PRELIMINARY ENGINEERING SCOPE OF WORK
HIGH SPEED RAIL
SALT LAKE CITY, UTAH – LAS VEGAS, NEVADA

STUDENT ENGINEERING ASSOCIATES
UNIVERSITY OF UTAH

FEBRUARY 3, 2015

- Include binding
- Consider color with frame or modest watermark
- Use logo
- Include prepared for Utah Transit Authority
- Recommended general order:
  - Introduction
  - Project Description (Understanding)
  - Objectives/Goals
  - Task Descriptions
  - Schedule
  - Budget
  - Management Plan
  - Appendices
TABLE OF CONTENTS

INTRODUCTION .................................................................................................................. 2
PROJECT MANAGEMENT APPROACH .............................................................. 2
PROJECT SCOPE ........................................................................................................... 2
MILESTONE LIST ........................................................................................................... 2
SCHEDULE BASELINE AND WORK BREAKDOWN STRUCTURE ..................... 3
CHANGE MANAGEMENT PLAN .............................................................................. 4
COMMUNICATIONS MANAGEMENT PLAN ......................................................... 5
COST MANAGEMENT PLAN ..................................................................................... 6
SCHEDULE MANAGEMENT PLAN ........................................................................... 6
QUALITY MANAGEMENT PLAN ............................................................................ 7
STAFFING MANAGEMENT PLAN .......................................................................... 7
RESOURCE CALENDAR ............................................................................................. 8
COST BASELINE ......................................................................................................... 8
SPONSOR ACCEPTANCE ........................................................................................... 10
ALIGNMENT .................................................................................................................. 11
DRAINAGE .................................................................................................................... 13
ENVIRONMENTAL ....................................................................................................... 15
GEOTECHNICAL ........................................................................................................... 17
TRANSPORTATION/UTILITIES ............................................................................. 19
STRUCTURES ............................................................................................................... 21

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- List of Figures
- List of Tables
INTRODUCTION

Utah Transit Authority (UTA) has recently hired Student Engineering Associates (SEA) to perform an alignment study for potential High Speed Rail lines between Salt Lake City, Utah and Las Vegas, Nevada. High speed rail is the way of the future and could provide critical infrastructure connecting the metropolitan areas.

SEA will be looking at many aspects involving potential alignments. This includes the track alignment itself, structures needed, geotechnical data, drainage aspects, utilities, right-of-ways, environmental impacts, and the intricacies associated with each aspect.

PROJECT MANAGEMENT APPROACH

The project management team has the overall authority and responsibility for managing and executing this project according to this project plan. The project will consist of the management, alignment, drainage, environmental, geotechnical, structural, and utilities and transportation teams respectively. The management team will coordinate with all teams to perform project planning.

The principle engineers will provide direction on the project. The client, UTA, will provide feedback on potential alignments and desired direction after initial alignment option presentations. The management team will then be responsible for communicating to team leaders on how to proceed.

PROJECT SCOPE

The scope of SEA's SLC-LAS High Speed Rail Project includes the comparison of two rail alignments: A western alignment that approximately follows the Union Pacific Corridor (referred to as the UP RR), and an eastern alignment that approximately follows the Interstate 15 corridor. Deviations from these corridors will be explored where it is deemed appropriate. The general comparison will include the pros and cons of the two alternatives regarding general alignment, drainage, geotechnical, transportation, utilities, structural, and environmental considerations. Details of these considerations will be explored by specialized teams, and will be discussed later in this document. The scope of this project also includes overall cost estimating and scheduling for each alternative, to be completed by the project management team. It is important to note that the purpose of this project is only to compare each alternative, and not to make a recommendation based on the completed work.

MILESTONES

The below chart lists the major milestones for the project. This table shows the major project milestones and their anticipated completion dates. If any delays are to be expected from the technical teams, the team leader will notify the management team immediately. The management will take appropriate action to assist the team with resources to get the timeline
back on track. Any changes to these completion dates will be communicated from the management team to all team leaders.

The focus should be the client. Internal workings are not that important to the client. The client expects an on-time delivery.

**SCHEDULE BASELINE AND WORK BREAKDOWN STRUCTURE**

The Work Breakdown Structure (WBS) for the SLC-LAS High Speed Rail Project is comprised of 6 hours of work during the specified classroom hours, and 6 hours of work outside of the specified classroom hours each week. Work completed during the specified classroom hours will be monitored by Dr. Steven Bartlett and Byron Foster. Work completed outside of the specified classroom hours will be monitored by the project management team and the associated team leaders via timesheets. Timesheets consist of eight 2-week tabs, to be submitted every 2 weeks to the associated team leaders. Each team member is required to have logged at least 12 hours per timesheet section on average. Each team member is allowed 6 total hours of leave outside of the specified classroom hours for the entire length of the project, with the exception of Spring Break.
REVISE

CHANGE MANAGEMENT PLAN

Once work for the general tasks has begun, all changes to the process will be administered as per the following steps:

Step #1: Identify the need for a change (any member)
    Requestor will submit a completed SEA change request form to the project manager

Step #2: Log change in the change request register (Project Manager)
    The project manager will maintain a log of all change requests for the duration of the project

Step #3: Conduct an evaluation of the change (Project Manager, Team Leader, Requestor)
    The project manager will conduct an evaluation of the impact of the change to cost, risk, schedule, and scope

How is this important to client?
Step #4: Submit change request to Principle Engineer/Client (Project Manager)
The project manager will submit the change request and analysis to the Principle
Engineer and Client for review

Step #5: Principle Engineer/Client decision (PE/C, Project Manager)
The principle engineer, client, and project manager will discuss the proposed change and
decide whether or not it will be approved based on all submitted information

Step #6: Implement change (Project Manager)
If a change is approved, the project manager will update and re-baseline project
documentation as necessary as well as ensure any changes are communicated to the team
and stakeholders

Any team member may submit a change request for the SLC-LAS High Speed Rail Project. All
change requests will be logged in the change control register by the project management team
and tracked through to completion whether approved or not.

COMMUNICATIONS MANAGEMENT PLAN

This communications management plan sets the communications framework for this project. It
will serve as a guide for communications throughout the life of the project and will be updated as
communication requirements change. Contact information for the project management team as
well as team leaders can be seen below.

Communication should be made through team leaders to the management team, or in meetings
with the project management team. At times, it may be more efficient to have team leaders
coordinate with one another on aspects of the project; this may be done frequently, but the
project management team should remain updated on progress. Contacts made with outside
sources may be done directly, but the project management team should approve and be informed
on resources. All communication with the client will be done through the project management
team.

Project team directory for all communications is:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>E-mail</th>
<th>Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alejandro Medinilla</td>
<td>Project Manager</td>
<td><a href="mailto:amgtenis@hotmail.com">amgtenis@hotmail.com</a></td>
<td>801.512.6519</td>
</tr>
<tr>
<td>Daniel Thompson</td>
<td>Project Manager</td>
<td><a href="mailto:dannyt833@gmail.com">dannyt833@gmail.com</a></td>
<td>801.680.8295</td>
</tr>
<tr>
<td>Dane Janak</td>
<td>Project Manager</td>
<td><a href="mailto:d.janak@utah.edu">d.janak@utah.edu</a></td>
<td>208.431.8789</td>
</tr>
<tr>
<td>Jeff Thomas</td>
<td>Programmer</td>
<td><a href="mailto:jthomas3592@gmail.com">jthomas3592@gmail.com</a></td>
<td>303.250.1492</td>
</tr>
<tr>
<td>Devin Weder</td>
<td>Alignment Team Leader</td>
<td><a href="mailto:devin.weder@utah.edu">devin.weder@utah.edu</a></td>
<td>801.201.5660</td>
</tr>
<tr>
<td>Joe Bolton</td>
<td>Drainage Team Leader</td>
<td><a href="mailto:joe.bolton@utah.edu">joe.bolton@utah.edu</a></td>
<td>401.533.0600</td>
</tr>
<tr>
<td>Joseph Wells</td>
<td>Environmental Team Leader</td>
<td><a href="mailto:josephlawrencewells@gmail.com">josephlawrencewells@gmail.com</a></td>
<td>435.840.5894</td>
</tr>
<tr>
<td>Name</td>
<td>Position</td>
<td>Email</td>
<td>Phone</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------------------</td>
<td>----------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Krystal Harman</td>
<td>Geotechnical Team Leader</td>
<td><a href="mailto:krys32889@gmail.com">krys32889@gmail.com</a></td>
<td>808.429.0113</td>
</tr>
<tr>
<td>Eric Soto</td>
<td>Structures Team Leader</td>
<td><a href="mailto:erics01@live.com">erics01@live.com</a></td>
<td>801.369.9568</td>
</tr>
<tr>
<td>Karlo Velez</td>
<td>Utilities/Traffic Team Leader</td>
<td><a href="mailto:karlo.velez@gmail.com">karlo.velez@gmail.com</a></td>
<td>801.897.2542</td>
</tr>
</tbody>
</table>

Communications Conduct:

Meetings:
The project management team will conduct meetings with teams frequently. Coordination with
the team leader will be made to find an appropriate time and place to meet. Meetings will be to
check in on progress, discuss certain aspects of the project, or settle conflict.

Email:
All email pertaining to the project should be professional, free of errors, and provide concise
communication. Email should be distributed to the correct project participants as described
above. All attachments should be in one of the organization’s standard format as described in
the standard operating procedure. If the email is to bring an issue forward then it should discuss
what the issue is, provide a brief background on the issue, and provide a recommendation to
correct the issue. The project management team should be included on any email pertaining to
any major aspect of the project.

Informal Communications:
While informal communication is a part of every project and is necessary for successful project
completion, texts, phone calls, messaging, and verbal communication pertaining to the project
should be done in a professional manner (see the emails section above). Any issues, concerns, or
updates that arise from informal discussion between team members must be communicated to the
project management team for appropriate action may be taken.

COST MANAGEMENT PLAN

The project management will be responsible for managing and reporting on the project’s cost
throughout the duration of the project. Costs will be assigned according to student rates as well
as professional rates provided by Dr. Bartlett. The project management team will present and
review the project’s costs during the alternatives study and completed alignment study.

SCHEDULE MANAGEMENT PLAN

Project schedules for the SLC-LAS High Speed Rail Project will be created using MS Project
2010 starting with the deliverables identified in the project’s Work Breakdown Structure (WBS).
Activity definition will identify the specific work packages which must be performed to
complete each deliverable. Activity sequencing will be used to determine the order of work
packages and assign relationships between project activities. Activity duration estimating will be
used to calculate the number of work periods required to complete work packages. Resource
estimating will be used to assign resources to work packages in order to complete schedule development.

Once a preliminary schedule has been developed, it will be reviewed by the project management team. The project management team and resources must agree to the proposed work package assignments, durations, and schedule. Once this is achieved the project sponsor will review and approve the schedule and it will then be base lined.

**QUALITY MANAGEMENT PLAN**

All members of the project team will play a key role in quality management. It is imperative that the team ensures work is completed at an adequate level of quality from individual work to the final project deliverables.

The project management team is responsible for assembling and presenting final documents. They will have these done in a timely manner in order to allow the rest of the project team time to review the work; however, the project management team will take final responsibility for the quality of work throughout the project.

Review processes will be taken with complete seriousness. It is preferred that any reviewed documents from team members be submitted to the project management team in paper form. Red or colored pen is to be used to mark errors and changes.

**STAFFING MANAGEMENT PLAN**

The project will consist of hierarchal structure with seven different teams supervised by the Project Principal Engineer and a Vice President. All work will be performed internally. The organization of resources is as follows:

Principal Engineer – Dr. Steven Bartlett will represent the main consulting source for all teams in this project. The Principal Engineer's role will be to provide each team with guidance to perform their duties up to the professional standard expected from the client.

Vice President – Byron Foster will perform the role of the Vice President. In this project this position represents the main consulting source, below the Principal Engineer.

Project Management Team – Responsible for all management of the project. The project management team is responsible for planning, organization and/or managing all work activities. They are also responsible for tracking, reporting, communication, performance evaluations, resource management, conflict resolution, and coordination with technical teams.

Alignment Team – Responsible for all track layout estimates. The alignment team is responsible to provide geometric design, maximum slopes allowed, crossings needed throughout alignment, suitable pedestrian crossing structures and locations, cut and fill areas as well as determine alignment constraints.
Drainage Team – Responsible for sewer and storm drainage along the alignment as well as irrigation features of the area. The drainage team will also be responsible for the track’s drainage system (ballast, angling, cut and fill)

Environmental Team – The team is responsible for preliminary environmental identifications, which could potentially become alignment constraints, such as endangered species, marshlands, and culturally sensitive lands. The environmental team is also in charge of estimating private acreage, state and federally owned land, railroad owned and right-of-way acreage along the alignment.

Geotechnical Team – Responsible for soil constraints along the alignment. The geotechnical team will conduct soil-type research along the alignment to determine the appropriate structural foundations that correspond the region as well as tunnels and ballast materials.

Structures Team – In coordination with the alignment team, the structures team will study and evaluate potential roadway crossings along the route as well as design typical pedestrian crossings, elevated track evaluation, and tunneling methods.

Utilities/Traffic Team – Responsible for all fiber and telecommunication lines, both sub-surface and aerials. The utilities/traffic team will evaluate the alignment route to identify constraints related to access rights, crossings, and track spur locations. The team will also determine the current utilities and easements along the alignment. Preliminary relocation logistics with utility easements will be studied, as well as estimates of railroad owned and right-of-way acreage.

**RESOURCE CALENDAR**

The project will require all project team members for the entire duration of the project although levels of effort will vary as the project progresses. The project is scheduled to last one semester with an average of 6 hour work weeks, excluding class time. Each person is allowed 6 hours of sick/vacation time throughout the semester. Spring break is an exception to this rule.

**COST BASELINE**

The costs for the project includes all budgeted costs for the successful completion of the project.

<table>
<thead>
<tr>
<th>Team Name</th>
<th>Hours</th>
<th>Engineering Rate</th>
<th>Student Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle Engineer</td>
<td>24</td>
<td>$202.5/ hr</td>
<td>$81/ hr</td>
</tr>
<tr>
<td>Vice President</td>
<td>24</td>
<td>$162/ hr</td>
<td>$33/ hr</td>
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<tr>
<td>Project Management</td>
<td>560</td>
<td>$108/ hr</td>
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<tr>
<td>Alignment</td>
<td>962</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
</tr>
<tr>
<td>Drainage</td>
<td>504</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
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<tr>
<td>Environmental</td>
<td>335</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
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<tr>
<td>Geotech</td>
<td>707</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
</tr>
<tr>
<td>Structural</td>
<td>828</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
</tr>
<tr>
<td>Transportation &amp; Utilities</td>
<td>722</td>
<td>$81/ hr</td>
<td>$22/ hr</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>$397,926</strong></td>
<td><strong>$124,622</strong></td>
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<td>Task Name</td>
<td>Cost</td>
<td>Work</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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<td>------------</td>
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<td><strong>Scope of Work Estimate</strong></td>
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<tr>
<td>Alignment</td>
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<td>962 hrs</td>
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<tr>
<td>East &amp; West rough draft</td>
<td>$7,290.00</td>
<td>90 hrs</td>
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<tr>
<td>Horizontal Alignment</td>
<td>$9,720.00</td>
<td>120 hrs</td>
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<tr>
<td>Vertical Alignment</td>
<td>$12,960.00</td>
<td>160 hrs</td>
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</tr>
<tr>
<td>Finalized Alignments</td>
<td>$9,720.00</td>
<td>120 hrs</td>
<td></td>
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<tr>
<td><strong>Drainage</strong></td>
<td>$40,824.00</td>
<td>504 hrs</td>
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<tr>
<td>Storm Drainage</td>
<td>$6,804.00</td>
<td>84 hrs</td>
<td></td>
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<tr>
<td>Irrigation Features</td>
<td>$6,804.00</td>
<td>84 hrs</td>
<td></td>
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<tr>
<td>Design of Drainage for Rail Line</td>
<td>$13,608.00</td>
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<td><strong>Environmental</strong></td>
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<tr>
<td>Right of way research</td>
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<tr>
<td>Sensitive Lands research</td>
<td>$2,430.00</td>
<td>30 hrs</td>
<td></td>
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<tr>
<td>Collection of Data</td>
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<td>30 hrs</td>
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<tr>
<td>Collaboration</td>
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<td><strong>Geotech</strong></td>
<td>$57,267.00</td>
<td>707 hrs</td>
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<tr>
<td>Soil classification &amp; Problematic characteristics</td>
<td>$3,240.00</td>
<td>40 hrs</td>
<td></td>
</tr>
<tr>
<td>Research &amp; Design of tunnels, retaining systems and foundations</td>
<td>$4,455.00</td>
<td>55 hrs</td>
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</tr>
<tr>
<td>Calcs &amp; Drafts of cuts, stability analysis, and fill materials</td>
<td>$2,025.00</td>
<td>25 hrs</td>
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<tr>
<td>Additional issues</td>
<td>$4,050.00</td>
<td>50 hrs</td>
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<td><strong>Project Management</strong></td>
<td>$60,480.00</td>
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<td><strong>Structural</strong></td>
<td>$67,068.00</td>
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<td>Design Criteria</td>
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<tr>
<td>Structures count estimate</td>
<td>$9,720.00</td>
<td>120 hrs</td>
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<tr>
<td>Revised count based on alignment changes</td>
<td>$8,100.00</td>
<td>100 hrs</td>
<td></td>
</tr>
<tr>
<td>Final count and total cost estimate</td>
<td>$3,240.00</td>
<td>40 hrs</td>
<td></td>
</tr>
<tr>
<td><strong>Transportation &amp; Utilities</strong></td>
<td>$58,482.00</td>
<td>722 hrs</td>
<td></td>
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<tr>
<td>Research possible utility lines</td>
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<td>25 hrs</td>
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<tr>
<td>Research possible railroad</td>
<td>$2,025.00</td>
<td>25 hrs</td>
<td></td>
</tr>
<tr>
<td>Construction access</td>
<td>$1,620.00</td>
<td>20 hrs</td>
<td></td>
</tr>
<tr>
<td>Preliminary cost estimate of utilities and crossings</td>
<td>$2,835.00</td>
<td>35 hrs</td>
<td></td>
</tr>
<tr>
<td>Feasibility study submit</td>
<td>$3,645.00</td>
<td>45 hrs</td>
<td></td>
</tr>
<tr>
<td>Present cost estimate of relocations for overall plan</td>
<td>$2,430.00</td>
<td>30 hrs</td>
<td></td>
</tr>
<tr>
<td><strong>Principle Advising</strong></td>
<td>$8,748.00</td>
<td>48 hrs</td>
<td></td>
</tr>
</tbody>
</table>
SPONSOR ACCEPTANCE

Do not understand
why this is here?

Approved by the Project Sponsor:

____________________________________________  Date: ________________
<Project Sponsor>
<Project Sponsor Title>

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ALIGNMENT

Overview
The alignment team will be studying the feasibility of two alignments for the SLC-LAS High Speed Rail Project. Both alignments will start and end at the Salt Lake City and Las Vegas Airports, respectively. The eastern line will generally follow the Interstate 15 corridor. The western line will follow the Union Pacific Railroad (UPRR) line that connects the two cities. These routes will be roughly 450 miles long. A design speed of 250 mph will be utilized for the alignment design. Decreased operating speeds should be expected in areas where curvature and grade specifications approach the maximum limit values discussed below.

Tasks
Track layout
The two primary constraints that govern the track alignment are the horizontal and vertical alignment of the rail line. The primary horizontal constraint is the allowable degree of curvature; the primary vertical constraint is the maximum tolerable grade. The geometry of the alignment will be created to provide the highest allowable speed.

The minimum radius of curvature varies with speed. The minimum curve radii range from 3,600 to 28,000 feet at 90 mph and 250 mph design speeds, respectively. These minimum values for curve radii have associated recommended values that are about 60% increases (California High-Speed Rail, 2012). The recommended radius of curvature will be used unless geographic restraints are present.

A maximum grade of 3.5% is acceptable for the high-speed train. For lengths of track exceeding 10 miles, the grade should be kept below an average of 2.5% (California High-Speed Rail, 2012). At higher grades the speed will decrease to suitable limits.

Cut and Fill
After the team determines the horizontal alignment, the estimated surface data for each alignment (through GIS, online files, or google earth data) as well as the horizontal alignments will be imported into AutoCAD Civil 3D to create an existing surface along each alignment. The vertical alignments (grades and vertical curves) will then be designed within AutoCAD. A profile of each alignment showing existing grade and proposed grade along each alignment will be created. AutoCAD tools will then be utilized to create a proposed surface along the horizontal alignment (based on the proposed vertical grades for a corridor) in order to calculate the cut and fill quantities based on the existing surface before construction and the proposed surface after construction.

The vertical design of each alignment is financially crucial to the project and therefore, where possible, care will be taken in the geometric design to ensure that the amount of soil removed (cut) is not greater than the amount of required fill soil. Bringing in imported fill to remote
locations along the alignments would be both costly and inconvenient. Computer software will be used to effectively calculate cut and fill quantities.

Coordination with the geotechnical and structural teams will be paramount in determining necessary cut and fill requirements for the alignments being considered. Specific fill material may be necessary in certain areas of cut or under specific structures.

**Constraints**

Throughout design of the two proposed alignments, constraints will play a key role in determining the final routes. Each alignment will encounter different problems, but in general, the constraints that will be considered for each alignment include: cost, time, geographic, crossings, utilities, land access, and environmental concerns. As the alignment becomes more refined, the alignment team will convey information to other groups about specific locations that require further investigation into specific constraints. Based on other teams’ findings, the alignment team will decide whether the proposed alignment needs to be adjusted.

**Milestones**

- **February 9th**
  - East and West alignments are completed up to the design of the horizontal alignment
  - 90 man hours
- **March 1st**
  - Horizontal alignment complete
  - 120 man hours
- **April 1st**
  - Vertical alignment complete
  - 160 man hours
- **April 25th**
  - Both alignments finalized
  - Cut & Fill Calculations complete
  - 120 man hours
Overview
The drainage team will be responsible for large scale drainage considerations such as areas of runoff and existing streams, flood plains, channels, and rivers which will cross the proposed high speed rail alignments. There will also be coordination with the geotechnical team on this project to design the drainage of the track bed itself.

Tasks
Storm Drainage
Hydrologic analysis will be performed to find the approximate discharge of watersheds nearby the proposed alignments whose runoff would cross the high speed rail line. To do this analysis the length and width of the watershed in question will be measured and soil groups and vegetation in the areas will be identified and classified. Next, research will be done on rainfall for period storms. This data will be used to run a HEC-HMS analysis to find peak outflows that would cross the rail line. This data can also be used to identify streams and channels that need to be moved or redirected. From these outflows, culverts and piping can be designed to run the water below the track and headwater can be calculated to ensure the water does not overtop the railway.

Irrigation Features
Open channel analysis will be done on existing rivers and channels that the rail line will cross. Next, survey and HEC-SSP data will need to be obtained from the counties, cities, or engineering companies who have already run analysis to map the river or channel. A HEC-RAS analysis will then be run to predict potential damage that could be done to any bridges or structures over the rivers or channels. If redesign of bridges is necessary, coordination with the structures team will be done to change the bridges in order to allow water to flow safely underneath.

Design of Drainage of the Rail Line
Drainage options will be explored for transport of storm water away from the soil beneath the rail line and have water move to an appropriate outflow from the site.

Milestones
- February 26th
  - Problem areas identified
  - Remedies such as culverts identified
  - 144 man hours
- April 9th
• All hydrologic analysis complete
• Typical culverts designed
• Channel analysis complete
• 120 man hours
ENVIRONMENTAL

Overview

Given the large area of land covered by this project, there will need to be an initial assessment of the environmental impact of construction and impact on sensitive lands. This will help in making decisions of rail alignment and environmental costs associated with the project. The environmental team will also consider land ownership and right-of-way considerations. All information will be provided to the alignment team and be a critical element in determining the best possible final alignment.

Tasks

Collection of Data

The first task relating to environmental impact is to locate all impact areas that could be negatively affected by the construction of the SLC-LAS high speed rail system. This task will be completed by gathering geographical information from nationally recognized databases provided by agencies such as the US Geological Survey (USGS) and the National Oceanic and Atmospheric Administration. (NOAA) GIS will be utilized to compile data.

Right-of-Way

The environmental team will identify different right-of-ways along the alignments. Land ownership will be determined. This includes private, state, federal, and Indian reservation lands. Private lands are owned by non-governmental entities. These lands can be owned by persons, business, or other organizations. State and federal lands are lands owned by any State or Federal government entity. Indian reservation lands are lands preserved for the use of Native American Tribes. These lands have cultural or religious significance among differing Native American Tribes.

Sensitive Lands

The environmental team will also identify wildlife reserves, wetlands, and other sensitive lands along the alignment paths. Wildlife reserves are lands that are protected and preserved for the use of wildlife. These lands have strict laws and regulations that protect them from outside influence. Wetlands are environmentally sensitive lands that have public interest. Although some may not be technically protected, these lands require careful planning as to not upset public interest in the project. Other sensitive lands can include any other sensitive lands not exclusively mentioned above. These include, but are not limited to, culturally sensitive lands, hunting grounds, campsites, hiking trails, migration paths, or nesting grounds. Although most are not technically protected, these lands require careful planning as to not upset public interest in the project.

Milestones
• February 7\textsuperscript{th}
  - Identification of Land Ownership
  - 10 man hours

• February 27\textsuperscript{th}
  - Identification of major environmental problem areas
  - Right-of-Way research complete
  - 20 man hours

• April 9\textsuperscript{th}
  - Environmental Impact Studies
  - 100 man hours
GEOTECHNICAL

Overview
The geotechnical team is responsible for identifying many materials aspects along the alignment. This includes identifying soil types, preliminary sections, slope stability, and fill materials analysis, identifying the rock type and tunnelling methods when necessary, preliminary retaining system design, and preliminary foundation design. Details associated with these tasks are outlined below.

Tasks

Soil Type Analysis
An overview of soil types and problematic areas will be completed. Testing should be completed to provide classification of soils and depth of layers including the water table. Concerns on settlement, expansive soils, liquefaction and lateral spreading will be considered by SEA.

Sections, Slope Stability, Fill Materials
Elevation differences will require cut and fill solutions; the possibility of tunnels or raised sections will be addressed in the next section. Preliminary design sections for the various types of soils and needed track will be provided in detail in the final deliverable. Possible materials will be included to ensure the accuracy of the stability analysis.

Tunnels and Raised Rail
Mountains and other extreme elevation differences may require tunnel systems or elevated rail. Tunnels will require ventilation and proper stability analysis and consideration of retaining systems and drainage around the tunnel system. Additional research to identify seismic affects and materials shall be completed to provide adequate information for preliminary design.

In the event of an elevated rail system, a more in depth analysis of soil bearing limit and ultimate capacity would be required to accurately provide the design.

Retaining Systems
Retaining systems will need to be installed in any route chosen. Preliminary design will be completed on various retaining systems to provide solutions with the soil information gathered. These systems will be required in highly urbanized areas where cut and fill solutions would not be feasible.

Foundations
Foundations will be considered in design for loading and unloading stations, pedestrian and main line bridges, electrical pole mats, and the possibility of deep foundations if an elevated rail design is chosen.

OTHER ISSUES and additional studies
Potential overall drainage issues may occur where SEA’s geotechnical team will work with the drainage team to determine feasible solutions. This multi-discipline project will require all teams to work together as additional unforeseen problems may arise. If a highly problematic area is found, SEA will recommend further studies.

**Preliminary Schedule and Cost**

Soil classifications and identification of problematic characteristics will require approximately 2 weeks (40 hours) to complete. Research and design of tunnels, retaining systems, and foundations as they occur will require approximately 3 weeks (55 hours). Calculations and drafts of section cuts, stability analysis and fill materials pending test results will require approximately 1.5 weeks (25 hours). Additional issues as they occur may require up to 3 weeks (50 hours).

**Milestones**

- **February 14th**
  - General soil maps created
  - 40 man hours
- **March 26th**
  - Identification of tunnels and tunneling methods
  - Preliminary retaining system and foundation design complete
  - 55 man hours
- **April 9th**
  - Section cuts
  - Stability analysis
  - Fill materials
  - 25 man hours
TRANSPORTATION/UTILITIES

Overview
The utilities/transportation team will be researching existing utilities throughout the western part of Utah along with effected areas within Arizona and Nevada. Along with existing utilities the team will be looking for private and industrial railroad track locations, along with access rights, and possible crossing that may interfere with the rail alignment.

Tasks

All fiber and telecommunications lines
The team will look to locate fiber and telecommunications lines both underground and overhead along with utilities. This is financially critical due to the expensive price of relocating power poles.

Private and Industrial Track Spur Locations, Access rights, and Crossings
Along with utility relocation, the team will be looking into current railroad track locations that may follow or cross the proposed alignment. While researching this area, the team will also be looking at road crossings that may be of concern; once found, this information can be relayed to the structures team.

Determine Current Utilities and Easements.
The team will look for utilities that may be of concern to the proposed alignment. The goal is to identify as many utilities as possible, determine which will be a concern, and rate each utility line with a possibility of relocation. Each utility of concern will be assigned a grade of 1, 2, or 3 where 1 is being either low or not touched and 3 being needing relocated. These lines will be transported to a CAD program where it can be placed on top of the alignment to better help determine what needs to be relocated. Once completed, the team will create a cost estimate of the utility lines that will need relocated.

Construction Considerations
A general consideration of constructability for each alignment will be provided. This overlook will discuss the pros and cons of each potential alignment. This will be assessed based upon general construction needs including fuel, resource availability, and delivery of both equipment and supplies. General conditions of the working crews will also be discussed.

Milestones

- February 10th
  - Identify all utility lines
  - Locate all potential railroad crossings
- Identify construction access restrictions
  - 70 man hours

- February 19th
  - Provide preliminary cost estimate of utilities and crossings
  - 60 man hours

- April 9th
  - Cost estimate of utility relocation
  - 50 man hours
STRUCTURES

Overview
The structures team will be responsible for classifying the type of structures associated with grade separations such as roadway and pedestrian crossings. Other considerations include research on elevated tracks and tunnels. Once a proper design criterion has been placed, the structures team will coordinate with the alignment, geotechnical, and drainage team to determine the proper structure to be placed at each crossing.

Considerations
The following is a preliminary design criterion for structure placement. Further research will be required according to state and federal codes. A final design criterion shall be done as indicated by the indicated date found in the milestones section. A large portion of the man hours will be spent on identifying which structures will be placed at which crossings.

Roadway Crossings
RR Bridge (small)
Description:
- Span length less than 20 feet long.
- Total bridge length less than 100 feet.
- Height bridge length less than 25 feet above grade or water.
Materials: Steel girders on concrete foundation unless special conditions apply. The use of piers will be subject to engineering judgment.

RR Bridge (medium)
Description:
- Span length between 20 and 75 feet long.
- Total bridge length between 100 and 300 feet.
- Height between 25 and 50 feet above grade or water.
Materials: Concrete girders on concrete piers and foundation unless special conditions apply.

RR Bridge (large)
Description:
- Span length greater than 75 feet long
- Total bridge length greater than 300 feet.
- Height greater than 50 feet above grade or water.
Materials: Steel or concrete girders on concrete piers and foundation unless special conditions apply.

Special RR Bridge
Description:
- Rail underpasses traffic above. Ideal for urban areas.
- Span length between 20 and 75 feet long.
- Total bridge length between 50 and 300 feet.
- Height between 25 and 50 feet above grade or water.

Materials: Steel or concrete girders on concrete piers and foundation unless special conditions apply.

**Typical Pedestrian Crossings**

Description: The minimum vertical clearance for a pedestrian bridge over a high-speed track shall be 32'-0" measured from the top of the rail elevation to any pedestrian substructure. This will ensure a max clearance of 10 feet between top of electrical equipment to any substructure. Piers supporting the bridge shall have a minimum horizontal clearance of 25'-0" measured from the centreline of the rail to the edge of the pier or foundation wall. Further research shall be conducted on the proper design of reinforced crash walls for piers.

Materials: Composite or concrete deck on steel or concrete piers or columns on concrete foundation.

**Typical Elevated Track**

Description: The minimum vertical clearance above grade or water for an elevated track shall be 16 feet. Typical piers supporting the track shall be spaced at a minimum distance of 200 feet on center unless the design calls for a tighter spacing.

Materials: Steel or concrete girders on concrete piers on concrete foundation.

**Tunnels**

Description: Tunnels shall be designed for train lengths of 660 feet to 1300 feet. The tunnels shall be designed to accommodate continuous equipment such high and low voltage electric cables, fire lines, emergency air pipes, hand rails, trackside radio cables, communications and signaling equipment, portal hood structures, and the mitigation of sonic booms.

Materials: Concrete cast in-situ or segmental lining or sprayed lining.

**Milestones**

- **February 3**\(^{th}\)
  - Final design criterion to be handed to alignment, geotechnical, and drainage teams.
  - 16 man hours

- **March 10**\(^{st}\)
  - Preliminary estimated count of structures along horizontal alignment.
  - 120 man hours

- **April 7**\(^{st}\)
- Any changes made to horizontal alignment shall have a new estimated count of structures.
  - 100 man hours

- April 25th
  - Final count and grand total cost shall be submitted.
  - 40 man hours