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1.0 Project Understanding

1.1 Project Purpose

The purpose of designing and building an OHV park for the Findlay Toyota automotive dealership is to provide a variety of terrains and obstacles which will be used to highlight the off-road features of the Toyota 4Runner SUV and Toyota Tacoma pickup trucks. The Findlay Toyota OHV park will provide potential vehicle buyers a chance to test features of Toyota 4-wheel drive vehicles that cannot normally be tested during a typical test drive. The location on which the OHV park is to be built in is a very high-traffic area, so bringing in potential vehicle buyers who would like to drive on the park is another purpose of the project.

Designing an OHV park for the Findlay Toyota automotive dealership benefits both Findlay Toyota as well as the Department of Civil Engineering at Northern Arizona University. For Findlay Toyota, the OHV park will attract potential buyers of 4-wheel drive vehicles, and will aim to increase vehicle sales. For the NAU Department of Civil Engineering, the OHV park will provide the students on this capstone team a real-world engineering design project, as well as recognition for partnering with Findlay Toyota.

1.2 Project Background

The Findlay OHV park project is located within the intersection of Test Dr. and Historic Rte. 66. Flagstaff, AZ. Two Aerial photographs and street-level picture of the site is provided below (See Figure 1, Figure 2, and Figure 3 below.)



Figure 1: Aerial Overview of the Site

Figure 2: Location of Parcel



Figure 3: Street View of the Site

The team met with the client on the 15th of September, 2016 at the Findlay Toyota Dealership in Flagstaff, AZ. The Findlay Toyota Dealership is close to the project site, which gave the team the opportunity to make closer observations and assess the condition of the site. The current condition of the site is a flat surface with varying amounts of vegetation throughout the site. Figure 2: Street View of the Site provides a street view of the site, which is a total of approximately 3.1 acres, only two of which will be used to create the park per request of Findlay Toyota. Based on the outcomes of the meeting, the following items were discussed and considered in the team's agenda in order to meet the client's needs:

1. Build an off-road adventure park where Toyota can demonstrate the 4-wheel drive capabilities without bottoming out and getting stuck, this demonstration will include some of the features that Toyota need for their Tacoma, and 4Runner cars.
2. Considering some designs for the site such as, rock garden, steep slope, and site tower.

1.3 Technical Considerations

Geotechnical work will need to be done to properly create an OHV test park. This includes taking soil samples to determine the types of soil that are available at the park. With the types of soils identified, it can be decided if they are appropriate for the uses required or if different types of soils will need to be brought in to create specific road conditions. This will require not only researching the properties of the soils at the project site, but also other soils as well, should the currently available soils not be appropriate. The types of soils required for this project may vary from obstacle to obstacle, however, they will primarily be fine, clayey soils for situations where a vehicle may become stuck. There will also be a need for soil that retains its shape over time and does not deform easily, as it will be driven over very often and maintenance for this park should remain low. Other

soils that may be required may be soils with large volumes, such as boulders and large rocks. This should all generally include research into the stability of all of these soils over time to provide a park that is safe to use. On top of this, all of the soil used for this track should be readily available to the client within Flagstaff, not only for ease but also to reduce material costs.

Both hydrologic and hydraulic effects on the road designed by the team must also be taken into consideration. This will include research into the wet weather that affects the location of the park as well as behavior of water on roads, as well as any special obstacles that are included in the park. Water will flow differently depending on the soil used as it may either infiltrate or become runoff. In the case of infiltration, any effects on soil strength will need to be found. For muddy areas used in testing, this may not be an issue, but not all areas of the park will be designed to test the vehicles in muddy conditions. As for runoff, proper drainage will need to be developed. This will require using surveying equipment to develop a topographic map and finding elevations to determine any low points in the park that will be susceptible to flooding and thus, need drainage. These areas may require grading to be done on them and the team will need to determine what the new grading will be to prevent flood damage. Drainage may include different types of strategies such as using drainage ditches, or culverts. Design techniques and benefits or disadvantages to any of these drainage options will have to be considered as well. It will also be important to understand where this water will be drained to, whether it will be redirected to a muddy area of the park, drained away using city drainage or other methods. Proper city coding will have to be revised in order to determine any special conditions that must be met should the water need to be drained away from the park site.

Land surveys will need to be taken in order to model the land and create topographic maps, which, as mentioned before, may show low points that are susceptible to flooding damage. This will also show higher elevation points, which can then be transformed into steep hills or sandy inclines in a much easier manner than points that are on a flat surface. This surveying data will be collected using a total station, Geographic Information Systems (GIS), and other miscellaneous surveying equipment. Property lines will need to be found, and staking will also need to be done while surveying to ensure that the park does not intrude onto any property that does not belong to the client. Distance and angle measurements will be found during this process as well. Once the data is collected, it will need to be compiled into AutoCAD and Civil3D to plot contours and create a map.

Road design specifications will also need to be considered. Lane width will need to be designed to be in line with city code specifications. Speed limits dictated by the city will also be followed, though this should not pose a challenge, as vehicles using 4-wheel drive on LO, which is the setting used to drive the vehicles through rock gardens or up steep hills, is primarily used in lower speeds, between 0-10 mph. However, to maintain safety, speed limits and other traffic based warning

signs will still be posted for the various obstacles, as each will have different speeds and conditions at which that they need to be driven through. Sight poles will also need to be installed on steep hills. These sight towers will provide a visual to the driver about how far up the hill they are, since on such steep inclines, most drivers are only able to see the sky. Installing these sight towers will improve overall driver safety, especially for more inexperienced drivers. The height of the sight poles will vary from hill to hill, and as such, the required height will need to be calculated for each situation.

1.4 Potential Challenges

The park will mostly be constructed of soil and exposed to all weather conditions. This will cause a concern when it comes to maintaining the park. A maintenance plan will need to be considered for the life of this park to ensure the safety of the drivers and proper demonstration of vehicle off-road features.

All aspects of this project must be designed in accordance with City of Flagstaff Code. The team may have to take into consider water runoff provisions as well as other ordinances regarding parking and driveways.

1.5 Stakeholders

There are four primary stakeholders in the Findlay OHV park project, and one secondary stakeholder. The primary stakeholders of this project include the Findlay Toyota Automotive Dealership, the Flagstaff Auto Park, the Civil Engineering Department at NAU, and the NAU capstone project team tasked with designing the Findlay Toyota OHV park. The Findlay Toyota dealership is the primary client of the project having requested the project from the NAU Civil Engineering department. The Findlay Toyota dealership owns the land on which the OHV park is to be built, and is the sole contributor of project funding, making them the largest stakeholder of the project. The second primary stakeholder in the Findlay Toyota OHV park project is the Flagstaff Auto Park, which oversees the area in which the park will be constructed. The Findlay Toyota OHV park will reflect directly on the quality and interest of the Flagstaff Auto Park, therefore considering the needs of the Flagstaff Auto Park is imperative. The third primary stakeholder of the Findlay Toyota OHV park is the NAU Civil Engineering Department, as they accepted the offer from Findlay Toyota to assign a capstone project team to design the OHV park project. The quality of the work done by the capstone team as well as the ultimate results directly reflects on the reputation of the Civil Engineering Department, making them a stakeholder in this project. The final primary stakeholder of the project is the capstone team tasked with designing the Findlay Toyota OHV park. Findlay Toyota has stated that if the work done by the capstone team is acceptable, they will endorse the students by providing portfolio content, letters of recommendation, and anything else the students may need for professional development. Therefore, the incentive set out by Findlay Toyota as well as the work required in order to successfully pass the capstone project is enough to make the capstone team a primary stakeholder.

The secondary stakeholders of the Findlay Toyota OHV park are the potential vehicle buyers who will use the OHV park to determine which 4-wheel drive Toyota vehicle is appropriate for their needs. The clients of Findlay Toyota are going to be using the OHV park under the assumption that it is completely safe for them to be on, making them a stakeholder of the project. In addition, as testing Toyota 4-wheel drive vehicles on the Findlay OHV park may be the selling point for many potential vehicle buyers, the entertainment and educational value of the OHV park makes the clients of Findlay Toyota a stakeholder.

2.0 Scope of Services

The following is a list of services that the team, The Toyota 4Runners, will complete and provide to the client by May 12th, 2017. The 4Runners will complete the following tasks in order to design an OHV Park for Findlay Toyota that will allow the staff and vehicle buyers to demonstrate the abilities of Toyota 4x4 vehicles.

Task 1.0 Site Analysis

1.1 Initial Field Visit

The team will conduct a visit of the proposed project site to collect information on current site conditions and potential challenges. During the field visit the team will be accompanied by the Findlay Toyota Marketing Director who will be available to express any ideas or concerns regarding the site and answer any questions the team may have.

1.2 Test Drive Vehicles at Mormon Lake

Per recommendation of the client, the team will visit an existing OHV park located in at the Mormon Lake Lodge in Flagstaff, AZ. The MML OHV Park contains may terrain and safety features that the client would like to see in Findlay Toyota OHV Park design. The team will document the terrain and safety features for consideration in the design process.

1.3 Site Survey

The team will conduct a land survey of the proposed project site to aid in the creation of a topographic map. The project site boundary, existing features and visible utilities, as well as the Findlay Volkswagen parking lot adjacent to the project site will be surveyed. The Findlay Volkswagen dealership is owned by the same entity as Findlay Toyota, and therefore may be a site of ingress/egress for the Findlay Toyota OHV Park.

1.4 Topographic Map Development

The team will create a topographic map of the proposed project site as well as the Findlay Volkswagen parking lot adjacent to the project site. The Topographic map will be used in design of the site layout and conditioning, park features, hydrological evaluation, and potential materials sourcing.

Task 2.0 Code Review

The City of Flagstaff City Code will be reviewed to determine requirements for ADA, lighting, parking lot and parking space, ingress and egresses, landscaping, and facilities. The Title 10: Flagstaff Zoning Code, and Title 13: Engineering Design Standards will be the primary design codes used in the development of the Findlay Toyota OHV Park. The Findlay Auto Park will be contacted to determine if there are any special requirements that the potential design and development of the parcel must adhere to that are not covered by City Code.

Task 3.0 Geotechnical Testing and Analysis

A preliminary soil portfolio will be completed using the US Department of Agriculture Web Soil Survey and soil records available online. Further determination of soils available at the site will be done with a sieve analysis and triaxial soil testing. If the soil is deemed to be appropriate, it will be used in the development of the terrain features in the OHV Park to reduce project costs. Soil testing will be completed at the Northern Arizona University soils lab in Flagstaff, AZ.

Task 4.0 Drainage Analysis

The course will be exposed to the diverse weather of Flagstaff, AZ. In the event of serious rainfall or other precipitation, a hydrological analysis of the site will need to be conducted to determine the drainage characteristics of the site. This will require estimating the runoff generated before and after the course is built.

4.1 Storm Water Collection Design

According to City of Flagstaff Design Standards for runoff, the amount of runoff after development of a piece of land must be the same as the undeveloped land. If the development of the terrain and other features present in the OHV park produces more runoff than the undeveloped land, detention basins will need to be included within the site. These detention basins will hold the first inch of runoff from any of the areas that become impervious due to development, and will follow the Low Impact Development requirements set by the City of Flagstaff.

4.2 Water Drainage Design

The collected storm water will need to be discharged into a sewer pipe to be transported away from the site. Detention basins that will hold excess runoff caused by the track will hold storm water and release it slowly over time. Culverts and will be placed in key areas, to ensure proper drainage into storm sewers or detention basins. Drainage ditches on the sides of the course will be designed drain runoff onto portions of the course itself to reduce the amount of runoff being discharged into storm sewers.

Task 5.0 Project Site Design

The complete plan set for the Findlay Toyota OHV Park will be provided to the client in the form of a 22" x 34" (ANSI D) hard copy as well as the digital AutoCAD drawing file (dwg format).

5.1 Site Development Design

5.1.1 Site Location

A map displaying the location of the project as well as the two-acre building envelope specified by the client will be provided in the plan set. This will be an aerial view of the site.

5.1.2 Site Layout

A dimensioned version of the site plan will be provided. This plan will dimension the parcel, OHV park, and other notable park features. The layout of the track will be designed to maximize features and space usage while remaining in the proposed location within the parcel and leaving room for potential retention/detention basins and landscaping.

5.1.3 Track Alignment

An Alignment will be laid out along the centerline of the track to assign elevations and sections at each location along the track.

5.1.4 Track Profiles

Profile views will be created along the track alignment of each of the atypical section along the track. This will include hills, the mud pit(s), the sand pit, and the boulder garden.

5.1.5 Parking Plan

A plan detailing client parking for the OHV Park will be created in accordance to City of Flagstaff code and Findlay Auto Park requirements. The parking plan will include the location of parking stalls dedicated to the clients and users of the OHV Park, including specified ADA compliant parking stalls.

5.1.6 Ingress/Egress Plan

A plan detailing the location and design of ingress and egress to the OHV Park will be provided. This will include a plan detailing the removal and disposal of any current sidewalk, curb, and wheel stops that are in the way.

5.1.7 Safety Plan

A safety plan will be developed to ensure that the users of the Findlay Toyota OHV Park are able to navigate the course safely without damage to the terrain features, vehicles, and people. The safety plan will include placement and design of sight-poles/flags, warning signs, and emergency vehicle access points.

Task 6.0 Park Features Design

Below are the following features that will be designed for construction in the Findlay Toyota OHV Park:

6.1 Hill and Off-Camber Turn Design

The hills and off-camber turns will be designed in order to demonstrate the capabilities of the 4x4 vehicles that will be tested on the course. To do so, specific measurements of the vehicles will be applied, including wheelbase and ground clearance.

6.2 Mud Pit Design

A mud pit will be designed to test vehicle 4x4 modes. This will consist of a depression in the track made of a clayey soil in order to imitate the conditions of muddy areas. The water used to create this mud will be from a city water source or will be moved from the detentions system, when available.

6.3 Boulder Garden Design

A boulder garden will be designed to test vehicle 4x4 modes. The boulders will either be harvested from any excavation done or ordered from a local distributor. The boulder garden will allow for the demonstration of the suspension and 4x4 capabilities of the vehicles.

6.4 Sand Pit Design

A sand pit will be designed in some parts of park in order to give more opportunities for the user to test the capabilities of Toyota's Crawl Control feature. This will require finding a granular soil and placing it on an incline plane, as this most properly showcases the Crawl Control feature.

6.5 Material Schedule

A material schedule will be provided exhibiting the type and quantity of materials used to create the park in its entirety. This will also include the material sources as well as the unit cost and overall cost so the client can be aware of the materials used.

Task 7.0 Project Deliverables & Project Management

7.1 50% Report

This report will include a preliminary design of everything, and will be used as a check to ensure that everything has been accounted for and is on track to being completed.

7.2 Final Report

The final report will include all of the completed designs required to complete the project.

7.3 Website

A website showcasing the process, information, scheduling, and other relevant to the project information will be created and updated until project completion.

7.4 Presentation

This final presentation will show off the completed design and all actions taken to achieve the design. That entails discussing why specific course features were used and the process used to design the OHV park. This will take place at the UnderGraduate Research and Design Symposium (UGRADS), in the Spring of 2017.

7.5 Plan Set

The complete plan set for the Findlay Toyota OHV Park will be provided to the client in the form of an 11x17 hard copy as well as the digital AutoCAD drawing file (dwg format).

7.6 Meetings

The team will meet with the client to gain an understanding of the project requirements. Additional meetings include team meetings, technical advisor meetings, and additional client meetings will be scheduled throughout the project as needed.

7.7 Scheduling

Project scheduling may change. Any changes that impact the deliverables to the client will result in all interested parties, including the client being notified of the change.

7.8 Budgeting

The cost of the project will be dependent on the materials and labor used to construct the OHV Park. A final materials budget will be provided to the client in the form of a material schedule in the plan set.

Exclusions

E.1 Utility Plan

Any required utilities such as gas, water, or electricity requirements will not be determined, nor designed.

E.2 Traffic Impact Analysis

Any impact on the local traffic due to the construction and operation of the OHV park will not be completed by the team. A traffic study may be recommended if deemed necessary by the team.

E.3 Buildings/Facilities Plans

Any buildings that are required for the proper operation and maintenance of the facility will not be designed. Locations of facilities may be recommended as needed.

E.4 Park Maintenance Plan

A plan that details the upkeep and maintenance of the site once the design and construction is complete, will not be created. Park and feature maintenance will be the responsibility of the client.

E.5 Landscaping Plan

Due to the legal requirements that a landscaping plan must be created by a certified landscape architect, the team will not provide a landscaping plan as part of the plan set. The team may provide landscaping suggestions if needed.

Broader Impacts

This design may have impacts that are broader than the scope, including economic, social, and cultural. The off-road test course is designed to demonstrate the capabilities of the vehicles specified by the client, to the customers. With no other off-road test courses in the area, the client will be able to provide an exclusive test-drive experience to the customer, which may likely increase the chances of a customer buying a vehicle as well as draw in other potential customers, both positively impacting the economy. Since this test course will be unique to area, residents of Flagstaff are expected to discuss it in a social setting and circulate interest. Lastly, the test course will resonate with and grow the

cultural of off-roading in Flagstaff by attracting new customers and allowing them to experience off-roading on a closed course.

3.0 Project Schedule

The attached Gantt Chart displays the proposed task schedule that the team will follow in the form of a Gantt chart. The time frame of the proposed tasks is between September 1st, 2016 and May 12th, 2017, with varying amounts of time to complete each specific task. The critical path as determined by the team is shown as red arrows.

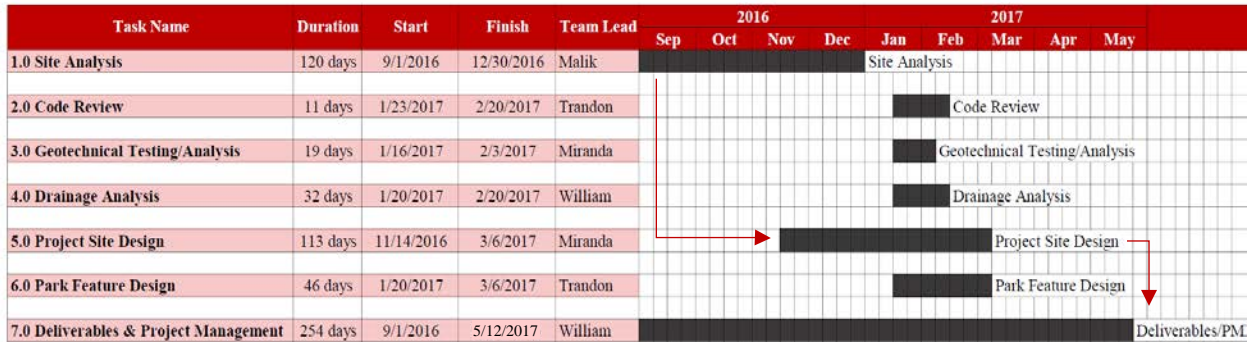


Figure 4: Gantt Chart

4.0 Staffing and Cost of Engineering Services

4.1 Staffing

The Toyota 4-Runners Capstone Team developed a cost of engineering services analysis to brief the client on the projected costs associated with the design of the Findlay Toyota OHV Park. The design team is composed of four positions, which are listed below in Table 1 along with their identifying code and billing rate.

Table 1: Team Positions and Billing Rates

Classification	Code
Senior Engineer	SENG
Engineer	ENG
Engineering Intern	INT
Project Manager	PM

4.2 Cost of Engineering Services

The cost of engineering services presented uses estimates of the number of hours that will be spent by each position working on the project design. Each proposed task and sub-task

involved with designing the Findlay Toyota OHV Park is designated a specific number of hours estimated to be completed by each team member. The tasks with their estimated design hours is below in Table 2: Project Task Assignments.

Table 2: Project Task Assignments

Task	SENG Hours	ENG Hours	INT Hours	PM Hours	Total
1.0 Site Analysis	8	8	20	5	41
2.0 Code Review	20	10	10	4	44
3.0 Geotechnical Testing & Analysis	8	20	20	6	54
4.0 Drainage Analysis	10	20	20	6	56
5.0 Project Site Design	40	80	80	30	230
6.0 Park Feature Design	40	70	70	30	210
7.0 Deliverables & Project Management	20	20	20	40	100
Total	146	228	240	121	735

The cumulative total for the estimated personnel costs associated with designing the Findlay Toyota OHV Park is \$70,833. The hours projected as well as the cumulative personnel costs may not reflect the actual distribution of time spent on the project design. The client will be contacted regarding any work necessary to complete the project design that falls outside of the projected task assignment prior to the work being completed. Transportation costs are anticipated to be minimal and therefore are not included in the cost of engineering services nor expected to be the responsibility of the client.

The cumulative total for the estimated equipment cost associated with designing the Findlay Toyota OHV Park is \$1,000. The client will be contacted regarding any additional equipment costs necessary to complete the project design that falls outside of the projected task assignments before the equipment is procured.

A summary of the projected cost associated with the design of the Findlay Toyota OHV Park is below in Table 3: Project Design Cost Summary.

Table 3: Project Design Cost Summary

Item	Classification	Hours	Rate (\$/Hr)	Cost
1.0 Personnel	SENG	146	167	\$24,382
	ENG	228	106	\$24,168
	INT	240	51	\$12,240
	PM	121	83	\$10,043
	Total			\$70,833
2.0 Equipment	Rental/Lab	10	100	\$1,000
3.0 TOTAL				\$71,833

The total projected cost for completion of the design plan of the Findlay Toyota OHV Park including personnel costs, equipment costs, subcontracting costs, and overhead costs is \$71,833. This is an estimate of costs and may not reflect the actual cost of the project design.

5.0 References

[1]"City of Flagstaff Official Website - Zoning Code", Flagstaff.az.gov, 2016. [Online]. Available: <http://www.flagstaff.az.gov/index.aspx?nid=1416>. [Accessed: 13- Dec- 2016].