Letter of Transmittal

Wall E. Wallerson & Associates Inc.

NAU Civil Engineering Department • Tracks • Chris Cook, Josh Endersby, Hunter Schnoebelen

05/07/2019

Stephen Irwin
Shephard-Wesnitzer, Inc.
110 W Dale Ave,
Flagstaff, AZ 86001

Dear Mr. Irwin,

We are writing to you with the project proposal titled Trax Retaining Wall for Shephard-Wesnitzer, Inc. The purpose of writing this proposal is to analyze the project in detail in terms of designing, analyzing, and testing. This project officially started on August 26th and was completed on December 6th, 2019 in the NAU Facilities. The proposal focuses on the testing and design of the retaining wall and includes details on the testing and analysis of the project. This is submitted as a final copy of the proposal. Please let us know if you have any concerns.

Sincerely,

Wall E. Wallerson & Associates Inc.
Civil Engineering, NAU
bcc88@nau.edu

Proposal For

Route 66 / Fourth Street
Trax Development Retaining Wall

Prepared For:
Stephen Irwin
Shephard-Wesnitzer, Inc.
110 W Dale Ave,
Flagstaff, AZ 86001

Submitted by:
Wall E. Wallerson & Associates INC.
NAU Civil Engineering Department

May 7, 2019

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1.0 Project Understanding

This section describes Wall E. Wallerson & Associates Inc.'s understanding of the project and includes the project purpose, background, technical considerations, potential challenges, stakeholders, and constraints and criteria.

1.1 Project Purpose

The purpose of this project is to design a retaining wall and construction plan which will allow the land owner, Tracks, to efficiently use their land. The goal of the project is to optimize land use by designing a retaining wall to allow stability for the proposed construction of the Holiday Inn, including its proposed parking lot, and the coinciding construction of the Flagstaff Urban Trail System (FUTS).

The objectives for this project include:

- Design an efficient retaining wall that meets City of Flagstaff standards and codes, and is adequately designed to avoid structural failures, does not induce soil failure, can handle the hydrologic design events specified by the Coconino County Drainage Design Manual, and is economically feasible.
- Design a retaining wall that meets the City of Flagstaff standards and codes, including the use of a rail or fence, to prevent pedestrians and/or cyclists from injuring themselves by falling off the adjacent elevated FUTS.

1.2 Project Background

The project is located in Flagstaff, Arizona on the corner of Route 66 and 4th Street, this is shown in Figure 1.1. The land originally was occupied by the railroad tracks as they ran parallel to Route 66. The project location was created by the movement of the railroad tracks in 2005 that moved the tracks approximately 400 feet southeast of Route 66.

Figure 1.1: Project location. [3]

Due to the movement of the tracks, the soil at the site is a mix of existing soil and leftover soil from the cut and fill from the project relocation. The steepness of the slope between the project site and the railroad tracks makes it necessary for a retaining wall to be designed to ensure the area of the land can be maximized and to allow for proposed businesses to be built. In Figure 1.2, the current project location is identified in red, with the existing road, 4th street, in black and railroad tracks in grey. Currently, the project land is undeveloped and has been undisturbed since the movement of the railroad. The soil is disturbed from the railroad realignment but the type of soil has not been identified. The location does not lie in an identified flood plain [2]. The area is confined on all sides as it has the railroad tracks and land to the southeast, Fourth Street to the west, and Route 66 to the north. The property has a total acreage of 8.7 acres with estimated dimensions of 2000 ft. in length and 325 ft. in width on the south-west side of the site. The north-east width of the site is almost nonexistent because the site closes to one point creating a triangular shape. The site is relatively flat with minimal slopes, but the steep slope between the site and the railroad needs retaining wall support to ensure that the land is maximized. Figure 1.4 includes the location of the proposed retaining wall along the FUTS trail extension.

Figure1.2: Project site in 2005. [3]

Figure 1.3: Existing slope south of the proposed retaining wall

Figure 1.4: Location of the proposed retaining wall, in red, and the FUTS path in blue. [3]

1.3 Technical Considerations

For this project, many technical considerations will need to be considered. These technical considerations will include:

- Procuring, testing, manipulating, and analyzing soil samples to form a comprehensive geotechnical report, which will aid in the understanding of various soil properties such as soil particle size distribution, soil classification, shear strength, friction angle, and unit weight.
- Flagstaff's seasonally based precipitation, which includes an annual average of 100 inches of snow, and 22 inches of rainfall [1] present a major threat to any infrastructure design project. Retaining walls, in particular are very susceptible to failure as the retained soil becomes saturated and creates unstable soil conditions. As such, proper stormwater drainage will be an important consideration paramount to the success of the project. If the provided drainage is inadequate or lacking in information, a watershed

delineation and time of concentration analysis may be necessary to estimate flows, volumes, velocities, and likely concentration points of stormwater runoff.
- Multiple design options with differing materials, types of retaining walls, possible reinforcement requirements, and drainage solutions will be needed to determine the best design candidate in defense against the likely failure modes of overturning, sliding, uplifting, and bearing capacity.
- Although existing and proposed finished grade elevations along the project alignment will be provided, the creation of a contour map through the acquisition of survey data may be needed to better define the drainage basins and sub basins, and the existing slope, which slopes down from the project location towards the railroad.

1.4 Potential Challenges

- Soil testing for this project will be a major challenge. The lack of access to equipment will make it difficult to collect samples below the surface. Also, the varying location of the bedrock across the site means that the soil properties will also vary which will create difficulties during the design process.
- There is proposed storm drain that will be located between the wall and railroad that will create a challenge during the design process because the depth of this storm drain may dictate the depth of the retaining wall footing.
- The slope behind the wall will be a major challenge in retaining wall design because the steep slope creates a risk of the wall overturning.
- The amount of space left between the wall and the property line is around six inches, which means the toe of the retaining wall is restrained and that also creates a risk of overturning.
- A possible difficulty may come from communications and (working with) railroad since the wall will be located very close to their property line. The railroad may not consider this job a priority if communications with them become necessary. It will be difficult to create a design and construction plan that does not interfere with the railroad property.
- The retaining wall must not exceed a height of five feet above finished grade, and must be a minimum depth below finished grade to ensure it surpasses the depth of the frost line, as specified by the City of Flagstaff codes and regulations.
- Provide a proposed design that meets the tight restrictions of the client. This includes fitting in the boundary lines of the property and adjusting to all proposed constraints.

1.5 Stakeholders

With the new construction of the Holiday Inn hotel, the effects that this project will have on others must be considered. The stakeholders that have been identified are Shephard-Wesnitzer Inc., the City of Flagstaff, Coconino County, the Burlington Northern and Santa Fe (BNSF) Railroad, and the citizens and visitors of Flagstaff.

- The client, Shephard-Wesnitzer Inc., is a stakeholder as they have identified the need for a retaining wall on the property that they are developing.
- The City of Flagstaff is a stakeholder as the project is located in the city.

- The Coconino County is involved as the project is within Coconino County boundaries.
- The BNSF railroad is a stakeholder as the retaining wall will be a minimum of 6 inches from their property.
- Citizens of Flagstaff are stakeholders as the overall design will affect visitors of the proposed hotel/users of the FUTS path.

1.6 Constraints and Criteria

The overall success of the project relies heavily on the design of the wall. The following constraints and criteria will be pertinent factors in the design of the wall.

- **Cost** - While there is not a known upper limit on the budget for this project, an economically friendly design is always an important factor.
- **Hooking mechanism for railing** - City of Flagstaff Codes and Standards require the use of a specified railing. However, the use of different retaining walls may require different methods of attaching the railing to the wall.
- **Intrusion level of construction upon railroad** - A design that results in the need for excessive use of railroad land for construction will be less desirable than a design that results in little-to-no need for the use of railroad land.
- **Limited Space** - The FUTS Trail has a minimum width, according to the City of Flagstaff Codes, of 10 feet and the proposed Holiday Inn has predetermined dimensions for their building and coinciding parking lot that cannot be changed. These two dimensional constraints result in a very limited room for design.
- **Minimum and Maximum Required Wall Dimensions** - City of Flagstaff requires that retaining walls with a protruding height greater than 5 feet above finished grade are required to be terraced. It also requires that the minimum depth of footing be deeper than the frost line (30”).
- **Geography** - The existing land presents the challenges like poor soil, and the slope in between the railroad and site.
- **Lab/Equipment Access** - While it is not expected, it is possible that the team’s access to equipment through Northern Arizona University may be a limiting factor in the team’s ability to conduct some of the experiments. If this is the case, equipment will need to be ordered or tasks sub-contracted.
- **Water Conveyance** - The wall must be able to convey water, and prevent over saturation of soil.

2.0 Scope of Engineering Services

This section describes the breadth and depth of the engineering services to be provided by WEW Inc. Any tasks not explicitly defined as work to be provided by WEW Inc. will be considered an exclusion, which is an item that must be completed for the overall success of the project, but will explicitly not be completed by WEW Inc.

2.1 Task 1.0 Site Investigation

A site visit is needed to determine the location of existing features and possible issues when designing the retaining wall, such as the general location of the proposed retaining wall alignment existing slope, and distances to property boundaries.

2.2 Task 2.0 Field Sampling

Soil samples will need to be collected on site and brought back to the lab for testing.

2.2.1 Task 2.1 Field Work Plan

This document will include, but is not limited to, the sampling and safety plans for the field work. The sampling plan will identify sampling methods used to acquire soil, means of transportation to the NAU lab facilities, and analytical procedures to be performed.

2.2.2 Task 2.2 Field Work

The field work will include the collection of 10 $\pm$5soil samples across the site, using NAU's boring equipment, and the transportation of the samples to the lab facilities.

2.3 Task 3.0 Geotechnical Analysis

A geotechnical analysis will be crucial to a comprehensive understanding of the soil on site. Listed below are the tests that will be performed, according to ASTM standards and methods. All testing and equipment for geotechnical analysis will be located at the NAU civil engineering soils lab, located in the NAU Engineering building. ASTM methods will be followed as listed below.

2.3.1 Task 3.1 Sieve Analysis (ASTM D6913M - 17)

This test will be used to determine the soil particle size distribution soil sample from the project location. Using progressively smaller size sieves, soil samples will be filtered through to determine the amount of particles following in major categories such as sand, clay, and gravel.

2.3.2 Task 3.2 Hydrometer Analysis (ASTM D7928-17)

This test will be used to determine the soil particle diameter size distribution of the fine soils (finer than the #200 sieve). This data will be used to classify the existing soil.

2.3.3 Task 3.3 Atterberg Limits (ASTM D4318-17)

This test is done to determine the liquid and plastic limits of the soil. This test is best for granular or silty soil, whose soil composition primarily consists of particle diameters which do not pass through the #200 sieve.

2.3.4 Task 3.4 Sand-cone (ASTM D1556M-15)

This test will be used to determine the unit weight of the in situ soil. This also will determine the water content and density of the soil after compaction.

2.3.5 Task 3.5 Tri-axial (ASTM D4767-11)

This test will be conducted to determine shear strength and comprehensive stresses of the soil.

2.3.6 Task 3.6 Consolidation (ASTM D2435M-11)

This test will be done to determine possible long term settlement of earth fill. This is important for any engineered or designed structure.

2.4 Task 4.0 Hydrological Analysis

The hydrological analysis is the determination of the existing flow from surrounding buildings and landscapes. This is to determine the movement of the water to the wall.

2.4.1 Task 4.1 Watershed Delineation

The watershed delineation will be used to determine the flowrate of water and the effects of the hotel development.

2.4.2 Task 4.2 Time of Concentration

The time of concentration will be used to understand the amount of time that it will take for the runoff to reach the wall.

2.4.3 Task 4.3 Storm Event Runoff

Storm event runoff is the determination of a fifty and hundred year storm and the amount of precipitation that will be produced for the pre and post wall conditions.

2.5 Task 5.0 Hydraulic Analysis

Hydraulics is the flow movement throughout the system. This determination of water movement will provide drainage information that meets the City of Flagstaff Stormwater Manual requirements.

2.5.1 Task 5.1 Proposed Water Drainage

The proposed water disbursement will use the provided grading and drainage plan for the site to determine the proposed water drainage moving towards the wall.

2.5.2 Task 5.2 Pre / Post Floodplain Mapping

Pre/post flood mapping will be assessed whether the site is located in an existing floodplain and determine if the development of the site will change any potential flooding in the area.

2.5.3 Task 5.3 Low Impact Development

Low impact development strategies will be used to design drainage and treatment of the stormwater flowing through the project, while minimizing the change in water disbursement.

2.6 Task 6.0 Wall Design

A retaining wall meeting the City of Flagstaff requirements will be designed. The best possible design will be produced based on the analysis from gathered information through the testing above. The design will include a plan and profile drawing, handrail connection detail, footing detail, and reinforcement detail as needed.

2.6.1 Task 6.1 Wall Design Options

Three alternatives will be preliminarily designed and evaluated. All of the walls will be analyzed using the Rankine Active and Passive Earth Pressure method from N. Braja M. Das' Principles of Foundation Engineering [4]. The parameters required for the retaining wall design will include calculation checks for sliding, overturning, uplifting, and bearing pressure. The handrail connection to the top of the wall will also be included in the parameters.

2.6.2 Task 6.2 Plan and Profiles

Hardcopy drawings of a plan and profile, handrail connection detail, footing detail, and reinforcement details as needed will be provided for each wall design.

2.6.3 Task 6.3 Final Design Recommendation

A decision matrix of the design options will be performed to evaluate the strengths and weaknesses of each wall in a tabular manner. The walls will be compared on the cost, construction process, water conveyance, and durability in order to select the final wall recommendation.

2.7 Task 7.0 Impacts

The full extent of the impacts of the proposed retaining wall will be analyzed once a final design is determined. These impacts will be identified as environmental, economical, and social. Environmental impacts will include how the retaining wall will impact the surrounding environment. Economic impact will identify the walls impact on the local economy and on the proposed Holiday Inn, as well as the surrounding businesses. Social impacts will identify how the design impacts the community.

2.8 Task 8.0 Project Management

This objective of this task is to ensure the timely progression of the project and to ensure proper communications with all parties of vested interests.

2.8.1 Task 8.1 Meetings

These meetings will be paramount in aiding successful project progression and confirming successful time and budget allocation.

2.8.1.1 Task 8.1.1 Team Meetings

Meetings will be held for 1 hours, twice a week, or alternatively, for 2 hours once a week.

2.8.1.2 Task 8.1.2 Grading Instructor (GI) Meetings

Meetings between the team and the grading instructor will be held weekly, for one hour.

2.8.1.3 Task 8.1.3 Technical Advisor (TA) Meetings

These meeting will occur by phone, for an hour each meeting. The meetings will be bi-weekly, or by appointment.

2.8.1.4 Task 8.1.4 Client Meetings

These meetings will take place in person with Stephen Irwin to discuss details and progress on the project. The frequency and duration of these meetings will be dependent on the project progression, but there will be a minimum of two meetings.

2.8.2 Task 8.2 Schedule and Resource Management

This will include tracking the schedule to ensure time is appropriately managed to ensure required deadlines are met.

2.8.3 Task 8.3 Deliverables

Deliverables will be hard copy submittals and are required for the client and the grading instructor. The deliverables track progression throughout the project and ensure that all requirements are being met. Included will be a breakdown of the project in to portions represented by the percent of project completion. The conclusion of the project will consist of a final report, and presentation of the final design.

2.8.3.1 Task 8.3.1 30% Submittal

The first draft submittal is roughly 30% completed and will expect major edits to be made. Included in the submittal is a report and presentation of the work completed by September 24, 2019.

2.8.3.2 Task 8.3.2 60% Submittal

The second draft submittal is roughly 60% completed and will have major edits from the 30% submittal completed and minor edits are expected. This include a report and presentation of the work that will be completed by October 29, 2019.

2.8.3.3 Task 8.3.3 90% Submittal

This third submittal should be the first version of the completed proposal. It is nominally the 90% submittal to allow for small revisions. This will include the revised report and the website. This will be completed by November 26, 2019.

2.8.3.4 Task 8.3.4 100% Submittal

The final submittal for the retaining wall design proposal. This will be completed by December 6, 2019. This will consist of the final presentation, final report including all revisions made based upon the 90% redlines, and the website for the project.

2.9 Exclusions

The following items will be excluded. It shall be understood that the effects of any exclusions inadequately addressed by the client are not the responsibility of WEW Inc., such that it affects the duties and tasks explicitly listed above to be completed by WEW Inc., thus releasing WEW Inc. from any fault arising from the inadequacies of the exclusions.

- **Survey Data and Drainage Plans**
  The client will provide the survey data and drainage plans.
- **Environmental Impact Study & Report**
  The impact study will need to be completed before the construction of the wall and the Holiday Inn. The study will determine any long term effects on the surrounding environment.
- **FUTS Trail Design**
  Other than the FUTS railing detail, design elements required for the FUTS trail will not be performed.
- **Temporary Traffic Control Plan**
  The traffic control for the construction process will not be determined.

3.0 Schedule

This section identifies the estimated timeline and order of tasks that must be completed for the project to be completed, with adequate quality, on time and on budget. This is graphically represented by the Gantt chart titled *Figure* 3.1. This Gantt chart displays the estimated time and dates of completion for each task and sub task, assuming a 40 hour, Monday through Friday work week. Specific milestones and deliverables are shown which will serve as major

checkpoints. This will allow all vested interests to evaluate the progress of the project. This schedule may be subject to change to ensure adequate completion and project progression.

3.1 Critical Path

The critical path is the sequence of the tasks that if not completed on time results in time overrun. This is the path that should be followed throughout the project to complete for the final deliverable.

Critical Path-

- 1.0 Site Investigation (2 days)
- 2.1 Field Work Plan (2 days)
- 2.2 Field Work (10 Days)
- 3.1 Sieve Analysis (3 days)
- 3.2 Hydrometer (3 days)
- 3.3 Atterberg Limits (3 days)
- 3.4 Sand-Cone Test (3 days)
- 3.5 Tri-Axial (3 days)
- 3.6 Consolidation (3 days)
- 6.1 Wall Designs (16 Days)
- 8.4.2 60 % Submittal (3 days)
- 8.4.2 60% Revisions (6 Days)
- 7.0 Impacts (6 Days)
- 8.4.3 90% Submittal (7 days)
- 8.4.3 90% Revisions (4 days)
- 8.4.4 100% Submittal (4 days)

3. 2 Milestones

The milestones for this project are the 30% and 60% milestones. These represent the completion of tasks necessary for the final project to be considered 30% and 60% complete. Below are lists of the tasks that are deemed necessary for these milestones. Note that the milestones do not coincide with the submittals, they signify where the team thinks major checkpoints are throughout the project. Note that the 30% and 60% milestones extend past the 30% and 60% submittals.

30% Milestone

- Task 1.0 Site investigation
- Task 2.0 Field sampling
- Task 2.1 Field work plan
- Task 2.2 Field work
- Task 3.0 Geotechnical analysis
- Task 3.1 Sieve analysis
- Task 3.2 Hydrometer analysis

- Task 3.3 Atterberg limits
- Task 3.4 Sand-cone test
- Task 3.5 Tri-axial
- Task 3.6 Consolidation
- Task 4.0 Hydrology
- Task 4.1 Watershed delineation
- Task 4.2 Time of concentration
- Task 4.3 Storm event runoff
- Task 5.0 Hydraulics
- Task 5.1 LID development
- Task 5.2 Pre/Post floodplain map
- Task 5.3 Proposed water drainage

60% Milestone

- Task 6.0 Wall design process
- Task 6.1 Wall design options
- Task 6.1.1 Wall parameters
- Task 6.2 AutoCAD drawings
- Task 6.3 Final design recommendation

4.0 Staffing

The design phase of the project will be staffed by a Senior Engineer (Sr. ENG), an Associate Engineer (Assoc. ENG), and an Engineer In Training (E.I.T). The Sr. Engineer, being a licensed Professional Engineer (P.E.) in the state of Arizona, will provide oversight and guidance on the project, and will primarily serve in a reviewing capacity. The Engineer in Training, having passed the Fundamentals of Civil Engineering Exam, and having fulfilled all licensing requirements through the Arizona State Board of Technical Registration, will serve in the largest capacity on the project, doing most of the calculations, testing, and analysis. The Associate Engineer, also being a licensed P.E. in the state of Arizona, will serve in a manner that represents the partial capacities of both the E.I.T. and the Sr. Engineer. The Associate Engineer will do the preliminary reviews of the aforementioned calculations, testing, and analyses of the E.I.T. and will perform these tasks should the scope or magnitude of any particular task fall outside the range of abilities of the E.I.T.

Table 1: Project Staffing, below, is broken up by hours per personnel per task and subtask. These hourly budgets have been summed for each employee and a total project duration (in hours) established.

Table 1: Project Staffing

Task	Hours Per Staff Member			Total Hours
	Sr. ENG	Assoc. ENG	EIT	
1.0 Site Investigation	3	3	3	9
2.0 Field Sampling				
2.1 Field Work Plan	1	1	7	9
2.2 Field Work	1	9	20	30
3.0 Geotechnical Analysis				
3.1 Sieve Analysis	1	2	15	18
3.2 Hydrometer	1	2	15	18
3.3 Atterberg Limits	1	2	15	18
3.4 Sand-Cone Test	1	2	15	18
3.5 Tri-axial	1	2	15	18
3.6 Consolidation	1	2	15	18
4.0 Hydrology				
4.1 Watershed Delineation	1	3	8	12
4.2 Time of Concentration	2	6	16	24
4.3 Storm Event Runoff	1	3	8	12
5.0 Hydraulics				
5.1 LID Development	1	3	8	12
5.2 Pre/Post Floodplain Map	1	3	8	12
5.3 Proposed Water Disbursement	1	3	8	12
30% Milestone				
6.0 Wall Design Process				
6.1 Wall Designs	4	48	38	90
6.2 Plan and Profiles	1	1	7	9
6.3 Final Wall Design Selection	2	6	1	9
60% Milestone				
7.0 Impacts	3	3	3	9
8.0 Project Management				
8.1 Meetings				
8.1.1 Team Meetings	10	10	10	30
8.1.2 Grading Instructor Meetings	15	15	15	45
8.1.3 Technical Advisor Meetings	8	8	8	24
8.1.4 Client Meetings	2	2	2	6
8.2 Schedule and Resource Management	16	3	1	20
8.3 Deliverables				

8.3.1 30% Submittal and Revisions	1	6	17	24
8.3.2 60% Submittal and Revisions	1	6	17	24
8.3.3 90% Submittal and Revisions	6	12	30	48
8.3.4 100% Submittal	1	6	17	24
8.3.5 Website	4	10	14	28
PROJECT TOTALS	92	182	356	630

5.0 Cost of Engineering Services

The itemized costs of the engineering services, as identified and elaborated upon in Section 2.0 Scope of Engineering Services, to be provided by WEW, are displayed in yellow in *Table 2: Itemized Costs*, below. The sum of these itemized costs represents the total cost of the engineering services and is displayed in green.

Table 2: Itemized Costs

Item	Description	Cost per Unit	Number of Units	Units	Cost
	Sr. Eng.	$180	92	Hours	$16,560
	Assoc. Eng.	$135	182	Hours	$24,570
	EIT	$90	356	Hours	$32,040
1.0 Personnel:	Total Personnel:				$73,170
2.0 Supplies:	Lab Rental	$100	108	Hours	$10,800
3.0 Travel	12 miles round trip @ 10 visits	$0.62	120	Miles	$74
4.0 Total					$84,044

6.0 References

[1] Hdsc.nws.noaa.gov. (2019). *PF Map: Contiguous US*. [online] Available at: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html [Accessed Feb. 2019].

[2] Gismaps.coconino.az.gov. (2019). *Coconino Parcel Viewer*. [online] Available at: https://gismaps.coconino.az.gov/parcelviewer/ [Accessed 25 Feb. 2019].

[3]Earth.google.com. (2019). *Google Earth*. [online] Available at: https://earth.google.com/web/ [Accessed 25 Feb. 2019].

[4] N. Braja M. Das, Principles of Foundation Engineering, 9 ed., Boston, Massachusetts: Cenage, 2017.