

WPI

Treasure Valley Road Design

A Major Qualifying Project Report

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*in partial fulfillment of the requirements for the
Degree of Bachelor of Science*

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Abstract

The intent of this project was to design a roadway for Treasure Valley Scout Reservation of Rutland, MA that would address the existing limitations of both existing road links. ArcGIS was used to identify alignments and Civil 3D was used to model alignments. Finalized alignments were selected and the designs were judged on a criteria developed from user needs. Full plans and costs were created for the two highest scoring alternatives. Recommendations were provided for construction planning and processes.

Authorship

The names listed at each section were the primary authors of that section. All indicates that equal portions were contributed by each team member. All team members contributed to the edits of all sections.

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Capstone Design

The Treasure Valley Road Design MQP addressed issues at the Treasure Valley Scout Reservation (TVSR) in Rutland, MA concerning access to the western half of the reservation, known as West Camp. This was accomplished through two new road designs that would bypass the current road, known as Roger's Road, and provide access to West Camp. Roger's Road was designed in the 1970s and incorporates many tight turns to minimize the slope of the road. Difficult driving conditions brought about by steep slopes also impacts the main access to West Camp known as Snake River Road. Roger's Road has turns too tight to easily traverse, particularly for large vehicles such as buses. As a result, Roger's Road received minimal use and has become increasingly overgrown.

The project group produced new designs that met the intent of Roger's Road to better fit the current and future needs of TVSR. The project group used Civil 3D as well as ArcGIS to create potential layouts that plot the new road designs as well as to determine the cut and fill quantities of those designs. In addition to determining cuts, fills and layout, the group evaluated various alternative design standards, such as surface material, lane widths, shoulder widths and drainage control. The decisions for these criteria followed relevant guidelines published by various federal and state transportation agencies though the road is not bound to these guidelines.

Once alternatives had been created for the road design standards, the group created a detailed analysis of the benefits and costs of each alternative. The group consulted with TVSR staff to determine the criteria by which each alternative was judged. With a final alignment in mind the group determined the specific design standards to create a detailed plan with which the road may eventually be built. Finally, the group created a series of recommendations that would form the next steps that TVSR would take to complete implementation of the preferred design.

This project required the group to utilize the knowledge and skills acquired through past coursework to evaluate constraints, apply engineering standards and create a design to meet the stated needs. The first major constraint that was evaluated is economic, which is reflected in the cost comparisons the group created for various design alternatives, as well as the final design cost. The group also evaluated environmental constraints, primarily regarding wetlands, runoff and drainage. Social aspects were addressed by studying and analyzing the needs of the road's intended users and the surrounding community. In keeping with the ASCE code of ethics, the health and safety of the public was the highest priority for any design; the group issued only truthful statements and made recommendations only in areas of competence. When the final design was created, the group ensured that the design can be built and maintained in an efficient manner. The road design also had to be able to withstand physical and environmental conditions which was primarily addressed in the design of drainage and application of techniques that reduce runoff.

Professional Licensure Statement

In the field of civil engineering many professionals choose to acquire a license as a professional engineer (PE). Being licensed as a PE opens an individual's career to many opportunities that otherwise would be unattainable. Many positions require that applicants be licensed as a PE. Once licensed an individual can use a PE seal which must be on all final engineering plans as per regulations in every state. To be licensed as a PE an individual must complete four requirements:

1. Earn a four-year degree from an accredited institution.
2. Pass the Fundamentals of Engineering (FE) exam.
3. Gain four years of experience working under a PE.
4. Pass the Principles and Practice of Engineering (PE) exam.

In addition to being a legal requirement to sign engineering plans, being a licensed PE has other benefits. It demonstrates competence to clients and employers, which could lead to higher trust and responsibility. It commands respect amongst colleagues in the field and it should be a point of pride for the individual. Additionally, professional engineers benefit the general public by ensuring that qualified individuals are responsible for engineering plans and in charge of work. All individuals pursuing careers as civil engineers should strongly consider becoming a licensed PE because of the flexibility it lends your career, the prestige associated with it, and the authority it grants you.

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1. Introduction

Treasure Valley Scout Reservation (TVSR) is a 1,600-acre Boy Scout camp in Rutland Massachusetts that hosts summer camps, races and festivals. Currently, TVSR has two major roads, Snake River Road and Roger's Road, that link the reservation's west side and east side. The existing alignments of Roger's Road and Snake River Road can be seen in Figure 1. Snake River Road has



Figure 1: Map of TVSR

gradients that exceed 17%, which has proven difficult for the heavy vehicles, including school buses, that must traverse the distance between the east and west sides of the camp (Chamberland, 2017). Roger's

Road was built several decades ago as a bypass for vehicles that could not surmount the gradients of Snake River Road. Additionally, Roger's Road was intended to provide another route to the west side of the camp in an emergency. Roger's Road does not require vehicles to overcome steep slopes; however, the design relies on two extremely tight and difficult to traverse curves. Because of this, Roger's Road is no longer used regularly and users must continue to rely on Snake River Road. Access issues are compounded by TVSR's vision for future growth on either side of the camp. Addressing the issues that Roger's Road faces is critical to the continuing operations of TVSR (Chamberland, 2017).

The goal of the Treasure Valley Road Design MQP is to create a design that addresses the existing access issues of TVSR's West Camp. The following set of objectives were developed to facilitate the previously mentioned goal of the MQP.

- Conduct a detailed assessment of the current conditions and needs of TVSR
- Produce several alternative designs with a variety of alignments
- Narrow the range of potential designs and conduct a detailed comparison to choose a final design
- Decide the final design standards and evaluate all considerations that will go into the final design
- Assess costs and environmental concerns for the final design. The group created a final report and presentation outlining was done in addition to a schematic design of the road

Ultimately, the project team produced a final report and give a presentation on findings to TVSR.

2. Background

2.1 TVSR and Roger's Road

TVSR is the primary camp used by the Mohegan Council of the Boy Scouts of America, consisting of Boy Scout troops from over 30 towns in central Massachusetts. It is owned and operated by the Board of Trustees of Treasure Valley. Several organizations are below the board, including the Executive Board, Executive Committee, Board of Directors and the Camping Committee. Each of these groups, in addition to the local community, are involved in major decisions related to the reservation and its facilities. Thomas Chamberland is the Vice President of Programming for the Mohegan Council, and he was the primary TVSR contact for the project group.



Figure 2: Entrance to Roger's Road

TVSR primarily acts as a Boy Scout camp, however it hosts a variety of programs and events including races and festivals. During the summer months, when the reservation is the busiest, there are a considerable number of parents who drop off and pick up their children. One of the main areas of the reservation that parents must access is West Camp. There are two major ways of accessing this area of the reservation: the main paved road and Snake River Road, or Roger's Road. While Roger's Road

provides a more direct path to West Camp, it is not a perfect solution. Roger's Road was added to the reservation with the hopes that it could become a viable alternative to the exceedingly steep slopes of Snake River Road; however, excessively tight corners prevented Roger's Road from becoming a regular means of accessing West Camp.

The project team conducted a site visit on 9/14/17 to assess potential projects and to speak with Tom Chamberland. After discussing various issues on the reservation, the group concluded that improving Roger's Road would be the most beneficial to TVSR. Roger's Road is located underneath a set of power-lines that lie on an inclined slope. While the slope is not drastic, it does make roadway layouts more challenging. When the road was designed in the 1970's, TVSR staff had incorporated several tight turns that were in specific areas to reduce the incline that vehicles would encounter. The modest turning radii in these areas made navigating the road extremely challenging for larger vehicles, such as buses (Chamberland, 2017).

Additionally, although the layout was aimed at reducing the grades of Roger's Road, grades were steep enough to cause significant damage due to runoff. The limited top surface that was placed on Roger's Road has given way to erosion, which was an issue many of the roads on the reservation face. Roger's Road was encroached upon on both sides by vegetation that brushed against vehicles as they made their way along the road. Furthermore, drivers encountered an exposed grounding cable from the power lines at two separate locations along Roger's Road.

Treasure Valley Scout Reservation also indicated that they were looking into expanding their site and the programs they run. To do this, the reservation will need to find a viable solution to the traffic problems they faced from the hundreds of parents that must ply the route to West Camp on summer days (Chamberland, 2017). There were a great number of variables that were considered in achieving the goal of improving Roger's Road. Some of the most appropriate options included:

1. Allowing for two-way traffic

2. Utilizing stronger top surfaces for smoother driving and resilience to weather conditions
3. Providing low grades and more accommodating turning radii

This group considered all of these and many more to provide TVSR with the information they needed to improve site conditions. Guidelines and recommendations provided by different institutions helped inform the design process. Civil 3D, an engineering modeling software and ArcGIS mapping data aided in the process of enhancing Roger's Road. The original project proposal is included as appendix A.

2.2 Roadway Design

The first step when beginning a roadway design process is to determine the project and community needs. This includes collecting information on the context of the roadway, such as the surrounding area, roadway type, and roadway access. It is also important to consider the future use of the road. The area surrounding a road can be broken down into three classifications: Rural, Suburban, and Urban (MassDOT, 2006).

Rural areas are often far from metropolitan areas and are characterized by sparse and low-density development along a small number of roadways. Rural areas are sub classified as natural, village, or developed. Suburban areas are usually found surrounding a metropolitan area and share some characteristics with rural areas while sharing other characteristics with urban areas. Suburban areas are sub classified as suburban high density, suburban town center, or suburban low density. Urban areas are found at the core of metropolitan areas and are sub classified as urban park, urban residential, or central business district. The physical characteristics of the surrounding land, such as topography, is also a consideration for site conditions (MassDOT, 2006).

A roadway's type is often referred to by its functional classification and is defined by its role in the transportation system. The common roadway classifications are freeways, major arterials, minor arterials, major collectors, minor collectors, and local roads and streets. These classifications typically depend on the inversely related characteristics of connectivity and access. For example, freeways have the most connectivity but lowest level of access to adjacent land, while local roads have the least connectivity but high access to adjacent land and abutting properties (MassDOT, 2006). A roadway is typically expected to meet various standards published by government agencies, such as the Massachusetts Department of Transportation. These various standards are based on the roads functional and area classifications. Private road designs should aim to meet these standards but are not required to.

Another key component the project team and TVSR must consider is the cost associated with maintaining a gravel roadway. Studies have shown that while gravel roads may have similar maintenance costs in the early stages of use, the costs to keep these types of roads operable do not remain equal. In a study conducted by Iowa State University's Civil Engineering Department, cumulative costs to maintain a gravel road can reach over \$70,000 per mile after 18 years of use. The study created maintenance cost estimates in which consistent grading efforts were made along with a re-graveling every five years. The results showed that cumulative costs summed to \$20,800 after five years, or \$4,160 annually (Jahren et. al, 2005). The majority of these costs are associated with transporting aggregate after the road has been in operation for five years.

While this study focused on counties in Minnesota, it provides a detailed outlook into the maintenance considerations that must be addressed when planning for a new gravel road. The project team conducted its own cost estimation based on the needs and design that is undertaken for this project. However, as time progresses TVSR will also need to implement their own maintenance plan like the one outlined in the study.

A roadway's intended users must be considered when beginning the design process. The primary objective when designing a road is always the safety of the road's users. Another key consideration is ensuring an efficient method of transportation. The users on a given road must be determined before design, to ensure safe and efficient use when complete. Roadways have a variety of users including pedestrians, bicyclists, motor vehicle operators and passengers. The expected, current, and future traffic demands must be defined for an effective roadway design.

2.2.1 Developing Alternative Roadway Options

Based on the project area, functional classification, and traffic needs of the users, the designer must next create a variety of alternative roadway options including differing alignments and materials.

The quantitative criteria should be based on measures such as grade, cost and runoff. There should also be qualitative criteria, such as environmental impact. The designer should analyze and compare these alternatives before consulting with the owner of the project and deciding which alternative to pursue.

Once a basic alternative has been selected, including rough alignment and surface material type, the major design elements can be determined. The major elements that must be designed are horizontal alignment, vertical alignment, cross sectional elements, and drainage facility placement. The horizontal alignment is the layout the road follows. Special attention should be taken when deciding horizontal alignment to ensure all curves have sufficiently long radii. Vertical alignment includes the grade of all sections of a road. Grades as well as the vertical curves transitioning between them should be designed to ensure safe travel and to properly control storm water runoff. Cross sectional elements include lane and shoulder width as well as roadside design, cross slope, drainage ditches and slopes. Drainage facilities include culverts and other structures designed to control runoff. These elements in addition to all signage and traffic markings must be specified in the schematic design. Once the final design has been completed cut and fill quantities can be determined, and a price can be estimated based on materials quantities and labor costs. This process is summarized in Figure 3.



Figure 3: Design Process Flowchart

3. Methods:

The goal of the Treasure Valley Road Design MQP is to create a design that addresses the existing access issues of TVSR's West Camp. The first objective required the group to acclimate themselves with the current conditions at the reservation. Subsequently, preliminary layouts were developed based on current site conditions. Once multiple layouts were established, the group evaluated each of the layouts and eliminated those that were determined to be nonviable. Exact vertical and horizontal layouts were determined and those layouts were plotted in Civil 3D. Finally, the last objective was to assess environmental impact and estimate construction costs. The final stage also provided TVSR with a final design and all necessary deliverables. The proceeding sections will outline the group objectives in greater detail.

3.1 Research Current Conditions and Understand User Needs

A. Current Conditions

The group first investigated the current conditions that exist in the area surrounding Roger's Road. Current MassGIS data provided key information on topographic data such as elevation, contours, protected streams and wetlands. Additional data layers created by several MQPs that occurred previously in conjunction with TVSR were utilized for additional site-specific information. The group also examined and digitized two printed maps that were provided by TVSR staff. One site visit on 10/18/2017 was used by the project group to walk the entire length of Roger's Road as well as substantial portions of East Camp and West Camp, taking note of land features and conditions. Additionally, the project team developed a land ownership map that presented the properties that a potential alignment could impact. Understanding the current conditions allowed the group to determine speculative areas for layouts while also identifying locations that would not be suitable.

One key component of the overall project was to conduct a survey of the Roger's Road site that would confirm the validity of the topographic data provided on the MassGIS website. The first technique used to establish a survey of the existing site conditions used a Topcon Total Station for elevations and a cell-phone based GPS for locations. This technique was utilized during a site visit on 10/20/2017. Later, the group conducted a second survey using a Topcon PS-105A Robotic Total Station for elevations and a Garmin GPSMAP 64st for elevations. An excel spreadsheet was utilized to document the locations, elevations changes, and horizontal distances from point to point. This technique ultimately validated the topographic data on the MassGIS website which allowed the project team to use that topographic data to develop tentative layouts.

B. Understanding User Needs

Initial stages of the project included understanding the goals of TVSR. These goals would inform both the alignment selection process as well as the final design process. The project team held several meetings with both Tom Chamberland and several members of TVSRs staff to establish these goals:

- 09/14/2018 First Site Visit
- 10/18/2017 Second Site Visit
- 10/20/2017 Surveying Visit
- 11/11/2107 Second Surveying Visit
- 11/12/2017 Third Surveying Visit
- 11/17/2017 Final Surveying Visit
- 11/21/2017 Preliminary Report Meeting

Meeting minutes and site visit reports are included in the appendices B and C respectively. The project team also sent two pages of questions to TVSR in the weeks after the first site visit, to which TVSR answered. These questions and their answers are also included in appendix D. The full text of

preliminary report can be found in appendix E. Following the establishment of user needs, the project team began to research road design fundamentals.

C. Developing a Roadway Cross Section

The group examined the cross-sectional elements of the design. TVSR informed the project team of the likely material set that was to be used on any proposed alignment, which was considered in the development process. The group determined alternatives for the surface layer, road base, sub-base, and subgrade of the road. Cost, driving condition and the structural integrity of the road were considered in the cross-sectional design process. The chosen cross slope of the surface layer was evaluated to see if it was appropriate for the surface material and grade. The shoulder slope was also analyzed to ensure it was steep enough for proper drainage but gradual enough to minimize danger to any vehicle that may temporarily leave the road. Standard acceptable slopes are published by state departments of transportation and vary depending on the material the shoulder is made from.

The project team next examined lane and shoulder width. Lane width standards are established based on functional class, surface material and design speed and can be found in department of transportation manuals. The shoulder should be sufficient to create a buffer between vehicles that leave the road and unyielding objects.

3.2 Create Alternative Designs

Once current conditions were determined, it became possible to create several preliminary alignments routed primarily upon land ownership, existing topographic data and land features such as wetlands. Preliminary alignments were drawn with the intent of producing a road profile with substantially lower gradients compared to the existing Snake River Road. These alignments were drawn either by hand or using ArcGIS.

3.2.1 Alignments

When determining the layout, the group referenced the topographic maps provided by TVSR and as well as those available as .layer files from MassGIS.gov. Steep gradients and wetlands were all avoided while plotting alignments. The alternative layouts could have differing start and end points, so long as those layouts linked West Camp to a public roadway or an existing TVSR roadway that would bypass Snake River Road.

3.3 Screen Alternatives

The project group ultimately produced several different possible alignments which required an initial screening to determine viability. Excessive linear distance was one characteristic that demonstrated low viability and was therefore used to eliminate alternatives. Unfavorable and unavoidable topography was another characteristic identified that reduced viability. Proximity to existing property boundaries as well as wetlands was the final characteristic identified that could threaten viability. Eliminating alternatives based on characteristics that threatened viability left the project team with two preferred alternatives.

3.4 Determine Final Design

Once the most promising alternatives were determined through screening, the group established final roadway designs. These designs reflected the needs expressed by TVSR in section 3.1. This stage of the project required the group to investigate institutions that have compiled information on rural road design, such as The University of New Hampshire and the USDOT. The horizontal alignments were designed so that they followed a path that avoided steep slopes and other obstacles, while minimizing length to connect the two desired points. Vertical alignment was mostly dependent upon the horizontal alignment chosen, so the vertical grade was carefully considered when deciding the horizontal layout. Curves were designed with sufficient radius to allow a vehicle to safely traverse. Next, the group evaluated the final vertical and horizontal alignment, ensuring that all vertical and horizontal curves had sufficient length and radii to allow safe navigation. The group also confirmed that all grades fell within the acceptable range and that the alignment did not interfere with storm water drainage.

Roadside design was evaluated for the entire length of the road. In addition to trying to provide as wide as a buffer as possible to unyielding objects, the group located drainage ditches and slopes to control storm water runoff. These slopes and ditches as well as other obstacles near the road should either be easily traversable or treated for safety with structures such as a guardrail.

Civil 3D was used to plot all final design data. First a “surface” was introduced by importing MassGIS.gov topographic layers to create the existing contours of the land, as seen in figure 4:

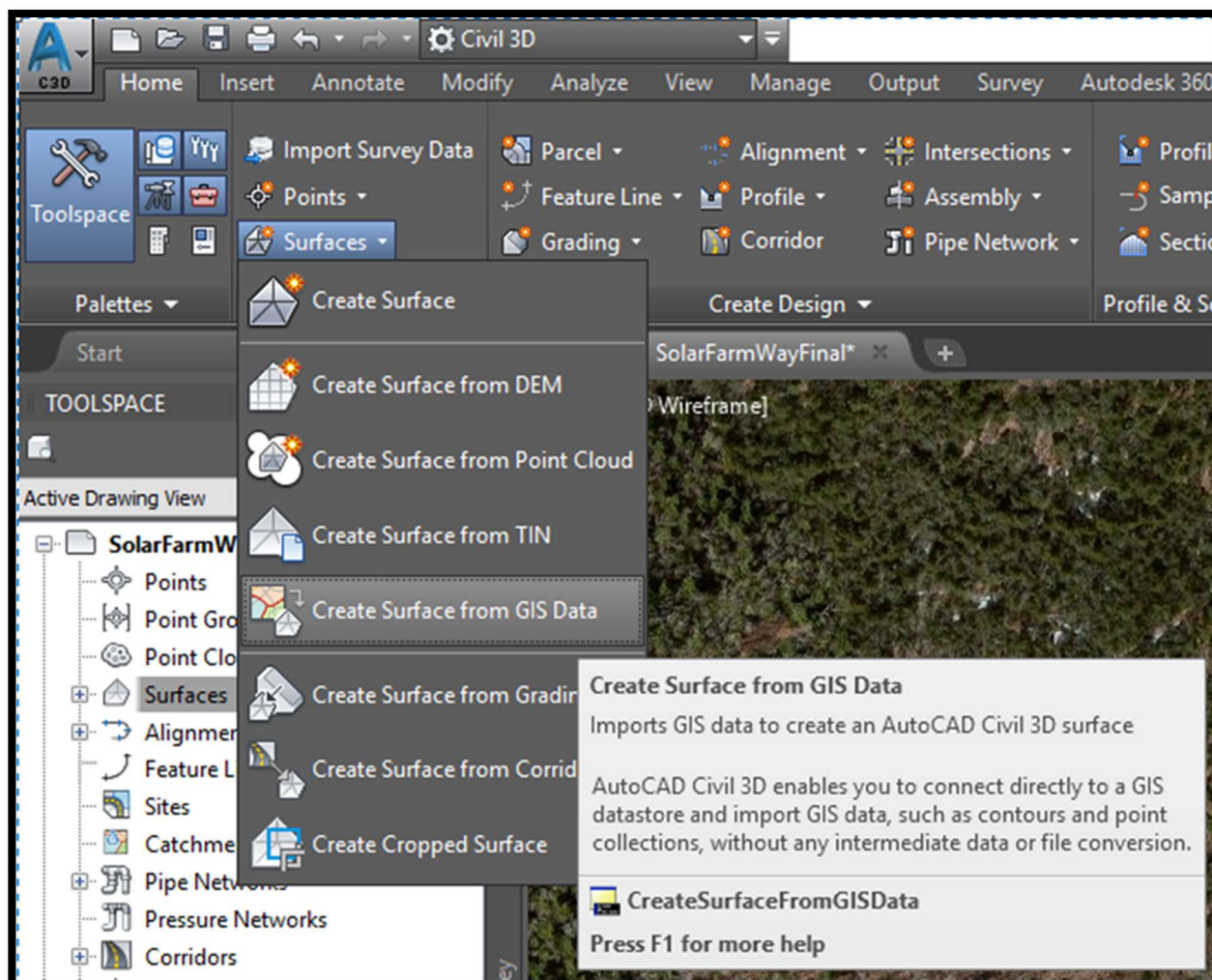


Figure 4: Creating a Surface from GIS Data.

With the existing conditions entered as a surface, the project team next considered alternative alignments. Alignments were carefully drawn along the top of the surface with the intent of avoiding gradients, tight turns and property lines. Once an alignment was completed, the project team created a profile view, which showed the overall profile of the alignment in relation to the topographic surface. From the surface profile, new target profiles were created for the alignment. These new target profiles were a compromise between target gradients, cuts and fills. The Civil 3D process was performed iteratively to meet all design standards. Once all standards relevant to the alignment were met, corridors were created that ran along the alignments. These corridors used “assemblies”, which are cross sections

of roadways, to create a fully 3D model roadway. An example of a corridor, with an applied assembly is in figure 5:

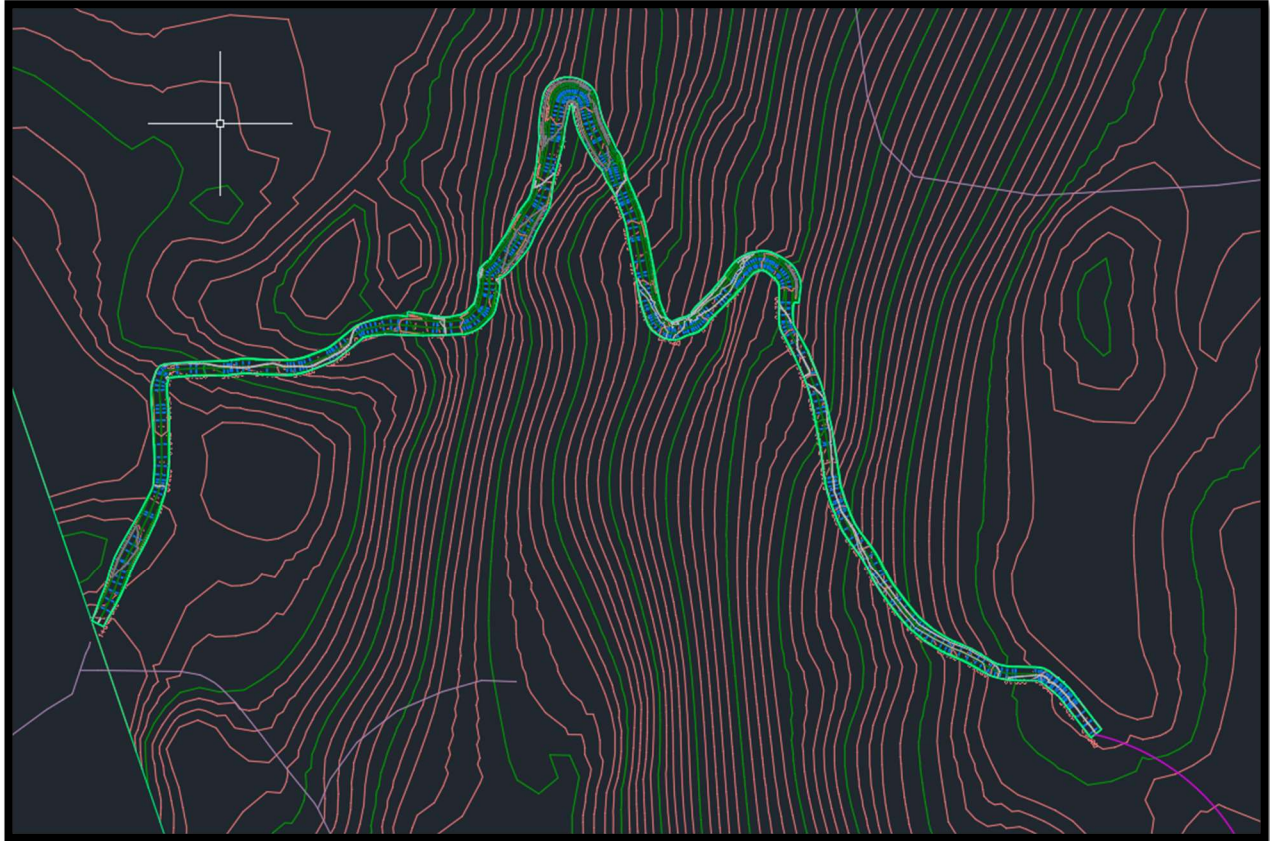


Figure 5: Alignment with an Applied Assembly

The assemblies created for the alignments in Civil 3D matched design standards and were identical to the cross-sectional drawing of the roadway. Once the assembly was applied across the length of the alignments, a new surface with the cut and fill data was created in the corridor profiles. This surface reflected the new topography that would exist after road construction. Comparing the new surfaces to the existing surfaces allowed for a calculation of cuts and fills during final analysis.

3.5 Final Analysis and Takeaways

After every element of the final road design was reconsidered and reconfirmed, costs and other factors were analyzed, and final deliverables were created. Using information gathered previously about existing conditions and the final design, the group calculated the cut and fill quantities through Civil 3D and the quantities of all other materials to be used in the road's construction. The group created an overview of the construction methods necessary to implement the final design and created a list of labor tasks.

The project produced several design alternatives. Choosing the correct alternative required determining relative strengths and weaknesses in areas such as cost, environmental impact and utility to TVSR. Measurements were based on data collected in Civil 3D. A list of on materials and equipment needed for each alignment was compiled. These two lists also contained hourly labor requirements by trade. RSMeans Building Construction Costs 2017 was used to price out materials, equipment and labor.

The group also addressed how the final design met the needs of the owner and community as well as how it will continue to do so in the future. Maintenance guidelines were specified for the road as well as how the road could be adapted in the future to meet the growing traffic needs of TVSR. The project group created a detailed report, a project poster, a presentation and several detailed GIS and Civil 3D files in the TVSR Projects folder for future use. The full presentation was included as appendix F. These deliverables will allow TVSR to have all information necessary to plan and execute the construction of our groups proposed redesign of Roger's Road.

4. Results

The project team found two preferred alignments; Realigned Roger's Road and Solar Farm Way. Based on the scoring criteria developed during this MQP, Solar Farm Way is the option that most closely meets the needs expressed by TVSR. Both Realigned Roger's Road and Solar Farm Way were given final routes, profiles and cross sections. Mass.gov topographic data was verified to be correct within the surveyed region and the project team identified the limitations on all alignments. Furthermore, the project team found that the original Roger's Road, although it did not meet the needs of TVSR, had relatively low gradients that also provided a drivable surface despite limited resources.

4.1 Current Conditions and User Needs

The current conditions of TVSR and TVSR's needs were critical to defining the problem and finding a plausible solution to the problem. TVSR's user needs were the basis for the development of the screening and selection criteria that alignments were scrutinized under. User needs were also the basis for the design standards upheld in the finalized alignments.

4.1.1 GIS Data

GIS data provided key information about land owned by the Mohegan Council. Locations for proposed alignments were determined through TVSR property boundaries. Property ownership was determined through use of the Massachusetts Interactive Property Map. Figure 6 below was key in determining the limits of the reservation:

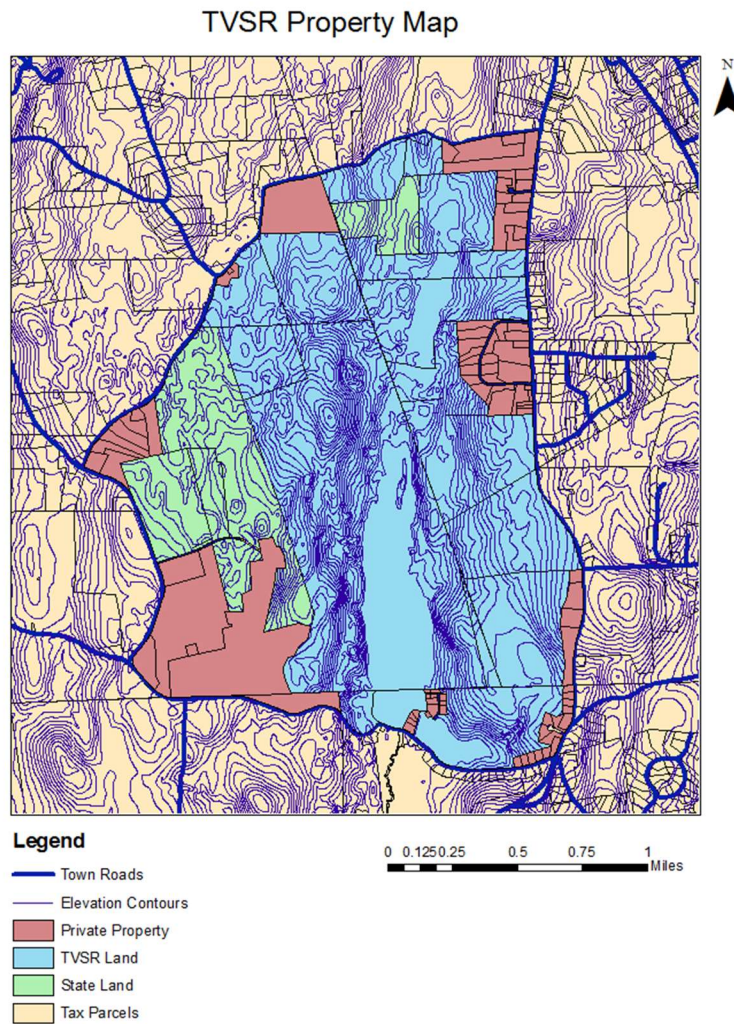


Figure 6: Land ownership map of TVSR bounded by public roadways.

With existing boundaries illustrated, the group recognized that the proposed alignments, especially the Roger's Road option, would not cross over into the property of any neighbors.

Contour data provided by Mass.gov was validated by the group through several field land surveys, described in detail in section 4.1.2. The group then imported the validated contour data into Civil 3D and established the paths of each alignment based off these contours.

4.1.2 Surveying

Surveying the proposed alignments for the Realigned Roger's Road and Solar Farm Way was initially conducted with a Trimble Total Station and a cell-phone based GPS app. Many of the coordinates and elevations of the initial survey appeared to be largely inaccurate based upon field observations and existing topological data. The project team therefore found it necessary to survey the site again. Data provided by the Topcon equipment allowed the group to establish that the contours had been incorporated into the Civil 3D file accurately. The points that were taken by the Topcon Total Station are as seen in Figure 7 on the following page.

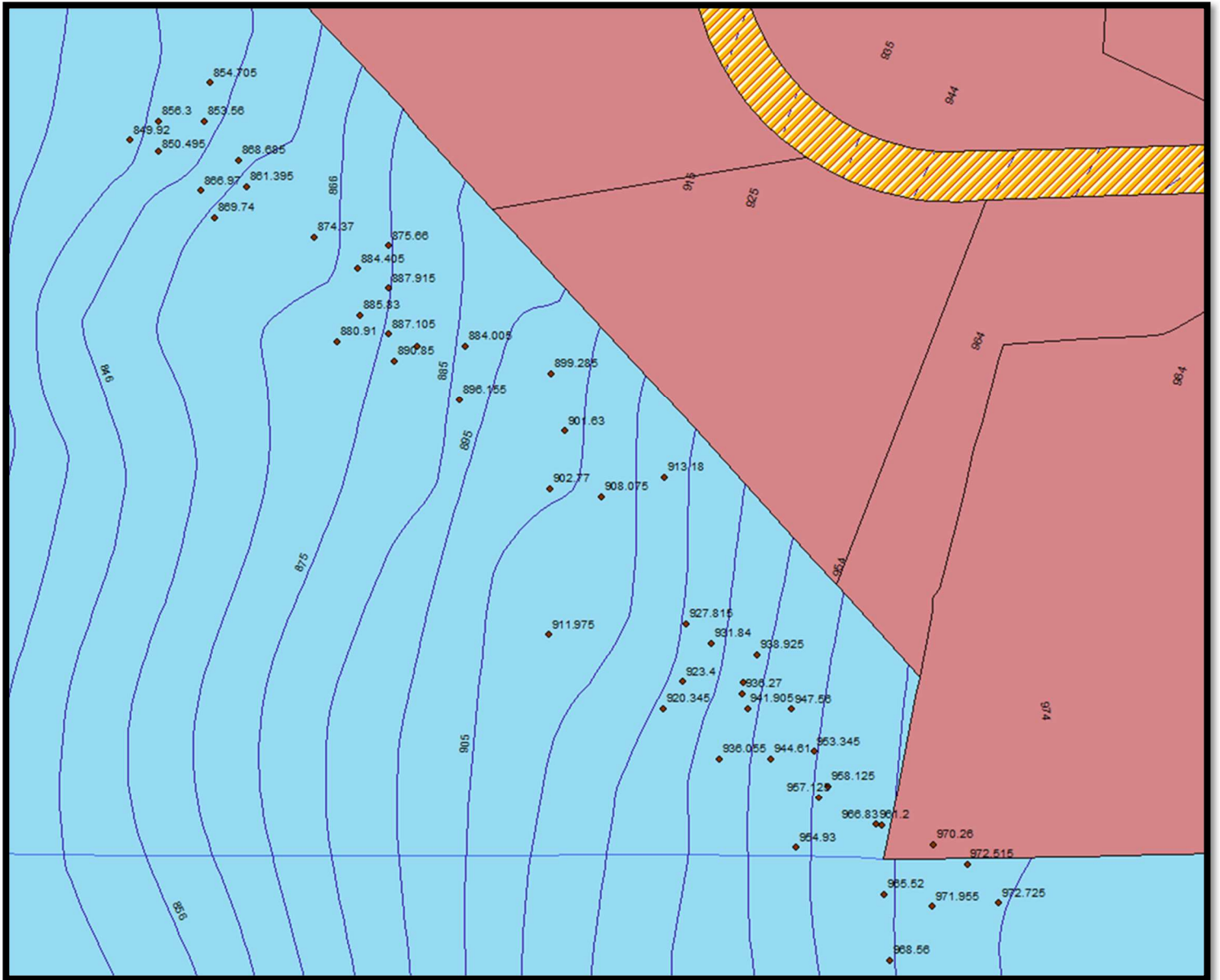


Figure 7: Elevations taken in the area surrounding Roger's Road. Solid blue indicates TVSR held land, blue lines contours and red privately held property.

4.1.3 General TVSR Needs

Discussions with TVSR staff were instrumental in determining the need for a new means of access to West Camp. Mr. Chamberland indicated that recent events held at the reservation resulted in

more than 1,000 individuals visiting the site (Chamberland, 2017). Meeting minutes, site visit reports and emailed questions that further document TVSR's expressed needs are included in Appendix B, C and D respectively. TVSR hopes to be able to continue to host such functions but the current layout of the reservation raised concerns.

Current traffic conditions are not ideal and TVSR expressed that they will increase the number of functions at the camp. TVSR hopes that a new roadway would help improve logistics during events by providing additional routes to traverse the site. Additionally, a new means of accessing West Camp could provide a safer and more direct path for visitors, especially parents, to navigate to previously difficult to reach areas.

4.1.4 Screening Criteria

After meetings with TVSR staff, the group was able to establish screening criteria that were later used to eliminate preliminary alignment options. The group's screening criteria were as follows:

1. Cost to Build
2. Earthwork
3. Gradients
4. Tightness of Turns
5. Length of New Construction
6. Maintenance Costs
7. Construction Duration
8. Impact to Neighbors
9. Security Constraints
10. Addresses Traffic Flow
11. Distance from Protected Zones

A complete breakdown of the selection criteria can be found in the Preliminary Screening document of Appendix H.

4.1.5 Design Standards

The project team participated in site visits, meetings and email chains that resulted in a series of standards that TVSR required. These design standards were adhered to when the finalized alignment and cross section of the roadway were developed. Table 1 features the standards.

Table 1: Design Standards of Finalized Alignments

Type	Standards	Source
Gradients	8% Target Gradient	11/21/2017 Preliminary Report Meeting
Lanes	1 Lane, Both Directions	Emailed Response
Turning Radius	34.9 Foot Turning Radius*	09/14/2018 First Site Visit, AASHTO Green Book 2001
Paving	Exclusively Gravel	11/21/2017 Preliminary Report Meeting
Setbacks	30ft Inside of TVSR Property Lines	1/23/2018 Selection Criteria Review Meeting

* 34.9 Foot Turning Radius is the minimum inner turning radius for a 40' school bus which reflects TVSR's need for safe navigation for school busses.

4.1.6 Roadway Cross Section

The group developed a cross section based upon the relevant design standards expressed by TVSR and by best unpaved roadway best practice guides. The group developed an assembly comprised of six inches of crusher run stone, over another six inches of aggregate. Drainage ditches that have been placed at alternating edges of Roger's Road to control runoff at high gradient locations. The results from the Civil 3D data can be seen in Figure 8.

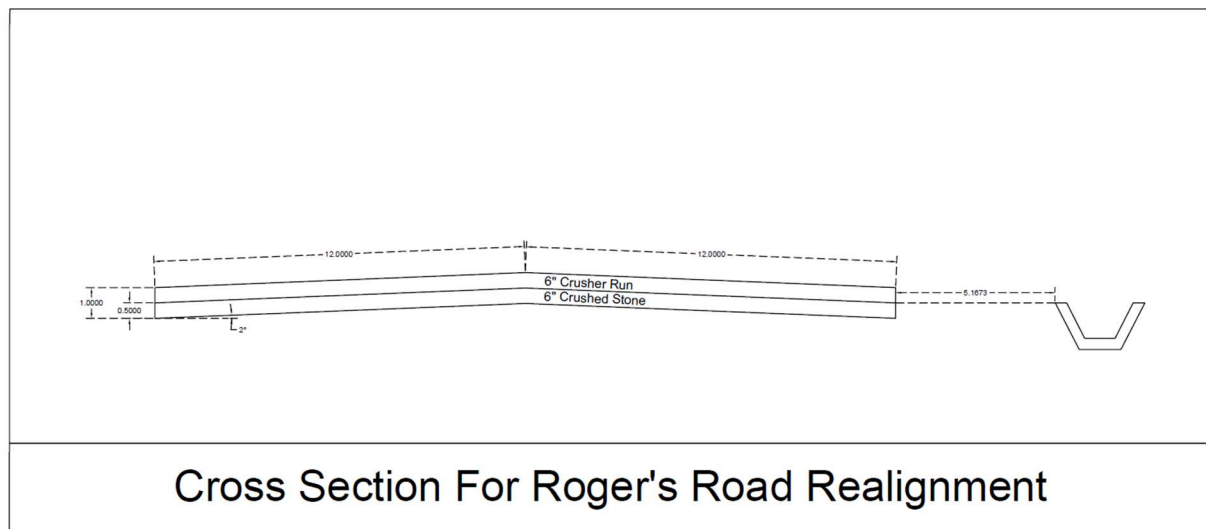


Figure 8. Cross Section for Roger's Road Realignment

The project team also highly recommended the use of a geotextile filter fabric in the final design, immediately beneath the 6" layer of crushed stone. Geotextiles help improve road performance and longevity. They do this by supporting and increasing the integrity of the subgrade which has the effect of minimizing erosion of the unpaved surface. Geotextile use can save substantially on annual maintenance thanks to this decreased erosion, an issue that the TVSR regularly deals with (Bhattacharyya, 2010).

4.1.7 Selection Criteria

A substantial amount of time was spent developing a selection criteria to establish which alignment, the Realigned Roger's Road or Solar Farm Way, was the best option for TVSR. The project

team consulted many resources, ranging from RS Means to various state and federal government transportation documents, to select criteria. Each category is not only weighted with a specific number of points, but these categories are also broken up into percentages. The percentages allow the group to determine how well each alignment meets the needs of TVSR and ultimately which alignment is the ideal choice. The following sections detail how the project team researched each category, and the reasoning behind the specific attributes assigned to each respective category.

A. Cost to Build

The cost to build category was established primarily from the use of the RSMeans Building Construction 2017. Initial site visits yielded key information about costs that TVSR had incurred when paving the main entry way onto the reservation. It was disclosed that a single layer of pavement along the main road had cost TVSR just over \$100,000, and a second layer would soon be necessary. The project team used this information as an indicator for how the Roger's Road project would be assessed cost wise. In conjunction with the RSMeans data, the team was able to establish that a basic, unpaved road project of less than a mile could cost over \$300,000 depending on the equipment and various forms of labor that are chosen. Finally, \$400,000 was decided upon as a potential final cost, but this price point would deem the alignment as a failure, if such a result occurred.

B. Absolute Cut and Fill

Another very important category is absolute cut and fill quantities. A careless effort in establishing an alignment trajectory could result in massive quantities of earthwork, which would result in equally large costs. During initial design phases, the project team recognized through calculations made by Civil 3D that poor planning, and improper placement of surface profiles, could lead to absolute cut and fill quantities in the hundreds of thousands of cubic feet. The project team decided that 200,000

to 40,000 cubic feet would receive the lowest possible score. Increasing profile grades to reduce earthwork demands resulted in the 40,000 to 10,000 cubic foot range. The project created a minimal absolute cut fill range, anything under 10,000 cubic feet of absolute cut and fill, which is a perfect score.

C. Gradients

The criteria that was chosen for this category resulted from discussions with TVSR staff members as well as initial gradient calculations performed by Civil 3D. Mr. McQuaid had indicated that there should be no sections of the new alignment that exceeded 11% (McQuaid, 2017). The project group decided that based off Mr. McQuaid's statement, and initial Civil 3D profiles that the lowest score for a new alignment would include one quarter of the road having gradients between 11 and 9%, while the rest would be below 9%.

From running gradient checks on different alignment profiles, the project team also recognized between 8 and 9% gradients were very common. The project team felt that this range was a realistic grade to strive for while also remaining well below the 11% maximum. Furthermore, the perfect score would be achieved by an alignment that had grades that were all below the 8% mark.

D. Tightness of Turns

An issue that TVSR has struggled with is the inability of larger vehicles, such as school buses to make the tight turns along Roger's Road. Early discussions with reservation staff members focused on the limited turning radii at several locations along Roger's Road. Seeing this as a central concern for the current layout of Roger's Road, the project team wanted to create a new design where new turns would be constructed. The lowest category for the criteria involved turns that had a turning radius of 35 feet. A turn with such a radius is the minimum required radius for a school bus to make a turn. From this point,

the scores improved as the radius increased by fifteen feet to a 50 foot radius, and a perfect score would provide wide turns of a 70 foot radius.

E. Length of Construction

The goal for new construction was to reduce labor time and the overall distance of new roadway as well. A longer road increases the labor, equipment and material costs that the reservation will incur from the project. The project team decided that the lowest possible score for this category would fall within new construction that was approximately half a mile. Ultimately, the lowest possible score resulted in an alignment with new construction totaling between 2,000 and 3,000 feet. To receive 67% of the total points possible, new construction would be 1,000 feet less than the previous range, between 1,000 and 2,000 feet of new construction. All 9 points are attained if the new construction results in less than 1,000 feet.

F. Maintenance Costs

The costs associated with this category were based off a study conducted by Iowa State University's Department of Civil Engineering (Technical Report, 2005). Portions of the study focused on the costs that several Minnesota counties paid in order to maintain gravel roads. Using the results from this study, the lowest score was determined based off the county which had the highest average cost for maintenance on a gravel road, which exceeded \$3,600 annually per mile. In order to receive 67% of the total possible points, annual maintenance would be between \$3,600 and \$2,500 annually, which is the range that most counties fell between in the study. All nine points were achieved if the maintenance costs were less than \$2,500 annually.

G. Project Duration

Requests from meetings with TVSR were instrumental in the decisions made regarding the ideal duration for Roger's Road construction project. Mr. Chamberland indicated that three seasons would be the longest span of time the reservation would like construction to take. More than nine months would require halting construction for winter, which would mean little to no maintenance would be conducted in this area until spring. For this reason, any more than nine months constituted a failing grade in this category. Between three to nine months would result in 67% of the six total points. A perfect score would result in a project that took about only one season, or less than three months.

H. Impact to Neighbors

Construction of the original Roger's Road resulted in a dispute between TVSR and several neighbors. Governing bodies were brought in to mitigate the conflict. The project team is looking to and TVSR is committed to the well-being of neighbors. 30 feet is the setback as dictated by the Town of Rutland's bylaws for construction. The project team decided this would also be the closest construction could be in terms of proximity to neighboring property boundaries. One hundred feet from neighboring property boundaries will result in the alignment receiving two of the possible three total points, and 200 feet from neighboring properties is a perfect score.

I. Security Constraints

Security Constraints evaluations were decided upon by the judgment of the project group. New construction, which provides a new means of travel, and potentially a new entry way, could have significant security impacts on the reservation. For example, Solar Farm Way will require a new entrance, which introduces new security difficulties. TVSR will need to diligently monitor who is

coming onto the reservation from this entrance and will need to allocate current or new resources accordingly to meet this new demand.

The project group decided that a failing score where any new construction, whether it's the Realigned Roger's Road or Solar Farm Way, results in negative impacts upon the current security plan TVSR has in place. Two thirds of the total points are attained if the new alignment affects the current security plan to the point where some incidents are reported, but overall the new alignment does not negatively impact the reservation. All three points are earned if new construction allows for TVSR staff to create new security measures, which improve the conditions on the reservation

J. Addresses Traffic Flow

TVSR's goal is to have a new alignment not only provide a safer approach for visitors and staff, but to also reduce the need for vehicles to use other roadways in conjunction with the new alignment. Therefore, a failing score in the traffic flow category results if the new alignment forces users to rely heavily upon Snake River Road in order to access West Camp. The project group receives two points if the new alignment results in users traveling upon Snake River Road for only small portions of their drive. A perfect score is achieved if the new road does not require users to access any other roads to enter West Camp.

K. Distance from Protected Zones

While several of the preceding categories address environmental concerns, this category addresses potential environmental impacts to the wetlands at the lower region of the current Roger's Road. The distance from protected zones is a topic that has received more attention than would be assumed by recognizing that this category is at the bottom of the scoring criteria. This category is solely about the potential impacts upon the wetlands at the lower region of where Roger's Road currently extends.

The different scoring options for this category were determined after consulting documents put forth by the Rutland Environmental Commission. The project team would fail this category if any new construction came within 30 to 50 feet of the wetlands. Fifty to 100 feet would earn two points, and if construction is 100 feet or further from the wetlands, the project team would receive all three points.

4.2 Create Preliminary Options

The project group created and screened five alignment options. Figure 9 shows the approximate path of each of the alignments as they were initially proposed.

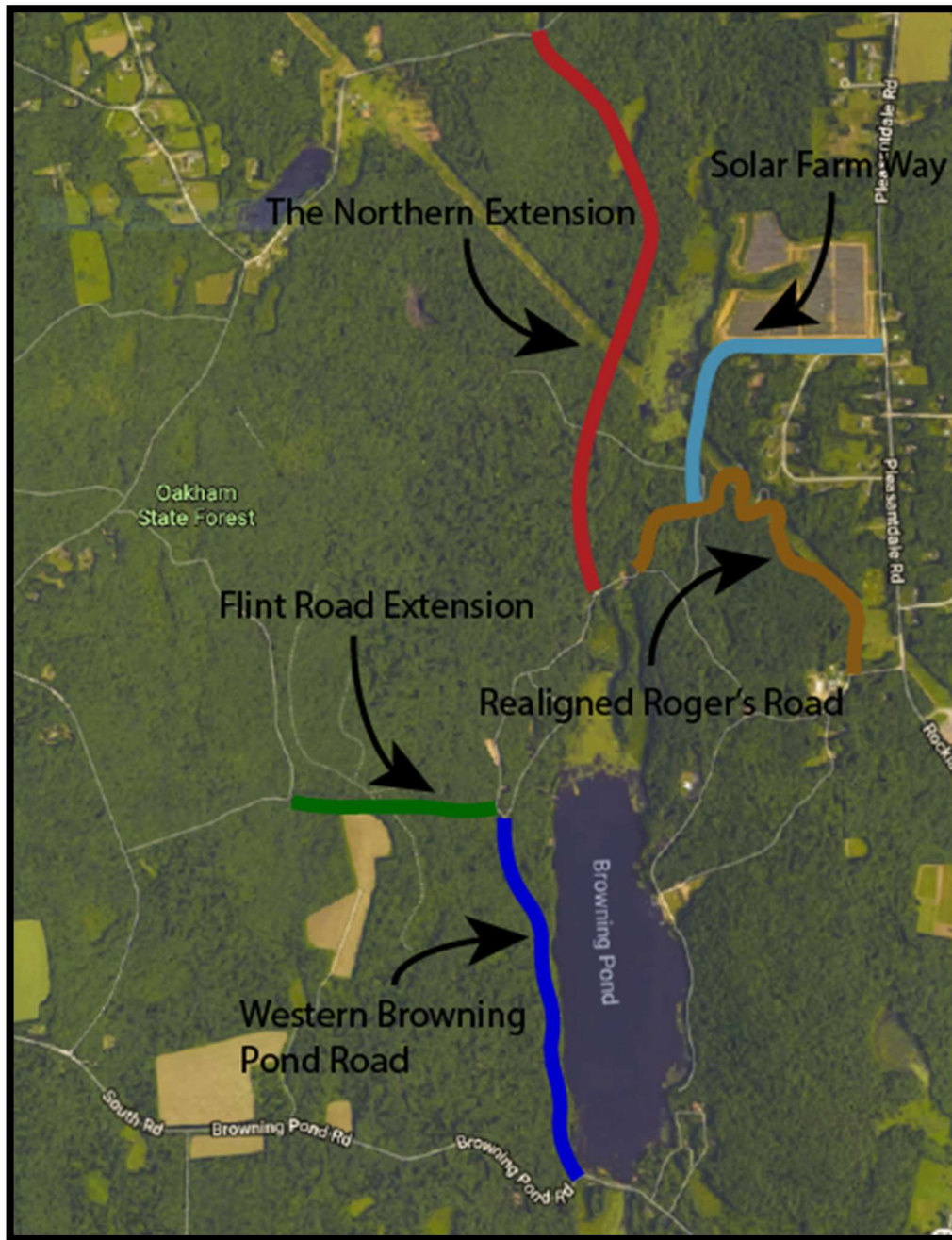


Figure 9: Map that features all created alignments.

4.2.1 Western Browning Pond Road

Along the southern region of TVSR there is a footpath that connects the site to Browning Pond Road, which could provide a new entrance to the camp. After taking field observations in this area, it was found that regions of the path are less than one foot from the edge of Browning Pond. On the opposite side of the path there is a steep, densely wooded, embankment. Furthermore, wetlands toward the Browning Pond Road portion of the path would necessitate two wooden bridges.

In terms of construction considerations, the path is currently only wide enough for a single vehicle. To make two lanes, the existing embankment would need to be cut, an expensive and time-consuming task. The Browning Pond Road option was also significantly longer than most potential alignments, at about one mile in length. Construction and vehicular use would also result in adverse environmental impacts.

4.2.2 Flint Road Extension

Another unimproved pathway lies on the West Side of the TVSR property. Incorporating an entrance along this path would have allowed visitors to access Snake River Road without having to utilize the main entrance. Flint Road was found to be unsuitable; the road is narrow, steep and overgrown with brush. Extensive cuts and fills would be necessary to create low gradients on this alignment. Additionally, the roadway is owned by the state, which further complicates the situation by introducing additional stakeholders.

4.2.3 The Northern Extension

One possible alignment suggested to the project team during the Preliminary Report Meeting was a link between West Camp and East Hill Road (Chamberland, 2017). East Hill Road runs parallel to the northern boundary of TVSR. Gradients in this region of the camp are gentle relative to the areas that

Snake River Road and Roger's Road traverse. However, this alignment option would be the longest at over 1 1/4 miles. Thick forest extends over the entirety of this region. Furthermore, there are many wetlands in the area that could be impacted by the placement and use of a new road.

4.2.4 Realigned Roger's Road

Realigning specific regions of Roger's Road is another viable option. The group's proposed alignment would have created a more direct route than the current Roger's Road. A more direct route meant turning radii that would have allowed for larger vehicles to traverse turns with relative ease. Brush and other vegetation are also less dense in this area of the camp, substantially reducing needed equipment and impact.

However, this realignment has several major drawbacks. The proposed realignment requires earthwork to reduce grades and allow for desired lane widths. This option would rely on the congested main entrance as well. Furthermore, the gradients of this region are steep, meaning that there still may have been several sharp turns.

4.2.5 Solar Farm Way

During the project group's initial surveying trip, a large solar farm was identified in the northeast corner of the reservation. A service roadway of approximately 700 ft runs parallel to the solar farm and connects out to Pleasantdale Road. Gradients along this roadway were relatively low and an existing footpath provided a connector from the solar farm to the lower section of Roger's Road.

Not only would this option necessitate more clearing and grubbing than previously mentioned realignments, but a new entrance would also require additional earthwork. The path itself would not require significant cuts and fills but a new entryway would necessitate the construction and staffing of an additional checkpoint. Additionally, the lower regions of a new road would have been close to existing wetlands, which was a constraint.

4.3 Screen Alternatives

A. Western Browning Pond Road

This option was deemed impractical for several reasons. Safety and runoff issues were among the greatest concerns. A road running along this portion of the camp would have been within inches to feet of Browning Pond. A second constraint were the steep gradients on the side opposite Browning Pond, gradients that would have likely necessitated both cuts and retaining walls. Wetlands that exist along the alignment introduce both technical and regulatory hurdles that would have to be overcome. Finally, the Western Browning Pond Road option was significantly longer than most other options. At more than one mile in length, it would be an immense undertaking and unrealistic given the budget and resource constraints of TVSR.

During the 11/21/17 meeting with staff from TVSR, a question was brought up as to whether the entrance to this alignment could be moved. After researching the discussed option, the group determined that this would not be possible given the hostility of the terrain in both brush and gradient.

B. Flint Road Extension

Flint Road was found, during the project team's second site visit, to be viable only as a walking path. Building a drivable Flint Road would entail extensive labor efforts. Brush and tree removal coupled with eliminating grades that exceed 30% in some regions eliminated this alignment as an option.

C. Northern Extension

Ultimately this route was eliminated because of excessive length. The time and resources needed for new construction through dense forest would have been outside the realm of possibility for TVSR. Additionally, clearing and grubbing required for the alignment would produce substantial environmental damage in a relatively undisturbed portion of TVSR.

The Preliminary Screening document that provides additional images and details about the alignments and their limitations can be found in Appendix E.

4.4 Final Design Alternatives

The elimination of three of the five potential alignments meant that only two viable alignments were left. The first was Realigned Roger's Road and the second Solar Farm Way.

4.4.1 Realigned Roger's Road

The final design for the Realigned Roger's Road option incorporated some elements of the pre-existing Roger's Road. The group determined that the initial section of Roger's Road towards the front entrance was adequate. Changes to the pre-existing roadway were made where the road started to curve. The group created wider turns at these areas and specifically placed them in areas where the new turns would cross over contours to lessen grades. Civil 3D allowed for proposed profiles to be easily laid over the existing terrain.

Although the group ultimately decided upon several alterations to Roger's road, it is worth noting that the initial alignment of Roger's Road achieved exceptionally low gradients given terrain constraints. The project team's design had to have slightly high gradients to accommodate a more generous turning radius. The group's focus was to create a profile for this alignment with grades no greater than 11% and with no net cut or fill. Ultimately, the group was able to achieve both goals. No grades exceeded 9.5% and the net cut and fill quantities yielded a fill of only 0.26 cubic meters or 9.18 cubic feet.

4.4.2 Solar Farm Way

The alignment for Solar Farm Way contrasted with that of the Realigned Roger's Road option. Solar Farm Way was found to have much more manageable grades and would not require cuts and fills. The assembly created for this alignment included a drainage ditch.

Difficulties with the Solar Farm Way option were introduced when the group recognized that the GIS data did not match with the existing conditions mapped out from survey data. It became apparent the

contours towards the entrance of solar farm road in Civil 3D were steeper than the actual grades, on site. This discrepancy is a result of the solar farm construction occurring after the most recent iteration of Mass.gov topographical data. The project group attempted to reach out to Nexamp, the company which built the solar farm, to obtain as-built plans of the area; however, received no response. Because of this, the project group chose to reuse the service roadway that runs adjacent to the solar farm, unchanged, as a portion of Solar Farm Way.

4.4.3 Alternative Alignments

Table 2 below illustrates eliminated options as well as those that moved on to the design phase of the project: As discussed previously, two alignment options remained after the pre-screening phase. The final designs of those alternatives are discussed in the next section of this MQP.

Table 2: First Screening of Alternative Alignments

Alignment Name	Eliminated after Screening Criteria Considerations	Moved to Design Phase
Western Browning Pond	Yes	No
Flint Road Extension	Yes	No
Partial Realignment	Yes	No
Fully Realigned Roger's Road	No	Yes
Solar Farm Way	No	Yes

4.4.4 Realigned Roger's Road Design

The first of the two alternatives chosen for further design was Realigned Roger's Road. This option reused substantial portions of both ends of the current Roger's Road while adding two lanes in each direction. In figure 10, Realigned Roger's Road follows a path in roughly the

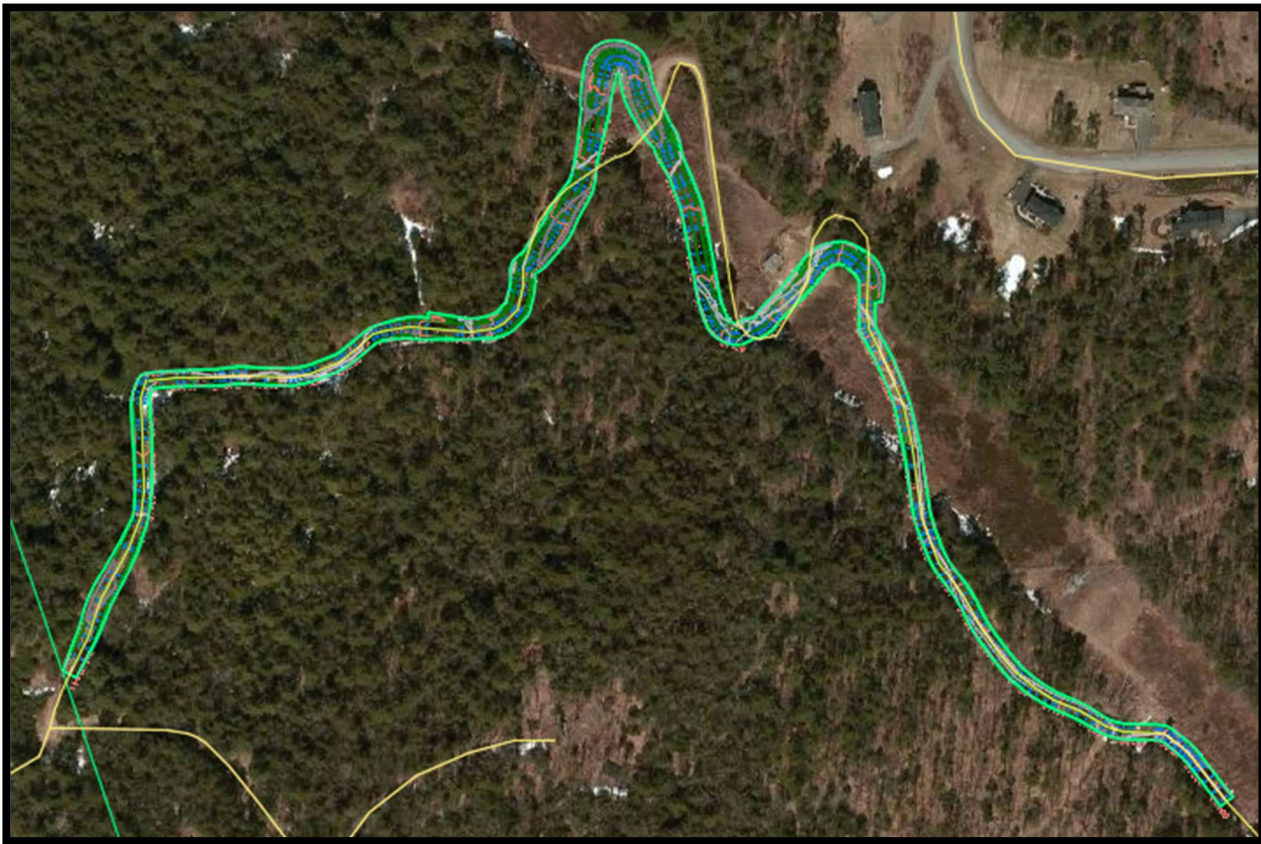


Figure 10: 2D View of Realigned Roger's Road with Existing Roads in Yellow same region as the original Roger's Road, opting for wider turns, although one tight turn was unavoidable without compromising the design standards on slope or distance to neighbors. Drainage is included in the center section as seen in section 4.1.6, making it larger than either cross sections at the ends of the roadway. The profile of the road features maximum gradients of 9%, higher than the maximum 6.5% gradients of the existing Roger's Road. Lower gradients would only be attainable at the expense of turning radii.

4.4.5 Solar Farm Way Design

The second of two alternatives chosen for further design is Solar Farm Way. This alignment, as seen in Figure 11, has two simple two-lane cross section from end to end:



Figure 11: 2D Top View of Solar Farm Way with Existing Roads in Yellow.

The first cross section on the southern portion of the road does not include a drainage ditch as the existing roadway already featured enough drainage to have prevented erosion. A drainage ditch is featured on the cross section of the northern half of the roadway, just after it passes under the power lines. This drainage ditch should control runoff traveling east to west on the side of Treasure Valley. The new alignment would connect the ends of a road accessing the solar farm to the westernmost portion of the original Roger's Road. Slopes on Solar Farm Way are modest and do not exceed 9.5% on any new constructed sections. Topographic data of the existing roadway at the western end of Solar Farm Way did not appear to be accurate and the project team did not have time to survey the full extent of the existing service roadway. However, this road appeared to be in good condition and largely maintainable as seen in figure 12 and should be reused for Solar Farm Way.



Figure 12: Overhead view of Roadway. Credit: Bing Maps.

The strengths of this alignment were numerous, given that existing roadway could be reused, along with features such as low gradients and gentle curves. Because of these strengths, Solar Farm Way scored highly on the selection criteria and was therefore chosen as the final design as discussed in the following section.

4.5 Final Analysis

With two final design alternatives left, further analysis had to be performed for environmental considerations and construction costs to choose a recommended alignment. Environmental considerations were especially important given TVSR's desire to preserve Browning Pond and Treasure Valley. Construction costs were also determined so that the alignments could be compared fiscally. Finally, construction costs, environmental considerations and other properties such as maintenance and earthwork were scored to ascertain the best possible alignment.

4.5.1 Environmental Considerations

Any construction project brings with it an array of environmental impacts and concerns, and these must be addressed to mitigate their potential effects. The need to mitigate environmental concerns on this project was particularly important as TVSR had been a responsible steward for Treasure Valley and Browning Pond. Work within or near wetlands is also heavily regulated by local bylaws and state law. For this reason, no proposed work fell within 100 feet of a wetland area as seen in Figure 13. There was also water flow that resembled an intermittent stream that fell in the Solar Farm Way alignment,

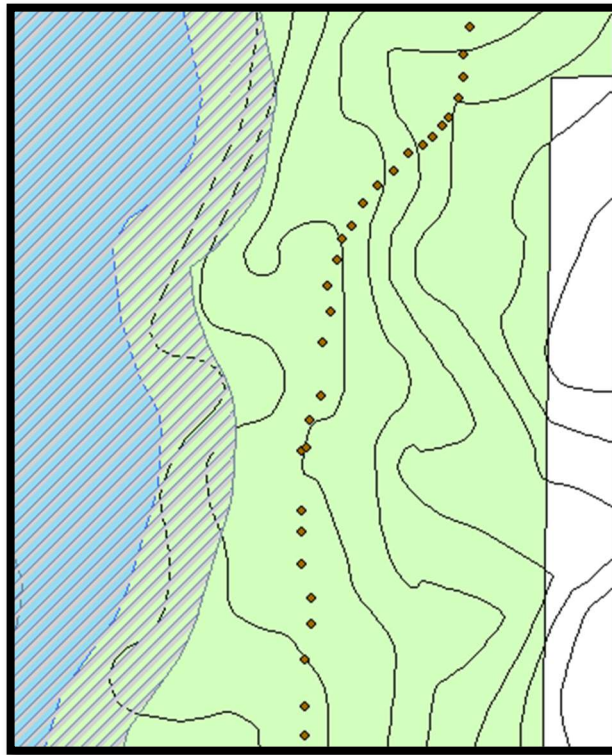


Figure 13: GPS Points taken on the existing pathway that makes up the center of the proposed Solar Farm Way. Solid blue is wetlands, gray stripes are a 100 ft. wetland buffer, solid green is TVSR owned land and the burgundy dots are the GPS points.

upgrade of a marsh. The Massachusetts Wetlands Protection Act by the Massachusetts Department of Environmental Protection does not define running water to be a stream if that running water is upgrade of a marsh (2017).

The most obvious environmental impact due to this project would be the land consumption of the road leading to a loss of habitat primarily for flora in the area, including the removal of vegetation both within and outside of the roadway. The preferred alignments for the project minimized the need for destruction of native vegetation, particularly trees. Emissions from construction vehicles will also be unavoidable and as such, the scope of work should be limited to the greatest extent available.

Earthwork also contributes to runoff effects, compounding with removal of vegetation to create erosion and stabilization concerns. For this reason, it is important to minimize the area of work and to use temporary stabilization methods such as mulch, jute matting and wood excelsior blankets to prevent some erosion until replanting can occur and ensure slope stabilization (Berkshire Regional Planning Commission, 2001). Earthwork also reduces soil productivity by compacting the soil under large equipment so vehicle use should be minimized. Excess cut material will also likely be disposed of on site as transporting it somewhere else can be expensive. This spoil material can kill vegetation where it is dumped and increase erosion issues. Because of this, the project team minimized the amount of cut and fill and recommends that TVSR carefully chooses where to dispose of the excess cut material.

Possibly the most important environmental consideration for any project is water. The construction of roads decreases infiltration and increases surface flow to the detriment of water quality (Berkshire Regional Planning Commission, 2001). Because of this it is important to design for proper drainage and to provide a vegetation buffer to all wetlands. The proposed roadway design of Roger's Road includes the design of a drainage ditch to control runoff. This ditch should be stabilized with riprap or vegetation, and replanting should occur around the road to allow for the vegetation buffer.

4.5.2 Construction Costs

Using the information that the project team gathered from the RSMeans book the project team developed spreadsheets that detail the costs of expected construction activities. These spreadsheets, which can be found in appendix G, include a breakdown of the breakdown of material, labor, and equipment costs that combine to total the cost of an activity so that TVSR could calculate their own costs if they were to self-perform work. A margin for overhead and profit is added to the sum of these costs as recommended by the RSMeans book. The final costs with the margin applied are \$295,594 and \$268,804 for the Solar Farm Way and Realigned Roger's Road options respectively. It is interesting to note that 61% of this cost for the Realigned Roger's Road alignment, and 66% of the Solar Farm Way alignment, comes from the cost of crushed stone for the surface and subgrade of the road. If the material were able to be obtained at a price significantly lower than that found in the RSMeans data, costs could be reduced as 86% of the cost for this activity is the material cost.

4.5.3 Final Scoring of Alternatives

Once environmental considerations were studied and construction costs were estimated, the alignments were scored. The alignment with a higher score moved onto the final design phase and was provided with additional recommendations for construction, maintenance and use. Table 3 lists the scores of each of the two chosen alignments. The criteria used to evaluate the two final alternative alignments is outlined in detail in section 4.1.7, while specific scoring for each category is outlined in Appendix H.

Table 3: Scoring of Final Alternatives

Category	Solar Farm Way Score	Realigned Roger's Road Score
Cost to Build	12	12
Earthwork	6	6
Gradients	10	10
Tightness of Turns	12	4
Length of New Construction	3	6
Maintenance Costs	2	2
Construction Duration	4	4
Impact to Neighbors	2	2
Security Constraints	2	2
Addresses Traffic Flow	3	2
Distance from Protected Zones	2	3
Total Score	58	53

Based on the scoring criteria, the Solar Farm Way option scored a 58 out of 99, and the Realigned Roger's Road option scored a 53 out of 99, making Solar Farm Way the better option. The two options received similar scores in all the major categories, except for "Tightness of Turns" and "Length of New Construction". Solar Farm Way outscored the Realigned option in "Tightness of Turns" by a score of 12

to 4. Realigned Roger's Road outscored Solar Farm Way in "Length of New Construction" by a score of 6 to 3. Due to the weighting of these categories and the differences in how well the alignments scored in these areas, Solar Farm Way scored 5 points better than Realigned Roger's Road. Ultimately, this was the difference in the final scores. Realigned Roger's Road also scored one point higher in "Distance from Protected Zones", but this section was canceled out by Solar Farm Way scoring one point higher in "Addresses Traffic Flow". Based on these results, the group concluded that the Solar Farm Way alternative best suits TVSR's needs, and we recommend that TVSR utilize this alignment.

5. Conclusion and Recommendations

The development of conclusions and recommendations of alternatives hinged upon the choice of a single final alternative. The alternative that the group is suggesting is the Solar Farm Way alternative. In this section, we will be discussing this alignment, provide recommendations for construction and develop insight for what TVSR could do going forward in relation to the proposed roadway.

5.1 Highest Scoring Alignment

As stated in section 4.5.2, the Solar Farm Way option outscored the Realigned Roger's Road option 58 to 53. Even though the Realigned Roger's Road requires less new construction, Solar Farm Way does not have the turn constraints that will require considerable labor like the Realigned Roger's Road option requires. In fact, there are few turns that users will have to traverse while driving along the proposed Solar Farm Way. Additionally, the current gradients that exist along the solar farm are manageable and will eliminate the need for cut and fill work. Even though there is more construction, the alignment requires substantially less cuts and fills as compared to Realigned Roger's Road, the construction duration will still be approximately the same.

While TVSR has voiced concerns regarding new safety considerations, Solar Farm Way also provides a new entryway to the reservation. A secondary entrance will alleviate demands placed on the current entrance. Traffic flow will be more manageable as visitors and staff alike are able to access different areas of the site without a queue forming along a singular route. Alleviating traffic flow issues that currently exist will also create a safer mode of transportation for all users. The addition of a security gate would provide TVSR with the means to regulate the visitors looking to gain entry to the reservation. A new entrance may allow TVSR to explore new security protocols that allow for a heightened level of security.

Based on these results, it can be concluded that Solar Farm Way is the better alternative. The group recommends that TVSR construct this alternative as it addresses their needs better than the current Roger's Road, the Realigned Roger's Road alternative and any other alternatives that were examined throughout the process of selecting alternatives. The project group has devised a series of recommendations that should help in making construction more efficient and improve the longevity of a new alignment.

5.2 Construction Recommendations

There are several recommendations regarding construction that should be considered to best accomplish the project goals. The first recommendation would be to self-perform as much work as possible with volunteer labor to reduce costs. Erosion controls should be utilized throughout the work zone wherever runoff is a concern, specifically areas with steep slopes or exposed soil. Another important recommendation is that areas be designated for the storage of equipment and material stockpiling, and surrounded by erosion controls to avoid clutter and prevent runoff from materials. An additional site should be designated for all small construction vehicles to be refueled by can so as to avoid contamination by petroleum product pollution. Watering the site with a truck may also be necessary to mitigate dust during construction.

5.3 Operations and Maintenance Recommendations

To ensure the longevity of an unpaved road proper maintenance is key. The first way that the roadway must be maintained is that the surface profile must be preserved. Compaction from vehicle use as well as erosion from surface runoff will alter the surface profile of the road. In order to combat this it may be necessary to bring in more material to replace any that is lost and to regularly regrade the road. It is generally recommended that a road be graded three to five times per year, and gravel replaced every five years, however this varies depending on how much a road is used (Platt). Roadside ditches must

also be maintained to ensure proper drainage. Ditches should be inspected regularly and cleaned every few years. Ditches should retain compact rounded bottoms, be sufficiently free of sediments and debris. Re-grading of the roadside ditch should only occur when necessary and the ditch should be lined with grass or rock to promote stability. We also recommend that if possible the road be closed over the winter. This will limit the wear on the road and eliminate the need to plow and treat the road which leads to quicker degradation of the road and pollution of the area.

5.4 Future Planning Recommendations

Implementing either two of the alignment options would substantially improve access to West Camp. However, both alignment options depend on several concrete bridges that have clear signs of external decay as seen in Figure 14 and Figure 15 as well as appendix I. Additional

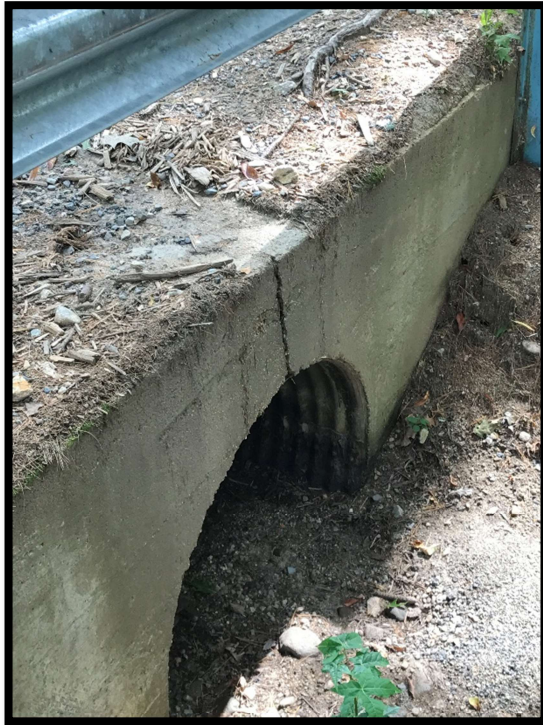


Figure 14 (Left): Substantial Wear on Concrete Bridge 1



Figure 15 (Right): Substantial Wear of Concrete Bridge 2

events will worsen traffic and accelerate the process of deterioration for the structures. Evaluating the structural integrity of each the three bridges should be a priority for any future MQPs. Furthermore, since portions of Snake River Road must be reused, Solar Farm Way will alleviate but not completely eliminate the access issues that challenge West Camp. Snake River Road's bridges are only wide enough for one-way traffic and the roadway on land is not graded enough in most sections to support two-way traffic. While Solar Farm Way supports two-way traffic, there will be bottlenecks on the Snake River Road segment to West Camp.

Longer term considerations may include completely paving one of the proposed or existing alignments that access West Camp. Paving such a distance would be an expensive undertaking but would improve capacity and reduce wear on traveling vehicles. Gradients on paved roads are less daunting for drivers and their vehicles than those on gravel. Furthermore, it would improve access for emergency vehicles and service vehicles.

Finally, although the construction costs of Solar Farm Way include estimates for the cost of a gate and basic entrance, this facility may not be adequate for a more developed West Camp. If West Camp hosts more frequent events with more participants, it may be necessary to expand Solar Farm Way's Pleasantdale Road entrance with a small parking lot and a more permanent weather resistant shelter.

5.5 The “No Build” Option

It is important to consider no action when evaluating several courses of action. No action or “no build” means that the issues regarding access to West Camp that TVSR faces will either remain exactly as they were or grow worse. Infrastructure will not keep pace with the growth of camp to the detriment of the camp's users. However, the no build option has no tangible financial, environmental or time cost. Finally, the no build option preserves the limited resources of TVSR for other, more pressing, capital projects.

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Appendix A Project Proposal

Authorship:

Item:	Group Member(s):
Capstone Statement	Kevin Walsh
Introduction	Phillip Royal
Background	Garrett Peters and Kevin Walsh
Methods	All Team Members
Conclusion and Schedule	Phillip Royal
Site Visit Report	Garrett Peters
Photos and Appendices	Ryan Coran

Treasure Valley Road Design
9/28/2017
Outline Draft

Introduction:

_____ The goal of the Treasure Valley 2017/2018 MQP is to produce a new road design which will reduce gradients, while minimizing cost and runoff, for a scout reservation in Rutland, MA. Currently, Treasure Valley Scout Reservation (TVSR) has two major roads, Snake River Road and Roger's Road, that link the reservation's west side to its east side. Snake River Road has gradients that exceed 17%, which has proven difficult for the heavy vehicles that must traverse the distance between the east and west sides of the camp (Chamberland, 2017).

Roger's Road was built several decades ago as a bypass for vehicles that could not surmount the gradients of Snake River Road. Additionally, Roger's Road was intended to provide another route to the west side of the camp in an emergency situation. The road unfortunately accomplishes neither task adequately as the tight turns prove challenging even for small cars. This issue is compounded by TVSR's

vision for future growth on either side of the camp (Chamberland, 2017). Addressing the issues that Roger's Road faces is critical to the continuing operations of TVSR.

A new design for Roger's Road should ultimately eliminate or reduce the limitations of the road in its present state. An analysis of alternative alignments, established through use of print maps, GIS data, and site survey should be completed. The analysis should also investigate paved and unpaved alternatives that reflect the expected uses of the road. Additionally, the analysis should account for design alternatives and techniques that minimize cost and environmental impacts. An evaluation for runoff control will also be produced. Analysis results will be transmitted in both a presentation and a final report to TVSR.

Background:

During the summer months, when the reservation is the busiest, there are a considerable number of parents who drop off and pick up their children. One of the main areas of the reservation that these parents must make their way to is West Camp. There are two ways of accessing this area of the reservation. One option is to take the main paved road and switch between several other gravel roads, which can be a circuitous means of accessing West Camp (Chamberland, 2017). The other option is utilizing Roger's Road. While Roger's Road does provide a more direct Path to West Camp, it is not a perfect solution. Roger's Road was added to the reservation with the hopes that it could become a viable alternative to the other cumbersome options. Unfortunately, Roger's Road has not provided the ease of travel that TVSR staff had hoped.

Roger's Road is located underneath a set of power-lines that lie on an inclined slope. While the slope is not drastic, it does make roadway layouts more challenging. When the road was designed in the 1970's, TVSR staff had incorporated several switchbacks that were located in specific areas to reduce the incline that vehicles would encounter. Like the road itself, the intent of these switchback is understandable, but they provide their own set of challenges. In a few specific spots, the switchbacks make for hairpin turns (Chamberland, 2017). Staff at the reservation have indicated that larger vehicles must make several difficult adjustments before they can continue along Roger's Road.

Additionally, although the layout was aimed at reducing the grades of Roger's Road there has been enough slope to cause significant damage due to runoff. The limited top surface that was placed on Roger's Road has given way to erosion, which is an issue many of the roads on the reservation face. Along with reductions in width due to runoff, Roger's Road has been encroached upon on both sides by vegetation. The plants growing on both sides of the road brush vehicles as they make their way along Roger's Road. Drivers will also encounter an exposed grounding cable from the power lines at two separate locations along Roger's Road. In turn, not only will new layouts be necessary, but there are a myriad of other issues that will need to be considered in maintaining a new roadway.

Treasure Valley Scout Reservation has also indicated that they are looking into expanding their site and the programs they run (Chamberland, 2017). In order to do this, the reservation will need to find a viable solution to the traffic problems they face. There are countless variables that must be considered in achieving the goal of improving Roger's Road. Some of the most appropriate options include allowing for two-way traffic, including stronger top surfaces to provide smoother driving and resilience to weather conditions, and implementing a layout that will provide low grades without tight switchbacks. This group will need to consider all of these and many more in order to provide TVSR with the information they

need to improve site conditions. In order to properly execute a new road design, there are guidelines and recommendations provided by different institutions that help in mapping out proper means and methods to perform the task.

The first step when beginning a roadway design process is to determine the project and community needs. This includes collecting information on the context of the roadway such as the surrounding area, roadway type, and roadway access. It is also important to consider the future use of the road. The area surrounding a road can be broken down into three classifications, each with sub classifications. These classifications are Rural, Suburban, and Urban (MassDOT, 2006).

Rural areas are often far from metropolitan areas and are characterized by sparse and low density development along a small number of roadways. Rural areas are sub classified as natural, village, or developed. Suburban areas are usually found surrounding a metropolitan area and vary widely in characteristics. Suburban areas share some characteristics with rural areas while sharing other characteristics with urban areas. Suburban areas are sub classified as suburban high density, suburban town center, or suburban low density. Urban areas are found at the core of metropolitan areas and are sub classified as urban park, urban residential, or central business district. The physical characteristics of the surrounding land, such as topography, is also a consideration for site conditions (MassDOT, 2006).

A roadway's type is often referred to by its functional classification, and is defined by the road's role in the transportation system. The common classifications for road type are freeways, major arterials, minor arterials, major collectors, minor collectors, and local roads and streets. These classifications typically depend on the inversely related characteristics of connectivity and access. For example, freeways have the most connectivity but lowest level of access to adjacent land, while local roads have the least connectivity but high access to adjacent land and abutting properties (MassDOT, 2006).

A roadways intended users must also be considered when beginning the design process. The primary objective when designing a road is always the safety of the road's users in addition to ensuring a fast method of transportation. All roadways have a variety of users including pedestrians, bicyclists, and motor vehicle operators and passengers. The composition of these users on a given road must be determined before design in order to ensure safe and efficient use when complete. The expected, current, and future traffic demands must be defined for an effective roadway design.

Based on the project area, functional classification, and traffic needs of the users, the designer must determine an appropriate design speed for the planned roadway. Using the contextual information gathered and design speed specified, the designer must next create a variety of alternative roadway designs including differing alignments and materials. These alternatives should be evaluated based on costs, how well they fulfill the particular goals and needs of the project, and how stormwater runoff is affected. The designer should analyze and compare these alternatives before consulting with the owner of the project and deciding which alternative to pursue.

Once a basic alternative has been selected, including rough alignment and surface material type, the major design elements can be determined. The major elements that must be designed are horizontal alignment, vertical alignment, cross sectional elements, and drainage facility placement. These elements in addition to all signage and traffic markings must be specified in the schematic design, which the proposed roadway will be based off of. The designer must also follow any relevant environmental standards or regulations, and all designs should abide by all applicable laws and codes. Once the final design has been completed, final cut and fill quantities can be determined and a price can be estimated

based on materials quantities and labor costs. Detailed stormwater analysis should also be performed on all final roadway designs.

Methods:

_____ Roadway designs come from the needs of the users. Initial considerations include determining functional adjustments for a new Roger's Road. TVSR has expressed that the main goal is to allow visitors to gain access to West Camp. However, there will inevitably be other vehicles that will need to gain access to this part of the site as well. For example, Tom Chamberland mentioned that school buses are one expected form of traffic (Chamberland, 2017). The project group will need to address the types of vehicles that will use Roger's Road. Establishing expected traffic determines the quantities and types of materials that will go into new design of Roger's Road.

Other needs that will have to be considered will be the various forms of traffic that will be permitted. As mentioned earlier, Roger's Road can only facilitate traffic in one direction (Chamberland, 2017). The reservation is looking to expand its operation in many different forms, so this may result in the desire for Roger's Road to become a larger roadway that allows for traffic in multiple directions. Research and analysis of a two-lane road in such conditions will be much different than planning a road that needs only one-way traffic. Additionally, considerations will need to be made to determine some more general conditions such as speeds and types of turns.

One of the best tools to help address this topic will be data provided by ArcGIS. ArcGIS will allow the group to understand the contours and elevations, locations of various wetlands, and other components of the terrain that may need to be worked around. TVSR has also provided several maps of the area that will prove useful in understanding what the conditions around Roger's Road look like.

_____ Choosing alignments is one key component of road design. The first step to doing so is to sketch routes on a topographic map or GIS software. During this process, hills, flood prone areas, and gradients should all be avoided. Good alignment choices should also minimize the need for earthworks and cuts to

reduce construction and maintenance costs. Once an alignment is chosen, a survey should be carried out on the route. A standardized form should be used to record site conditions during the survey (Johannessen, 2008). The horizontal alignment should follow a path that avoids steep slopes or other obstacles while minimizing length to connect the two desired points. Any curve in the design should have a sufficient radius to allow a vehicle to safely traverse it at design speeds without leaving the roadway due to centrifugal force, and so as to ensure the proper sight distance is met. Careful consideration will need to be made to better understand the costs and challenges associated with different layouts (Garcia, 2014).

Special attention must be paid to the design of vertical curves which are used to transition from one section of road to another with a different grade. Vertical curves are classified as either crest vertical curves or sag vertical curves. The primary consideration a designer must evaluate when designing a vertical curve is to ensure that the stopping sight distance is available over the peak of or at the bottom of a hill (Garcia, 2014).

Once the vertical and horizontal alignment of a road have been determined, the cross sectional elements must be designed. The first cross sectional element which should be considered is the cross slope of the roadway surface. Flatter surfaces are easier to drive on however perfectly flat surfaces leads to standing water creating unsafe road conditions. For this reason, cross slopes are generally around 2% and should not be less than 1% (Garcia, 2014). The shoulder of the road should also be sloped to allow drainage but not so much so that it creates a safety hazard for vehicles that leave the roadway or so much as to jeopardize the stability of the slope (Garcia, 2014).

The next cross sectional element to design is the lane width. This width is generally determined based upon the traffic needs, functional type, and design speed of a road. Lane widths for low speed streets are generally 11-12 feet with 14 feet being the recommended lane width to accommodate bicyclists (Garcia, 2014). The lane width should be designed to be wide enough to ensure safe travel of the road at design speeds and should fit the context of the project environment and needs. The designer must also determine an appropriate shoulder width for the design. A shoulder acts as emergency parking space, lateral support to the structure, a maneuvering area, increases sight distance, and gives a sense of a safe open roadway. The appropriate shoulder width depends on the needs of an individual project but in general at least a one foot offset to all obstacles should be maintained and the wider the shoulder width the more safe it is (Garcia, 2014).

Roads themselves generally consist of several layers, which includes a surface layer, a road base, a sub-base, and a sub-grade. Surface layer prevents water from entering the lower levels of the road and consists of natural gravels or pavement. Road base, also known as a binder, is a layer of crushed materials or specific soils which give the road strength. The sub-base which is also made of larger crushed materials, dissipates the load further. At the bottom of the road is the sub-grade which is the soil the road sits upon. Earth and gravel should be used in roads that have limited traffic. Performance of the earthen road is largely dependent upon the quality of the soil it is placed on (Johannessen, 2008).

Roadside design is a critical cross sectional design criteria as it can help prevent fatalities from vehicles leaving the roadway. Such accidents account for one-third of all traffic fatalities (Garcia, 2014). Safety is increased when the area adjacent to a roadway is relatively flat and free from unyielding objects. If unyielding objects are indeed present, safety precautions should be taken. It is important to make sure that roadside ditches and slopes control drainage while maximizing the safety of vehicles,

which may temporarily leave the road. Sometimes stabilization techniques must be taken to ensure slopes are not susceptible to erosion (Garcia, 2014).

Drainage facility placement is one more element that must be incorporated in every roadway design. The goal of drainage design is to accommodate surface runoff along and across the right of way of a road. All drainage facilities should maximize the safety of vehicles that may leave the roadway by either being traversable or by other designed safety measures. Cross drainage culverts are a common structure used in roadway design and they must be sufficiently strong to support the load of traffic, wide enough to allow sufficient drainage, and treated for safety (Garcia, 2014).

Preliminary estimates on cost can be made on multiple alignments. A comprehensive estimate, called the Engineer's Estimate, should take place for the favored alignment. This estimate should be compared to estimates created by an outside bidder. Real costs like material, labor and equipment requirements are the largest expenses reflected in an estimate. Their estimates also reflect combinations of profit, overhead, risk allowance, site supervision in addition to real costs. Ultimately, the best estimates come from similar and recently accomplished or on-going work (Johannessen, 2008).

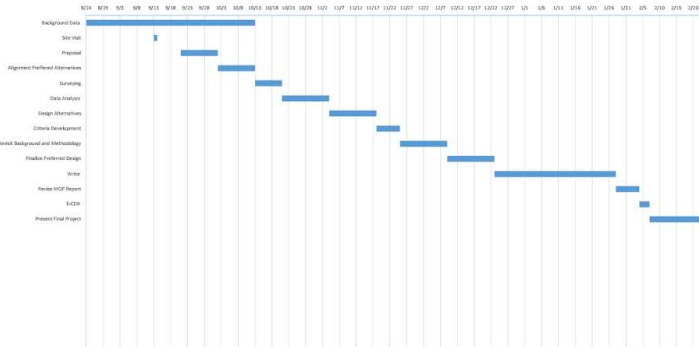
There will likely need to be signs on the road informing the drivers of changes in road conditions. These include sharp turns, narrow sections of road, oncoming traffic, and any large obstacles that may be near the road. The locations of these signs is also important. The signs should be placed in easy to spot locations not too far or too close to what the sign is referencing.

Conclusion:

It will take a considerable amount of research in order to provide TVSR with strong alternatives to the issues they face with Rogers Road and accessing West Camp. However, this group plans on providing several options comprised of differing alignments, materials, design, and cost in order to alleviate a central issue that the reservation has faced over the years. After consulting with TVSR staff our group will choose one of these alternatives in order to create a final roadway design specifying all relevant elements in a schematic design, final report, and presentation.

Schedule:

Task Name	Start	Finish	Duration (Days)	Days Complete	Days Remaining	Percent Complete
Background Data	8/24/2017	10/13/2017	50	0.00	50.00	
Site Visit	9/13/2017	9/14/2017	1	0.00	1.00	
Proposal	9/21/2017	10/01/2017	11	0.00	11.00	
Alignment Preferred Alternatives	10/2/2017	10/13/2017	11	0.00	11.00	
Surveying	10/13/2017	10/21/2017	8	0.00	8.00	
Data Analysis	10/21/2017	11/04/2017	14	0.00	14.00	
Design Alternatives	11/02/2017	11/16/2017	14	0.00	14.00	
Criteria Development	11/16/2017	11/20/2017	7	0.00	7.00	
Revisit Background and Methodology	11/23/2017	12/09/2017	14	0.00	14.00	
Finalize Preferred Design	12/09/2017	12/23/2017	14	0.00	14.00	
Write	1/23/2018	1/28/2018	6	0.00	6.00	
Revise MGP Report	1/28/2018	2/4/2018	7	0.00	7.00	
E-CDR	2/4/2018	2/7/2018	3	0.00	3.00	
Present Final Project	2/7/2018	3/3/2018	24	0.00	24.00	



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Appendix B Meeting Minutes

TVSR Staff Meeting

21 November 2017 / 10:00 AM / CONFERENCE ROOM

Attendees

Garrett Peters, Philip Royal, Kevin Walsh, Ryan Curran, Suzanne LePage, Tom Chamberland, Mike McQuaid, Christopher Baker and Rochelle Ray

Agenda

I. Accomplishments

- Reconstructed layouts in Civil-3D
- Completed surveying
- Completed preliminary screening of alignments report

II. Open Discussion

- Discuss the alignments from proposal; determine how they will be finalized
 - TVSR staff opinions on tentative proposals
- Determine the materials that will be used for alignments

III. Future Tasks

- Validate Points
- Finalize alignments
- Decide upon materials/assembly options

Notes

Alignment Discussion

- The use of Partial alignments will entail reusing much of the existing Roger's Road
- The Fully Realigned option may require a significant amount of clearing and grubbing, as it may enter into the wooded regions outside the cleared powerline pathway
- Mr. Chamberland and Mr. McQuaid emphasized that there should be no regions of new alignments that have grades exceeding those of the current layout
 - Mr. McQuaid indicated that one unimproved roadway, which had a grade of 11%, eroded due to the excessive gradient
 - Cited 8% grade as possible target
- When discussing the report put together by Mr. McQuaid, it was disclosed that existing conditions weren't a consideration
 - Mr. McQuaid focused on the topography of the region around the current Roger's Rd when considering his alternate layout
- National Grid would need to be informed of any proposed work, or permanent structures in the area of their power lines
- Mr. Chamberland stated that some recent events held on the reservation have had up to 1,000 participants

- This point helps the project group to understand the demand for a new layout that may help TVSR visitors to access different regions of the reservation with greater ease and safety
- The presentation introduced the possibilities of the Solar Farm Way layout
 - Although grades in the steepest region are approximately 11.2%, cuts and fills may be able to lessen the gradients
 - Staff members had not discussed this option in depth and were eager to explore this option in greater detail
- Discussions regarding the Solar Farm Way option brought up the issue of wetlands around this layout
 - In order for this to be a viable alternative, the Rutland Conservation Commission will need to be involved in the construction process
 - Mr. Chamberland indicated that TVSR and the Rutland Conservation Commission have a strong relationship
 - Professor LePage introduced the possibility of paving the steeper regions of the Solar Farm Way Layout
 - TVSR staff indicated that this is a possibility considering the relationship they have developed with the Rutland Conservation Commission
 - The Commission will need to ok any alterations to this parcel of land
 - Acquiring the funds to pave regions will require fundraising
- Safety measures upon completion of Solar Farm Way may limit the viability of the layout
 - TVSR staff has become very keen on the safety measures they have implemented on the main entrance onto camp
 - Creating a new entryway for Solar Farm Way, along Pleasantdale Rd, would require educating visitors, new signage and increased staffing to ensure all visitors are accounted for
 - Attendees discussed how a new hut may need to be placed at the entryway as a way to regulate visitors entering and leaving camp
 - Placing a gate at this new entryway would also be limited. Drop off and pick up times would not be allowed at all times of the operating hours
- Separate entrance is also a positive as it would allow access in the event that the main road into camp is blocked, as it has been in the past by felled trees
- Solar Farm Way also introduces difficulties regarding environmental impacts
 - The wetlands that are located near the cleared pathway connecting the solar farm to the powerline run would need to be addressed
 - Mr. Chamberland brought up the potential need for culverts, or dams
 - Culverts are subject to EPA regulations
 - Wildlife will need to be able to coexist in this region without disruption, which means culverts must provide ease of movement for all fauna
 - The Conservation Commission will scrutinize aspects of this layout if the proper options are not considered
 - If areas of runoff along the path can be classified as seasonal runoff, then the Conservation Commission will scrutinize plans less

- No work within 25 feet of wetlands, 50 feet is okay and commission involved if less than 100 feet from wetlands
- TVSR staff members also indicated that the owners of the solar farm (either Terra Forma or Sun Edison) may have declared bankruptcy (more information on this issue will be provided)
 - Any proposed modifications to the parcel being leased would be subject to the leasing agreement
- Issues regarding the rather proximity of certain areas of the current layout to some homeowners were introduced by Mr. McQuaid
 - Mr. McQuaid indicated that the excavation that took place for the original Roger's Rd resulted in one homeowner contacting the governor's office, because the road encroached upon their property
 - Any proposed work should fall farther from abutters property lines than the current layout of Roger's Road
 - Additionally, the project group's alignment titled "Partial Realignment" was deemed not viable due to its encroachment to abutting private property
- Conversation regarding layouts concluded with the project group's eliminated options
- It was unanimous that the use of Flint Rd was not viable
- However, Mr. Chamberland did request that the project group consider the Browning Rd entryway could be pushed up the hill 100 ft so that it would be outside of the Spencer town line
 - The reason interest was shown in moving the road 100 feet from any wetlands is that the Spencer Conservation Commission has been much harder to work with in the past
 - Mr. McQuaid did interject that vehicles due tend to travel at speeds up to 50 mph in this region, which would make entering and exiting in this region less than ideal

II. Assemblies and Materials Discussion

- The project group transitioned to the topic of creating assemblies in Civil-3D and what materials would go into physically creating the assemblies on site
- Mr. McQuaid and Mr. Chamberland indicated that the process of putting down an asphalt base along a 0.8 mile stretch of the main road resulted in a cost of \$108,000
 - An additional top coat required another \$108,000
- Paving an entirely new roadway would not be an option
- Instead, Mr. Chamberland introduced the likelihood that 100% Crusher Run would be used on a new layout
 - 100% Crusher Run of, dense grade, would incorporate aggregates ranging from 1.5" sieve size all the way down to fine grade
 - This option allows for sufficient binding without the need for a binding agent (i.e. emulsion or asphalt binder)
 - 100% Crusher Run will resist erosion, and will prevent TVSR from needing a top coat
 - Crusher Run can be researched in Massachusetts road specifications
- Attendees also introduced the option of milled asphalt, which has come up in past discussions
 - Millings would provide a material that could be incorporated at a relatively low cost
 - It was discussed as a possible top surface material

Action Items

1. Finalize Civil-3D alignments
2. Plot GPS points on Google Earth
3. Research classification characteristics for "seasonal streams/runoff"
4. Determine the grades on the profiles created in Civil-3D

5. Research possible construction material and costs
6. Create assemblies and corridors for finalized alignments
7. Look into creating cuts and fills in the software
8. Research Crusher Run in Massachusetts road specifications

Appendix C Site Visit Reports

Initial Site Report

Treasure Valley Group: Garrett Peters, Kevin Walsh, Phillip Royal, Ryan Coran

Advisor: Suzanne LePage

9/14/17

Initial Site Report

Because this was our first site visit, we had three different objectives. Our first objective was to meet with our sponsors. Our second objective was to look around the Treasure Valley Scout Reservation (TVSR) to get an idea of where we were working and what we were dealing with. The final objective was to figure out what TVSR wanted us to work on and decide on a project.

The visit started off with meeting the Vice President of Programming, Tom Chamberland. Mr. Chamberland gave the group a brief introduction to the TVSR. The initial discussion also included the priority of the various projects the reservation staff is interested in completing. In discussing the various projects with Mr. Chamberland, the group was able to get a better idea of what project to decide upon. From there, the group toured the reservation, and was provided with substantial background about the site.

TVSR is divided into two main locations, East and West Camp. Browning pond is the key landmark that splits the two sites. There are three main roads that are of key significance. The first is the main road, which is about 138 feet long and is paved. TVSR is looking into receiving a grant of \$109,000 that will allow for the main road to be repaved and receive other improvements. The last time this road was paved was 2011, and the asphalt layer on top shows significant wear.

All other roads on the entirety of the site are gravel roads. The gravel roadways do not include any type of erosion control. Due to the fact that there are no erosion prevention materials, the shoulders alongside these roads have eroded. Runoff conditions are worsened in areas around one other major road, Snake River Road, where the grades can exceed 17% in some spots. Mr. Chamberland indicated that when the gravel roadways were designed TVSR was not supplied with any as-builts, or other drawings that provided important details. The reservation staff is looking to put hardened surfaces on some of these gravel roads. There are several spots where milled asphalt pieces have been incorporated to try and provide an improved surface. However, the inclusion of these millings is not a long term solution to roadway issues.

The visit also provided details about difficulties staff and especially visitors have in accessing West Camp. During the summer months when the boyscouts are on site there are two points in the day, when parents pick up and drop off their children, where the unimproved roads along the way to West camp get quite a bit of traffic. The reservation is looking to find a way for these visitors to gain access to West Camp in a less complicated fashion.

In the early 1970's the reservation staff did try to alleviate the West Camp access issue by laying out an additional unimproved roadway. The road was called Rogers Road. Unfortunately, the road includes many switchbacks that are difficult to traverse. The switchbacks were added to reduce high grades along the road, but in order to limit steep grades the switchbacks have created very tight turns.

School buses, and other large vehicles, that are heading to West Camp must make several point turns in order to get over the switchbacks. In addition to difficult turns, Rogers Road also runs under a set of power lines, and in some areas the grounding cables have become exposed. Although the addition of Rogers Road was a good idea the execution and maintenance of the road is unideal.

Another topic that was discussed was the issue with several small bridges located throughout the reservation. Several of these bridges are in disrepair and are in need of maintenance. In similar fashion to the gravel roads, there were no as-builts created for these bridges. The staff at TVSR are unaware of the loads these bridges can withstand, or what materials have been included to build them. What is particularly concerning is that vehicles such as cement trucks occasionally use the bridges. Not knowing the weight constraints, but driving heavy trucks over the bridges is not a safe approach.

The group discussed potential projects ranging from bridge design to new site entries in several of the towns surrounding TVSR. However, after the talk with Mr. Chamberland, and amongst ourselves, we have collectively decided to go with the Rogers Road redesign. We not only feel that this is the most interesting project, but it also appears to be the one that is most useful to TVSR.



Entrance to TVSR



Side Road off of Snake River Road



Existing Culvert under Snake River Road

Surveying Site Visits Report

TVSR Site Visit Report

Visit Dates: 10/18/17, 10/20/17 Report Date: 10/25/2017

Authors: Ryan Coran, Kevin Walsh, Garrett Peters, Phillip Royal

Advisor: Prof. LePage

A



10/18/17 Initial Survey:

The first objective for this trip was finding any navigable existing paths or roads in that could provide access to West Camp if substantially improved for regular vehicular traffic in place of Roger's Road. We located a long path that ran along the West Bank of Browning Pond that connects to Browning Pond Road. We determined that the road is a potential option with multiple drawbacks. Although the path is flat, it's also long at roughly 3600ft. The road is flanked on its eastern side by Browning Lake and by steep slopes on West Side. Widening the road for two-way traffic would require significant excavation into the hillside of the path. Additionally, there are wetlands at the end of the path that necessitated the construction of a small wooden bridge.



Figure 1: Browning Lake to the east (Left) and Steep slopes to the west (Right).



Figure 2: This wooden bridge on the existing path allows the road to continue through the wetlands on either side.

The project group also explored the western boundaries of the camp to find an alternative to Roger's Road. Flint Road was one of these, but we eliminated this road as an option due to its steep grades and significant distance from West Camp. We recognized the amount of work that would need to go into grading, excavating, and purchasing materials for Flint Road would not be feasible. We also discussed opportunities for new entrances along Spencer Road. While driving in this area, we were able to locate another unimproved path that appeared to provide access to the general area around West Camp. We were not able to drive down this path because the entrance was gated.

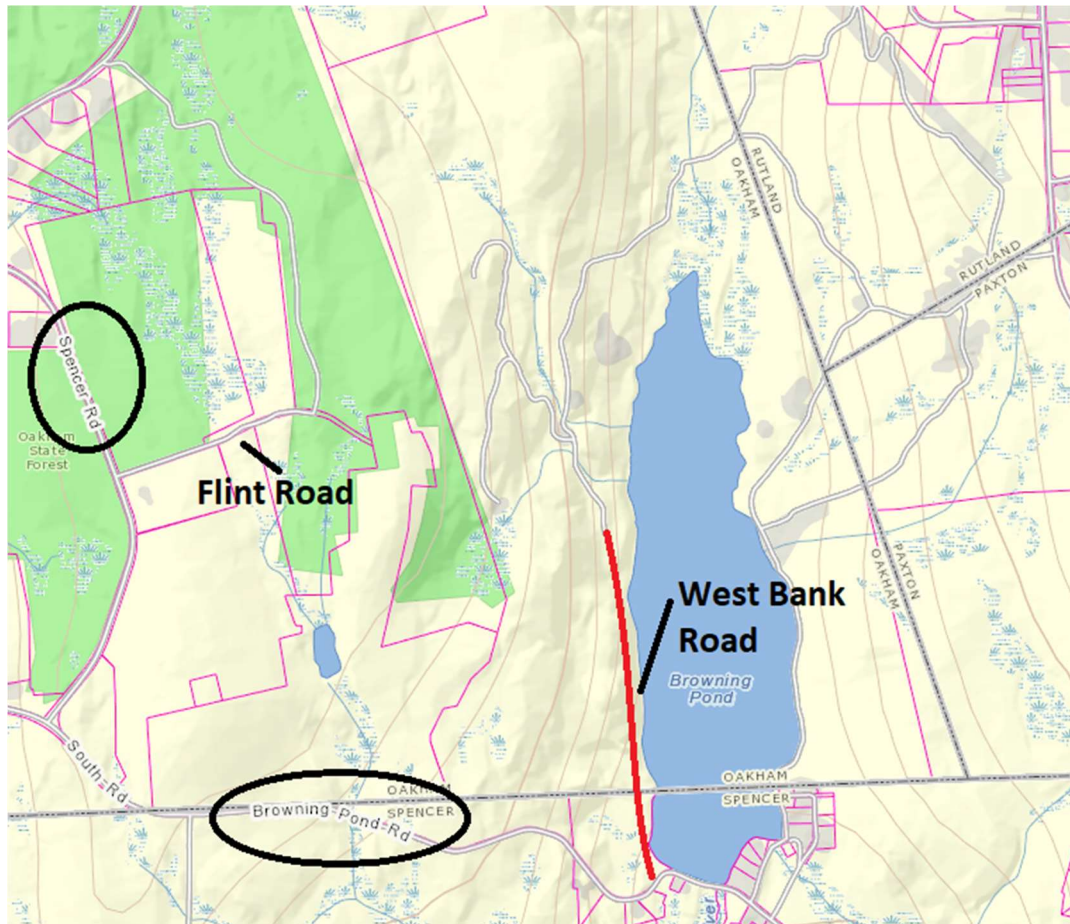
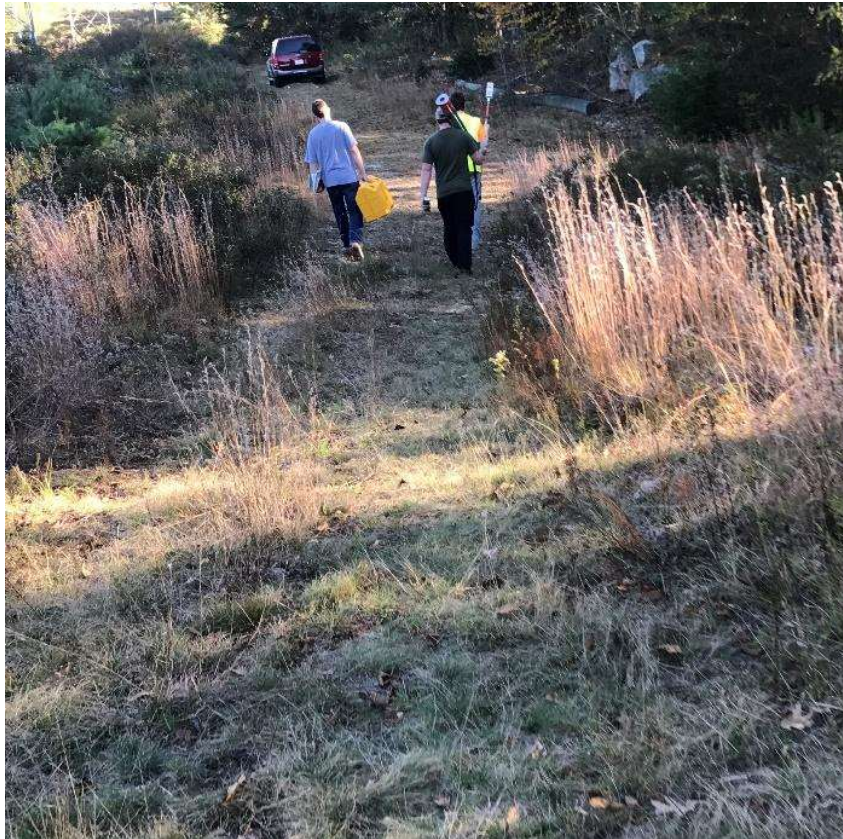


Figure 3: In red is the west bank road as pictured in figures 1 and 2. Flint road as well as Spencer and Browning Pond Road are highlighted.

The second goal of this visit was to determine the areas where the current Roger's Road was the least adequate and to locate relatively flat areas where a new layout could be placed. We thoroughly examined the areas along the power lines. In doing so, we found several relatively flat regions that were not utilized by the current layout. Despite significant vegetation along these areas, we recognized these less steep areas as having strong potential for an improved layout. We decided that in subsequent visits these would be the areas we would focus on.

The final goal was to establish field competency with the Trimble Total Station and related surveying techniques. The last two hours of our visit were spent re-acclimating ourselves with the Trimble Total Station. We were able to gather several readings from various points along the region of Roger's Road that ran underneath the power lines. However, after about an hour of successful surveying we ran into technical difficulties with the equipment. The total station would display only error messages. After spending a significant amount of time adjusting the settings, we decided it was best to try again with a fully charged battery.



10/20/17 Surveying:

The group decided to test the Trimble Total Station on 10/19/17, and the equipment was working without any issues. On 10/20/17, the group brought the Trimble Total Station and backup equipment, in the contingency that the Trimble Total Station began to malfunction again. Points were taken on the site in order to attain more data on the existing conditions under the power lines.

The group surveyed the area under the power lines, from where Roger's Road first enters the area, to where it leaves the power lines. When surveying, we mapped out each of 42 points and checked the distance and elevation changes between each point. We simultaneously used the "GPS Tour" app to find GPS coordinates at each point. The results from this surveying can be found in Table 1 below.

By surveying the entire area, the group will verify the GIS data for the area is accurate and can determine the most ideal route through the power lines as an alternative to Roger's Road. The group also walked down one of the paths leading away from the bottom of the existing road and found easy access to a solar farm, which is owned by TVSR, and there is an existing road there. This led to discussion of the final alternative by creating a connection between Roger's Road and Pleasantdale Road, which would run along a solar field located slightly North of the camp. TVSR would need to provide a connector between Pleasantdale Road and Roger's Road, as seen in Figure 4. The solar farm and all of the real estate required for the road is already owned by TVSR. This option is promising as the entire length would be relatively flat however it would require significantly more clearing and grubbing than following a path under the power lines. This route would also utilize lower parts of the existing Roger's Road.

Point	Station Point	HD (ft)	VD (ft)	Latitude (Degrees North)	Longitude (Degrees West)
1	n/a	n/a	n/a	42.324749	71.989976
2	1	82.645	4.339	42.324921	71.990127
3	2	45.942	-0.172	42.324868	71.99
4	2	73.474	-0.969	42.32481	71.989946
5	2	106.151	-1.52	42.324994	71.989813
6	2	144.304	-5.08	42.325053	71.990553
7	6	40.781	1.934	42.32518	71.990479
8	6	75.946	1.905	42.325182	71.990366
9	6	109.923	1.271	42.325252	71.990261
10	6	140.498	-3.392	42.325425	71.990384
10	11	131.981	11.45	42.325425	71.990384
11	6	96.494	-13.183	42.325327	71.980812
12	11	96.011	10.259	42.325382	71.990404
13	11	62.493	5.762	42.325353	71.990617
14	11	57.677	-0.982	42.325357	71.990452
15	14	43.474	0.173	42.325434	71.990794
16	14	56.293	5.5	42.325474	71.990793
17	14	103.131	-9.094	42.325594	71.991148
18	17	33.924	2.851	42.325607	71.991091
19	17	69.198	7.728	42.325712	71.990994
20	17	79.07	-13.212	42.325825	71.991355
21	20	43.809	5.659	42.325884	71.991293
22	20	87.013	9.69	42.325972	71.991249
23	20	153.058	8.604	42.326094	71.991248
24	20	131.189	2.326	42.326038	71.991317
25	20	300.682	-19.791	42.330475	71.996671
26	25	112.131	-15.134		
27	26	68.184	-7.548	42.328504	71.994192
28	26	68.782	-5.17	42.328387	71.994192
29	26	132.868	-13.33	42.326895	71.992392
30	26	121.974	-14.03	42.326748	71.992521
31	26	165.495	-17.568	42.326963	71.992512
32	31	59.165	-10.987	42.327036	71.99269
33	31	49.481	-7.096	42.326855	71.992607
34	31	84.422	-3.17	42.326941	71.992553
35	31	95.762	-3.777	42.326765	71.992729
36	31	116.154	-5.648	42.326815	71.992819
37	31	88.937	-5.664	42.326856	71.992797
38	31	108.738	-7.054	42.326776	71.992893
39	31	140.174	-9.426	42.326772	71.992887
40	31	127.152	-9.902	42.32707	71.992941
41	40	92.637	-16.426	42.327278	71.993228
42	41	254.754	-28.785	42.327749	71.993842

Table 1: Surveying Data

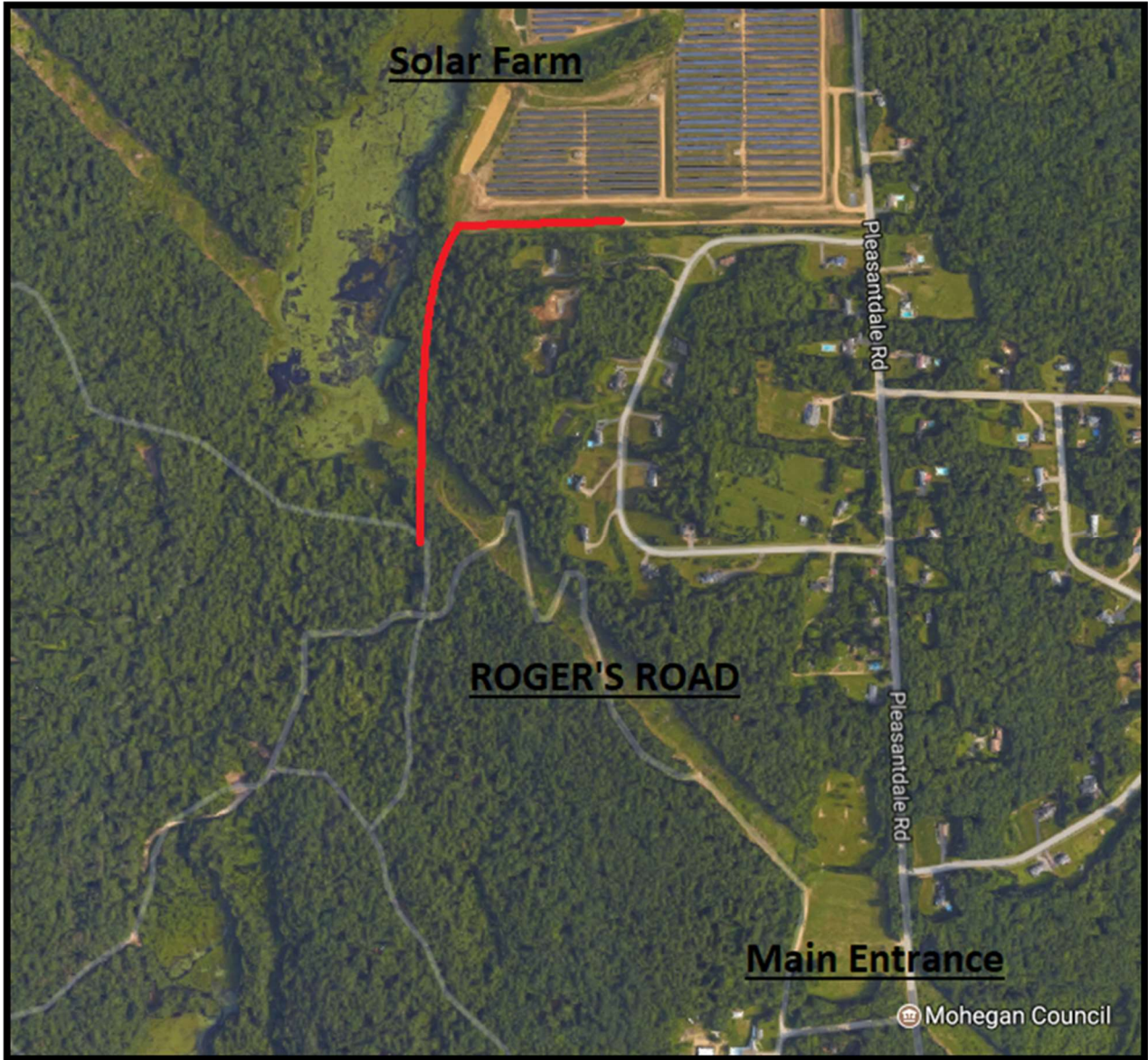


Figure 4: The alternative option between Roger's Road and Pleasantdale Road via the solar farm.

Appendix D Emailed questions

Treasure Valley MQP 2017/2018

Site Visit Questions:

1. What project topics are you considering for our group? Is the roadway design the top priority? *The bridge/culvert study followed by Snake River rd erosion control and last, Rodgers road improvement/relocation. However, In recognition of your individual career paths, whichever of these work best for your team is also OK with us.*
2. How much traffic could the existing road (Snake River Road) be typically expected to see during the day? *Weekdays during summer camp season would see approx 150 cars from 7:45 am to 8:30 am and then again from 4:30 Pm to 5:30 pm, Sundays from 2PM to 5 Pm would see 50 cars, and weekends for the remainder of the year would avg 20 cars per day. Otherwise vehicle use would mostly be camp service and occasional visitor, so 20 cars per day.....*
3. Do you anticipate this to increase in the future? *Yes slight increase to 200 cars on weekdays during summer camp*
4. Are there specific sections of the existing road that give vehicles more trouble than others? *Pot holes on the more "flat" sections, and rain ruts on the more steeper sections*
5. How well does the current road handle rainstorms? *We try to grade road with a dozer at least once a year, so the condition you see the road in is about the worse it gets, short of sum rutting at spring thaw.*
6. What is your current stormwater management plan? *There is none.*
7. How are current improvements approved and funded? *We have a part time Ranger, working with a full time Reservation Director, schedule road work as needed/required. Major repairs last took place about 6 years ago as a part of an overall "road upgrade" project and consist of the repairs/use of road grindings you now see.*
8. How is site administered? *Part time Ranger working with Volunteers*
9. How much maintenance does the road typically receive and how much would it receive ideally? *As mentioned, annually: rough grading with a small dozer, "pothole" filling, Ideal would be at least once a year grading with a road grader and application of 7/8" dense grade gravel to refresh surface.*
 - a. How is existing roadway treated for snow in the winter? *Roads are plowed and sanded using camp equipment. Kept open for weekend use all year.*
10. Is it more challenging to get labor or materials for projects? *Materials, as we would have to purchase that, we have a number of volunteers along with our ranger who can use equipment.*
11. What improvements are you considering, that have not been implemented? *Our "plan" is to harden the road with pavement grindings.*
12. Have you consulted with any other groups regarding roadway design improvements? *NO*
13. Are there any specific materials you are hoping to use to improve the unimproved roadways? *As mentioned, Pavement millings and 100% crusher run 7/8" dense grave material.*
14. What are your greatest concerns regarding the unimproved roadways? *Erosion, environmental degradation of water ways and aesthetics*
15. Have there been any roadblocks you have run into in terms of town zoning ordinances or bylaws? *NO* Has it been difficult working with three different towns' laws and regulations? *Not*

really, except for the Town of Spencer, their Conservation Commission have been hard to deal with.

16. *Do you have any drawings or specifications for the current roadway? Any drawings we have will be on the TVSR OPS site, with the possible exception of Rogers Road, I will have to check to see if we have it or not.*
17. *Do you have any topographical maps of the area of the roadway? Any drawings we have will be on the TVSR OPS site, I know we have some. There is a high resolution PDF file prepared by our National office, on the site.*

Appendix E Preliminary Screening Report

Eliminated Options

1. Western Browning Pond Road

Analysis of the TVSR boundary lines revealed a path on the southern portion of TVSR's property, which was considered by the project team for a potential site entrance. The path runs perpendicular to and meets a public road called Browning Pond Road. The path itself is flat and turning radii along it are large.

However, the path is wide enough only for one-way traffic as it is flanked on one side by steep slopes and on the other by Browning Pond. Sections of the road are less than 1' from Browning pond, introducing both safety and runoff risks. The northernmost portion of the road includes a steep embankment with old growth trees and thick vegetation. Wetlands have necessitated the use of a bridge to make walking over a portion of the path possible, meaning a bridge would need to be constructed for vehicular use as well. Additionally, the path is a mile long, making it longer than any other option. The material and labor that would be required to rebuild the bridge, shore the lakeside portions of the road, excavate a two way cross section over a long road would be immense and outside the realm of viability. Additionally, the scale of such project would have such a pronounced environmental impact on both West Camp and on Browning Pond that it would be counterproductive to the preservation goals of TVSR.

2. Flint Road Extension

The project group also explored another possible entryway on TVSR's West Side, which would could connect to Flint Road. Utilizing an entryway on Flint Road would allow for a visitors to access Snake River Road without having to use TVSR's main entryway. This would relieve pressure off the main entrance and provide another emergency means of entrance and egress.

Utilizing Flint Road as an entrance poses its own set of challenges. Flint Road is narrow, long, overgrown, unimproved and undrivable. Constructability of even an unimproved roadway in West Camp would be extensive given the high density of vegetation and the **steepness** of slopes. A great deal of excavation would need to be completed in order to reduce gradients on the existing portions of Flint Road. Flint Road sits on property owned by the state which introduces another stakeholder to consider. All of these challenges make this option not worth studying further.

Options Chosen for Further Analysis

1. Roger's Road Partial Realignment Option

Choosing only a partial realignment of Roger's Road presents a small number of benefits. Reusing much of the existing portions of the road would substantially reduce the need for cuts and grades compared to other options. The partial realignment would also have a smaller environmental impact relative to a new road. These benefits may be especially attractive if labor and resources are limited.

Drawbacks of the partial realignment are numerous. The largest single drawback is that a partial realignment would face some of the same restrictions that the original road faced, namely in turning radius and width. These limitations could be overcome with a new alignment. In sharing a main entrance with other routes, the main entrance will also continue to see heavy traffic. Portions of Roger's Road are also within several feet of abutting private property, meaning initial work, and the influx of additional traffic upon completion, may negatively impact the neighbors. Finally, the partial realignment would continue to use the portions of Snake River Road that contain deteriorating bridges and culverts, a condition that will be compounded by additional traffic. Mitigating the extensive drawbacks would be a substantial portion of the work associated with a partial realignment of Roger's Road.

2. Completely Realigned Rogers Road

A complete realignment of Roger's Road is another option that presents distinctive benefits. Routing the alignment along the right-of-way of the power lines would obviate the need for felling. Brush growth in the area is modest and could be cleared with ease relative to other paths to West Camp. Furthermore, the completely realigned road would be substantially more direct than Roger's Road as it exists today. Finally, the more direct alignment would be freed of the constraints on radius and width that only a partial realignment would be burdened with. Completely realigning the road does present some immediate and clear benefits.

Realigning Roger's Road would also present a number of issues. A path that is contained within the boundaries of the cleared space of the power lines will have a steeper maximum grade than the current Roger's Road. Cuts and fills will be necessary to provide the desired width and gradients for the realigned road. The road would also be intensive in both materials and labor. Lastly, just like the partially realigned option for Roger's Road, the completely realigned option would again rely on the front entrance and Snake River Road to link East Camp to West Camp. Although this option would be more labor and resource intensive while still inheriting some limitations, it would better accomplish the needs expressed by TVSR as compared to a partial redesign.

3. Solar Field Option

Examinations of the reservation allowed the project team to locate a solar farm on the Northeast portion of TVSR located close to Pleasantdale and Wildbrook Road. Immediately outside of the fencing of the solar farm is a wide 700 ft. dirt road that runs parallel to the southern boundary of the solar farm and could be integrated into the new Solar Farm Way. The gradients of the terrain allow the connection between the unimproved road to the lower portion of Roger's Road to be both wide and relatively flat. Solar Plant Way will have only a modest need for cuts and fills.

While there may not be the need for as much excavation as other alternatives, the prospect of an entry way along the solar farm would require more earthwork than the redesign of Roger's Road. Connecting the unimproved roadway to Roger's Road would require felling of mature forest and clearing of well-developed roots. The majority of newly constructed road will also fall within 100 feet of an existing wetland meaning that considerations have to be made on both the regulatory and environmental facets of the project.

Appendix F Presentation



Project Goal: Create a roadway design that addresses the existing access issues of TVSR's West Camp.

2

Create & Screen Alternatives

- The Northern Extension
- Western Browning Pond Road
- Flint Road Extension
- Realigned Roger's Road
- Solar Farm Way

3

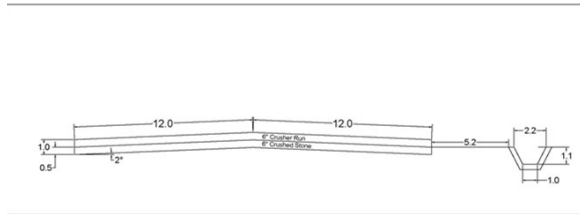
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Type	Standard	Source
Gradients	8% Target Gradient	11/21/2017 Preliminary Report Meeting
Lanes	1 Lane, Each Direction	Emailed Response
Turning Radius	34.9 Foot Turning Radius	09/14/2018 First Site Visit, AASHTO Green Book 2001
Paving	Exclusively Gravel	11/21/2017 Preliminary Report Meeting
Setbacks	30ft Inside of TVSR Property Lines	1/23/2018 Selection Criteria Review Meeting

4

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Roadway Cross Section



5

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Final Alternatives I: Realigned Roger's Road



6

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Final Alternatives II: Solar Farm Way



7

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Category	Solar Farm Way Score	Realigned Roger's Road Score
Cost to Build	12	12
Earthwork	6	6
Gradients	10	10
Tightness of Turns	12	4
Length of New Construction	3	6
Maintenance Costs	2	2
Construction Duration	4	4
Impact to Neighbors	2	2
Security Constraints	2	2
Addresses Traffic Flow	3	2
Distance from Protected Zones	2	3
Total Score	58	53

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[Scoring Criteria](#)

8

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Construction Costs

Material/Activity	Solar Farm Way			Realigned Roger's Road		
	Total Cost (O&P)	% of total cost	Construction Length (Days)	Total Cost (O&P)	% of total cost	Construction Length (Days)
1-1/2" Crushed Stone	\$ 195,756	66.22%	25	\$ 164,309	61.13%	21
Medium Brush Clearing	\$ 1,195	0.39%	1	\$ 970	0.36%	1
Trench Excavation	\$ 877	0.30%	1	\$ 548	0.20%	1
Rough Grading	\$ 5,200	1.76%	6	\$ 5,200	1.93%	6
Fine Grading	\$ 35,642	12.22%	59	\$ 46,704	17.37%	50
Barrier Gate	\$ 2,575	0.87%	1	\$ -	0.00%	0
stabilization fabric	\$ 11,745	3.97%	3	\$ 9,859	3.67%	2
Traffic Signage	\$ 145	0.05%	0.1	\$ -	0.00%	0
Excavating, Bulk, Dozer	\$ 22,498	7.61%	11	\$ 41,215	15.33%	21
Total:	\$ 295,594		107.1	\$ 268,804		102
		Total (Weeks):	21.42		Total (Weeks):	20.8

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Conclusions and Recommendations

- Construction Recommendations



10

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Conclusions and Recommendations

- Maintenance Recommendations



11

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Conclusions and Recommendations

- Future Recommendations



12

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Questions?

Links for Reference

- [Scoring Criteria](#)
- [Construction Costs Realigned Roger's Road](#)
- [Construction Costs Solar Farm Way](#)
- [Realigned Roger's Road Profile](#)
- [Solar Farm Way Profile](#)

Appendix G: Construction Costs

Realigned Roger's Road Costs

Qty	Total Cost (bare)	Total Cost (O&P)	% of total cost	Category	Material	Description	Crew	Labor Hours	Material Cost	Labor Cost	Equipment Cost	Total Unit Cost	Unit Cost (w/O&P)	Unit	RS Means Page Number	Item Number	Construction Length (Days)
9958.12	\$146,384	\$164,309	60.71%	Aggregate Base Course	1-1/2" Crushed Stone	12" deep	B-36B	0.017	\$12.65	\$0.80	\$1.25	\$14.70	\$16.50	SY	651	0304	21
3.66	\$776	\$970	0.36%	Earthwork	Medium Brush Clearing	W/ dozer and brush rake	B-11A	1.6	\$0.00	\$74.00	\$138.00	\$212.00	\$265.00	Acre	614	0500	1
76.1111	\$400	\$548	0.20%	Earthwork	Trench Excavation	1-4' Deep 1/2 CY Excavator	B-11M	0.074	\$0.00	\$3.43	\$1.83	\$5.26	\$7.20	BCY	50	0050	1
1	\$3,925	\$5,200	1.92%	Earthwork	Rough Grading	75100-100000 S.F., grader	B-11L	44.444	\$0.00	\$2,050.00	\$1,875.00	\$3,925.00	\$5,200.00	EA	615	0280	6
9958.12	\$35,351	\$46,704	17.25%	Earthwork	Fine Grading	Finish Grading Area to be paved with grader, small area	B-11L	0.04	\$0.00	\$1.85	\$1.70	\$3.55	\$4.69	SY	616	0012	50
5684.77	\$34,450	\$41,215	15.23%	Earthwork	Excavating, Bulk, Dozer	300 H.P. 300' haul common earth	B10-M	0.029	\$0.00	\$1.43	\$4.63	\$6.06	\$7.25	BCY	622	3320	21
9958.12	\$8,564	\$9,859	3.64%	Aggregate Base Course	stabilization fabric	polypropylene, 6 oz./S.Y.	B-6	0.002	\$0.72	\$0.10	\$0.04	\$0.86	\$0.99	SY	651	6000	2
Total:																102	
Total (Weeks):																20.4	

Solar Farm Way Costs

Qty	Total Cost (bare)	Total Cost (O&P)	% of total cost	Category	Material	Description	Crew	Labor Hours	Material Cost	Labor Cost	Equipment Cost	Total Unit Cost	Unit Cost (w/O&P)	Unit	RS Means Page Number	Item Number	Construction Length (Days)	
11864.03	\$174,401	\$195,756	66.22%	Aggregate Base Course	1-1/2" Crushed Stone	12" deep	B-36B	0.017	\$12.65	\$0.80	\$1.25	\$14.70	\$16.50	SY	651	0304	25	
4.36	\$924	\$1,155	0.39%	Earthwork	Medium Brush Clearing	W/ dozer and brush rake	B-11A	1.6	\$0.00	\$74.00	\$138.00	\$212.00	\$265.00	Acre	614	0500	1	
121.78	\$641	\$877	0.30%	Earthwork	Trench Excavation	1-4' Deep 1/2 CY Excavator	B-11M	0.074	\$0.00	\$3.43	\$1.83	\$5.26	\$7.20	BCY	50	0050	1	
1	\$3,925	\$5,200	1.76%	Earthwork	Rough Grading	75100-100000 S.F., grader	B-11L	44.444	\$0.00	\$2,050.00	\$1,875.00	\$3,925.00	\$5,200.00	EA	615	0280	6	
11864.03	\$42,117	\$55,642	18.82%	Earthwork	Fine Grading	Finish Grading Area to be paved with grader, small area	B-11L	0.04	\$0.00	\$1.85	\$1.70	\$3.55	\$4.69	SY	616	0012	59	
1	\$2,250	\$2,575	0.87%	Security	Barrier Gate	non-programable with reader and 12' arm	2 Elec	5.333	\$1,950.00	\$300.00	\$0.00	\$2,250.00	\$2,575.00	EA	404	5050	1	
11864.03	\$10,203	\$11,745	3.97%	Aggregate Base Course	stabilization fabric	polypropylene, 6 oz./S.Y.	B-6	0.002	\$0.72	\$0.10	\$0.04	\$0.86	\$0.99	SY	651	6000	3	
3103.2	\$18,805	\$22,498	7.61%	Earthwork	Excavating, Bulk, Dozer	300 H.P. 300' haul common earth	B10-M	0.029	\$0.00	\$1.43	\$4.63	\$6.06	\$7.25	BCY	622	3320	11	
1	\$125	\$145	0.05%	Signage	Traffic Signage	18"x24" stock reflectorized, 10' steel post	B-80	0.617	\$80.50	\$27.00	\$12.97	\$125.47	\$144.50	EA	378	0900/1500	0.1	
Total:	\$253,392	\$295,594																
																	Total:	107.1
																	Total (Weeks):	21.4

Appendix H Analysis Criteria

Analysis Criteria

TVSR Road Study 2017/2018

Factors	33%	67%	100%
<p>Cost to Build</p> <p>18 Points</p> <p>Cost is a key component of the viability of alignment options.</p>	Total building costs more than \$300,000 and less than \$400,000.	Total building costs more than \$200,000 and less than \$300,000.	Total building costs less than \$200,000.
<p>Earthwork</p> <p>18 Points</p> <p>Absolute Cut and Fill</p>	40,000-200,000 ft ³ net cut or fill.	40,000-10,000 ft ³ net cut or fill.	0 to 10,000 ft ³ net cut or fill.
<p>Gradients</p> <p>15 Points</p> <p>There should be no sections of the new road with gradients exceeding 11%. It is preferable to have as few segments as possible with grades between 9 and 11% as well.</p>	25% of the total road length has gradients between 9% and 11%.	Less than 10% of the road has gradients between 8% and 11%. The remaining segments have gradients under 8%.	All grades are 8% or lower.
<p>Tightness of Turns</p> <p>12 Points</p> <p>If the turns are too tight, the road will be undrivable. The greater the turning radius and fewer tight turns.</p>	All curves have a minimum curve radius of 35 feet.	All curves have a minimum curve radius 50 feet.	All curves have a minimum curve radius 70 feet.
<p>Length of New Construction</p> <p>9 Points</p>	2,000 feet to 3,000 feet.	1,000 feet to 2,000 feet.	Shorter than 1,000 feet.

<p>New construction length affects the time, effort and resources necessary to realize the design.</p>			
<p>Maintenance Costs</p> <p>9 Points</p> <p>After the roadway is constructed, the road will need to be maintained over its lifespan. It would be ideal to limit TVSR costs associated with road maintenance.</p>	<p>Average annual maintenance costs exceeds \$3,600 per mile.</p>	<p>Average annual maintenance costs are between \$3,600 and \$2,500.</p>	<p>Average annual maintenance costs are less than \$2,500 per mile.</p>
<p>Construction Duration</p> <p>6 Points</p> <p>The roadway should be constructed in a reasonable amount of time.</p>	<p>Construction will take over 9 months.</p>	<p>Construction will take between 3 months and 9 months.</p>	<p>Construction will take under 3 months.</p>
<p>Impact to Neighbors</p> <p>3 Points</p> <p>The road should aim to be as far removed from property owners that abut TVSR.</p>	<p>Road is within 30 feet of existing property lines.</p>	<p>Road is within 100 feet of existing property lines.</p>	<p>Road is more than 200 feet away from existing property lines.</p>
<p>Security Constraints</p> <p>3 Points</p> <p>TVSR has concerns about the addition of a new roadway, which include potential negative impacts to their current security measures. They are particularly wary of the ability of staff to keep track of all visitors during hours of operation.</p>	<p>TVSR has limited difficulties documenting who is on site during hours of operation.</p>	<p>There are very few incidents where TVSR is unable to account for all visitors during hours of operation.</p>	<p>New security protocols allow for a greater degree safety than the system in place before the new road was added.</p>

<p>Addresses Traffic Flow</p> <p>3 Points</p> <p>The current access to West Camp is through one route where everyone must go through. The new roadway should avoid these areas as much as possible.</p>	<p>Road provides access to west camp but uses significant length of snake river or other existing roads.</p>	<p>Road provides access to west camp that uses little to none of snake river road or other existing roads.</p>	<p>Road provides alternate entry to camp and uses little to none of snake river road or other existing roads to access west camp.</p>
<p>Distance from Protected Zones</p> <p>3 Points</p> <p>Construction within or near wetlands requires special considerations including the filing of a notice of intent with the local conservation commision and should be avoided if possible.</p>	<p>Construction falls between 25' and 50' of a protected zone within Rutland</p>	<p>Construction falls within 100' of a protected zone within Rutland</p>	<p>No construction will occur within 100' of a protected zone</p>
<p>99 Points</p>			

Appendix I Photos



