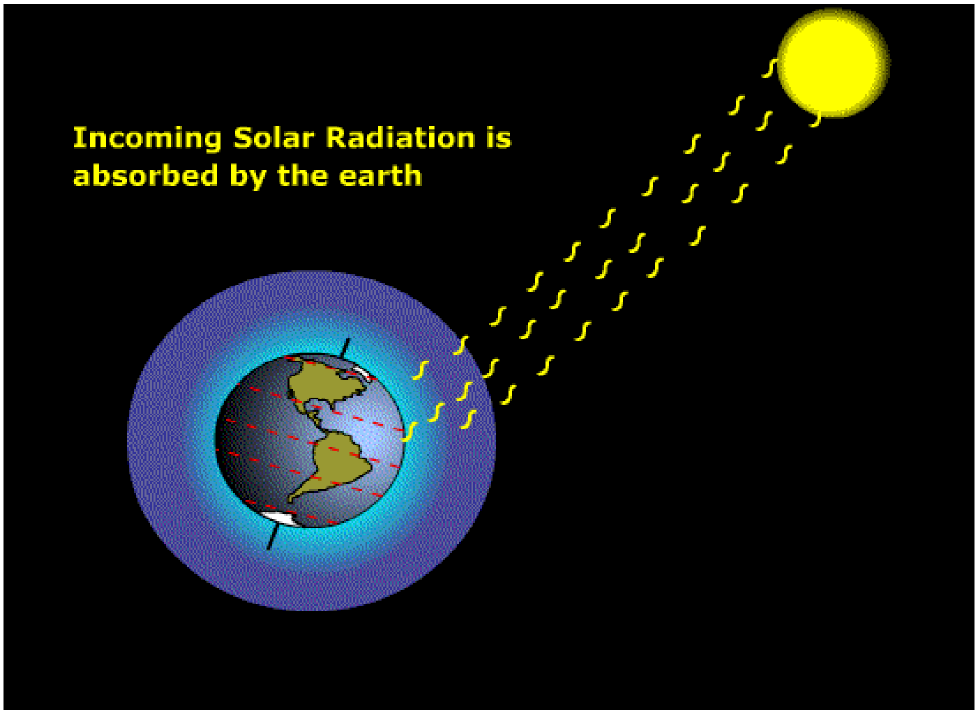


Figure 80: Animated visual of the greenhouse effect, taken from http://myweb.rollins.edu/jsiry/Picturing_the_Science_G-Schmidt-Climate.htm

Life depends on the flow of the suns energy through its systems

- Weather patterns are influenced by the suns energy (Linked to Figure 81)
- Plants produce energy from the sun through photosynthesis (Linked to Figure 82)
- Solar energy can be harnessed directly to make electricity with Photovoltaic cells
- Heat from the sun can be used to warm water and other fluids

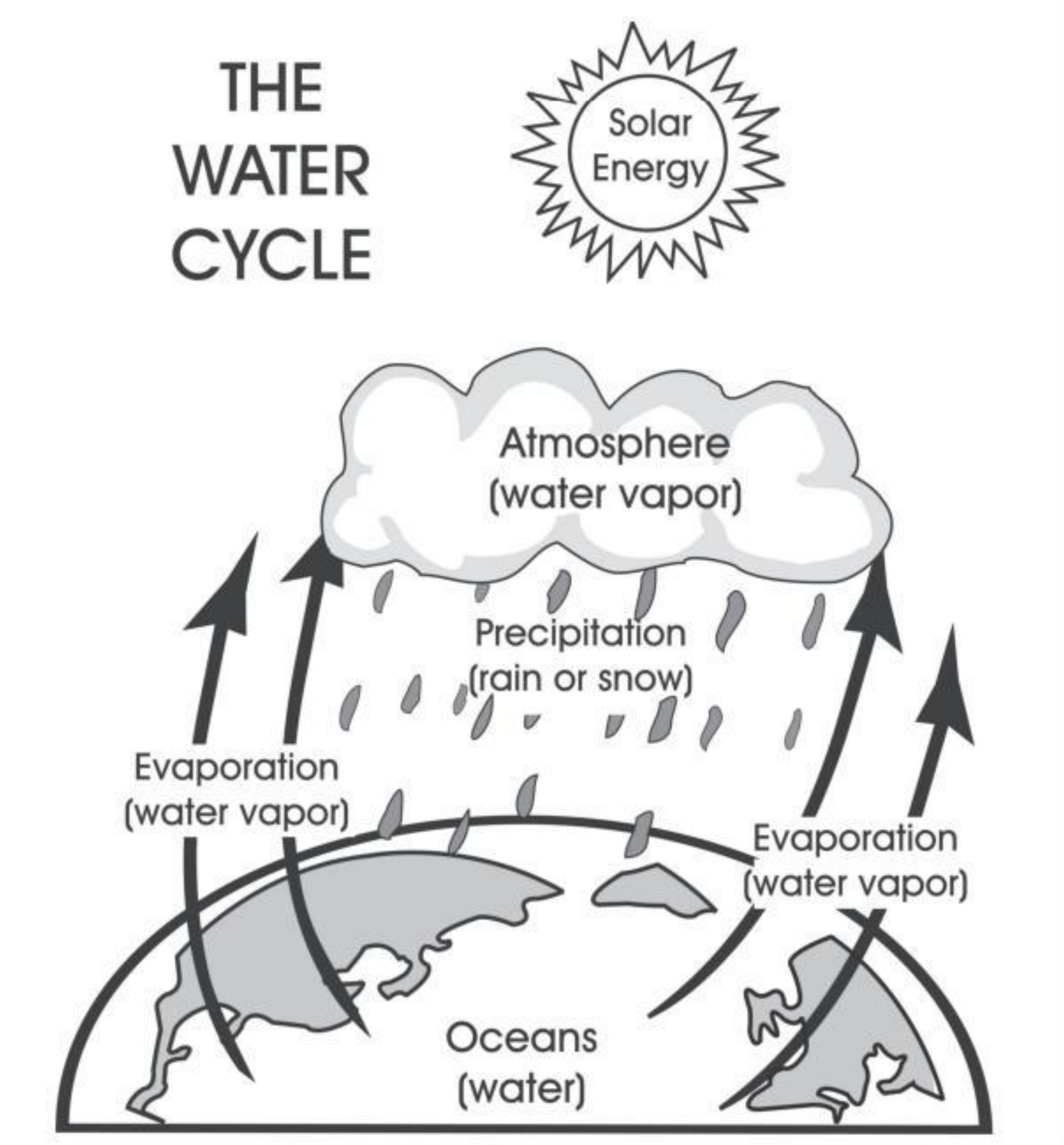


Figure 81: Image displaying how solar energy affects weather (DOE)

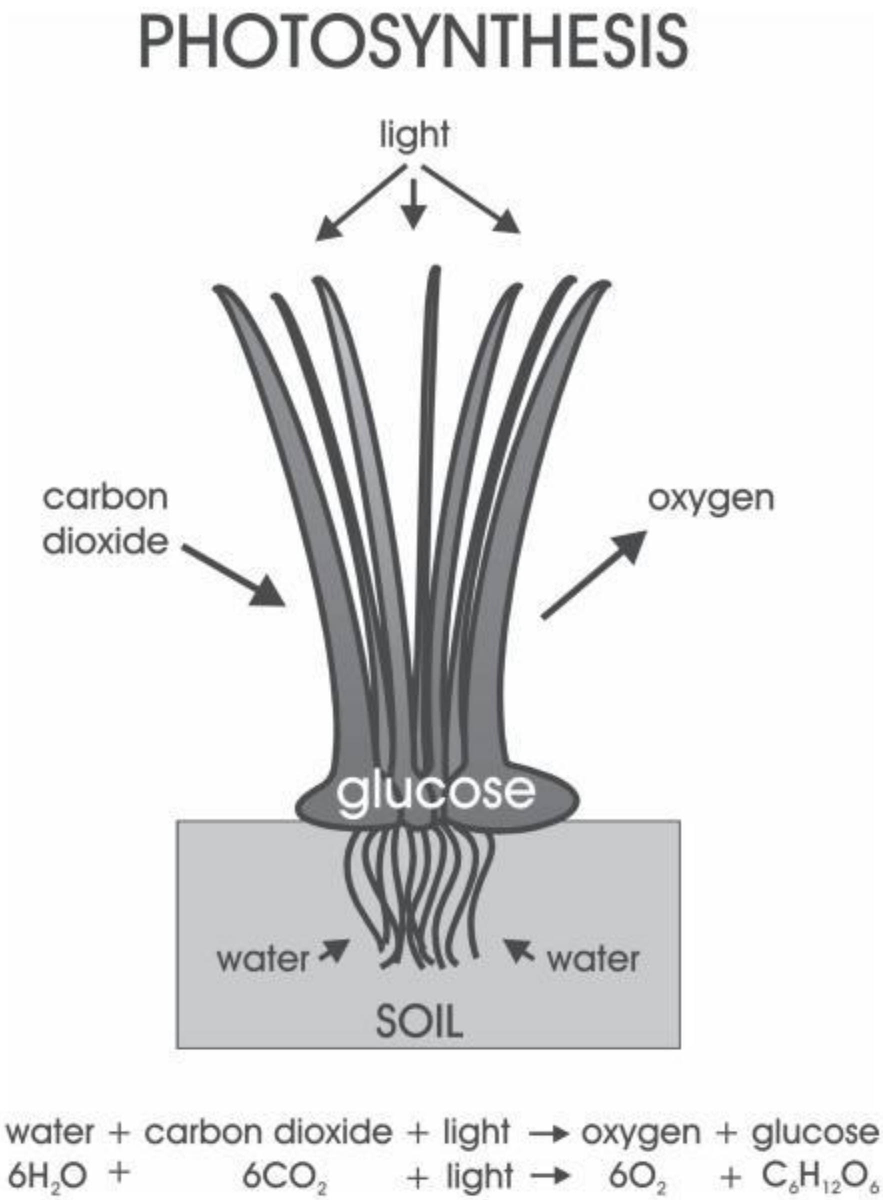


Figure 82: Image displaying how solar energy provides plants with life through photosynthesis

Click here for solar activities for Cub Scouts and Boy Scouts.

Resources used to create this page click here (DOE).

Solar for Cub Scouts

The files included here are activities for Cub Scouts to do at Treasure Valley to learn about solar energy. The lessons were gathered from resources from the US Department of Energy.

Solar for Boy Scouts

The files included here are activities for Boy Scouts to do at Treasure Valley to learn about solar energy. The lessons were gathered from resources from the US Department of Energy.

Photovoltaics

Solar Photovoltaic cells harness energy from the sun and convert it to electricity. Solar energy hits the Earth in most places, but the amount of energy depends on your place on the Earth.

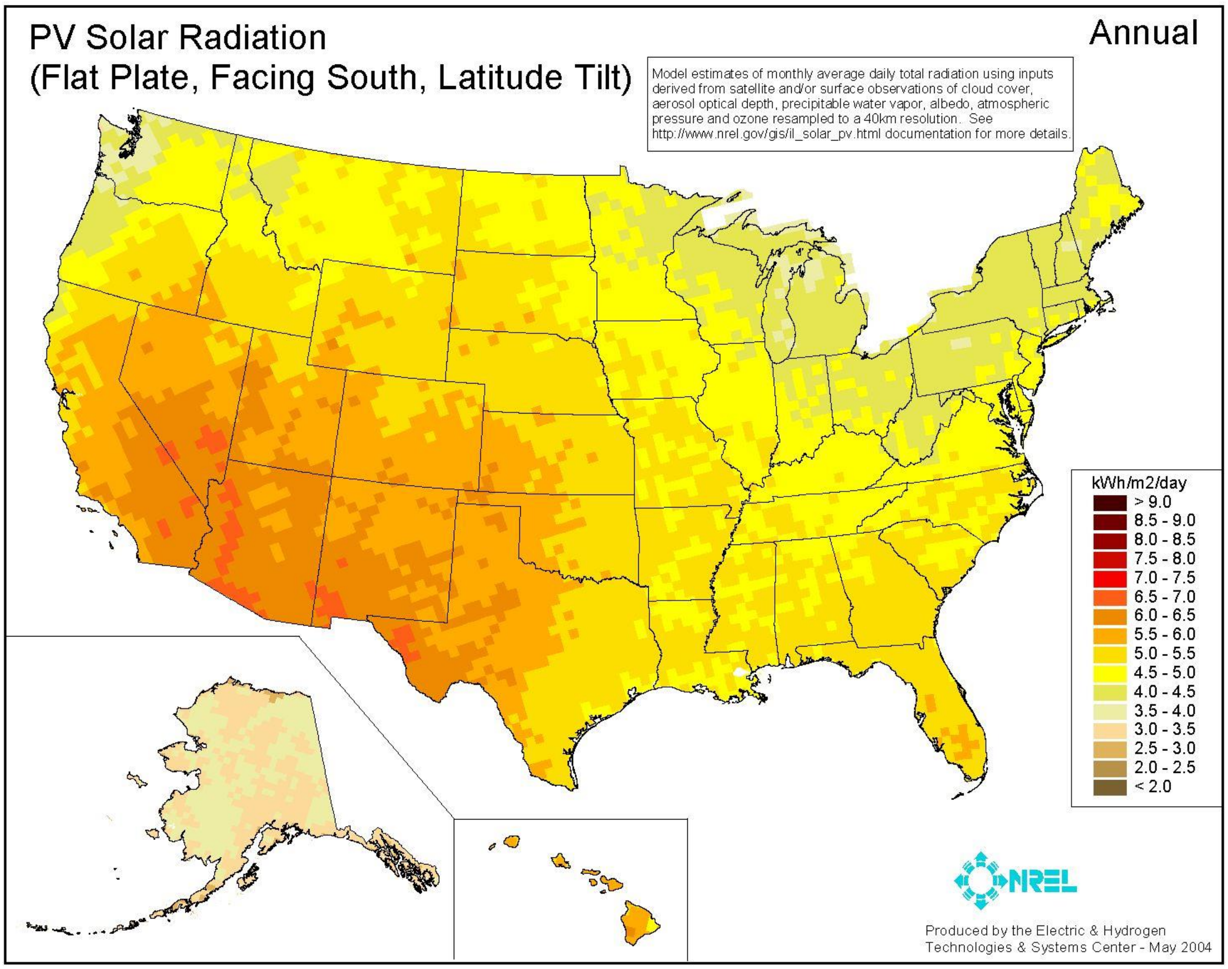


Figure 83: Map produced by NREL showing PV Solar Radiation in the US

Important definitions:

Energy is the **quantity** of electricity being produced. It is generally measured in Kilowatt Hours.

Power is the **rate** at which electricity is being produced. It is generally measured in Kilowatts.

Solar cells are used in many different ways, from your calculator to large scale solar farms (like the one at Treasure Valley). Around the world, many governments are offering incentives to install solar panels. One incentive that Massachusetts is offering to owners of solar panels Solar Renewable Energy Credits (SRECs) (DSIRE). For every 1000 Kilowatt Hours of electricity produced, the owner receives one SREC that they can sell for money!

Solar Energy is considered a renewable resource meaning it has a virtually limitless supply. In comparison, fossil fuels are a nonrenewable resource meaning that there is a finite supply on Earth (EIA).

Benefits of solar energy:

- No emissions created to generate electricity
- Minimal impact to the surrounding environment

Limitations of Solar energy

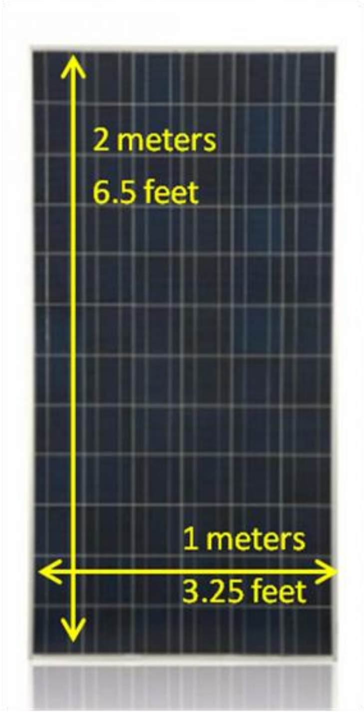
- Barriers to efficiency
- Clouds and other weather can decrease energy generation
- Uncertainty of what happens to the panels at the end of their life

Treasure Valley is very excited about bringing solar to the reservation. Check out the details of the 6 Megawatt Array and the Campsite Lighting System.

6 Megawatt Array

The panels used in the solar farms are made by a company called Hanwha. These solar panels are made from silicone. This is currently the most efficient material for electricity generation. These panels are 15% efficient (Civic Solar). This means that 15% of the energy from the sun that hits the panels gets converted to electricity. There are currently many scientists and engineers researching to improve the efficiency and materials of solar panels to make them more competitive (Discovery).

There will be 20,322 panels in the farm. These panels take up about 30 acres of land. The panels are mounted on metal stands that keep them pointing south and at an angle of about 20 degrees. This position is the best way to get the most access to direct sunlight (NREL).



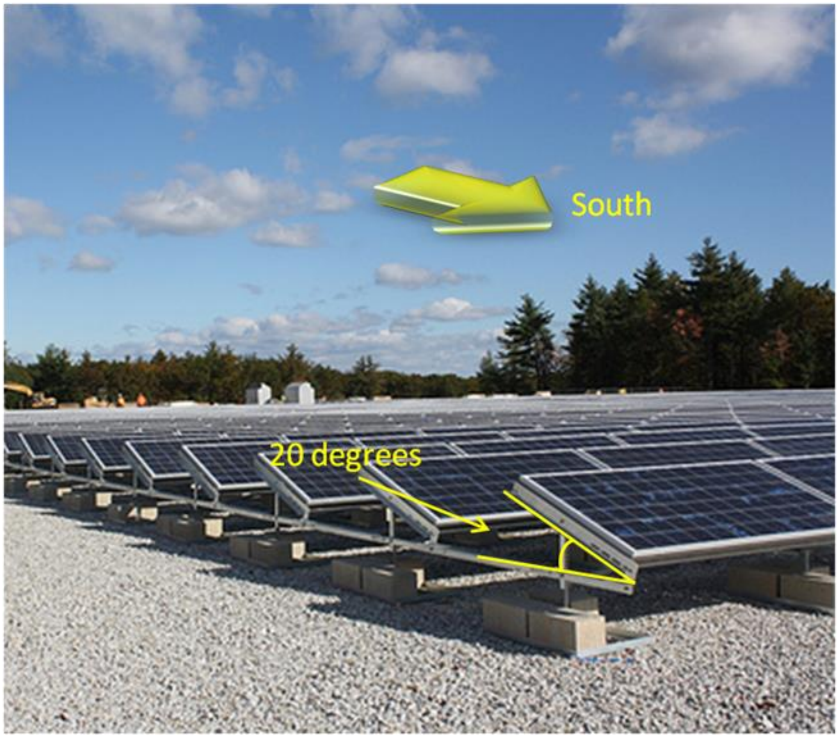


Figure 84: (left) Hanwha panel with dimensions, (right) Westford solar array with orientation details

**Info regarding the status of this solar array is tentative as of 4/23/13*

Treasure Valley Campsite Lighting

With this system, there are 3 solar panels near East Lodge. This is the Centralized Charging Station. This station charges 12 volt batteries. Scouts are responsible for transporting a battery every day from the charging station to their campsite. When the batteries are charged, they can last for up to 15 hours running the system components.

Figure 85: (left) 12 volt battery, (right) East Lodge, location of the centralized charging station

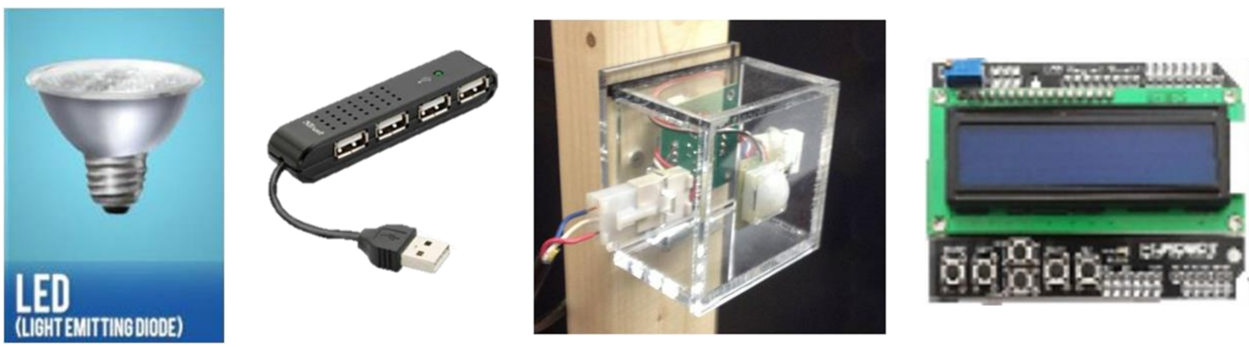


Figure 86: System components (left to right) LED Lights, USB Charger, Motion Sensor, Information Display

This system was a design project completed by WPI Students in 2013.

Questions

These questions are designed to encourage comprehensive exploration of the resources presented about photovoltaics. They also help to encourage further questions about solar in the context of society.

Table 24: Questions designed to require deeper thought into photovoltaics

What is the area of one solar panel in the farm in square meters?
Hint: Use the information on the "6 Megawatt Array" page to answer this question. Be sure to use all the links available. The formula for area is Area=WidthXLength.
Answer: The area of a solar panel is found by multiplying length times width (A=L*W). The panels used in this array are 2 meters in length and 1 meter in width. Therefore, the area of one panel is 2 meters squared.
How many panels are there in the solar farm at Treasure Valley?

Hint: Use the information on the "6 Megawatt Array" page to answer this question.
Answer: There are 20,322 panels in the farm.
Find the map from the NREL website that displays Annual solar radiation. What is the value in Massachusetts?
Hint: The units are in kWh/m^2/day. This value states how much *energy* hits each square meter of panel over the course of a day.
Answer: 4.0-4.5 kWh/m^2/day
What is the efficiency of the solar panels at Treasure Valley?
Hint: Efficiency means how much of the energy from the sun in actually converted into electricity. This means that only a certain percentage of the energy that hits a panel is turned into electricity. The remaining percentage is lost to other forms of energy such as heat, light, and sound.
Answer: The efficiency of the panels is 15%. Engineers and scientists are doing research to improve the efficiency of solar panels. This means that they want to be able to harness more energy in a smaller area. Already, some of the experimental panels have reached 50% efficiency. This research will help make solar more competitive in comparison to fossil fuels.
Based on your calculations, how much solar energy can be produced in one year?
Hint: the formula you should use is (Area of a Panel)X(number of panels)X(Annual solar radiation value)X(365 days in a year)X(efficiency) = energy produced in a year. Your answer will be in Kilowatt Hours which is a unit of energy.
Answer: 2 meters squared X 20,322 panels X 4.0 Kilowatt Hours/meter squared/day X 365 days/year X 0.15 = 8,901,036 Kilowatt Hours
If SRECs are given for every 1000 kilowatts generated, how many SRECs will be earned in 1 year?
Hint: The calculation can be done by dividing the answer to the previous question by 1000.
Answer: 8901 SRECs
If the maximum *power* that the array can produce is 6 megawatts, how many light bulbs can the array power?
Hint: The average light bulb generally takes about 100 watts. You will need to convert megawatts to watts to make the units match. There are 1,000,000 watts in 1 megawatt.
Answer: It could power 60,000 light bulbs at once! (6,000,000 watts /100 watts per bulb = 60,000 bulbs)

Solar Resources

These videos can be used in completions of the first step of the Start Your Engines! NOVA Award.

9.0 Conclusion

Starting as a project to develop solar powered lighting to the reservation, greater sustainability needs have been identified and worked upon. The team has provided recommendations and the framework for high level sustainability planning throughout the reservation. Additionally, the team has provided design recommendations for a solar powered lighting system and conceptual design recommendations for future building and facility development as part of the greater sustainability plan.

The groundwork for a longstanding working relationship between Treasure Valley and WPI has been reestablished. This MQP was a starting point that will provide a number of additional projects that will follow the direction of the sustainability plan framework created in this project. Future projects will endeavor to develop and update the sustainability plan, ensuring that it remains a living document that Treasure Valley and future projects can utilize.

Going forward, contact between Treasure Valley and WPI can easily be made through Ray Griffin who has been the main mode of communication to the stakeholders throughout this project. Professor Suzanne LePage and Professor Fred Looft, the advisors of this project, can be consulted to gain access to information regarding the information, processes, and data of this MQP.

This project group has also assembled a database of compiled information for use by the WPI groups who will work with Treasure Valley in years to come. This database includes a collection of all the information gathered from various stakeholders meeting and interactions, Treasure Valley documentation, applicable public records and data, and data gather by this project group. At the core of the database, the GIS database contains and organizes the relevant data downloaded from MassGIS, information digitized from print maps, and other relevant information added in the form of attributes to the geocoded data. This information will be useful in many of the projects of WPI student in collaboration with Treasure Valley in the future. A list of files and associated metadata of the database is included in Appendix J. In further development of the sustainable development plan, the established data can be utilized, edited, and added to. This will save time and effort in research for future groups.

Finally, in working towards creating the various areas of the sustainable development plan, this team has set the direction for this process. The vision statement and guiding principles that have been created will help to ensure that each portion of the plan work towards achieving the same general goal. This will help to ensure that all of Treasure Valley’s future planning is effective and consistent. Hopefully, the results of this project will aid in the future expansion of Treasure Valley, provide a local example of sustainability, advance the ideas of scouting, and encourage learning through nature and sustainable practices.

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Appendix A: Documents from Stakeholder Meetings

Agenda, Handouts, and Minutes of TVSR Stakeholder Meeting on November 28, 2012

Agenda

MQP Gannt Chart

Questions for Stakeholders

Vision statement

Minutes

Agenda and Minutes of TVSR Stakeholder Meeting on January 30, 2013

Agenda

Minutes

Minutes of TVSR Stakeholder Meeting on February 27, 2013

Minutes

November 28, 2012

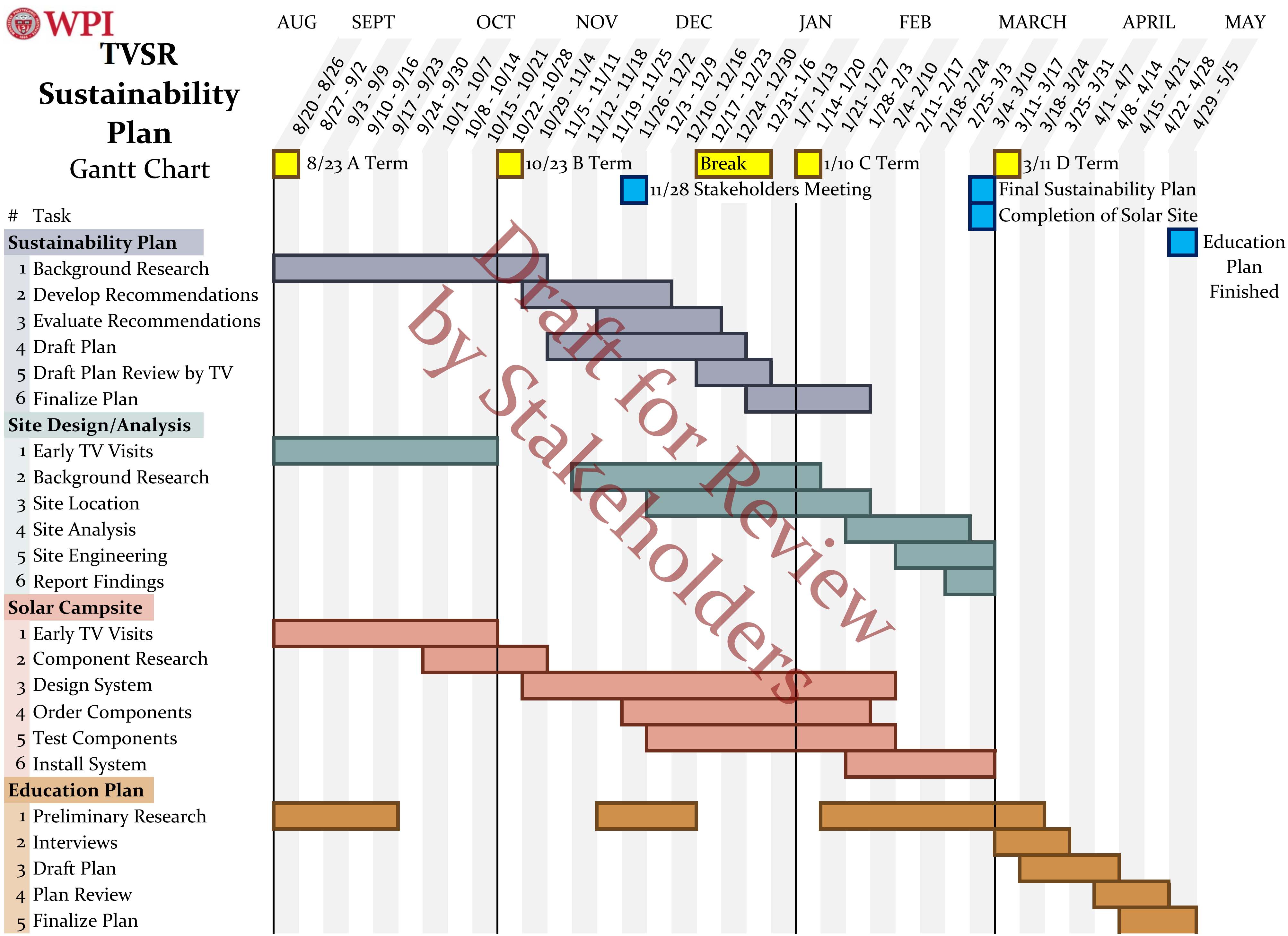
WPI Project TVSR Stakeholder Meeting Agenda

Stakeholders:
Charles Thompson; Jeff Hotchkiss; Joe Marengo; Warren D. Bock; Ted Coghlin; Thomas A NAE Chamberland; Michael DiPierro; John Atlas, Ray Griffin

Team Members: tvsrmqp@wpi.edu
Chris Girouard (cmgirouard@wpi.edu), Peter Aspinwall (paspinwall@wpi.edu), Lindsey Machamer (lindsey_machamer@wpii.edu), Joseph Szafarowicz (jszafarowicz@wpi.edu)

Advisors:
Fred Looft (fjlooft@wpi.edu), Suzanne LePage (slepage@wpi.edu)

1. Introductions (5 minutes)
2. Project Overview (10 minutes)
    a. 4 parts our project
    b. Importance of stakeholder input
3. Sustainability Plan (20 minutes)
    a. Introduction to our process/ the purpose of the plan
    b. Vision statement review
    c. Review categories for recommendations
        i. Overview/brief explanations of each section
        ii. Inventory of existing conditions
4. Site identification and design (15 minutes)
    a. Introduction and explanation
    b. Which potential future development
5. Solar Powered Lighting System (15 minutes)
    a. Summary of project and progress so far
    b. Question/comments
    c. Solar panel donation logistics
6. Education Plan (10 minutes)
    a. Summary of intent
    b. Questions/comments
7. Closing Activities (15 minutes)
    a. Coordination of future contact and feedback
    b. Further Questions?



Machamer - Szafarowicz - Aspinwall - Girouard

Explanation and Needed Data for the Areas of Sustainability
Treasure Valley Scout Reservation

Category	Data Needed
Wildlife *Wildlife is a crucial part of the natural system that we are all a part of. Treasure Valley is home to critical habitats that should be protected from overexploitation.*	❖ any wildlife protection initiatives ❖ any signage for habitats ❖ have vernal pools been declared ❖ garden locations
Energy Conservation *Conservation of energy helps the planet through a reduced need for the burning of dirty fossil fuels while also saving money in electricity and fuel expenses.*	❖ gas usage ❖ kerosene usage ❖ insulation in buildings ❖ HVAC and boiler systems
Energy Generation *Generation of clean sources of power can help reduce the need for electricity or fuel that is generated from dirty sources while increasing self-sufficiency for energy needs.*	❖ map of electricity lines ❖ restrictions (money, space, safety) for future development
Water Protection *Water quality preservation is important to maintain for habitats, drinking water, and recreation.*	❖ any collection tanks in use ❖ water wells - How/where/amount? ❖ lake usage
Resource Management *All endeavors function on the correct use, storage, treatment, and acquisition of resources ranging from fuel to water to money to personnel.*	❖ fuel (gas, diesel, kerosene) storage ❖ food storage, preparation, and acquisition ❖ capital equipment inventory ❖ employees
Waste Management *Human activity produces waste. It is incumbent upon the caretakers and users of an area to properly manage this byproduct through correct storage, responsible disposal, and mitigation of the amount of waste.*	❖ septic systems ❖ food cooking/service habits ❖ garbage collection company ❖ types of latrines
Green Building Development *As Treasure Valley moves into the future and develops further, it is important to minimize the environmental impacts of the development.*	❖ process for pursuing construction ❖ any past LEED initiatives ❖ any local materials initiatives
Economic Sustainability *In modern society, an enterprise like Treasure Valley needs funding to exist and function. Economic sustainability is just as important as the other facets of sustainability. Economic health depends upon the ability to manage resources, incomes, expenditures, maintenance costs, and future investments.*	❖ budget details ❖ tax information ❖ capital equipment plan ❖ resource purchasing habits ❖ future major repair expenses ❖ how are events scheduled ❖ how fees are evaluated and collected

November 28, 2012

TVSR Sustainability Vision

There are not many places where one can enjoy and experience nature or, at least, get away from the hustle and bustle of modern society. Treasure Valley is one of these exceptional places where someone can experience a different perspective of nature. The reservation presents this escape while fostering an environment based upon Scouting principles where a young person can learn and develop in a way that is unique.

The Boy Scouts of America have been advocates for sustainable living since their inception more than 100 years ago. Currently, the Boy Scouts are making a national effort to take their sustainable principles to the next level. "from stewardship to sustainability, and from "leave no trace" to leaving the world a better place. We're going from green to deep green." This desire to advance the influence of their actions combined with a desire to maintain Treasure Valley for future generations provides an impetus to develop a plan for sustainability.

This plan defines sustainability as:

> *balancing the fulfillment of present and future human needs while ensuring the conservation and protection of the natural environment.*

This is the working definition that influences the general decisions presented in this plan. These decisions are embodied in a set of guiding principles developed for the context of sustainable development within Treasure Valley.

Guiding principles of sustainable development of Treasure Valley Scout Reservation

- Ensure the operation of the reservation into the future
    - Maintain fiscal and operational sustainability of the reservation so it remains functional
    - Protect the Earth so that everyone will be able to appreciate it and learn from it
    - Keep the development up to date by finding a dynamic place for technology in scouting
- Foster environmental attitudes that the users will carry with them through life
    - Provide education to help with making the right decisions beyond the confines of the reservation
    - Prepare users to be future leaders in their community to further promote sustainable ideals
    - Foster interest in the math, science, and engineering

Worcester Polytechnic Institute
TVSR MQP
Minutes of Meeting
Wednesday, November 28 2012, 3:30 PM

Stakeholder Meeting - Coghlin Electric Conference Room

Present: Joe Szafarowicz, Lindsey Machamer, Christopher Girouard, Professor Looft, Professor LePage, Jeff Hotchkiss, Ray Griffin, Paul Sweeny, Tom Chamberland, John Atlas, Ted Coghlin, Ron Marsh.

I. Introductions: Stakeholders present
   a. Jeff Hotchkiss - scout executive / CEO of the Mohegan Council
   b. Ray Griffin - Vice President of innovative programs
   c. Paul Sweeny - Friends of TV, “eyes and ears on the electrical installation”
   d. Tom Chamberland - chairman of the camping committee
   e. John Atlas - scoutmaster, on the executive board
   f. Ted Coghlin - one of the three trustees
   g. Ron Marsh - Former scoutmaster, Friends of TV, worked on the solar comm.

II. Project overview (see visual and Gantt chart)

III. Sustainability Plan
   a. Review of Vision Statement
      i. Positives
         1. language from the National Boy Scout Jamboree 2013
         2. language from the World Bank definition of Sustainability
      ii. areas for improvement
         1. replace “escape” in first paragraph
         2. change “sustainable living” in second paragraph
         3. use “STEM” abbreviation in last bullet
         4. add another major bullet to encompass financial initiatives
         5. change “protect the Earth” - it is too grandiose
         6. emphasize relationship with WPI and collaborations with others
         7. Remove the “campsite” out of “Solar powered campsite lighting”
   b. further contact for exchange of information
      i. contacts for specific areas
         1. Tom - wildlife, water, resource management, waste management
         2. Jeff - energy conservation and generation (Ron)
         3. Trustees - economic sustainability
      ii. use the Conservation Plan and Forest Management Plan
      iii. meet before December 13th at Treasure Valley to see the As Built Plans

IV. Site Selection and Design - suggestions for ideas of civil engineering capstone design
   a. Water considerations - management of beaver situation, milfoil, and Sevenmile River
   b. Dining hall sitting - currently being designed
   c. Siting of the house for the Solar Decathlon
   d. TV doesn't have the infrastructure to support large groups like a jamboree
      i. parking is minimal and not the best location
   e. Develop the Cub Day Camp program
      i. only has the potential to support 15-17% of cub scouts
      ii. expand facilities, transportation, shelter
   f. Develop venturing program (coed group up to age 21)
   g. Camp roadway network
      i. just put in 1 mile of paved road
      ii. improve road access
   h. Dormitories for 5-6 graders
      i. bunk house for 75-100 boys and 75-100 girls
      ii. apartment for a couple equipped with kitchen
      iii. $7.5 million dollar project
   i. Heritage museum for memorabilia
   j. Evaluation and improvement of current buildings
      i. 3 buildings aren't being used to their fullest
      ii. rehab farmhouse
   k. Staff housing for the summer - multipurpose for winter use
   l. Develop "snow program" - establish facilities usable in winter.

V. Solar Powered Lighting System
   a. Overview of the project
   b. Feedback of the project
      i. positively received
      ii. more usb ports
      iii. check on the solar panel on the entrance sign
      iv. think of general solar recommendations for other existing infrastructure
      v. make sure kids cannot break into battery (safety)
         1. perhaps plan for them to play with batteries in a structured environment

VI. Educational plan
   a. Summary of the intent of project
   b. Feedback and input
      i. Future discussion will be had on NOVA program
      ii. Future MQPs and IQPs
      iii. Work with WPI students and vocational students
      iv. Program for Eagle Scouts at WPI to be merit badge counselors

VII. Wrap-up

Appendix B: List of sustainability definitions

Merriam Webster
1 : capable of being sustained **2 a :** of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged <*sustainable* techniques> <*sustainable* agriculture> **b :** of or relating to a lifestyle involving the use of sustainable methods <*sustainable* society>
Thomas Jefferson, 1789
"Then I say the earth belongs to each...generation during its course, fully and in its own right. The second generation receives it clear of the debts and encumbrances, the third of the second, and so on. For if the first could charge it with a debt, then the earth would belong to the dead and not to the living generation. Then, no generation can contract debts greater than may be paid during the course of its own existence."
World Commission on Environment and Development (the Brundtland Commission)
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
International Association of Public Transportation
Sustainable development is defined as balancing the fulfillment of human needs with the protection of the natural environment. Taking decisions understanding the impact and determining a good balance in terms of: Social Justice Environmental Protection Economic Sense Sustainable development is how you plan for the future while still operating in the now

Treasure Valley Scout Reservation
Stakeholder-Student-Ranger Meeting

Wednesday January 30, 2013

3:00 pm

I. Introductions

II. Project Update

III. Review of current maps and data

   a. Evaluation of maps – ensuring correct data

IV. Input on future development

   a. Presentation of constraints

      i. Preliminary findings

   b. Evaluation and feedback on constraints

   c. Future development priorities

   d. Questions

V. Addenda

Worcester Polytechnic Institute
TVSR MQP
Minutes of Meeting
Wednesday, January 30 2013, 3:30 PM

Stakeholder Meeting – Magee Building

Present: Joe Szafarowicz, Lindsey Machamer, Ray Griffin, Tom Chamberland, John Atlas, Warren Bock, Joe Marengo

I. Introductions
II. Project update
    a. WPI students report to TVSR about recent accomplishment and current direction project. At this time, the CE students are working on performing a constraints analysis for future development. This entails researching and analyzing data (such as infrastructure, wetlands, steep slopes, etc.) to determine sites of TVSR that are ideal for development.
III. Review of current maps and data
    a. Presentation of three maps (infrastructure, environmental, and constraints) generated by the CE students. Each map was reviewed by both groups.
        i. Infrastructure
            - This map contained the water, electricity, road, building, parking infrastructure. The purpose of this map is to organize all current development on TVSR. The data WPI used was provided by the State, maps from Ted Coughlin, and sketches from Tom Chamberland.
            - Much discussion and analysis (especially with Joe Marengo) on the map to ensure there was correct and complete information. All data was updated to best knowledge of the meeting members.
        ii. Environmental
            - This map contained the hydrography, wetlands, habitats, and forest management plan information. The purpose of this map was to ensure that there was complete data concerning wetlands and forest status.
        iii. Constraints
            - This map contained data from the previous two maps as-well-as further data that would constrain development. These constraints were classified as absolute constraints and limiting factors.
            - Students made sure that their data complete and accurate.
        iv. TVSR Map Updates
            - TVSR will send the findings, results, and information on two current projects with the reservation. The BSA is trying to create standard map

sized and scales for each reservation. TVSR also has Whitman and Bingham mapping and performing site analysis for the Cub Scout development in West Camp.

IV. Future Development

a. Discussion about the constraints from the constraints map.

i. WPI presented their preliminary findings of where development would be ideal. See table 1 for summary of location pros and cons.

Table 1

Area	Pros	Cons
Paxton East Camp	• No Steep Slopes, water bodies, or protected area • High Access to Town roads and TVSR roads	• Existing campsites and facilities • Future Solar Development
West Camp	• Access to TVSR roads • Benefits of hillside development	• Steep slopes, protected habitats, and wetlands • No access to town roads
North Camp	• Currently undeveloped • Access to TVSR roads • No steep slopes	• Possible beaver pond and wetland issues • Nearby campsite conflicts • Need to expand utilities
Northern Rutland	• Access to town roads • No steep slopes or wetlands • Currently undeveloped	• Not connected to rest of camp • Requires tree clearing • No existing infrastructure • Proximity to trails

b. TVSR Input and future development priorities

i. Educational Center (North East TVSR)

- Near the solar farm. Natures classroom with trails and natural environment available for study

ii. Venturing Program

- For teenagers. There are currently little to no program for this at TVSR. Possibly develop South East camp just for venturing program. Would require new dorms, new camps, new facilities, and new infrastructure.

iii. Cub Scout (West Camp)

- Currently having this portion of camp analyzed by an engineering company. They said that they could make west camp (with all of its steep slopes) work for the Cub Scouts. Currently, TVSR wished to at least double the capacity of the Cub program with even more expansion in the future. This expansion will require new and updated infrastructure.

iv. East-West Camp
   - TVSR wishes to have two distinctive areas of camp – the East Camp (for Boy Scouts) and West Camp (for Cub Scouts). This will require and utilize the natural boundary between the two sides of camp which includes Browning Pond and the undeveloped area of North TVSR.
   - Possibly have three district areas of camp which include the Boy Scouts, the Cub Scouts, and the Venturing Program (which would be south of the Boy Scouts on the western wide of Browning Pond)

v. Land Trading
   - TVSR owns a variety of parcels around TVSR. Some of these are undesirable to develop. TVSR is working on performing land swaps with some of the surrounding property owners. They would like to trade the land in north camp for property owned by Massachusetts (Rutland state forest). They also desire to trade land in south TVSR for land west of TVSR with Sister Cistercian Abbey which would create more "whole" contiguous properties for both parties.

vi. Larger Capacity
   - Expressed interest in being able to host larger events. Current infrastructure is very limited. Update and expand water infrastructure (not compliant with current regulations and need for new wells). They also lack adequate parking. Idea that, perhaps, there could be a centralized parking area with shuttles instead of having a lot of cars drive through TVSR (to get to Cub Scouts for instance)

V. Recap of meeting
   a. Discussion on plans going forward. CE students will be updating the maps and revaluating development constraints with new input and data.

Minutes of Meeting
TVSR - WPI
Wednesday, February 27, 2013
Coughlin Meeting Room - 3:30pm

Present: Raymond Griffin, Thomas Chamberland, Jeff Hotchkiss, Ron Marsh, Professor Looft, Professor LePage, Chris Girouard, Peter Aspinwall, Lindsey Machamer, Joe Szafarowicz, Jacob Lautman.

1 Introductions
2 General overview of the project
3 Solar Lighting
    a Chris and Peter presented their final design for the solar powered lighting system. Specifications and recommendations were presented along with a video and live demonstration.
    b Discussion on the specifics of the set-up (home many lights, sensors, having lights with switches (not sensor actuated), – *designed to be very customizable for the different campsites, uses a rail system that can easily accommodate different configurations of components*
    c Discussion on system costs
        i specifically the cost of the centralized charging station – this cost will be high (cost of solar panels)
    d Discussions on the consequences of the system (light pollution) – talked about the concerns of parents for scouts using the latrine at night
    e Battery Life concerns – *designed to handle more than one night of use*
    f Wiring concerns
        i wiring between latrine and pavilion – don't want to have exposed wires (solution – underground sprinkler system wires)
        ii Rodent concerns - *will use conduit to cover wires*
    g Scout Safety Discussion – concern about the weight of batteries
4 Future Development Recommendations
    a Lindsey and Joe presented the findings, results, and recommendations concerning future development of TV. On a large scale, group developed a zoning map for the different uses/areas of TV. Specific recommendations were made for the Venturing Program, Natures Classroom site, and TV parking.
    b Discussion on the zoning map - group updated about unrepresented desired parcel in North-East TV.
        i TV stakeholders identified the area that has been looked at for an observatory
    c Venturing Program discussion - group was asked if they consulted Venturing directors
        i Group used published BSA Venturing Program guidelines
        ii Discussion about the specific design criteria and constraints used
    d Education Zone

        i. Discussion on the capacity and needs of the proposed Nature's Classroom (dormitory space, septic system, access, etc.)
    e. Parking System
        i. Discussion on specifics for the parking lot recommendations (size, spaces, etc.)
        ii. Discussion on the Inter-Reservation Transportation (ITR) - shuttles
            1. concerns about the current lack of road infrastructure - road quality, width, bridges, etc.)
        iii. The First parking lot was closely looked at for a potential solar farm, therefore there is plenty of existing data of that site
        iv. Discussion on multiple points of entry to TV
        v. TV liked the idea of using the 2nd parking lot recommendation as another entrance that would be connected to the Venturing area
    f. Request to have the group provide TV with a CD (or other physical media) of the GIS data files used for this project
    g. TV identified that wish to no longer be "organic"
5. Education
    a. Lindsey discussed general plans for her part of the project that will be completed D term
    b. She will be in close contact with Ray about NOVA and other existing programs
6. Going Forward - future MQPs, IQPs, etc.

Appendix C: Potential Future Projects

Ray's List of Future Projects

email correspondence from Raymond Griffin, December 24, 2012

Potential MQPs and/or IQPs at Treasure Valley Scout Reservation

IQPs:

1. Design an effective communication system for use at TVSR by reviewing literature and creating a prioritized recommendation list. This system must satisfy the need for emergency alerts, person-to-person communication and building-to-building communications. This system must use alternative power.
2. Design a plan to extend solar power into program areas, support areas and camping areas.

MQPs

1. Create a plan to (a) eliminate existing milfoil and (b) reduce the potential for a re-occurrence of this non-indigenous weed. (Environmental and civil)
2. Create a containment plan for (2) existing beaver ponds, (Environmental and civil)
3. Create a master plan to address water systems: (a) potable water, (b) water for recreational use and (c) water for fire safety. (Environmental, civil and fire safety)
4. Create a maser plan for roads (except Snake River Road from Magee to the CSDC parking lot) bridges and culverts by (a) recommending improvements to existing facilities and (b) recommending new facilities.
5. Create a plan to sustain 70 miles of recreational hiking trails. (Environmental, civil)
6. Create a plan to refurbish and/or replace existing (under water) electrical system. (Electrical, civil, environmental).
7. Design a self-contained campsite based "facility" to accommodate waste disposal and potable hot water by reviewing equipment literature – equipment to be located in 15 remote campsites. This prioritized list of equipment must (a) accommodate human waste disposal and (b) create hot water for showers, food preparation and dish/utensil/pots cleaning. This equipment must use alternative power – preferably site based.
8. Create a "SOP" or master manual of camp operation - what needs to get done when and by who for total camp operations
9. Create a Maintenance Plan for buildings, equipment and infrastructure
10. The Massachusetts Sustainable Water Management Initiative (SWMI) Framework and the outlining of steps toward implementation – through the Mass. Executive Office of Energy and Environmental Affairs (EEA) - has set up a website (http://www.mass.gov/eea/swm <http://www.mass.gov/eea/swm>) that details the new Framework, and documents the extensive work to create a more up-to-date, scientifically-based process for balancing human and ecological water needs. How does this impact Browning Pond and TVSR?

Appendix D: Building Names and Uses

email correspondence from Raymond Griffin, December 18, 2012

Non-program buildings	Use #1	Use # 2	Comments
Farm House Complex	12 month residence	Training room	E/T/W/H by propane
Barn	Storage		E/NT/NH/NW
Ranger's shop – two floors	12 month repair facility	Storage (2nd floor)	E/T/W/first floor heated by oil; E/NW/NH 2nd floor
Open storage	Vehicle storage		
Coghlin	Dry storage		E/NH/NW/NT
Various bldgs – behind farm house complex	Storage –some dedicated storage		No utilities
King Cottage	12 month residence		E/T/W/H/propane
Directors Cottage	6 month residence		E/ST/SW/Heat by wood stove
Boonesville pump house	Pump for water system		E/NH/NT
Central Shower house	Gang showers		E/seasonal hot water - propane
Boonesville Shower house	Dry Storage		E/NH/NW/NT
Clivus – East Camp	All season waste disposal		E/T/W/H
CSDC change bldg	6 bay Changing facility		NE/NW/NT/NH
Winter shelter	Not in use		No utilities
Trails End Bldg	Not in use		No utilities
Doolittle	Not in use		E/W/T
69 Browning Pond Rd	12 month residence		E/W/T/H
Browning Pond Rd #1	Not in use		Should be dismantled
Browning Pond Rd #	Not in use		Should be dismantled

2			
Browning Pond Rd #3	Not in use		Should eb dismantled
East Campsites	15 seasonal sites with latrines and pavilions		SW/ST/NH/NE
6 Adirondacks	12 month camping		No utilities
Wash stand bldgs	Storage – only in a few sites		Should be dismantled
Webelos Woods pavilions	Open picnic shelters with charcoal cookers and picnic tables	Mixed use	NW/NE
West campsites -	10 abandoned/have flush toilets & septic systems		SW/ST/NE/NH
Power bldg	Houses a transformer		E
Program Buildings			
Magee	12 month visitor's center	Storage in cellar	E/W/T/H/
East Lodge	3 month dining	9 month mixed use	E/SW/ST/NH
Commissary	3 month product sales	9 month dormitory	E/SW/ST/SH by wood stove
East - Old TP	12 month Mixed use		E/SW
East - Handicraft Lodge	3 month arts/crafts	9 month mixed	E
East - Probus	12 month dormitory		E/SH by wood stove
East - Health Lodge	3 month health care	9 month mixed use	E/SW/ST/H by propane
East Field Sports	Program materials storage – 2 bldgs	Winter storage	E in one bldg
East Field Sports pavilion + 2 sheds	3 month program + storage	Occasional off-season training/programs	NE/NW/NT/NH
West Field Sports	Abandoned		No utilities
East - ECON Shelter	3 month program	storage	E/SW/NH/
East - ECON – pit latrine	3 month program		NW/NE/NH
COPE Tower	12 months		E at tower

Complex			
COPE shed	Program material storage		NE
West Lodge	12 month meeting facility with kitchen	Dormitory in cellar	E/W/H/T
West CC	12 month meeting facility with kitchen and dorm rooms		E/W/T/H/Note: WCC&WL share a leech field
Columbus	3 month cub program	9 month storage	E/SW
West Field Sports	Not in use		
Scoutcraft – 3 old wash stands	3 month program	9 month storage	SW/NE/NT/NH
McKinstry Trail, TVAA map shelter, life guard tower	Seasonal and mixed use		
Chapel	Seasonal use		

In comments column: SE = Seasonal electricity E = electricity; ST – seasonal toilets, T = 12 month toilets, SH = seasonal heat, H = 12 month heat, NH = no heat, W = water, SW = seasonal water

Appendix E: Solar Pathfinder Readings

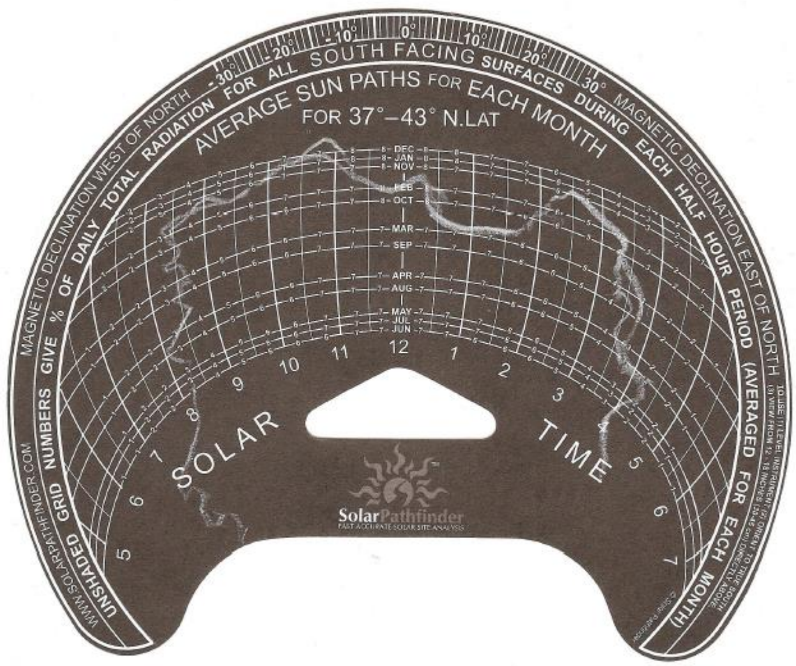


Figure 87: Health Lodge

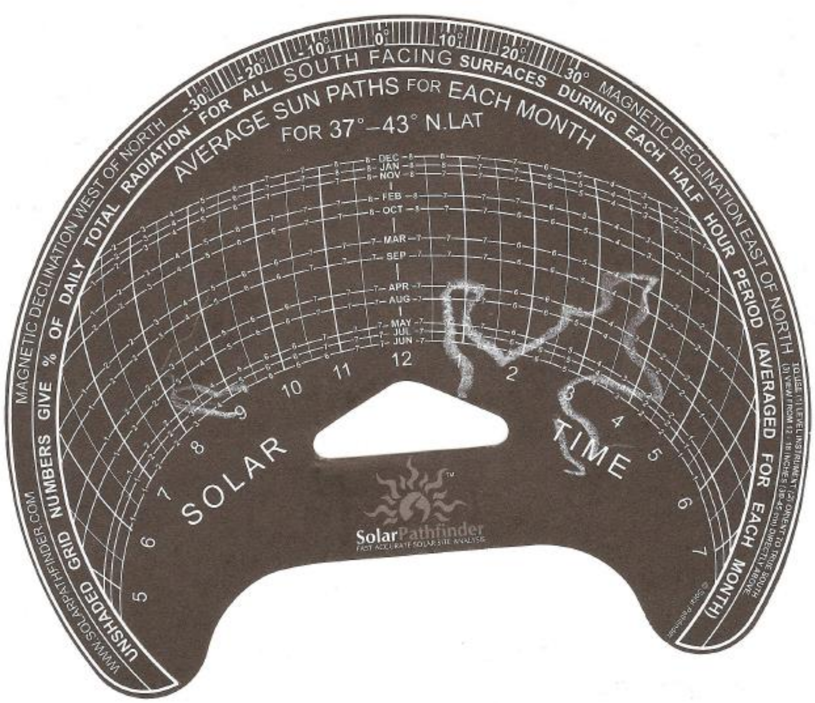


Figure 88: Proctor Campsite

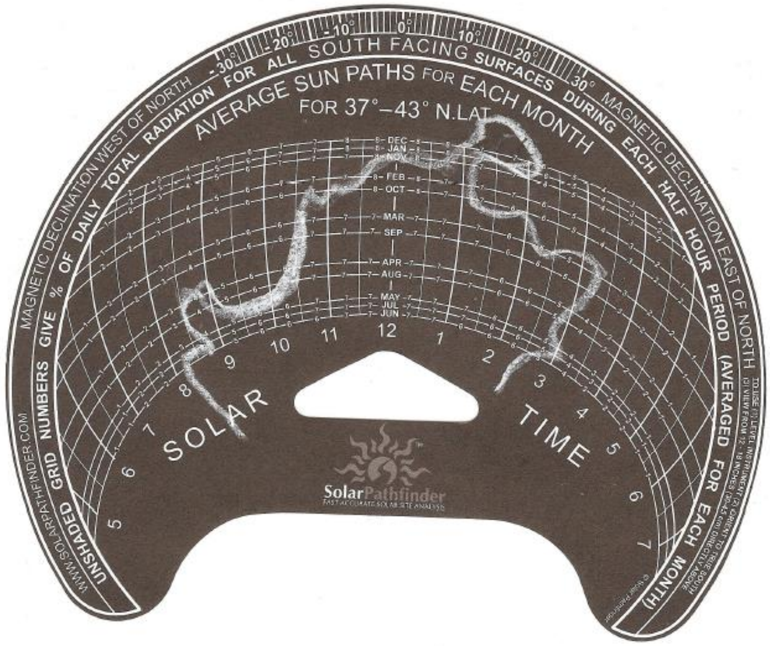


Figure 89: Evergreen

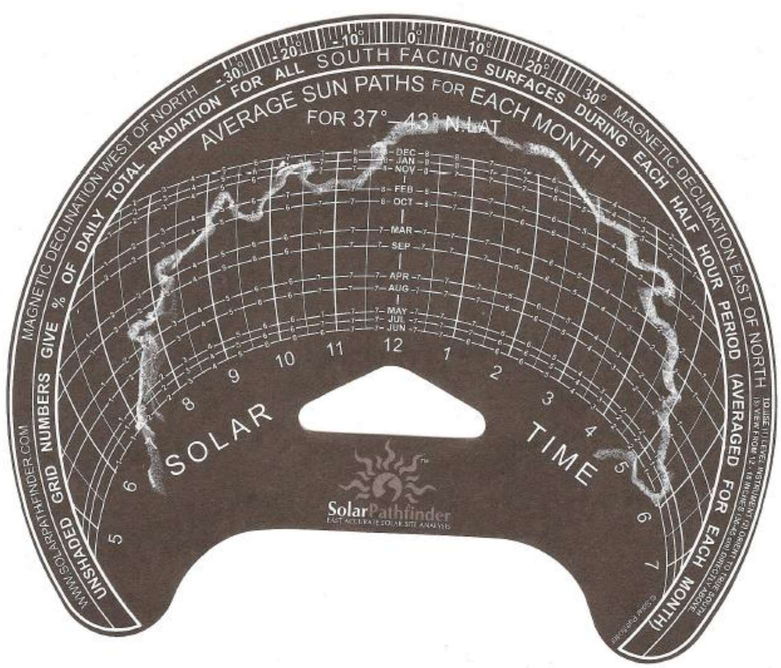


Figure 90: East Lodge

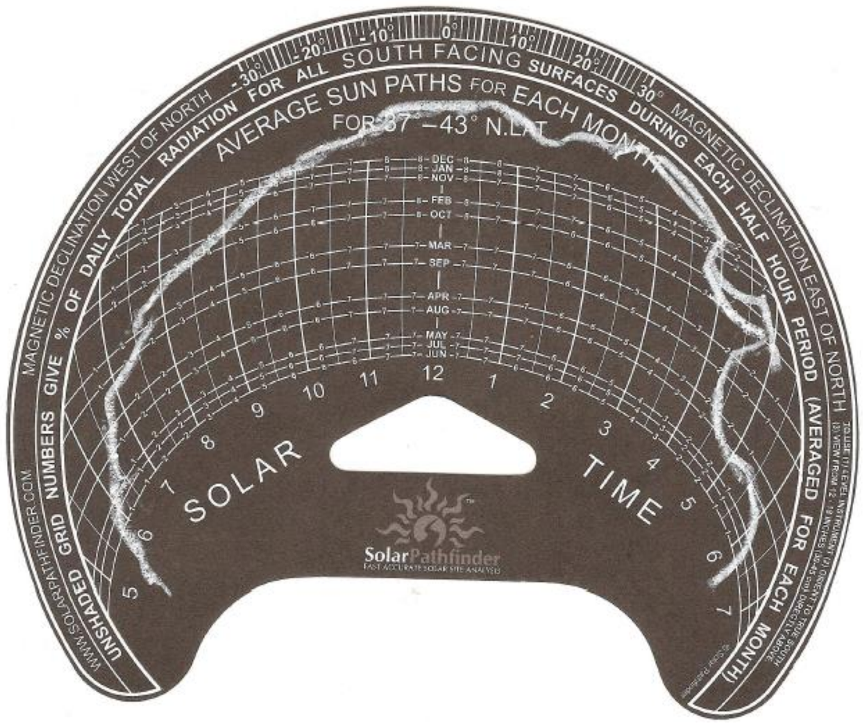


Figure 91: Waterfront

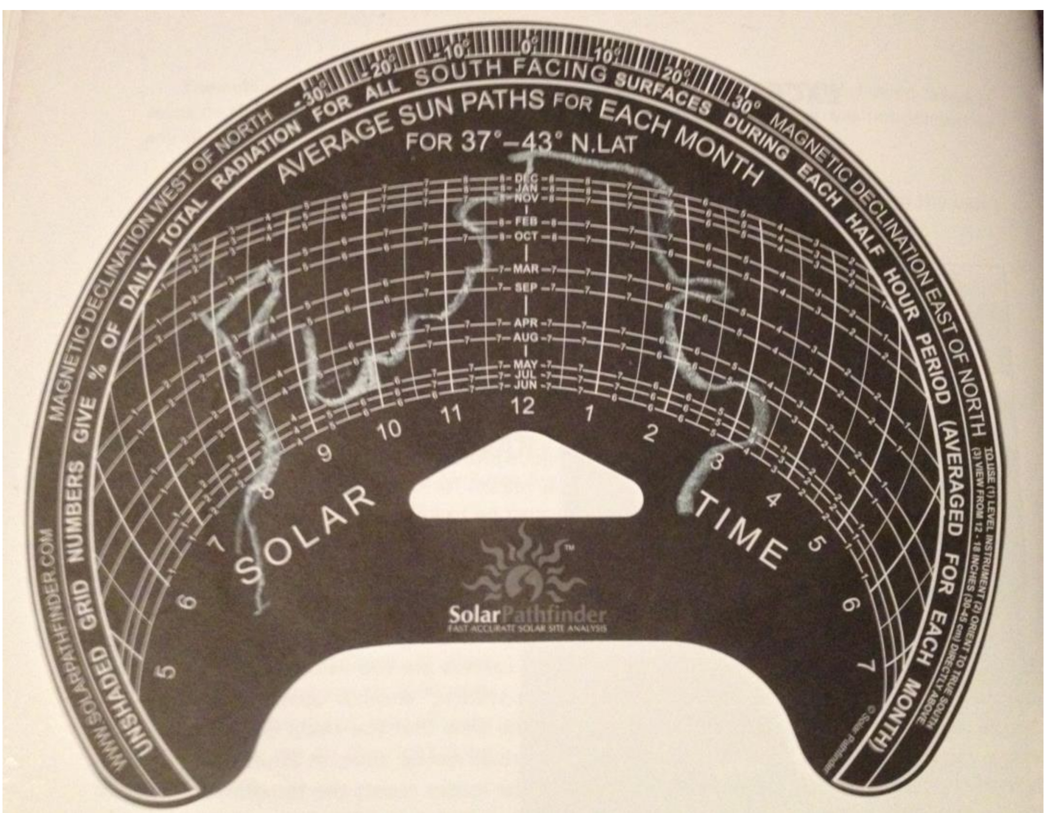


Figure 92: Cub Day Camp Building

Appendix G:Printed Circuit Board Schematics

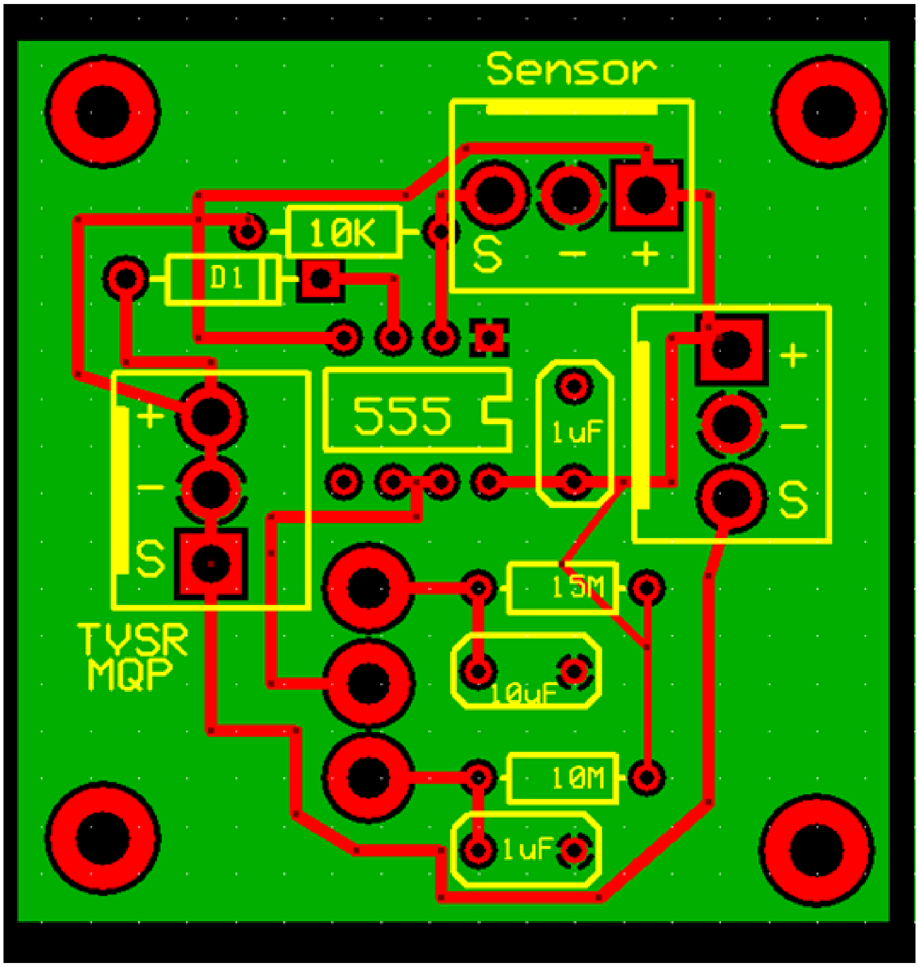


Figure 93: Sensor PCB

The sensor circuit board requires the use of a LMC 555 timer to regulate the shut-off time for the LED. The LMC 555 timer is configured with the correct capacitor and resistor ratios to allow for two shut off times. The different shut-off times are controlled by a switch that is integrated into the circuit board. A pin header connects the sensor and the rail connections are the two connectors on either side of the board.

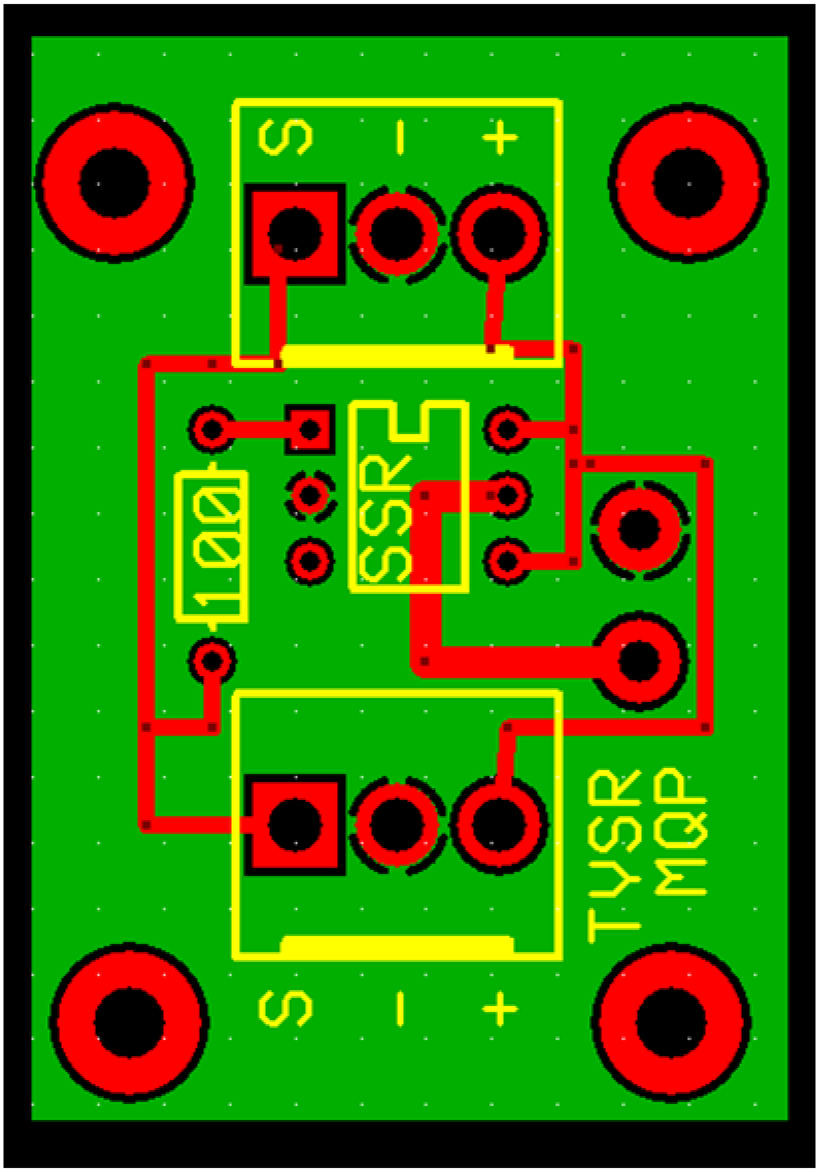
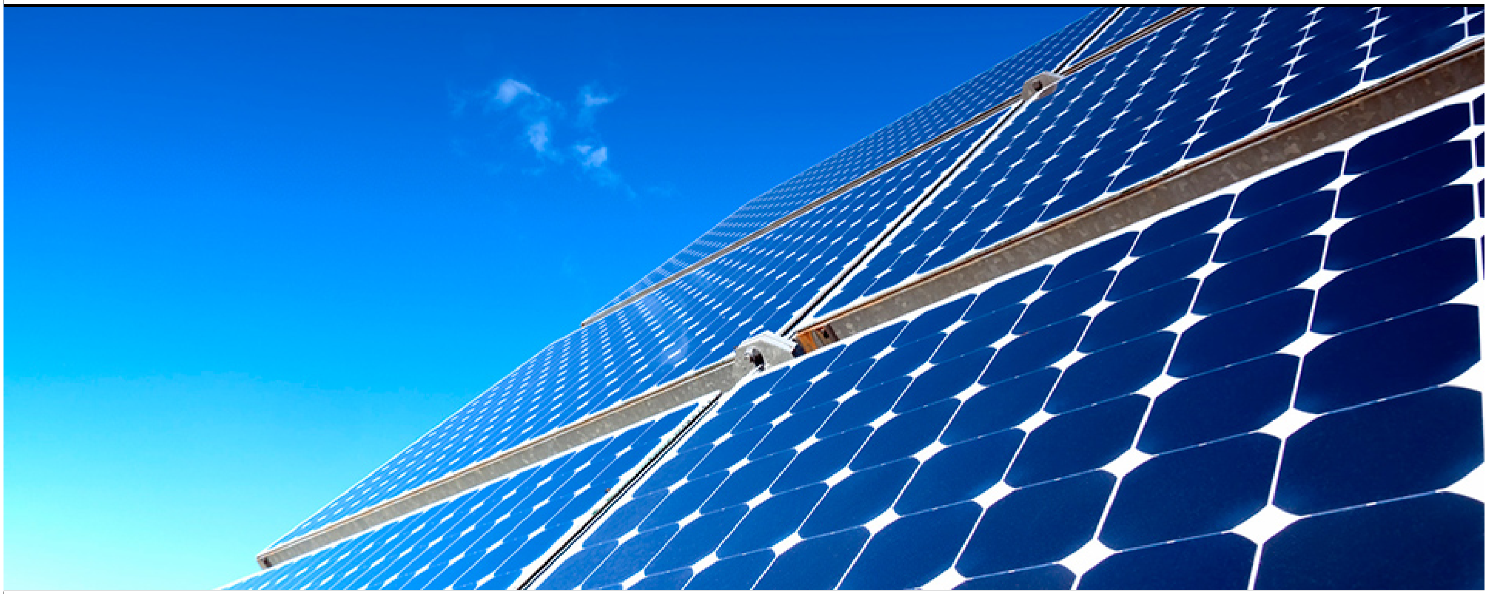


Figure 94: LED PCB

The LED Board only required the use of a solid-state relay to control when the LED turns on. The two pinholes allow for direct connection of the LED light. The two connectors on the sides of the board are the rail connections.

Appendix I: treasurevalleysolar.weebly.com

Solar at Treasure Valley



This website is for Cub Scouts and Boy Scouts learning about Solar Power. Solar power provides an excellent example for learning about energy and technology.

Treasure Valley is becoming a leader in the community for their dedication to renewable energy technology. Treasure Valley will soon be home to what is currently the largest solar array in the state of Massachusetts. Additionally, Treasure Valley has made an effort to incorporated small scale, off-grid, solar power into the daily operations of the reservation including the lighting of the entrance sign as well as campsites at night time.

The contents of this site present solar in a broad view and in the context of the solar projects on the reservation. These resources are designed to be used to help learning in Science, Technology, Engineering, and Mathematics (STEM) disciplines. These programs include the Nova program, merit badges, and a potential Nature's Classroom program.

Solar at Treasure Valley

Nova Program

NASA and the Boy Scouts of America have teamed up to create the Nova program. Nova awards are given to scouts who have shown exemplary learning in the areas of Science, Technology, Engineering, and Mathematics (STEM). There are four awards, one for each of the STEM areas, for each level of scouting. The Supernova awards involve more in depth programs in these areas, and are awarded at each level of scouting. The aim is for scouts to get exposure to and excited about STEM fields in pursuit of these awards.

Understanding energy is a vital concept in science and technology. The concept of solar energy is an illustrative example of energy from source, through generation, to application. The Nova award that is most applicable to Solar is the “Start Your Engines!” award. For details of each awards, follow the links below.

Cub Scout Awards

click to follow link

Boy Scout Awards

click to follow link

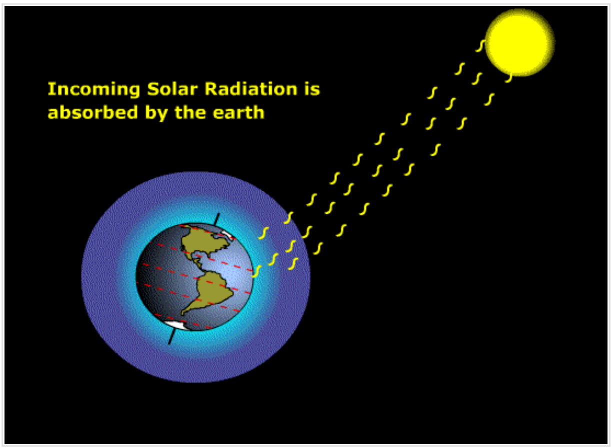
BSA Nova Award Details

Solar at Treasure Valley

Overview of Solar Energy

Energy from the sun is the main source of energy on planet Earth! The only sources of energy that do not come from the sun are geothermal and nuclear energy. Wind power, water power, and fossil fuels are all influenced by the suns energy.

The energy from the sun stays on the earth because of the greenhouse effect. In the same way that a greenhouse lets in light and keeps in heat, our atmosphere traps the energy from the sun.



Source: http://myweb.rollins.edu/jsiry/Picturing_the_Science_G-Schmidt-Climate.htm

Life depends on the flow of the suns energy through its systems.

- Weather patterns are influenced by the suns energy
- Plants produce energy from the sun through photosynthesis
- Solar can be harnessed directly to make electricity with Photovoltaic cells
- Heat from the sun can be used to warm water and other fluids

Click here for solar activities for Cub Scouts and Boy Scouts.

Resources used to create this page click here

Solar at Treasure Valley

Cub Scout Activities

The files included here are activities for Cub Scouts to do at Treasure Valley to learn about solar energy. The lessons were gathered from resources from the US Department of Energy.

solarpizzabox.pdf
Download File

solar_cellsimulation.pdf
Download File

solar_rainmachine.pdf
Download File

Solar at Treasure Valley

Boy Scout Activities

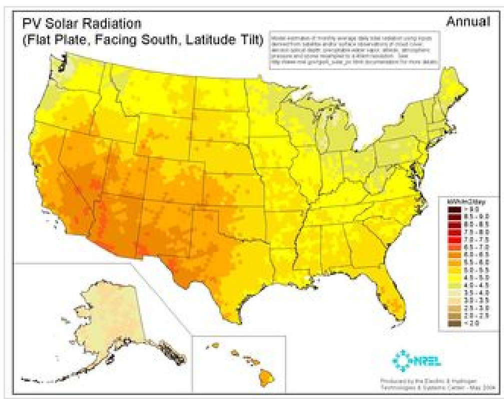
The files included here are activities for Boy Scouts to do at Treasure Valley to learn about solar energy. The lessons were gathered from resources from the US Department of Energy.

solar_photovoltaiccells.pdf
Download File

Solar at Treasure Valley

Solar Phototvolatic Cells

Solar Photovoltaic cells harness energy from the sun and convert it to electricity. Solar energy hits the Earth in most places, but the amount of energy depends on your place on the Earth.



National Reneweable Energy Labs (NREL) (click to view larger)

Important definitions:
Energy
Power

Solar cells are used in may different ways, from your calculator to 6 megawatt solar farms (like the one at Treasure Valley. Around the world, many governments are offering incentives to install solar panels. One incentive that Massachusetts has is offering owners of solar panels Solar Renewable Energy Credits (SRECs). For every 1000 Kilowatt Hours of electricity produced, the owner receives one SREC that they can sell for money!

Solar Energy is considered a renewable resource meaning it has a virtually limitless supply. In comparison, fossil fuels are a nonrenewable resource meaning that there is a finite supply on Earth.

Benefits of solar energy:

- No emissions created to generate electricity
- Minimal impact to the surrounding environment

Limitations of solar energy:

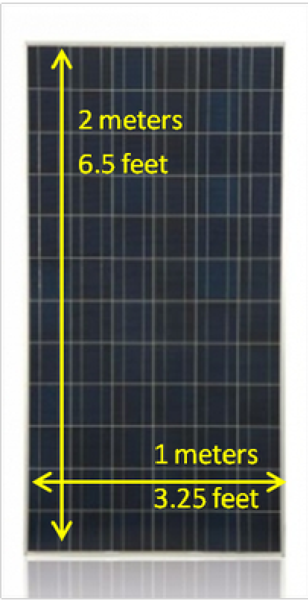
- Barriers to efficiency
- Clouds and other weather can decrease energy generation
- Uncertainty of what happens to panels at the end of their life

Solar on Treasure Valley

Treasure Valley is very excited about bringing solar to the reservation. Check out the details of the 6 Megawatt Array and the Campsite Lighting System.

Solar at Treasure Valley

6 Megawatt Solar Farm



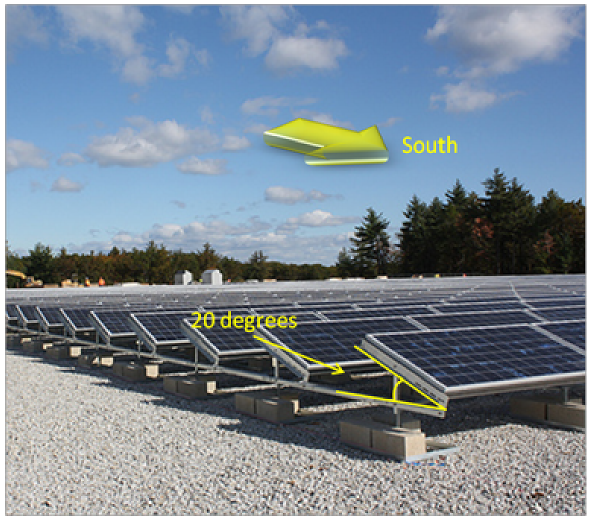
dimensions of a single panel

The panels used in the solar farms are made by a company called Hanwha.

These solar panels are made from silicone. This is currently the most efficient material for electricity generation. These panels are **15% efficient.** This means that 15% of the energy from the sun that hits the panels gets converted to electricity.

There are currently many scientists and engineers researching to improve the efficiency and materials of solar panels to make them more competitive.

There will be **20,322** panels in the farm. These panels take up about 30 acres of land. The panels are mounted on metal stands that keep them pointing south and at an angle of about 20 degrees. This position is the best way to get the most access to direct sunlight.



2.5 Megawatt array in Westford, MA developed by Nexamp

**Info regarding the status of this solar array is tentative as of 4/23/13*

Information from this page gathered from:
National Renewable Energy Labs
Civic Solar

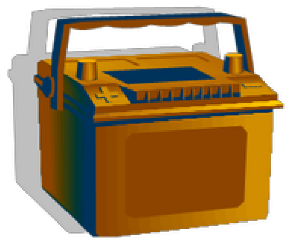
Solar at Treasure Valley

Solar Powered Campsite Lighting

With this system, there are 3 solar panels near East Lodge. This is the **Centralized Charging Station.**

This station charges 12 volt batteries. Scouts are responsible for transporting a battery every day from the charging station to their campsite.

When the batteries are charged, they can last for up to 15 hours running the system components.



12 Volt Battery

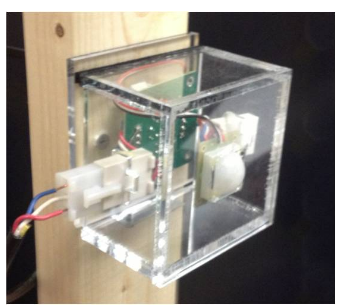
East Lodge

System Components

LED Lights

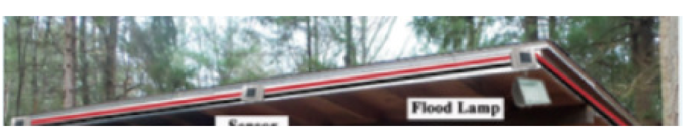
USB Charger

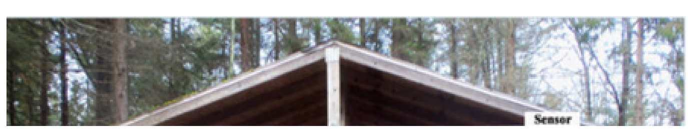
Motion Sensor



Information Display

lighting setup on the latrine and pavilion





This system was a design project completed by WPI Students in 2013

Solar at Treasure Valley

These questions are designed to encourage comprehensive exploration of the resources presented about photovoltaics. They also help to encourage further questions about solar in the context of society.

Solar Data Calculations

Mouse over the questions for hints and important details for answering the questions.

1. What is the area of one solar panel in the solar farm in square meters?

Check Answer

2. How many panels are in the solar farm at Treasure Valley?

Check Answer

3. Find the map from the NREL website that displays annual solar radiation. What is the value in Massachusetts?

Select One

Check Answer

4. What is the efficiency of the solar panels at Treasure Valley?

Check Answer

5. Based on your calculations, how much solar energy can be produced in one year?

Hint: The formula you should use is (Area of a Panel)X(number of panels)X(Annual solar radiation value)X(365 days in a year)X(efficiency) = energy produced in a year. Your answer will be in Kilowatt Hours which is a unit of energy.

Check Answer

6. If SRECs are given for every 1000 kilowatts generated, how many SRECs will be earned in 1 year?

Check Answer

7. If the maximum power that the array can produce is 6 megawatts, how many light bulbs can the array power?

Hint: The average light bulb generally takes about 100 watts. You will need to convert megawatts to watts to make the units match. There are 1,000,000 watts in 1 megawatt.

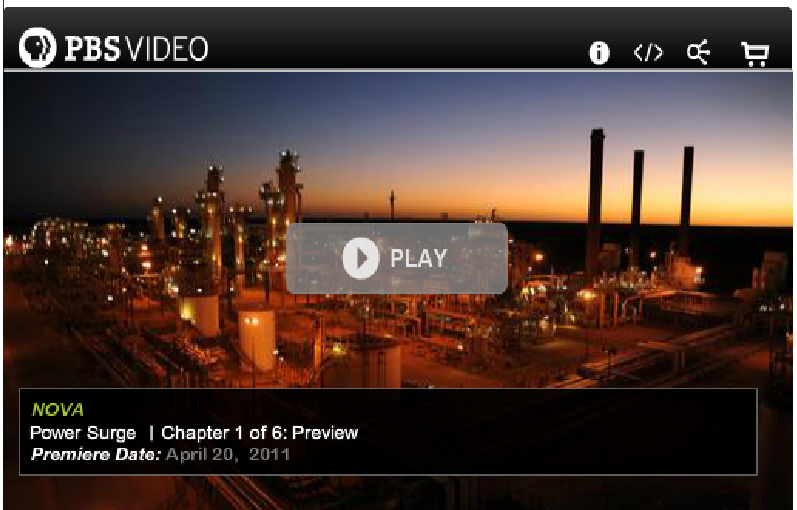
Check Answer

Solar at Treasure Valley

These questions are designed to encourage comprehensive exploration of the resources presented about photovoltaics. They also help to encourage further questions about solar in the context of society.

1. Answer: The area of a solar panel is found by multiplying length times width (A=L*W). The panels used in this array are 2 meters in length and 1 meter in width. Therefore, the area of one panel is 2 meters squared.
2. Answer: There are 20,322 panels in the farm.
3. Answer: 4.0-4.5 kWh/m^2/day
4. Answer: The efficiency of the panels is 15%. Engineers and scientists are doing research to improve the efficiency of solar panels. This means that they want to be able to harness more energy in a smaller area. Already, some of the experimental panels have reached 50% efficiency. This research will help make solar more competitive in comparison to fossil fuels.
5. Answer: 2 meters squared X 20,322 panels X 4.0 Kilowatt Hours/meter squared/day X 365 days/year X 0.15 = 8,901,036 Kilowatt Hours
6. Answer: 8901 SRECs
7. Answer: It could power 60,000 light bulbs at once! (6,000,000 watts /100 watts per bulb = 60,000 bulbs)

Solar at Treasure Valley



Watch Power Surge on PBS. See more from NOVA.

Play video

TED

Bertrand Piccard

Bertrand Piccard's solar-powered adventure

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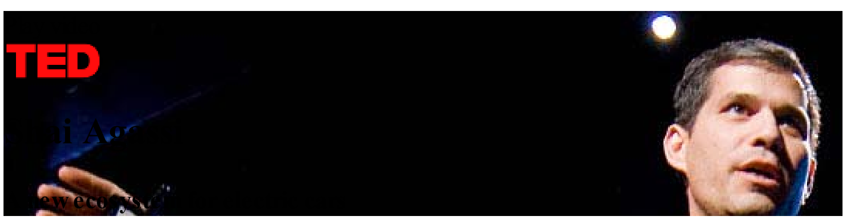

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Brink : Solar Textiles
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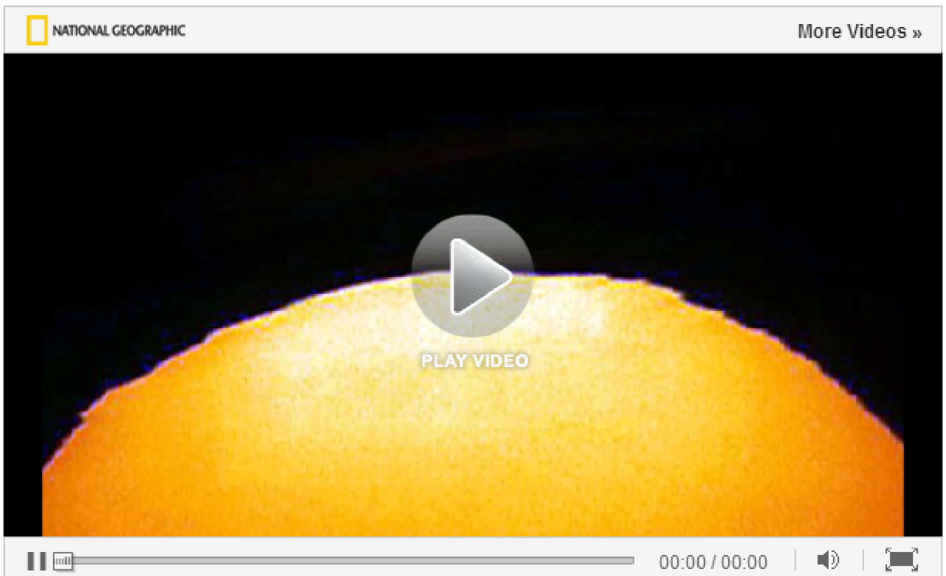

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Appendix J: Map Deliverables

Infrastructure Map

Constraints Map

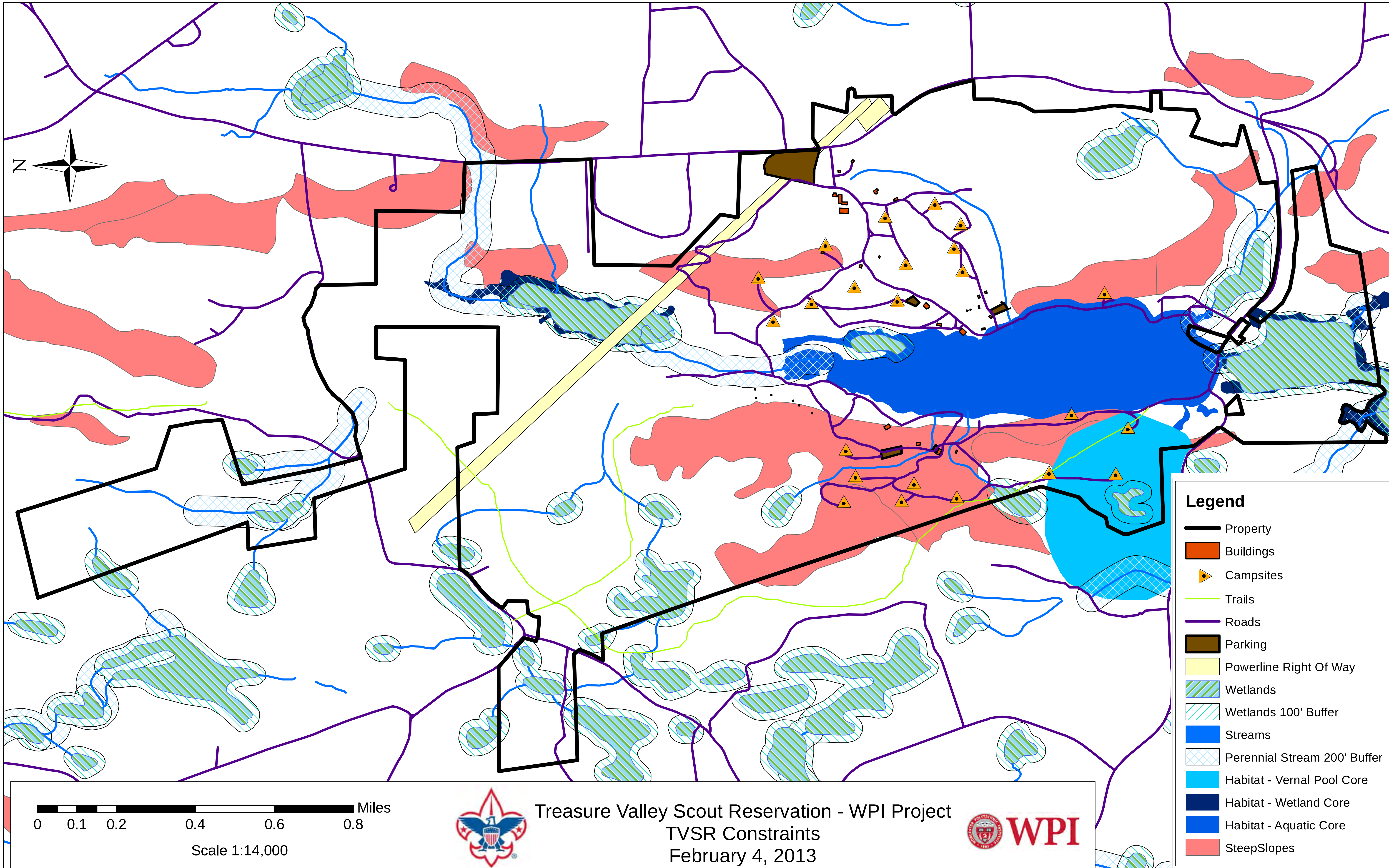
Zoning Map Recommendations

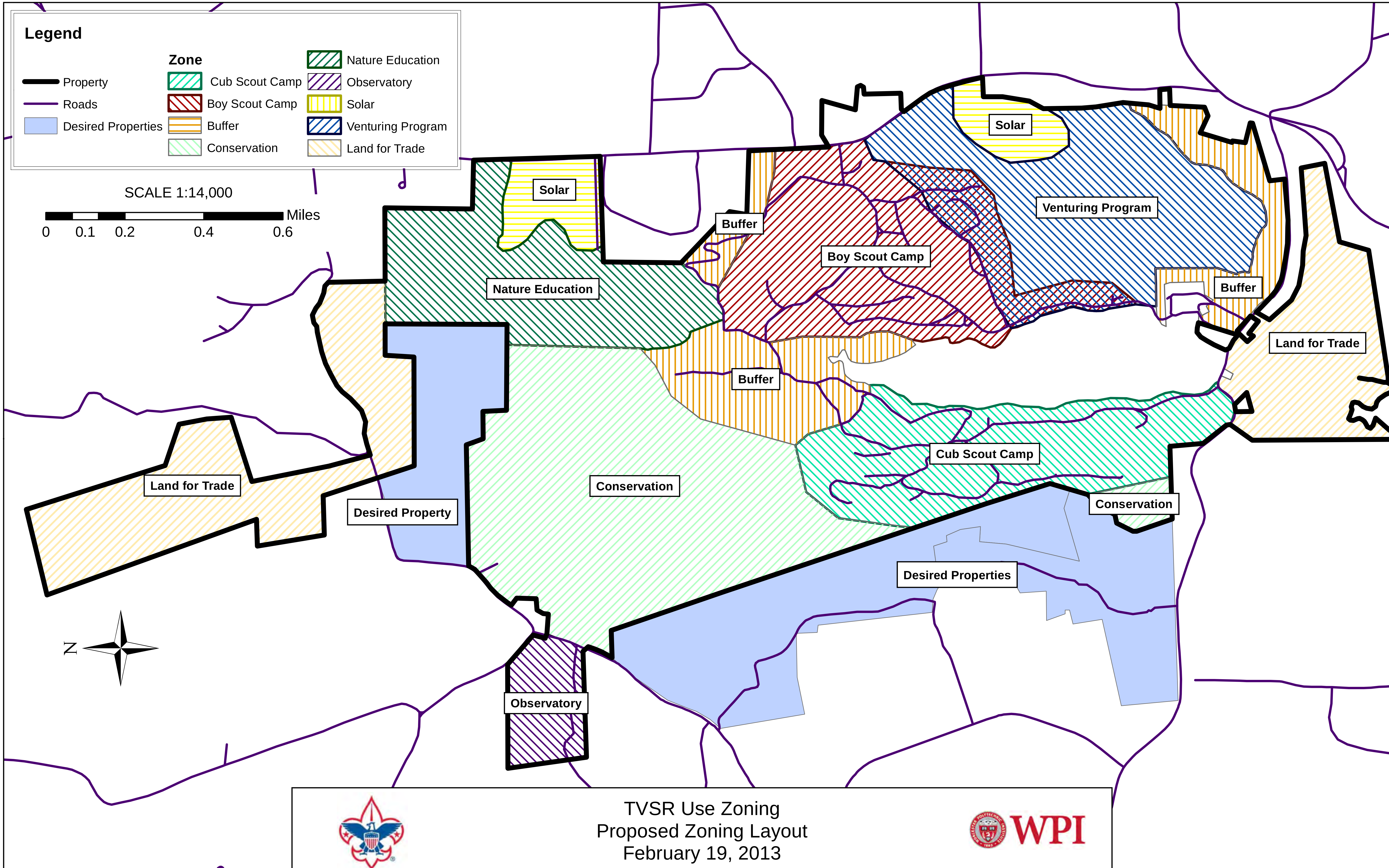
Nature Education Conceptual Recommendations

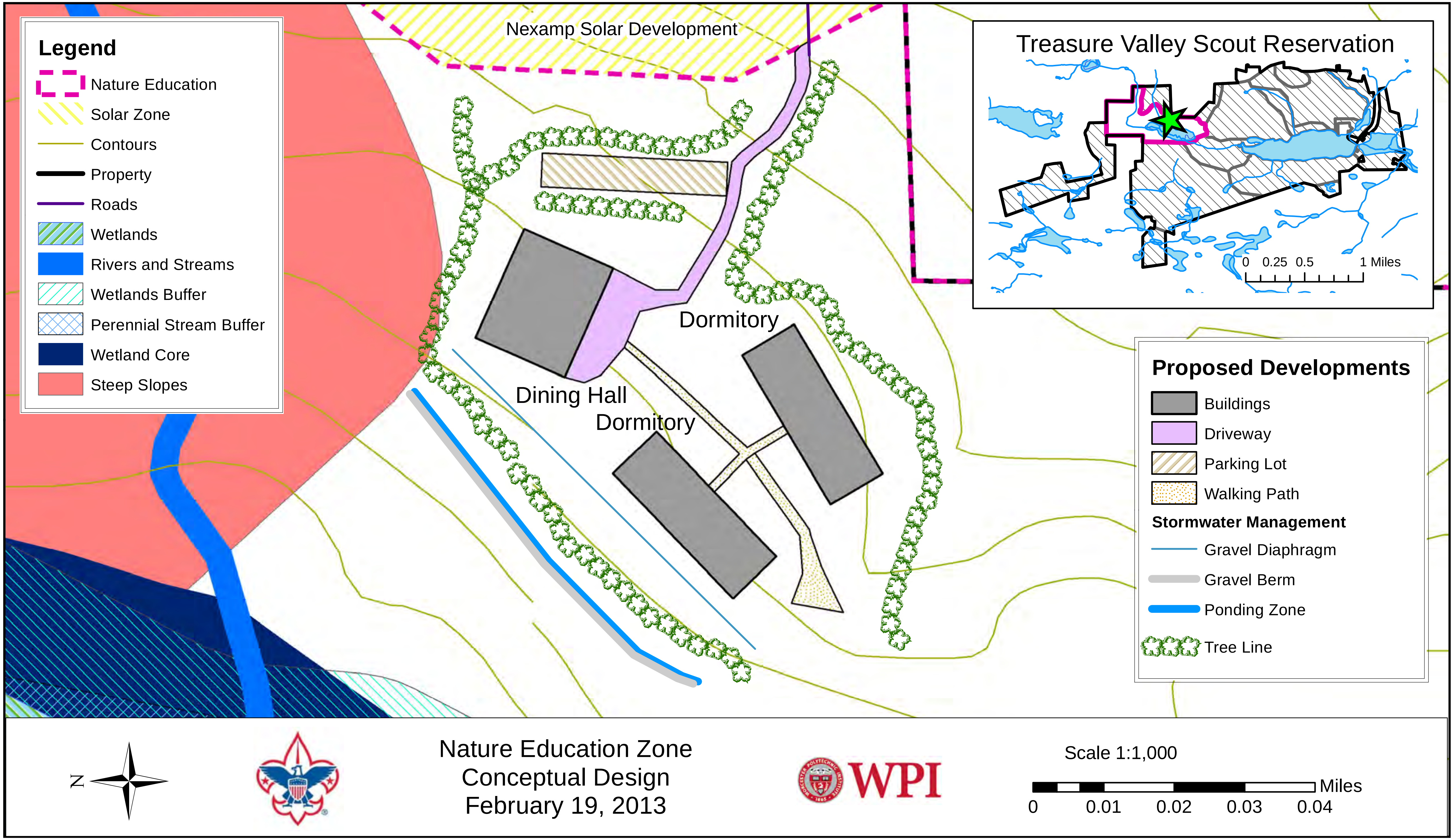
Venturing Program Conceptual Recommendations

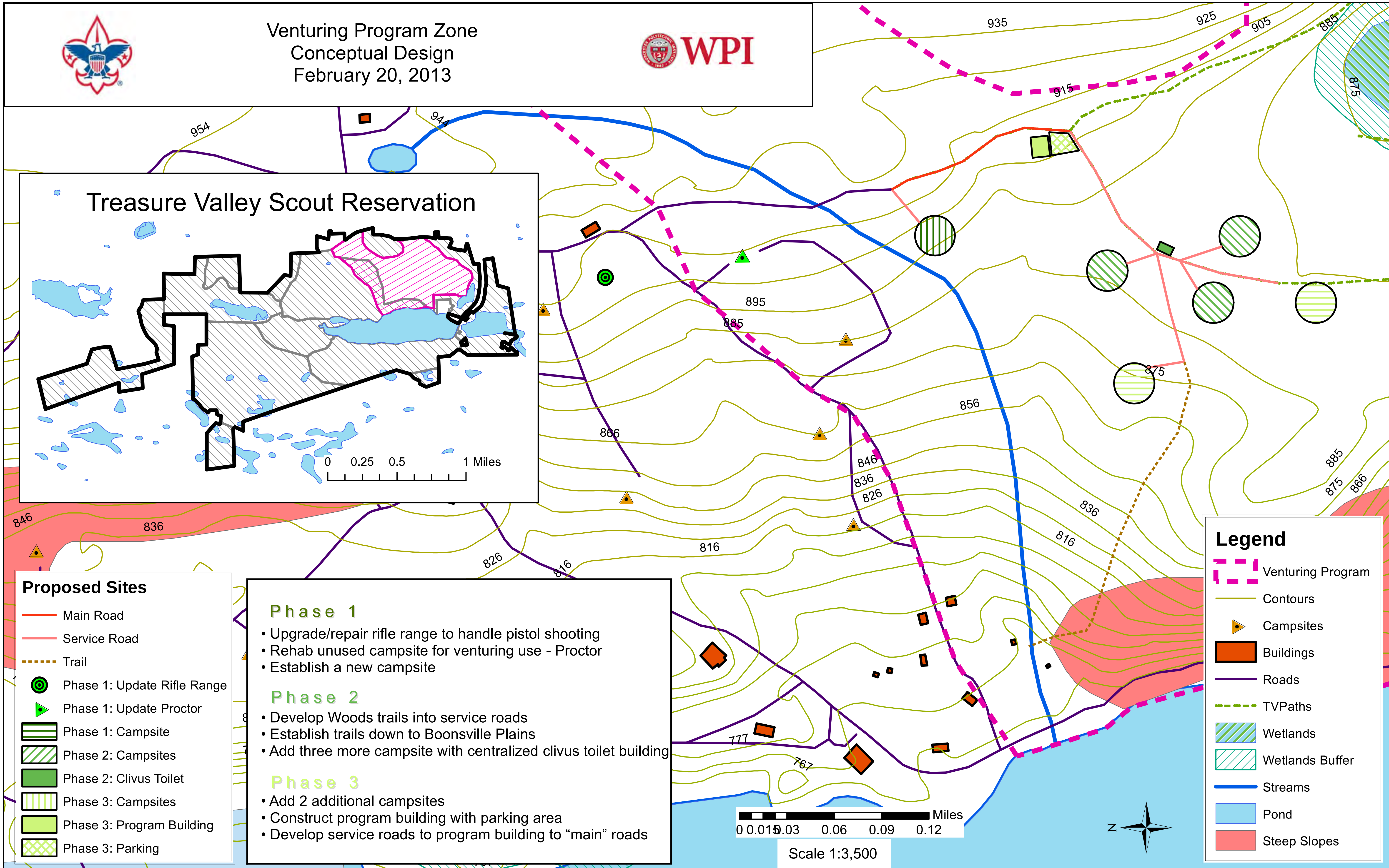
Parking Conceptual Recommendations


Treasure Valley Scout Reservation - WPI Project
TVSR Existing Infrastructure
February 26, 2013
WPI
N
Scale 1:3,000
0
0.05
0.1
0.2
0.3
0.4
Miles
Directors Cottage
King Cottage
Health Lodge
Rifle Range
Ranger farmhouse complex
Coghlin
Proctor
Baden Powell
Tall Maples
Arrow
Econ
Probus
Magee Center
Hickory
Chippewa
Sleepy Hollow
Madore
Pine Acres
High Mesa
Evergreen
East Lodge
Picnic Shelter
Picnic Shelter
Shower house
Hemlocks
Rest Rooms
Sports
Sports
Pump house
Thunderbird
Shower House
Handycraft
Commissary Building
Adirondack
Adirondack
Adirondack
Adirondack
Adirondack
Adirondack
Fort Courage
Columbus Bldg Cub Day Camp
Brownsea
West Lodge
West Conference Center
Old shower house
Katahdin
Kodiak
Deer Trail
Hardwood
Trail's End
Whispering Hill
Rocky Point
Legend
Buildings
Campsites
Wells
Parking
Trails
Roads
Waterlines
Powerlines
Above Ground
Below Groud
Right of Way


N
Legend
Property
Buildings
Campsites
Trails
Roads
Parking
Powerline Right Of Way
Wetlands
Wetlands 100' Buffer
Streams
Perennial Stream 200' Buffer
Habitat - Vernal Pool Core
Habitat - Wetland Core
Habitat - Aquatic Core
SteepSlopes
0 0.1 0.2 0.4 0.6 0.8 Miles
Scale 1:14,000
Treasure Valley Scout Reservation - WPI Project
TVSR Constraints
February 4, 2013
WPI


Legend
Zone
Property
Roads
Desired Properties
Cub Scout Camp
Boy Scout Camp
Buffer
Conservation
Nature Education
Observatory
Solar
Venturing Program
Land for Trade
SCALE 1:14,000
Miles
0
0.1
0.2
0.4
0.6
Solar
Solar
Venturing Program
Buffer
Boy Scout Camp
Nature Education
Buffer
Buffer
Land for Trade
Land for Trade
Cub Scout Camp
Conservation
Desired Property
Conservation
Desired Properties
N
Observatory
TVSR Use Zoning
Proposed Zoning Layout
February 19, 2013
WPI


Legend
Nature Education
Solar Zone
Contours
Property
Roads
Wetlands
Rivers and Streams
Wetlands Buffer
Perennial Stream Buffer
Wetland Core
Steep Slopes
Nexamp Solar Development
Dormitory
Dining Hall
Dormitory
Treasure Valley Scout Reservation
0 0.25 0.5 1 Miles
Proposed Developments
Buildings
Driveway
Parking Lot
Walking Path
Stormwater Management
Gravel Diaphragm
Gravel Berm
Ponding Zone
Tree Line
N
Nature Education Zone
Conceptual Design
February 19, 2013
WPI
Scale 1:1,000
Miles
0 0.01 0.02 0.03 0.04


Venturing Program Zone
Conceptual Design
February 20, 2013
WPI
Treasure Valley Scout Reservation
0 0.25 0.5 1 Miles
Proposed Sites
Main Road
Service Road
Trail
Phase 1: Update Rifle Range
Phase 1: Update Proctor
Phase 1: Campsite
Phase 2: Campsites
Phase 2: Clivus Toilet
Phase 3: Campsites
Phase 3: Program Building
Phase 3: Parking
Phase 1
• Upgrade/repair rifle range to handle pistol shooting
• Rehab unused campsite for venturing use - Proctor
• Establish a new campsite
Phase 2
• Develop Woods trails into service roads
• Establish trails down to Boonsville Plains
• Add three more campsite with centralized clivus toilet building
Phase 3
• Add 2 additional campsites
• Construct program building with parking area
• Develop service roads to program building to "main" roads
0 0.015 0.03 0.06 0.09 0.12 Miles
Scale 1:3,500
Legend
Venturing Program
Contours
Campsites
Buildings
Roads
TVPaths
Wetlands
Wetlands Buffer
Streams
Pond
Steep Slopes
N
954
944
935
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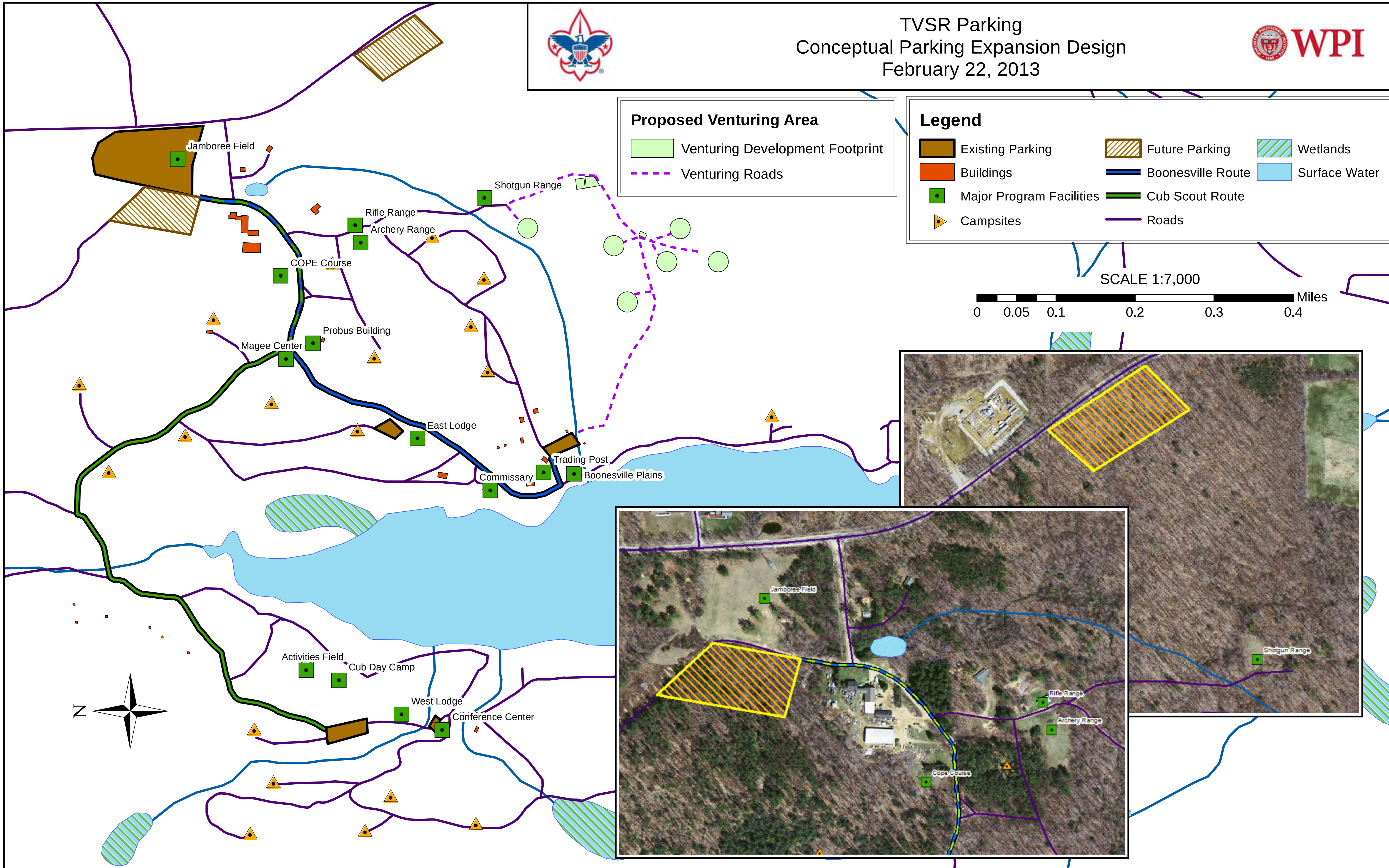
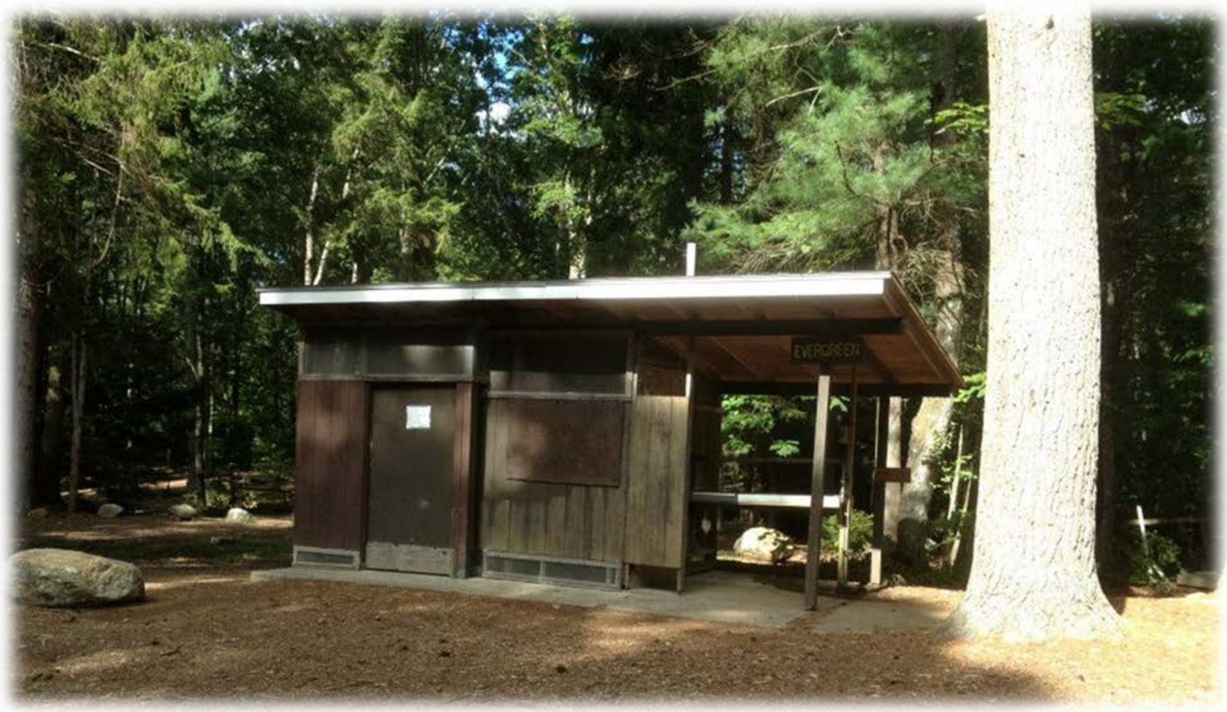
915
905
895
885
875
866
856
846
836
826
816
777
767


TVSR Parking
Conceptual Parking Expansion Design
February 22, 2013
WPI
Proposed Venturing Area
Venturing Development Footprint
Venturing Roads
Legend
Existing Parking
Buildings
Major Program Facilities
Campsites
Future Parking
Boonesville Route
Cub Scout Route
Roads
Wetlands
Surface Water
SCALE 1:7,000
0
0.05
0.1
0.2
0.3
0.4
Miles
Jamboree Field
Shotgun Range
Rifle Range
Archery Range
COPE Course
Probus Building
Magee Center
East Lodge
Trading Post
Commissary
Boonesville Plains
Activities Field
Cub Day Camp
West Lodge
Conference Center
N

Appendix K: Proposal

<u>Treasure Valley Solar MQP</u>



Report submitted to:

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In cooperation with:

Treasure Valley Boy Scout Reservation

October 11, 12

This project report is submitted in partial fulfillment with the major degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or options of the Treasure Valley Boy Scout Reservation or Worcester Polytechnic Institute.

Capstone Design Statement

Civil Engineering

This project will meet the requirements of the Accreditation Board for Engineering and Technology (ABET) for capstone design experience in Civil Engineering. ABET requires that engineering design be incorporated with "realistic constraints" to demonstrate a comprehensive engineering design. The project will address the constraints of economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political concerns.

Economic

One of the main constraints of developing renewable energy on the Treasure Valley Scout Reservation is the cost of implementation of the systems. Our plans and proposals will take into account the initial and operational cost of the plan recommendations and infrastructure for upgrading as well as the cost savings of reduced dependence on the electric grid. Our research will include any renewable energy or other sustainability incentives that exist for solar power and other sustainable solutions. The equipment selection and recommendations will include cost effectiveness considerations. These considerations are important to make the plan viable.

Environmental

The plan that we will develop will be aimed at reducing the reservation's impact on the surrounding environment. All proposed construction will be in compliance with the local, state, and federal environmental regulations including the wetlands protection act, watershed protection efforts and others. Given the Boy Scout's value for preservation of the environment, all tree cutting, land moving, or other processes that involve alteration of the natural environment will be avoided.

Sustainability

The development of a plan for Treasure Valley is mostly in an aim to ensure successful and sustainable development of the reservation. Our deliverable will include sustainable solutions for future developments including renewable energy, storm water management, energy conservation, and habitat preservation.

On a local level, these systems will be designed to be durable and replaceable so that many generations of Boy Scouts can benefit from the benefits of the system and the education they bring. In addition, we plan on developing a long term plan (on the scale of 20 years) for the reservation's future developments with recommendations for maintaining minimal environmental impact through renewable energy.

Manufacturability

The ability of our plans and recommendations to be executed and constructed is important for our objective to be met. The end product will be a plan that will be usable by the Boy Scouts.

Ethical

In the execution of this project, each group member will follow the guidelines of the Civil Engineers Code of Ethics. We will uphold the fundamental principles and canons by being honest in our presentation of information and working towards a product that will best meet the needs of our client.

Health and Safety

The health and safety of those who will be affected by any aspect of the project will be held paramount. With the majority of users being younger children, all safety risks will be assessed and minimized with cooperation of the Treasure Valley staff. Any safety risks associated with the electrical proportion of this project will be designed to protect the users of the equipment and those within the surrounding area.

Social

The benefits of this project will not only provide practical benefits such as lighting. The design of the renewable energy system will be used as an education tool for the Boy Scouts. The design of the system and the site as a whole will be designed to be user friendly with knowledge of the demographic of the users of the facility.

Political

In determining our methodological steps, we will monitor whether any of our plans will need approval by any town boards. Given that the Treasure Valley Scout Reservation spans the borders of four towns, we will cater our designs to any needs and restrictions that each town may have.

Electrical and Computer Engineering

This project will meet the requirements of the Accreditation Board for Engineering and Technology (ABET) for capstone design experience in Electrical and Computer Engineering. This project will address the following constraints: economic considerations, safety considerations, reliability considerations, aesthetic aspects, analysis, synthesis, integration of previous course work, and experimental work.

Economic Considerations
This project must be able to meet the client's financial needs. These needs are demonstrated by presenting estimates of the total cost of the product, producing a capital plan, optimizing cost vs. performance, and computing life cycle costs.

Safety Considerations
With the constraint that this project deliverable will be used around children, safety is a major concern. We will make sure that there is limited operator risk that would affect both the technicians and end-users as well as making sure that risks are properly assessed and presented.

Reliability Considerations
Reliability must be integrated well into the design because our device will be a safety device. We will demonstrate the ability to integrate safety into our design by testing (quality assurance, quality control) and analysis (reliability, availability, component tolerance).

Aesthetic Aspects
This project will display aspects such as power dissipation, weight, volume, form factor, and user interface were taken into consideration into the design process and implemented into the final design.

Analysis
This project will support design decisions with appropriate mathematical analysis and simulations.

Syntheses
This project will describe how the design was created from top-level system description into lower level specifications until component level specifications are reached.

Integration of Previous Course Work
This MQP will demonstrate our ability to integrate concepts from completed courses into a solution of an engineering problem.

Experimental Work

In this project, analytical results, computer simulations, and compliance with specifications are verified by experimental measurements.

Environmental Studies

The Environmental and Sustainability Studies major at WPI does not require a capstone design experience. However, the project is being completed in partial completion of the degree requirement. The project will show an understanding of the social impacts of engineering design and highlight the importance of the human component in the environment. The development of an educational program regarding renewable energy will provide a link between sustainable technology and how humans can affect the way we get our energy and develop the world. Providing this perspective for the younger generation will ideally stimulate interest for the young people who will be future engineers and scientists making decisions regarding environmental development.

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Table of Figures

1.0 Introduction

The Treasure Valley Scout Reservation (TVSR) in Rutland, MA, the primary camp for the Mohegan Council Boy Scouts of America (BSA), has identified a need for a long term sustainable development plan. More specifically, the stakeholders of treasure valley have indicated an interest in renewable energy development and feel that "technology has a dynamic place in the Boy Scouts," (Griffin).

In fulfillment of the Major Qualifying Project (MQP) for the areas of Civil Engineering, Electrical and Computer Engineering, and Environmental Studies, our project group will complete a project in collaboration with the stakeholders at Treasure Valley. In an effort to meet the needs of our client, we plan to develop a long-term sustainability plan to direct the future development on Treasure Valley. As a specific portion of the larger scale plan, we plan to develop a system of renewable electric generation, which is independent from the grid. This will include implementing a smart lighting systems and charging stations at various campsites for the safety, security, and peace of mind of camp goers without spoiling the camping experience. TVSR also sees the pursuit of renewable energy as an opportunity for education at the Boy Scout level of how clean energy is generated.

Two Civil Engineers (CE) and two Electrical and Computer Engineers (ECE) will work together to develop the project. The project will demand specialized work from each group (CE and ECE). Specifically, the CEs will seek the technical expertise and knowledge of the ECEs to properly plan and design any necessary infrastructure and provide insight for the development of the sustainability plan. Conversely, the ECEs will consult with the CE's to determine if their plans are feasible for the given location and what the impact to the environment will be.

1.1 Problem statement

Treasure Valley Scout Reservation currently does not have a development plan of any kind. Development of a plan to guide sustainable development will help Treasure Valley be able to provide a haven for Boy Scouts for many years in the future.

Currently, an outside contractor is developing and constructing a 6-megawatt solar array on Treasure Valley leased lands. This development has sparked Treasure Valley's interest in pursuing a renewable initiative. Unfortunately, none of the electricity from this array will be used directly on site before entering the grid, which leaves a potential for the development of a small scale solar setup that meets the projected needs of the reservation while displaying the process and results to the Boy Scouts for learning purposes.

Treasure Valley has identified their need in the specific areas of lighting applications at locations such as latrines, health lodge, and pavilions where boys of varying ages would benefit from installed and mounted lighting. Future applications for renewables include alternative sources of energy for the existing and future building on the reservation.

1.2 Objectives

Based on the identified problems statement, the objectives of the project are as follows:

- Understand stake holder's specific needs and constraints
- Develop a general sustainability plan for the reservation (large scale) based on existing infrastructure, future plans, and sustainable goals.
- Determine a feasible site for the solar system for off grid use in the facilities on TV
- Design a solar power model that can be used to power a lighting system throughout the reservation at different locations
- Create a workable plan for implementation of a renewable lighting system in a single site
    - Construct the working model for a single site
- Use the developed designs to create a display for the reservation to educate the scouts about renewable energy

2.0 Background

This section details the background knowledge that is necessary to set the groundwork to accomplish the objectives of the projects. The information presented details the existing condition of Treasure Valley Scout Reservation, the needs of our client, and concepts that will be utilized to complete the project.

2.1 Treasure Valley

The Treasure Valley Scout Reservation is the Boy Scout camp used by the Mohegan Council BSA. The land is approximately 1600 acres and spans the towns of Rutland, Paxton, Oakham, and Spencer (www.doubleknot.com). Given that TVSR spans four towns, regulations vary on different sides of the borders. The zoning bylaws for each town make the development of buildings difficult and require different approval processes in each town. Most of the facilities used on the property are located in Paxton and the major pond, Browning Pond, is located in Oakham. A map of the developed area of Treasure Valley that is utilized is shown below.

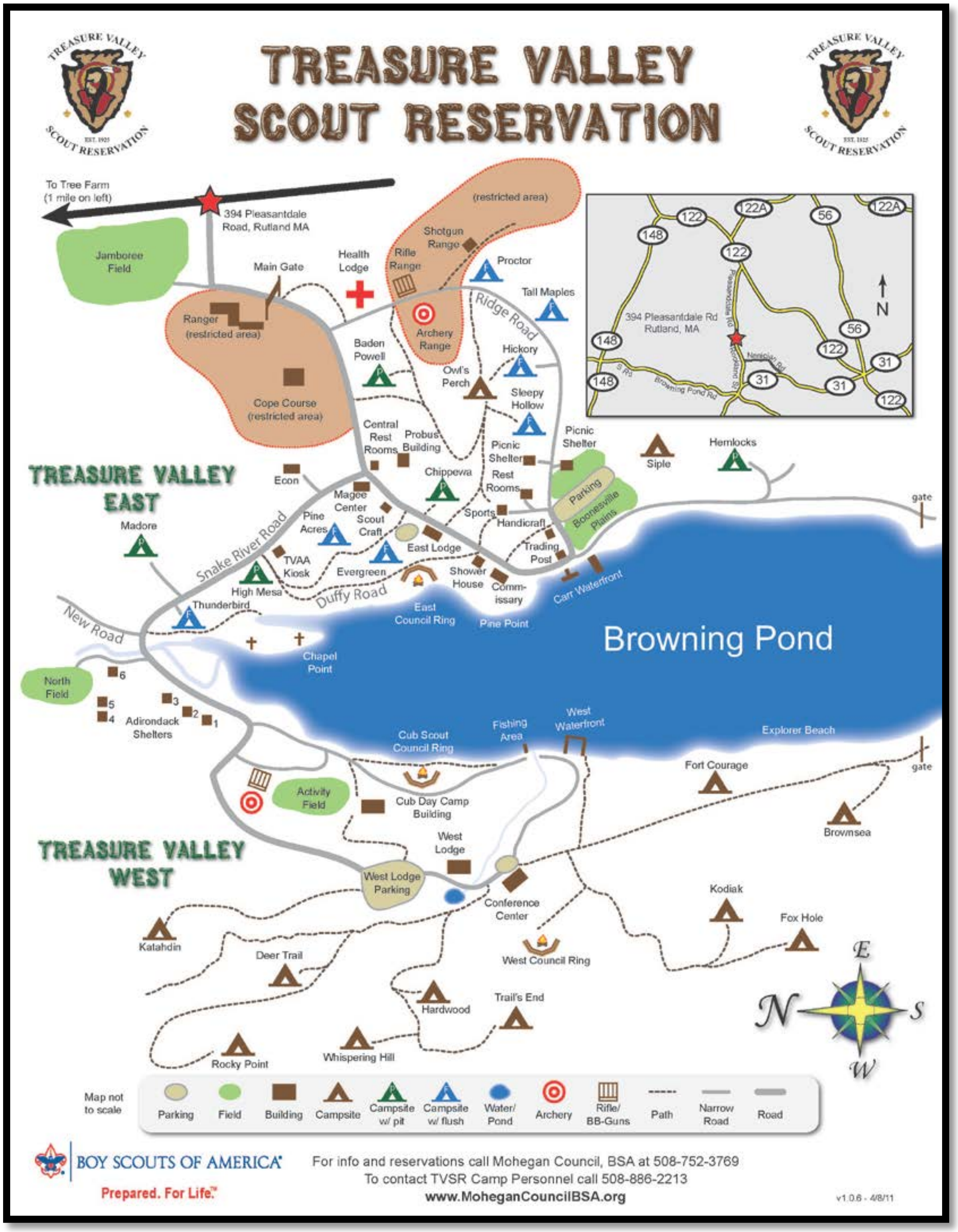

Figure 1: Boy Scouts of America's map of Treasure Valley Scout Reservation

The reservation is divided by Browning Pond into Treasure Valley East and Treasure Valley West. Treasure Valley West is mostly used by the younger boys ages 7-10 in Cub Scouts. Treasure Valley East is most often used by the older boys ages 11-17 in Boy Scouts. The facilities consist of 24 designated camping areas, various buildings, activity areas, and established roads to navigate the reservation (figure 1).

Treasure Valley was established in 1925. The reservation has never had a master plan to guide development in any area (Griffin). There is currently no organized budget for expected improvements or development of the reservation. Many of the minor improvements done on the reservation are done by volunteers or through donations. The main road running through the reservation was recently paved by donations with a “price per foot” of asphalt. Those interested in helping out with improvements could pay a $50 sum for and receive a ruler with the text, “I own this much from Pleasantdale Road to Pine Point - TVSR.” Additionally, the TVSR website currently has an entire page dedicated to materials they would like to see donated. A few things on the list are pressure treated wood, concrete mix, and paint. Treasure Valley relies mostly on generosity for basic improvements and upkeep of the facilities (www.doubleknot.com/).

In Massachusetts, there are ten Boy Scout Councils. The Mohegan Council is the regional division of the Boy Scouts of America in which Treasure Valley falls. It encompasses 30 towns in Central Massachusetts including the Massasoit District, Hassanamisco District, and Quinsigamond District. It is expected that in the future, these districts will be restructured in an effort consolidate. In this process, should it happen, Treasure Valley is expected to stay active as a majorly used reservation for the scouts given its extensive facilities and central location (www.doubleknot.com/).

2.2 Stakeholders

The main stakeholders in our project are:

- Treasure Valley Organizations
    - Board of Trustees
    - Executive board
    - Board of Directors
    - Camping Committee
    - Treasure Valley Alumni Association
    - Friends of Treasure Valley
- Boy Scouts of America
    - Mohegan Council

2.2.1 Treasure Valley Organizations

The land on which Treasure Valley is located in is in a trust. The owners of the land are the Board of Trustees of Treasure Valley. All decisions made regarding the Treasure Valley Scout Reservation and its facilities must be cleared by the Trustees. The Trustees focus on the preservation of TVSR for future generations, which includes long-term visions for development (Griffin).

Other organizations that are a part of decision making in Treasure Valley are the Executive Board, Executive Committee, Board of Directors, and the Camping Committee. The first three are part of the formal process for getting things approved. The camping committee is a group that has primary concern in the day to day functioning of the activities on the reservation and also with the safety and wellbeing of the kids (Griffin).

The Treasure Valley Alumni Association is a subsidiary of the Mohegan Council. This group is made up of members of any age who are or were at one point eligible to be Boy Scouts. The responsibility of the Association is to manage business matters to promote the experience and learning of the Boy Scouts at Treasure Valley (www.tvaa.us/). Though the TVAA have some influence, they are not the major authority in large-scale decision-making regarding Treasure Valley (Griffin).

The Friends of Treasure Valley is a group of retirees, scouts and non-scouts, who have a particular interest in helping out with the operations of the reservation. From year to year, they do improvement projects mostly in the buildings and grounds (www.doubleknot.com).

Worcester Polytechnic Institute used to be heavily involved with Treasure Valley. Students worked on projects with the reservations. Many people who are involved with TV are WPI alumni's. Reservation leaders are interested in rekindling this historic relationship with WPI (Griffin).

2.2.2 Boy Scouts of America

Boy Scouts of America is a nationwide organization founded more than a century ago in 1910. Since their founding, the Boy Scouts have been an organization for encouraging values and moral growth for the promotion of the youth to be the future leaders of the nation. Over their history, more than 2 million Boy Scouts have advanced through the program to the advanced level of Eagle Scout. The organization firmly believes in building character through community service, outdoor activities, and learning by doing (www.scouting.org).

The Mohegan Council is a regional division of the Boy Scouts of America. It encompasses 30 towns in Central Massachusetts. Their community contains about 5,000 children under the age of 18 and 1700 volunteer adults all-engaging in Scouting activities (www.doubleknot.com). It is estimated that on a yearly basis 15,000 people make use of the facilities at Treasure Valley. The main period of usage is in the summer months. During the winter months, the reservation sees little to no usage (Griffin).

2.3 Planning

In order to effectively accomplish goals and tasks, a plan is needed to organize the work progress and identify milestones and important dates. Many different organizations such as private and government entities follow a formal planning process. Local governments typically have planning departments to manage the direction of the community through development approvals and restrictions. Private organizations also plan to ensure their investments are managed and utilized properly.

With respect to a project, the planners have the responsibility to manage the scope, schedule, and cost of the project. The planner also must maintain relationships between the owners, users, designers, engineers, and builders of the project. Without proper coordination, the project can get out of hand and result in wasted time and/or money and a less than desired quality in the final project.

One important need while planning is to identify the scope of the work. Scope is how large of a picture the deliverable will envelope. The owner is responsible to define what needs are to be satisfied by the project. The quantity, quality, and the tasks to be performed must be defined and the scope can be broken down into individual work packages.

Cost is the fiscal demand of the project embodied in the price of construction materials, labor costs, design expenses, and etc. The cost of a project is a limiting factor in determining the feasibility of a project. The cost must be within the owner's budget or the project cannot be finished. Both the scope and the schedule heavily influence the cost of the project. An increase in the scope or a quicker schedule will translate to a more expensive project.

Scheduling is the key component to developing a plan. Knowing when, where, and how a part of the project is essential. The duration is important, but the relationship between each event is equally vital. Certain tasks will not be able to begin unless the prerequisite task(s) are completed. This chain of tasks from the beginning of the project to the end is known as the critical path. Analysis of the critical path will highlight the important activities that will delay the entire project when delayed themselves or what activities can be expedited to complete the project earlier. The activities outside the critical path will have flexibility in their competition time. This surplus of time is known was the "float" of the activity.

If a project is not properly managed, the disorganization can lead to many problems including running the project over budget, causing the project to take longer than planned, or not correctly satisfying the client's needs. (Oberlender)

2.4 Renewable Energy

Renewable energy is increasingly becoming a significant part of electricity generation all over the world. In the right location, energy from renewable sources can be very useful in compact or remote locations where large scale, non-renewable energy production cannot be used or accessed. In the case of Treasure Valley, renewable energy can also be used to teach the concepts of energy generation and demonstration the importance of energy conservation to children and young adults.

2.4.1 Why Solar?

There are numerous types of renewable energy technologies available. These include ways to harness wind, solar, geothermal, tidal, and biomass. Treasure Valley is familiar with solar energy because there is currently a large-scale solar development being planned for TVSR land. This close relationship with solar power generation has piqued the reservation's interest in finding a way to utilize solar power on a small scale for use in the reservation. More in-depth research is needed to make sure that solar energy is the best energy source for the project.

Solar systems are attractive because of their simplicity. There are no moving parts. They are noise free and potentially have low maintenance requirements. They are also easily integrated in a multitude of electric systems. (Tester)

From an ecological perspective, an off-grid power system for Treasure Valley may be worth exploring. An off grid system would allow the reservation to be independent from the electrical grid and would be an example for other businesses and educational facilities to follow. The power system would also allow for the integration of an educational element that would fit the style of learning that the Boy Scouts of America strive for. A potential drawback of an off-grid solar power system for Treasure Valley is lack of financial incentives specifically the large upfront capital cost and low return on investment.

2.4.2 Solar Technology

Instead of mechanical power generation, solar panels use photovoltaic (PV) cells to harness the sun's energy and convert it directly to electricity via the photoelectric effect. When a photon strikes a certain semi conductive material, the material's electrons are able to capture the photon's quantized energy. Under the right conditions, the striking of the photons releases electrons in the material creating voltage difference. The most common material used in PV cells is silicone (Tester). An illustrative example can be seen in figure 2. Currently, solar powered devices are widely used in both small-scale applications (such as a calculator) and large-scale power generation. Because of the versatility of both high and low power needs, solar energy can fit solar effectively into a variety of site locations and power situation.

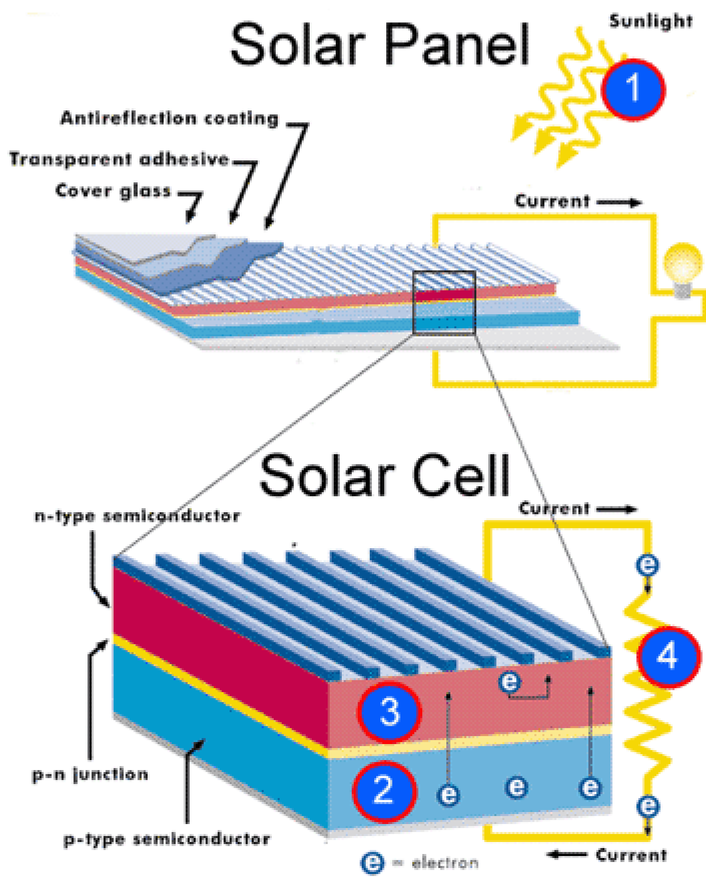

Figure 2: Operation of a solar cell (www.solarcell.net.in)

The most important advancements in solar power production technology are the efficiency of the cells and the cost effectiveness. As shown in figure 3, even the most popular consumer panels are between around 12-17% efficient (www.sroeco.com).

Manufacturer	ID	STC	Density	Eff.	Tier
Sanyo Electric	HIP-200BA19	200	14.89	17.24%	1
SunPower	SPR-200-WHT-U	200	13.55	16.08%	1
Canadian Solar	CS5A-200M	200	13.29	15.66%	2
Suntech Power	PLUTO200-Ada	200	13.28	15.66%	2
Trina Solar	TSM-200DA01A	200	13.12	15.64%	2
Kyocera Solar	KC200GT	200	12.03	14.74%	3
Schuco USA	SPV 200 SMAU-1	200	11.82	14.21%	3
BP Solar	SX3200B	200	11.52	14.17%	3
Yingli Green Energy	YL200P-26b	200	11.26	13.65%	4
ET Solar Industry	ET-P654200	200	11.18	13.61%	4
Evergreen Solar	ES-200-RL	200	10.69	13.40%	4
Sharp	ND-200U1	200	9.86	12.27%	5

Figure 3: Most popular consumer solar panels (www.sroeco.com)

2.4.3 Solar Incentives in Massachusetts

Currently, there are a variety of different incentives for Massachusetts residents and businesses to install solar power systems. The following information is from solarpowerrocks.com, a database of solar incentives based on each specific state as of October 2012. The solar power rebate program developed by the state of Massachusetts started in 2007 with a budget of $68 million and a goal of having 27MW of solar power installed on consumer and business property in 2010. So far the program has been successful and the budget has already been depleted. Massachusetts' incentive program is not the only one in the country with heavy usage. Most states have an incentive program coupled with a federal tax rebate to stimulate the growth of solar and other renewable power systems. The incentive program is expected to continue and grow in the amount of money that will be able to be used by Massachusetts residents. If Treasure Valley was to implement solar energy into their electrical system, they could be eligible to these benefits.

Government subsidies are important in the implementation of solar power because of the high initial costs that is incurred by a new system. For example, a 5kW solar system in the Boston area would cost around $26,000 but with the subsidies from both the state and federal governments, the cost can be reduced to about $12,000 including the tax credits. Though $26,000 is still a substantial amount to have to pay upfront for an energy system, it is best to think of the system as an investment. Typically, a system would take 5 years to pay for itself.

In order for solar power systems to become more pervasive in the current power system, two things must happen. Solar panels must become cheaper to produce. By advancing the technology to be more cost effective, it will become easier to implement by consumers and more attractive as an investment. Secondly, the efficiency of widely available solar cells must increase. With the currently available efficiencies, a large surface area of panels is necessary to produce electricity. In the previous example (solarpowerrocks.com), a 5kW system is 625 square feet. In places where space is limited, this can be a constraint that prohibits the effectiveness of solar. By increasing efficiency, the amount of space necessary per kW will decrease, which will help eliminate some space constraints.

2.4.4 Other Sustainable Technologies

Other than solar photovoltaic cells, Treasure Valley Scout Reservation can benefit from other sustainable solutions. A few areas of sustainable solutions to consider for future efforts on Treasure Valley include storm water management, water quality preservation, conservation of energy use, generation of renewable energy, and local wildlife preservation. Examples of solutions that fit these categories are LEED building certification, rainwater collection basins, geothermal and solar thermal heating.

Leadership in Energy and Environmental Design (LEED) certification is a program offered by the US Green Building Council established in 2000. The certification is internationally recognized and recognizes building design in the areas of sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. In order to become certified, a building must meet a certain number of requirements in each category, dictated by a list of potential innovations (www.usgbc.org). Since achieving LEED certification costs the sponsoring organization money, it can be more economically feasible to make a building LEED certified, meaning it meets the standards of the LEED rating system without the official certificate. The benefits of this include a guideline for sustainable building development without the added cost of certification. As Treasure Valley further develops its facilities, LEED certification has the potential to decrease the environmental impact of the reservation as whole.

2.5 Education

In the US and Massachusetts in particular, there has been recent governmental attention paid to the education in the areas of Science, Technology, Engineering, and Mathematics (STEM). The Massachusetts Department of Higher Education has developed the STEM pipeline program where they have a fund of $2.5 million to award in grants to states. In 2003, the Economic Stimulus Act was passed which set the goals of promoting interest in STEM, increasing proficiency and graduation rates in these areas, and preparing students in those fields for STEM careers (www.stemedcoalition.org).

Students are introduced to the concepts of energy and electricity for the first time in elementary school. At the elementary level, the main focus from a STEM pipeline perspective is to increase students' interest in the subject (STEM Ed Coalition). One suggestion for the improved method of teaching energy is to take a more visual approach. Since teaching energy is quantitative by nature, teachers and students can feel confined to an explanation or description that lacks context. By ensuring that students can visualize a qualitative description of the energy will make concepts more understandable and easier to follow with relevant calculations. For example it is positive to include visuals of a physical system such as a circuit to demonstrate electricity and an example of a source of the energy such as solar panels or a power plant (Lawrence). A real world example can provide the context necessary to emphasize the practical applications of learning the concept of energy

The Boy Scouts value a practical learning approach. To encourage this, they have a merit badge program. Boy Scouts earn merit badges by choosing from the over 100 badges that come in many different subjects. A merit badge councilor helps facilitate learning by following the merit badge guidelines set by the Boy Scouts. The guidelines require the boy scouts to gain a basic understanding of the concepts and to demonstrate that understanding. Badges can be earned by any age of scout (www.scouting.org).

3.0 Methodology

The purpose of this section is to detail the necessary steps required to accomplish the objectives of the project. The work has been divided into four categories of tasks in alignment with the objectives. For a list of steps by major area of study, see Appendix A.

1. Develop a long-term sustainability plan for the Treasure Valley Scout Reservation.
2. Design a solar powered lighting system that will meet the identified electricity needs on the reservation.
3. Construct a working prototype of the solar power system for a single campsite.
4. Develop a renewable energy educational program for the Boy Scouts.

The flowchart below (figure 4) depicts each task with feedback arrows of how the completion of each will affect the other tasks. Each of these steps involves recommendations on different levels of specificity. Including specific solar power system design in combination with a broader sustainability plan will do two things: Details on the small-scale campsite level will provide us with practical information that will be used to development a comprehensive large-scale plan. The small scale details will also provide tangible results expected with the execution of the comprehensive plan, which will make the comprehensive plan more accessible by those responsible for approving and implementing it.

Throughout the project, considerations will be made to accommodate learning by the Boy Scouts. We will design an education plan about the implementation of a renewable energy system. Our campsite prototype design and the overall sustainability energy plan will be used to educate the Boy Scouts about the science surrounding renewable energy.

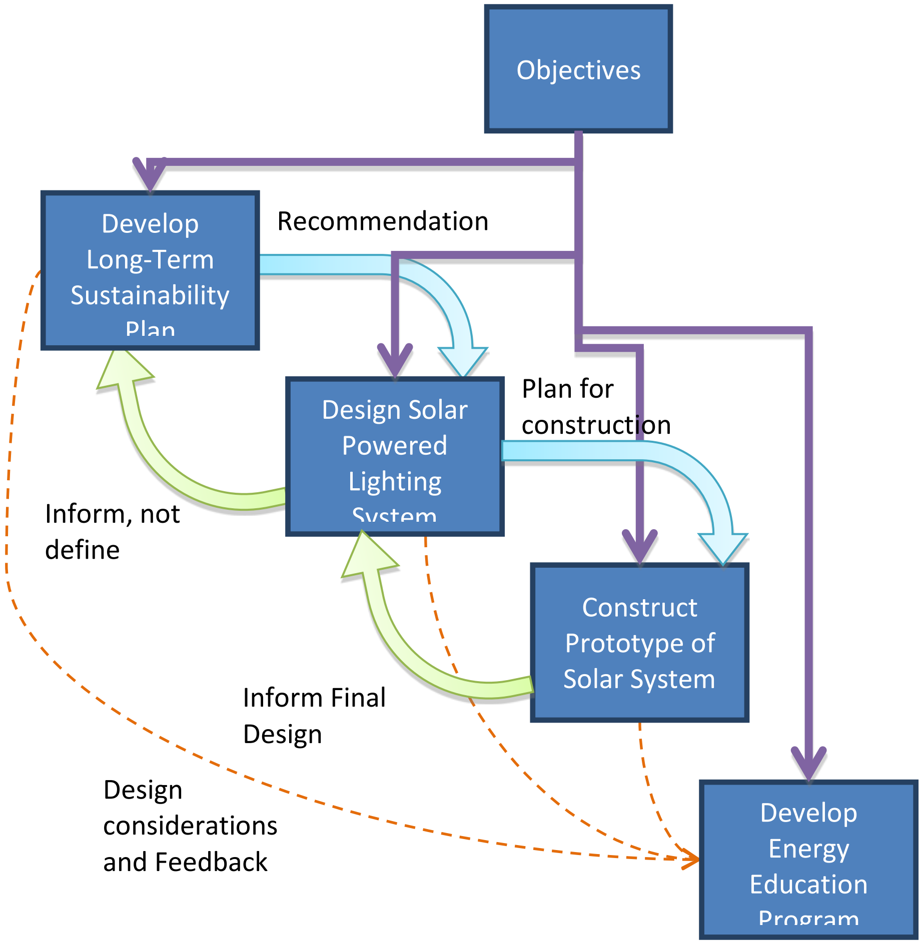

Figure 4: Objectives diagram

3.1 Sustainability Plan

Treasure Valley has identified a need for a comprehensive and long term plan for sustainable development of the reservation. The reservation does not have any type of long term plan (Griffin). This means that there is potential to develop a plan from the ground up. The process for developing a plan for Treasure Valley will follow the following steps, depicted in the flowchart below (figure 5).

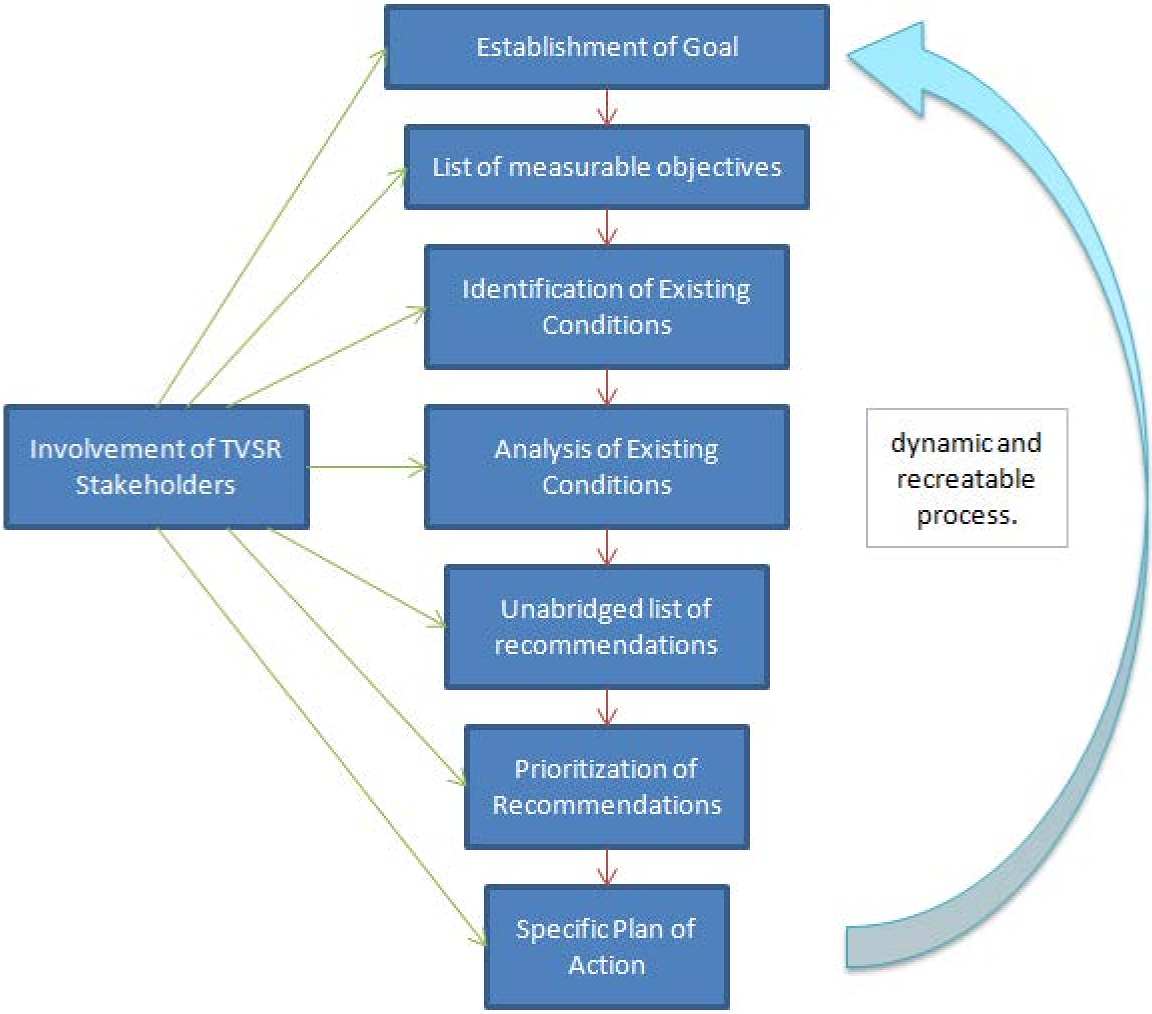

Figure 5: Sustainability Plan flow chart

We will first develop a goal and a list of measurable objectives. These objectives will be designed to create a starting ground from which to begin planning and as a reference for the formulation of specific goals. The list will be compiled with input from the Treasure Valley board of trustees and the Camp Council to account for different perspectives. The needs of the Boy Scouts will also be considered.

The next portion of the process will involve compiling a record of all of the existing conditions on the reservation. We plan to identify the current infrastructure. This includes buildings, roads, septic systems, activity areas, and any other constructed facilities. These features will be recorded in a GIS map for our reference. Additionally, for each of the features identified, we will determine how much energy it draws and the source of that energy. It is also necessary to accumulate a centralized list of all plans that the stakeholders at TVSR have for the foreseeable future. Upon identification of existing conditions, our group will evaluate and analyze them. For the existing infrastructure, we will determine the lifecycle of the facilities. We will also determine the user's feeling regarding the existing conditions. We want to have an understanding of what they feel is working and what they would like to see improved upon.

Following the analysis, we will develop a set of recommendations for the reservation. This list will be comprehensive and include all possible areas for improvement and future development in the area of sustainability. We will include suggestions for storm water management, water quality preservation, conservation of energy use, generation of renewable energy, and local wildlife preservation. These are areas that have been identified as important to the Boy Scouts and Treasure Valley. Any other areas of need that may be discovered through the initial steps of information gathering will also be included in the recommendations.

After the unconstrained list of recommendations has been developed, the team will prioritize the points. Prioritization will help ensure that the improvements that are most needed and most beneficial will be implemented. The ranking will be done through a cost benefit analysis of each recommendation. Economics and practicality will be weighed against the improvement to see which have the most potential for success.

Once the recommendations are prioritized, we will create a detailed plan of action. The action plan will include specific sets of instruction for each recommendation. Details included will be a timeline of events, the cost of each and source of the funds, and the party responsible for each action. The plan will be based on realistic expectations of the Reservation. Included with the action plan will be a detailed structure for how to monitor the progress. The plan will be designed to be working and developable over time as the needs of TVSR change. The monitoring plan will ensure that the plan functions as dynamic unit that will be beneficial to Treasure Valley in the present and future.

3.2 Solar Power System Design

As discussed earlier, the design of a solar power system for use on the reservation will provide a tangible result of sustainable planning efforts. The process for design will follow these steps:

1. Conduct a solar feasibility study of the Treasure Valley Scout Reservation.
2. Complete a prototype for an electrical design of the solar power lighting system.
3. Develop an implementation plan for construction and integration of the prototype.

3.2.1 Feasibility Study

The first step towards accomplishing the project goal is to conduct a feasibility study within Treasure Valley Scout Reservation to determine the proper location to site a solar power system. At this stage, decisions will be made about whether the system is centralized or distributed, roof mounted, ground mounted, or unconventionally mounted (i.e. pole, tree, water, etc.), and the approximate size of the system.

3.2.1.1 Data Gathering

We will collect site data on a weekly basis. Data for collection includes visual identification of potential sites, solar access testing, GPS locations of test sites and other landmarks. The equipment used for these visits includes cameras, solar pathfinder, handheld GPS, notebooks, maps, tape measure, and angle measurer. A detailed record of data and observations will be kept of each site visit for effective compilation of all information.

The Solar Pathfinder is an instrument used to determine the shading considerations of a specific location when siting solar. The instrument is used to determine the effects the surrounding shading will have on power output of a solar system. The solar pathfinder is shown in figure 6 below. The tool consists of a tripod topped with a plastic dome. Once leveled and oriented to true south, the plastic dome reflects and image of the surrounding environment, including shade-causing barriers. The outline of the horizon where it meets the sky is then traced onto a 'sun path diagram' that, when interpreted, details the amount of 'solar hours' that the given site will receive throughout the year.

Figure 6: Solar Pathfinder with a sun-path diagram adjusted for declination

To track location of test sites and other landmarks and to aid with GIS mapping, we will utilize a GPS device. The model of the device is Garmin eTrex Venture HC. This GPS was selected based on its availability and its level of accuracy. The altimeter in the device is accurate to 10 feet and has the potential to be accurate to one foot when calibrated by the user. The general GPS accuracy is less than 33 ft. In North America, the device has Wide Area Augmentation (WAAS) accuracy which means it is accurate within 10 ft. Both of the GPS accuracies are 95% typical (Garmin). Being in North America, the coordinates gathered in Treasure Valley will utilize WAAS accuracy. Each waypoint used to specify a solar test site or other landmark will be marked digitally on the GPS for mapping and physically in a data log notebook.

Figure 7: Garmin eTrex Venture HC (http://blog.discoveryeducation.com/msvmaher/)

Additional equipment will be used. A camera will be used to record visual information about the site. Additionally, qualitative site descriptions will be recorded in the data log notebook. A tape measure will be used to determine rough dimensions of a site for comparison to potential system size. We will also use a compass and angle measurer as needed to determine orientation and slope of surfaces for analysis.

3.2.1.2 Preliminary Calculations

Part of the feasibility study will include preliminary calculations of electricity demand, panel area, and system efficiency. These calculations will be done through a comparison of alternative equipment available including panels, lighting fixtures, inverters, and storage devices. Categorical determinations will be made at this stage of the planning based on efficiency, cost, availability, and siting feasibility. A decision matrix will be utilized to facilitate and detail the decision making process. All calculations will be recorded and detailed, as well.

Using the data gathered from the Solar Pathfinder, we will analyze on a location basis. Once solar hours are determined, the information can be used with available weather data through the

National Renewable Energies Laboratory (NREL) and typical system data to estimate expected production. An application such as PVWatts, which is also available through NREL, will be helpful in calculating production.

We will analyze locations based on the solar exposure in a systematic method. We will keep a list of each site to be tested including a qualitative description and the GPS coordinates. The testing locations will include a number of sites including campsites, open fields, waterfront, and rooftops. The group will test a wide range of sites to ensure the inclusion of a variety of options for comparison.

3.2.1.3 Initial Mapping

During the feasibility study, the group will archive the data in a GIS map. Each waypoint will be included to geographically map the testing progress. The map will also utilize various shape files available through MassGIS to locate potential constraints to siting a solar array. These include wetlands, floodplains, tree cover, and topography.

3.2.2 General Design

The design of the LED lighting system will be applied to an overall plan to implement the lighting system at all of the campsites. The general overview of the lighting system design as seen in figure 8 will be implemented in the long-term plan for camp-wide lighting systems. This design will also be implemented in our site-specific design when we build a prototype.

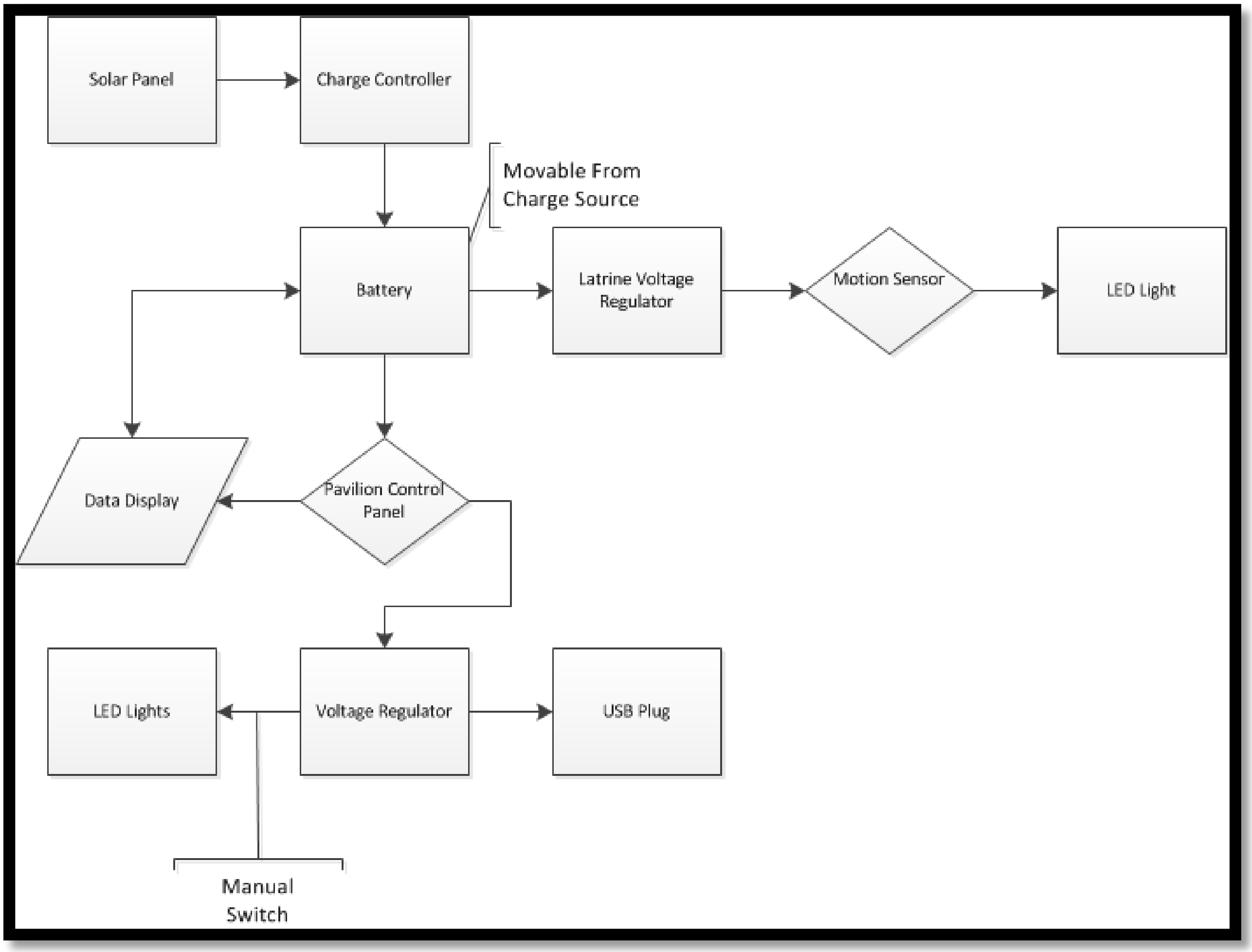

Figure 8: Overall lighting system design and components

3.2.3 Implementation Plan

In order to create an implementation plan for the solar power system, an inventory of the site must be completed. data from information provided from the Reservation and on-site data gathering will be compiled and organized. GIS software will be utilized to create maps organizing site information such as building/site locations, road/trail networks, topography, tree cover, utility lines, etc.

The first step in developing the plan is to define the scope of the project. The scope includes the short and long term plan. The short-term plan will be the specific campsite model, whereas the long-term plan will be a renewable energy plan with guidelines for implementation at every campsite.

Once the scope is defined, the next step involves clarification of the exact work that will be needed for construction, engineering, and operation. Work will be broken down to specific tasks. The project team will then estimate how long and how much each task will take and cost.

Once the single campsite plan is complete we can translate the site specific problems and goals into the broader, multi-campsite implementation plan. Each site is unique. For example, tree cover is the major factor determining how viable a solar system is. Some individual sites will be suitable to have their own solar panels while others will not be able to generate enough energy. By studying each site and analyzing its attributes, guidelines for implementation can be included for a multitude of configuration and needs.

Consideration on the adaptability of the system design will be high priority. As each site is unique, a general approach must be used to allow the system to be usable in different locations. Some sites may not be viable for the system that is developed and an alternative, such as a central charging location, must be well thought out. An area also may need to be expanded, so attention will be given to the modularity and expansively potential of design.

A portion of developing the implementation plan will be mitigation the effects of the system on the surrounding environment during the construction and during operation of the system. This will include an analysis of environmental impacts of solar power system and an analysis of development on scouting experience/atmosphere.

The data gathered from the specific site design will be modeled in CAD to show the placement of all LED lighting, solar panels, battery charging station, sensors and any other equipment that accompanies the lighting system. Specifically, Revit Architecture will be used to actually model the site. AutoCAD will also be utilized to assist with the construction of the Revit model as well as create site plans, floor plans, and other drawings need for construction. Any infrastructure framework/mounting system will be modeled in Solid works and the corresponding drawings will be created.

3.3 Construct the Lighting System Prototype

Constructing a working prototype of our lightings system requires three phases' consisting of several detailed steps including:

Design Phase:

- Design the circuit and system

Acquisition Phase:

- Acquire the components and materials

Construction Phase:

- Construct the circuitry
- Fabricate the circuit housing and weather protection
- Assemble and implement the system at the campsite

The majority of our engineering and prototype work will take place in B-term. The following objective chart outlines the timeline of our engineering portion of the project.

<table>
<tr><th rowspan="2">Objective</th><th colspan="7">B-term 2012 by Week</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td>Design circuit/system</td><td colspan="3">Design Phase</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Acquire components/materials</td><td></td><td colspan="3">Acquisition Phase</td><td></td><td></td><td></td></tr>
<tr><td>Construct circuit</td><td></td><td></td><td colspan="2">Construction Phase</td><td></td><td></td><td></td></tr>
<tr><td>Fabricate the housing/ protection</td><td></td><td></td><td></td><td colspan="2">Construction Phase</td><td></td><td></td></tr>
<tr><td>Assemble system prototype</td><td></td><td></td><td></td><td></td><td colspan="3">Construction Phase</td></tr>
</table>

Figure 9: Prototype construction phases and objective timeline for B-term 2012

3.3.1 Design Phase

After collecting the data from each specific site, and based on the needs of each site, a working prototype of the solar lighting system will be integrated into a site at treasure valley. Finding a suitable location for the prototype will be determined using the data we gathered and analyzing the various campsites at Treasure Valley. Our information will be analyzed through a decision matrix with five factors scored from 1 (lowest) to 5 (highest) dependent on the factor. These factors include solar potential, space availability, invasiveness of the system, environmental impact and the potential for the device to be damaged by weather or campers.

Site #	Analysis factors					
	Solar potential	***Space available***	***Invasiveness***	***Environmental impact***	***Damage potential***	***Total***
1						
2						
3						

Figure 10: Decision matrix to determine a suitable location for a prototype

The total of the factors is calculated and the site with the most points will determine the prototype site.

Next, we will need to perform a more detailed campsite specific analysis to determine:

- Where is lighting needed at the site?
- How will the lighting be arranged at the campsite to maximize the system?
  - What kind of LED lights do we need?
- How much energy will the system need to stay self sufficient
  - Battery size
  - Solar Panel size

This site analysis will be building off of the general feasibility study.

3.3.2 Acquisition Phase

The main components needed for our circuit can be seen in figure 8, the overall system design. These components include:

- Solar panels
- Battery
- LED lighting
- Data display
- USB plug
- Motion sensor
- Voltage regulator
- Charge controller

More specific parts are needed in the design phase when we build the charge controller and voltage regulator. However, we will not know what these parts are until we design these components.

We will also need materials for mounting the lights and housing the circuitry and battery. These materials are dependent on what our final circuit design size. Some of these materials will include:

- Plastic housing
- Rubber tubing for wires
- Mounting brackets

All of these materials will be acquired through online websites such as www.digikey.com and hardware stores like Home Depot.

3.3.3 Construction Phase

Once all of the materials have been acquired, our final task is to construct and install the system into the campsite. We first need to construct the circuitry and have everything fully working. The housing for the circuitry will be fabricated. Lastly, we will need to mount the lighting, set up the solar panel, set up the circuitry and housing, and finally set up the sensors. In this phase, we will set up and test our system during the day and our final test of the system will be conducted at night.

3.4 Education Program

Throughout the design of the solar power system to be installed at Treasure Valley, considerations for presentation to the users of the Reservation will be made. The presentation of the system will be user friendly and engaging for the Boy Scouts. This initial consideration during the design phase will allow for integration of an education program that will encourage interest in renewable energy in the scouts.

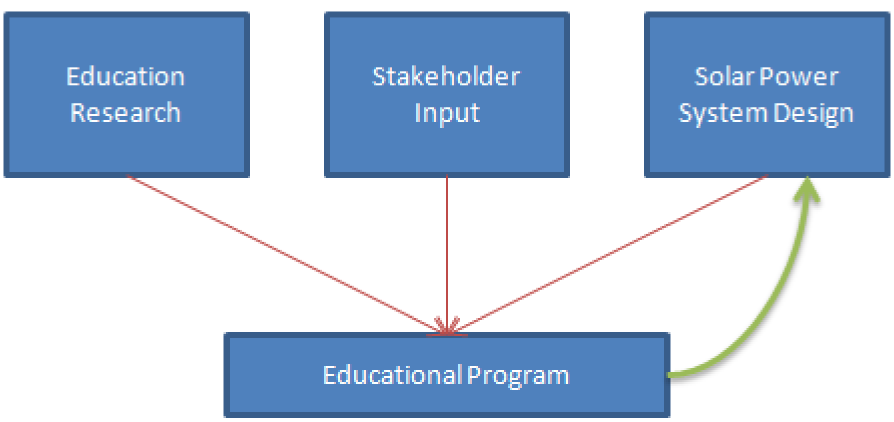

Figure 11: Educational program organizational flowchart

The development of the education program will involve the combination of three factors. The process will include research regarding effective methods for teaching the topic of energy. The methods researched will be utilized to develop a display and program. Another important factor will be input from the Stakeholders. The Boy Scouts are an organization that values learning by doing for the boys. Knowledge of these programs for integration into their methods will be beneficial. Additionally, the solar power system that our group designs will be an important factor in determining the type of information that will be presented and how it will be presented for the education portion.

4.0 Conclusion

The Treasure Valley Scout Reservation project presents us with a unique opportunity by combining both the engineering capstone design with education and conservation awareness. The reservation has historic ties with WPI and is eager to work with a student project team, which creates a positive working environment where both parties are enthusiastic to meet each other's needs. With three different majors working on the same project, we will be able to produce a comprehensive sustainability plan, a site specific solar lighting system design complete with prototyping, and an energy education program to fully encompass the identified needs of the client. Though there are little existing plans for TVSR's energy, the project will encourage creativity and accomplishment through both parties to innovate and create a better environment for scouting. With this project, the national ideals of the Boy Scouts of America will be driven forward to the scouts with the interaction that will take place between them and our prototype as well as with the education plan. We will work to revolutionize Treasure Valley's energy usage and plans to establish a more sustainable and energy conscious scout reservation.

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6.0 Appendix A – Task List by Major Area of Study

Civil Engineering

- Long term sustainability/renewable energy plan (see section 3.1 Sustainability Plan)
- feasibility study for the solar power systems (see section 3.2.1 Feasibility Study)
- implementation of solar power system (see section 3.2.3 Implementation Plan)

Electrical and Computer Engineering

- feasibility study for the solar power systems (see section 3.2.1 Feasibility Study)
- design of a solar power system (see section 3.2.2 System Design)
- construction of a working prototype of the solar power lighting system (see section 3.3 construct the lighting system prototype)

Environmental Studies

2/3 Unit double counted with Civil Engineering

- solar feasibility study (see section 3.2.1 Feasibility Study)
- development of a long term sustainability plan (see section 3.1 Sustainability Plan)

(1/3) Strictly Environmental Studies

- development of an educational program for the users of the Reservation for education about (see section 3.4 Education program)