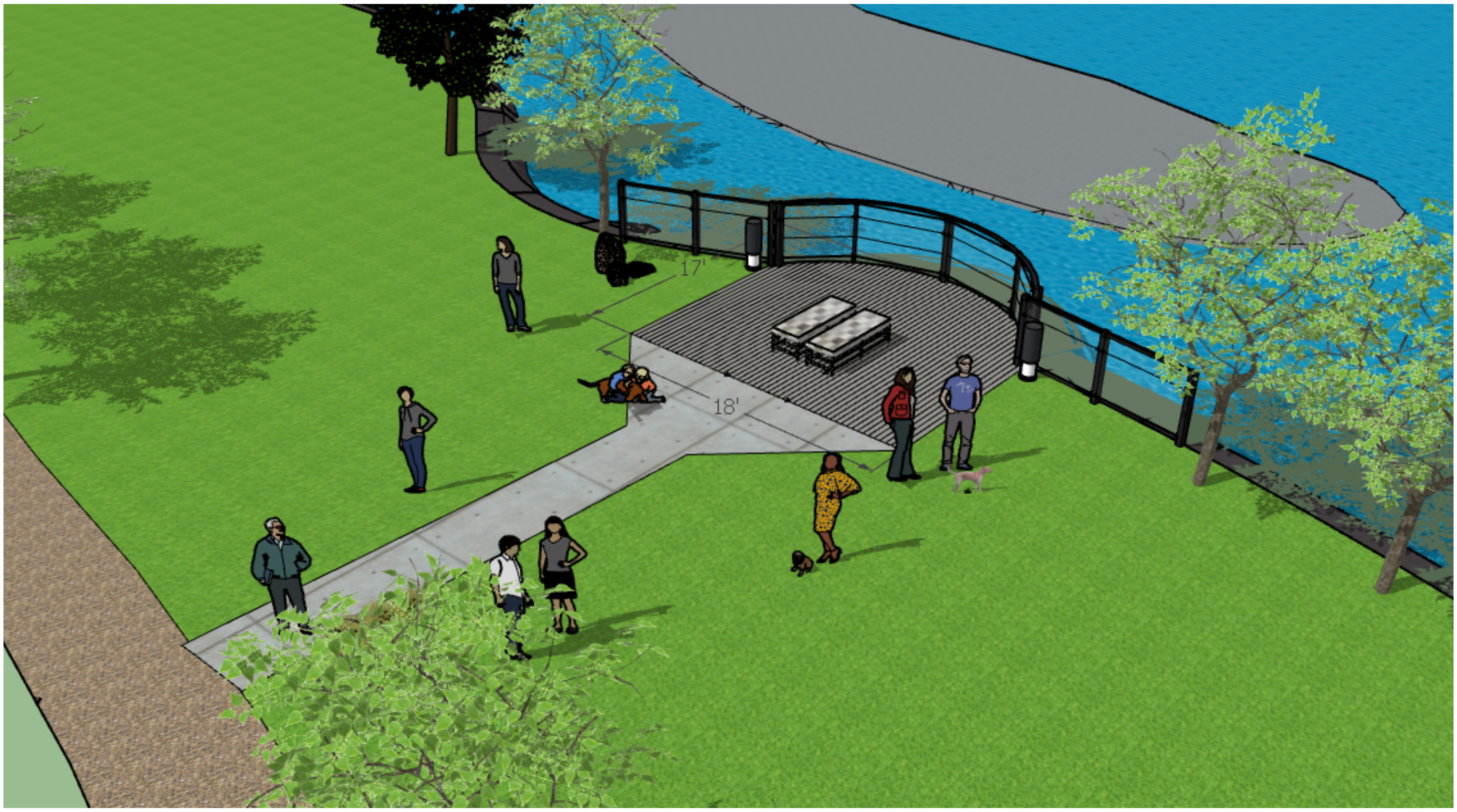

Spring 2021
Troutdale

Troutdale Observation Deck

Evan Kristof

PSU Civil & Environmental Engineering Capstone

University of Oregon | Portland State University | The City of Troutdale Oregon | SCI Sustainable Cities Institute | SCYP Sustainable City Year Program

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Evan Kristof
Senior Instructor • Department of Civil and Environmental Engineering

PORTLAND STATE UNIVERSITY

Acknowledgments

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This report was prepared as part of a class project for the Civil and Environmental Engineering Project Management and Design course at Portland State University. The contents of this report were developed by the student authors and do not necessarily reflect the views of Portland State University. The analyses, conclusions, and recommendations contained in the report should not be construed as an engineering report or used as a substitute for professional engineering services.

Contents

About SCI

The Sustainable Cities Institute (SCI) is an applied think tank focusing on sustainability and cities through applied research, teaching, and community partnerships. We work across disciplines that match the complexity of cities to address sustainability challenges, from regional planning to building design and from enhancing engagement of diverse communities to understanding the impacts on municipal budgets from disruptive technologies and many issues in between.

SCI focuses on sustainability-based research and teaching opportunities through two primary efforts:

1. Our Sustainable City Year Program (SCYP), a massively scaled university-community partnership program that matches the resources of the University with one Oregon community each year to help advance that community's sustainability goals; and

2. Our Urbanism Next Center, which focuses on how autonomous vehicles, e-commerce, and the sharing economy will impact the form and function of cities.

In all cases, we share our expertise and experiences with scholars, policymakers, community leaders, and project partners. We further extend our impact via an annual Expert-in-Residence Program, SCI China visiting scholars program, study abroad course on redesigning cities for people on bicycle, and through our co-leadership of the Educational Partnerships for Innovation in Communities Network (EPIC-N), which is transferring SCYP to universities and communities across the globe. Our work connects student passion, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCYP

The Sustainable City Year Program (SCYP) is a year-long partnership between SCI and a partner in Oregon, in which students and faculty in courses from across the university collaborate with a public entity on sustainability and livability projects. SCYP faculty and students work in collaboration with staff from the partner agency through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCYP's primary value derives from collaborations that result in on-the-ground impact and expanded conversations for a community ready to transition to a more sustainable and livable future.

About City of Troutdale

Troutdale is a dynamic suburban community in Multnomah County, situated on the eastern edge of the Portland metropolitan region and the western edge of the Columbia River Gorge. Settled in the late 1800s and incorporated in 1907, this "Gateway to the Gorge" is approximately six square miles in size with a population of nearly 17,000 residents. Almost 75% of that population is aged 18-64.

Troutdale's median household income of $72,188 exceeds the State of Oregon's $59,393. Troutdale's neighbors include Wood Village and Fairview to the west, Gresham to the south, and unincorporated areas of Multnomah County to the east.

For the first part of the 20th century, the city remained a small village serving area farmers and company workers at nearby industrial facilities. Starting around 1970, Troutdale became a bedroom community in the region, with subdivisions and spurts of multi-family residential housing occurring. In the 1990s, efforts were made to improve the aesthetics of the community's original core, contributing to an award-winning "Main Street" infill project that helped with placemaking. In the 2010s, the City positioned itself as a jobs center as it worked with stakeholders to transform a large superfund area to one of the region's most attractive industrial centers – the Troutdale-Reynolds Industrial Park.

The principal transportation link between Troutdale and Portland is Interstate 84. The Union Pacific Railroad main line runs just north of Troutdale's city center. The Troutdale area is the gateway to the famous Columbia River Gorge Scenic Area and Sandy River recreational areas, and its outdoor pursuits. Troutdale's appealing and beautiful natural setting, miles of trails, and parkland and conservation areas draw residents and visitors alike. The City's pride in place is manifested through its monthly gatherings and annual events, ranging from "First Friday" art walks to the city's long-standing Summerfest celebration each July. A dedicated art scene and an exciting culinary mix have made Troutdale an enviable destination and underscore the community's quality of life. Troutdale is home to McMenamins Edgefield, one of Portland's beloved venues for entertainment and hospitality.

In recent years, Troutdale has developed a robust economic development program. The City's largest employers are Amazon and FedEx Ground, although the City also has numerous local and regional businesses that highlight unique assets within the area. Troutdale's recent business-related efforts have focused on the City's Town Center, where 12 "opportunity sites" have been identified for infill development that respects the small-town feel while offering support to the existing retail environment. The next 20 years promise to be an exciting time for a mature community to protect what's loved and expand opportunities that contribute to Troutdale's pride in place.

Course Participants

CASEY KELLER
ANDREW HILL
ANH LE
JILLIAN PFEIFER
JUSTIN POTTS
JORDAN REAL
ELIJAH KING
MATTHEW STEWART
ELIZABETH GARTNER
LEEN QWIDER
BROOKE ANNOTTI
ARTHUR YUROV
EZRA ALBRIGHT
IAN BUSLACH
SAVKO ZAGARYUK
MARIE ROZA
TRAN TRAN

Executive Summary

The City of Troutdale has planned to construct Sandy Riverfront Park on a reclaimed site just north of downtown Troutdale, which previously housed an old water treatment plant. The park will be part of Troutdale's Urban Renewal Project, which aims to create a natural space for walkers and bicyclists to enjoy the local flora and the Sandy River. The city requested a cantilevered deck designed at 30% to provide a commanding view of the river and serve as a rest area for park visitors. The design considerations include cost-effectiveness, minimal deck deflection, minimal obstruction to existing site conditions, and ease of access for long-term maintenance tasks.

The proposed cantilever deck design was based on a "short and wide" layout, with a longer width parallel to the trail and a comparatively shorter cantilever length. After several design iterations and feedback from the City of Troutdale, the proposed design was restructured into a roughly square deck, with a width of 18' and a cantilever length of 17'. The reasoning behind this ultimate design includes enhancing the view of the Sandy River and providing enough space for both visitors and amenities, such as benches.

Materials involved in the design were chosen based on client preference, ease of maintenance, and overall resiliency. The decking material chosen was pultruded fiberglass paneling, the same material that will be used in the elevated walkway from the Sandy Riverfront Park Trail plan. These panels are a plastic product reinforced with fiberglass and are appropriately referred to as "fiberglass reinforced plastic" (abbreviated as FRP). The material is lightweight, weather-resistant, and manufactured to be ADA-compliant and slip-resistant. FRP can also be manufactured in grate panels, allowing easy maintenance and superb drainage.

Six steel stringers support the decking; all six utilize the wide flange beam shape due to its universal application in most designs and high flexural strength-to-weight ratio. These stringers will be spaced 3.4' on-center to keep the deflections of the deck panels within the allowable tolerance, while minimizing the number of stringers utilized.

There will be two reinforced concrete girders below the steel stringers; these girders will span the 17' cantilever distance and an additional 1.5 times the cantilever distance (25.5'), with a total girder length of 42.5'. The additional length extends behind the cantilever as the "backspan", and acts as a balance against the bending force exerted on the cantilevered portion. This backspan will be buried below grade from beyond where the deck ends, and the weight of the topsoil will provide additional resistance against bending. Since the girders will be in contact with soil throughout their service life, they will be constructed of reinforced concrete. This material was chosen for its extensive corrosion resistance when compared to steel, as well as its great compressive strength.

Since the site is sloped, a standalone retaining wall is recommended to prevent soil erosion from the loading on the deck. The retaining wall will be located at the beginning of the cantilever. The structure will be founded upon spread footings of reinforced concrete and connected to the backspan portion of the girders. This style of foundation was selected for its simplicity in construction. There was also a lack of deep soil data at the site - if more data was available, it could guide deep pile foundation design instead of spread footing design.

Included in this report is the 30% design plan set and a construction cost estimate. This preliminary design report informs the City of Troutdale the magnitudes of cost and construction efforts needed to bring the project to completion. As such, the design may be modified according to the preferences and vision of the City.

INTRODUCTION

The City of Troutdale has a planned park and trail system running along the Sandy River. The City wished to provide trail users with a scenic rest area and a commanding view of the river, and expressed a preference for a cantilevered observation deck to accomplish this. The 2021 Portland State University Capstone group, 2021.TROUT.03, has been assigned to compile a 30% design package and cost estimate. The package will include sheets containing plan and profile views of the structure on-site, super- and substructure dimensions, and detail sheets.

1.0 PROJECT BACKGROUND

The scope of the project is to design an observation deck for the Sandy Riverfront Park for the city of Troutdale. The Sandy Riverfront Park is a future project that is part of the city's 20-year plan for the Urban Renewal Area (URA) program, consisting of a 3 million dollar clean-up of the Sandy Riverfront. The future park will occupy 20 acres of land along the Sandy River, just north of Depot City Park and downtown Troutdale. The new park will be a natural attraction for residents and tourists to enjoy while out walking the trails or shopping in Troutdale's downtown area. The proposed observation deck will enhance the park with an impressive view of the Sandy River and will tie in with the planned Sandy River Access Trail.

The site of the Sandy Riverfront Park has had the historic water treatment structures removed. The Sandy River Access Trail project has completed its 60% design phase, which includes a section of trail that will feature an offshoot path leading up to the observation deck. An arborist report evaluating native and invasive tree species has been conducted, and provides guidance on which thickets to avoid constructing by. A geotechnical evaluation of the site soil properties was also completed and compiled in a report by GRI.

The ultimate goal of the project is to deliver a 30% cantilevered deck design package to the City of Troutdale. Design calculation sheets, drafted plan sets, and construction cost estimates will fulfill this deliverable. Collaboration with and guidance from the landscape architect and engineers designing the Sandy Riverfront Park trails is critical to facilitate project development. Feedback from these design professionals will also ensure that the deck's design elements are congruent with their trail designs.

1.1 EXISTING SITE CONDITIONS

The specific site location is the future Sandy Riverfront Park. It is located on the embankment of the Sandy River at the confluence site in Troutdale Urban Renewal Area, and is outlined in red in Figure 1.1. The park terrain includes gravel trails, sections of grass, thickets of brush and blackberry bushes, and a collection of trees along the riverbank. See Figure 2.10 for a magnified aerial view of the current site. There is a stormwater outfall pipe extending out from the river bank towards the river (Figure 1.3), with a 20'-wide easement.

The layout of the site and its use has changed multiple times over the past 100 years. USGS historical maps show the historic changes to this site from 1918 to 2020. One important piece of information that can be discerned from the oldest geological historic map from 1918 is that the location of the western river bank has not moved drastically in the last 100 years (Figure 1.10). This particular condition is a solid ground for designing in this area since the movement of the contours is minimal.

The historic site uses and features can be seen on the USGS maps in Figures 1.4-1.9. The current site layout is displayed in Figure 1.4. In 1918, a road ran parallel to the Sandy River through a portion of the site (Figure 1.5). A historic creek also ran through the middle of the site into the river. In 1941, a Camas, WA map, shows the formation of a small island in the middle of the river near the site (Figure 1.6); the island was smaller than the current island seen today. A Camas, WA map from 1954 displays the I-84 highway crossing the river on the upper edge of the site (Figure 1.7). The historic creek seen in the 1918 map is filled, and additional infrastructure has been added (including a water tank). In 1975, the Camas, WA map displayed a black and white aerial image taken over Troutdale and the site (Figure 1.8). Finally, the 1993 Camas, WA map shows the location of the previous wastewater treatment plant that took up a portion of the site (Figure 1.9). As part of the Urban Renewal Area, and in preparation for the new Sandy Riverfront Park, the wastewater treatment structures on site have been removed.

Figure 1.1: Area Map with Proposed Project Location (highlighted in red)

Figure 1.2: Current Site Conditions looking East from Site Entrance along Interstate-84

Figure 1.3: Drone Photo of Current Site Conditions from Above Sandy River Looking Northwest

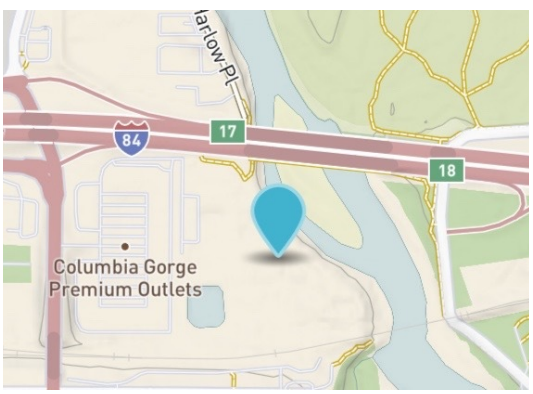

Figure 1.4: Current map

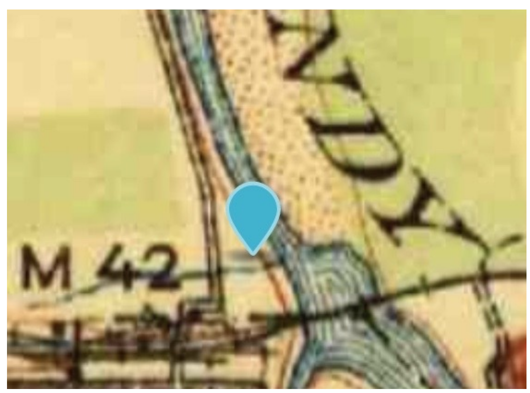

Figure 1.5: 1918 map

Figure 1.6: 1941 map

Figure 1.7: 1954 map

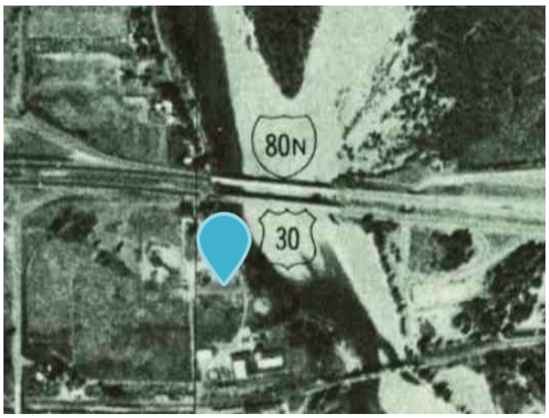

Figure 1.8: 1975 map

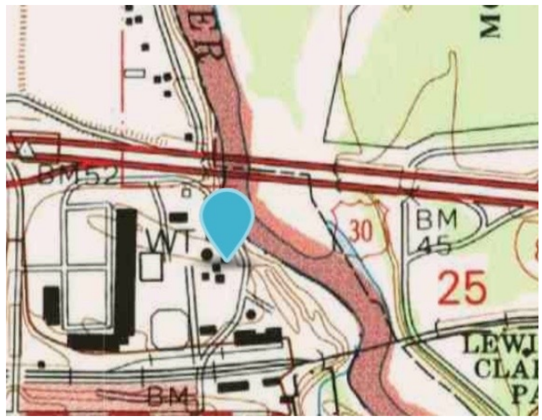

Figure 1.9: 1993 map

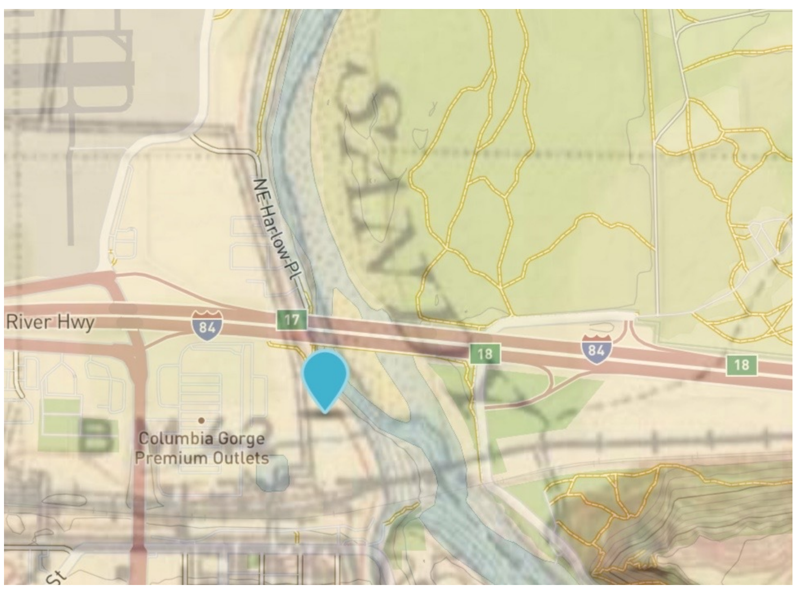

Figure 1.10: Overlay of 1918 map over a current map showing river bank

1.2 Stakeholders

This project was initiated by the City of Troutdale as part of the Sandy River Access Plan. The city of Troutdale collaborated with Oregon Metro, Eastwinds Development, LLC, Sandy River Watershed Council, and Troutdale Parks and Facilities. End-users of the Observation Deck shall be the local public.

1.2.1 The City of Troutdale (Urban Renewal Agency)

The City of Troutdale's Urban Renewal Agency is the principal stakeholder. They are the originators of the Sandy River Access Plan, which the observation deck is part of. They have the final say over planning and design decisions and serve as a link between the various stakeholders, contractors, and human resources being utilized for the project. Chris Damgen is the primary contact at the City of Troutdale who is overseeing the project.

1.2.2 Oregon Metro

The City of Troutdale has submitted an application for a NIN (Nature in Neighborhoods) grant from Oregon Metro for this project. Oregon Metro collects revenue from property taxes and enterprise activities. These funds are then disbursed as grants to voter-approved programs such as Nature in Neighborhoods, which focuses on the restoration of and sustainable access to nature sites in Oregon's populated areas. Oregon Metro's input will be considered in determining the appropriate allocation of funds throughout the life of the project.

1.2.3 Eastwinds Development, LLC

Eastwinds Development, LLC is a private company that owns 35% (7 acres) of the property being developed in the Sandy River Access Plan. Eastwinds has enthusiastically partnered with the City of Troutdale on this project and intends to match the funds provided by the Nature in Neighborhoods grant from Oregon Metro. They have committed to providing on-site project management, printing, and supplies. As a major sponsor, Eastwinds should have a considerable say in determining the appropriate allocation of funds throughout the project. As a landowner, Eastwinds should also be considered a resource for site-specific/access-related inquiries throughout planning and construction.

1.2.4 Sandy River Basin Watershed Council

The Sandy River Basin Watershed Council is a non-profit involved in restoring and conserving resources and habitats of the Sandy River, as well as its tributaries. The

Council is committed to recruiting additional stakeholders through their existing partners who can provide technical support in defining how this project can interface with existing restoration efforts in the area. The Council and its partners will be useful when considering stormwater and FEMA flood line impacts on the structure.

1.2.5 Troutdale Parks and Facilities

Troutdale Parks and Facilities will be charged with the maintenance of the observation deck as well as the rest of the park once it is complete. There are currently six city employees in this office including a superintendent, a maintenance technician, and four park maintenance personnel. Their input will be considered when determining the type and frequency of maintenance for the observation deck.

1.2.6 End Users

The end-users for this project will be the visitors who utilize the observation deck for recreation and leisure. This includes pedestrians, bicyclists, and anybody utilizing the river itself for fishing, kayaking, or other activities. As a public works project, the end users' enjoyment and access to the area is a primary goal.

2.0 Alternatives Analysis

The client, the City of Troutdale, has identified their preference for a cantilevered deck design. In order to evaluate the viability of different deck designs, an alternatives analysis was utilized. Four designs were compared, along with a control "No Build" option, using seven weighted criteria and a 1-5 score per criteria. The two highest-scoring designs were presented to the client for approval.

This section is divided into four subsections: Alternatives Considered, Criteria Descriptions, Alternative Scoring, and Preferred Alternative, wherein the components of the alternative analysis will be elaborated upon in detail.

2.1 Alternatives Considered

PSU CEE Capstone proposed a total of five alternatives, including a no-build option. These alternatives took into consideration the size, location, user experience, and public service requirements that the clients requested, as well as future maintenance. The alternatives were then presented and adjusted per client comments, and the Pugh matrix was used to evaluate and score each alternative.

2.1.1: Large Cable-stayed Deck

This design focuses on a cable-stayed structure with a large deck (Figures 2.1, 2.2). Smaller, intermediate foundations will be utilized. Foundations will be a combination of grade beams, piles, and pile caps with a post-tensioned deck. The deck will span the Sandy River. This design is suitable for multiple locations. It also allows the observation deck to be a visual attraction for the community and takes full advantage of the space and view of the river.

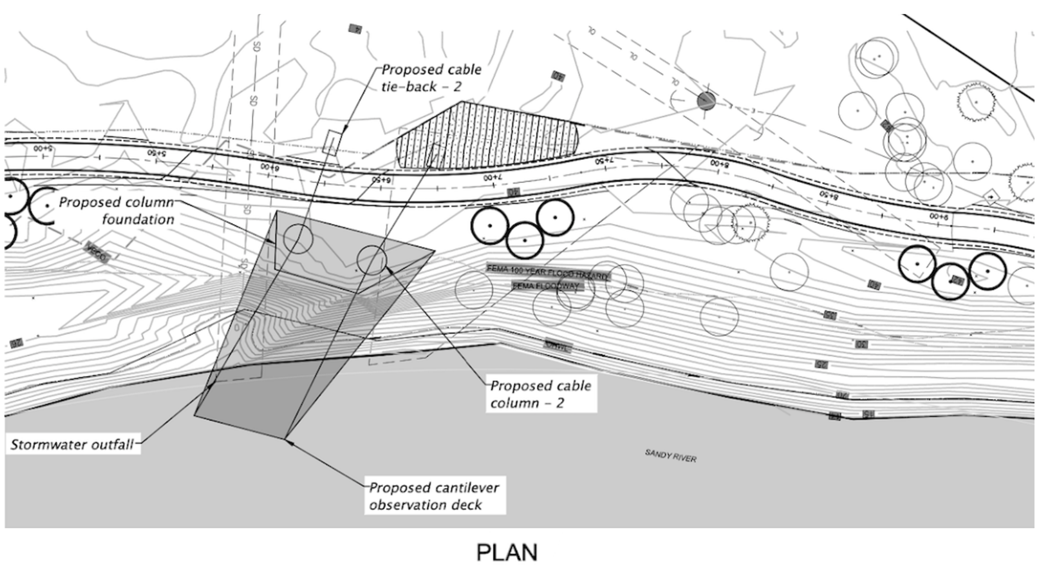

Figure 2.1: Plan view of the proposed large cable-stayed deck design

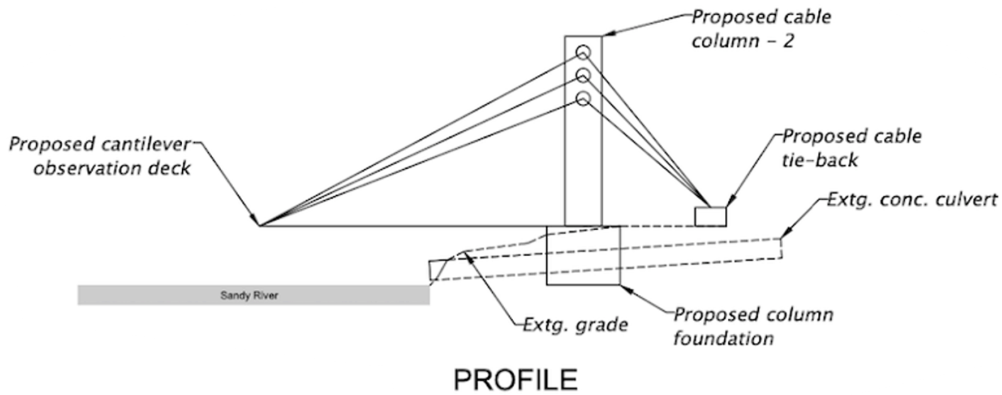

Figure 2.2: Profile view of the proposed large cable-stayed deck design

2.1.2: Large Cantilever Deck

This design focuses on a large cantilevered deck (not cable-stayed) (Figures 2.3, 2.4). This option would require the largest foundation, consisting of piles and tie-back anchors. The deck will span over the Sandy River. This design is suitable for multiple locations.

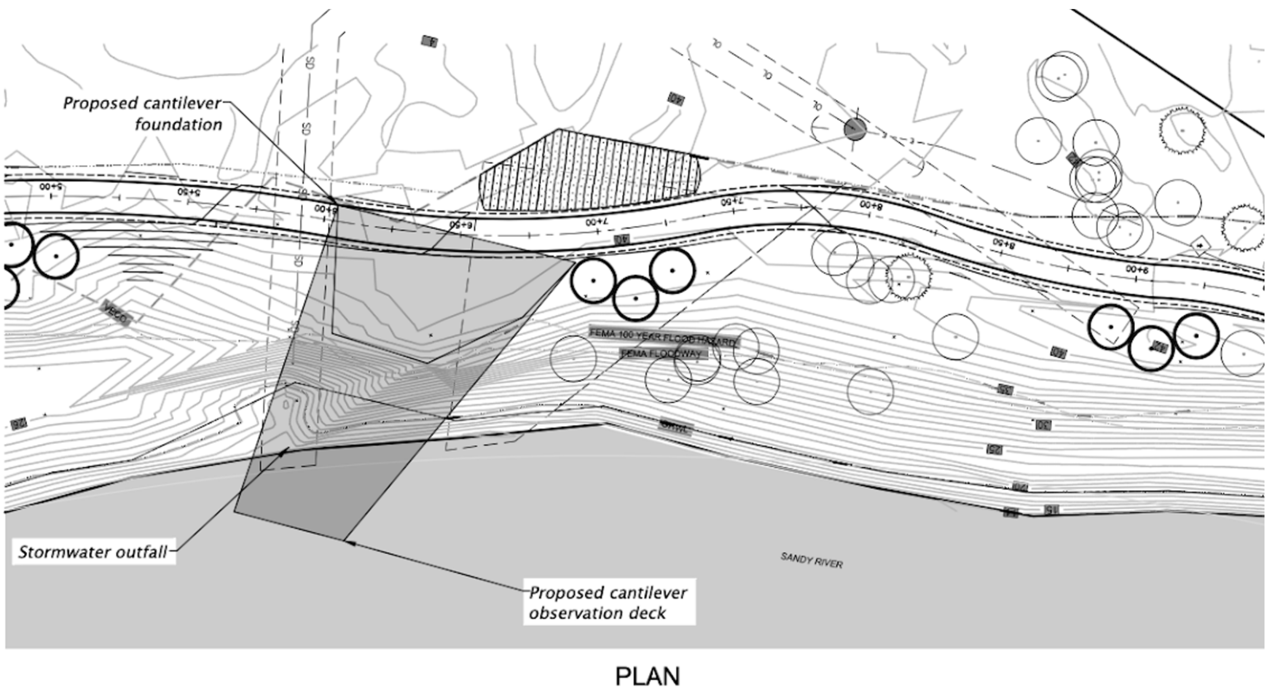

Figure 2.3: Plan view of the proposed large cantilever deck design

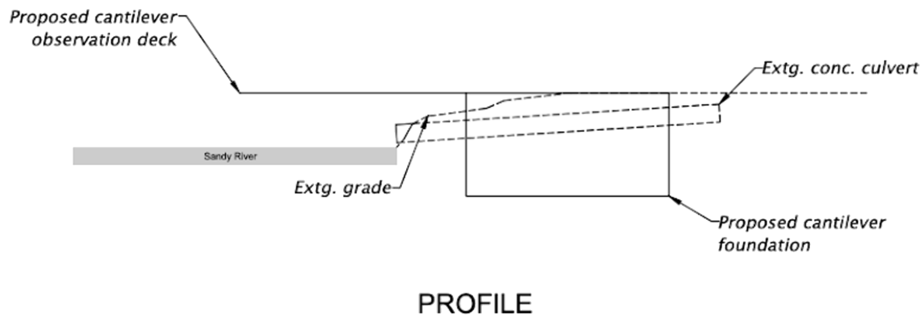

Figure 2.4: Profile view of the proposed large cantilever deck design

2.1.3: Small Cantilever Deck

This design focuses on utilizing a cantilevered deck with a smaller, intermediate-sized foundation to improve economy and sustainability (Figures 2.5, 2.6). The foundation will use piles and the deck will be supported on cantilevered joists. The deck will span the Sandy River. This design is also suitable for multiple locations.

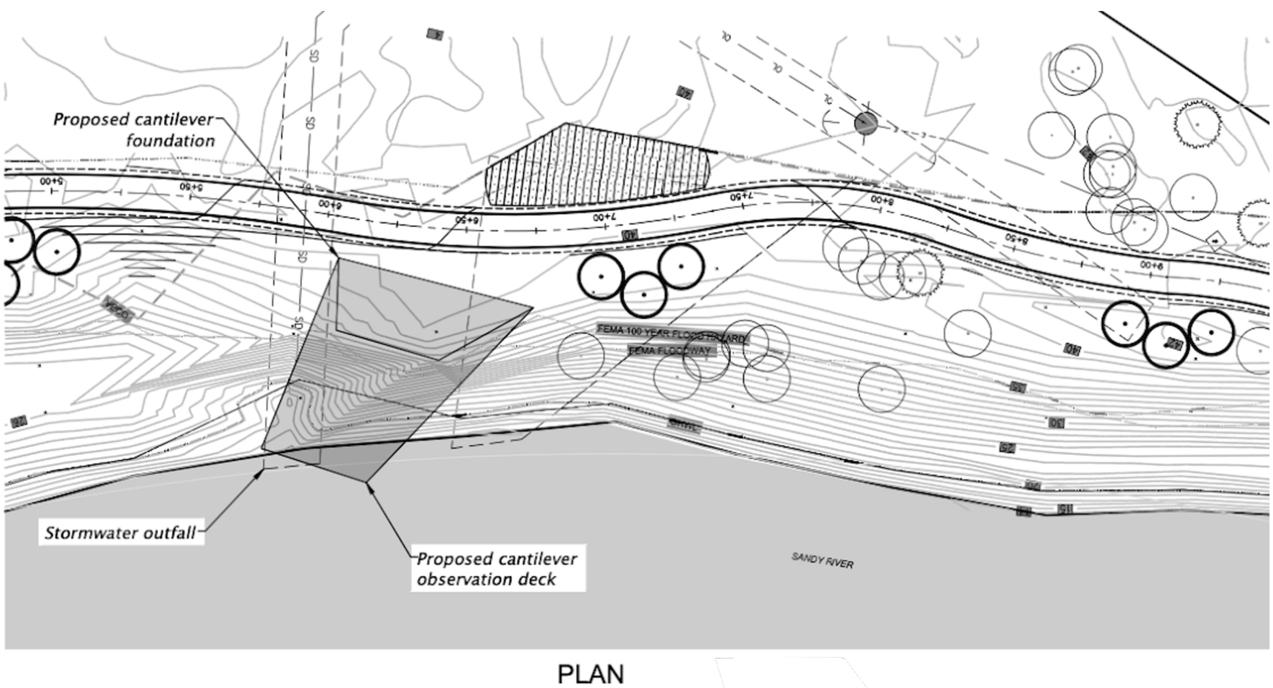

Figure 2.5: Plan view of the proposed small cantilever deck design

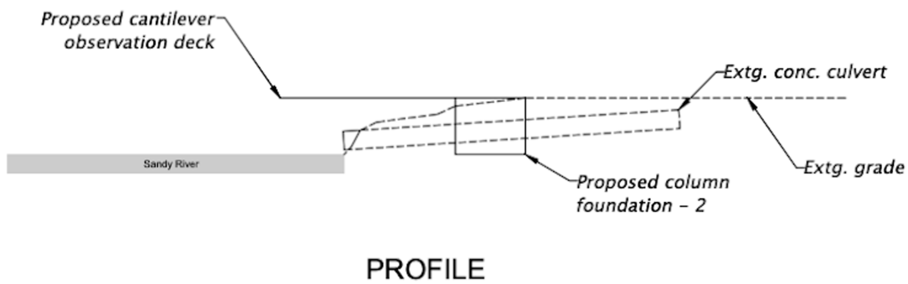

Figure 2.6: Profile view of the proposed small cantilever deck design

2.1.4: Wide Shallow Deck

This alternative consists of a longer and thinner design that focuses on economy and efficiency in multiple aspects of the design (Figures 2.7, 2.8). It will utilize a series of cantilever beams to support the deck. The foundation will include piles/micro piles. The platform to foundation ratio will be 1:1:5 (Deck:Foundation width:Foundation length). It is suitable for any location chosen. The foundation dimensions are subject to change based on the structure's location.

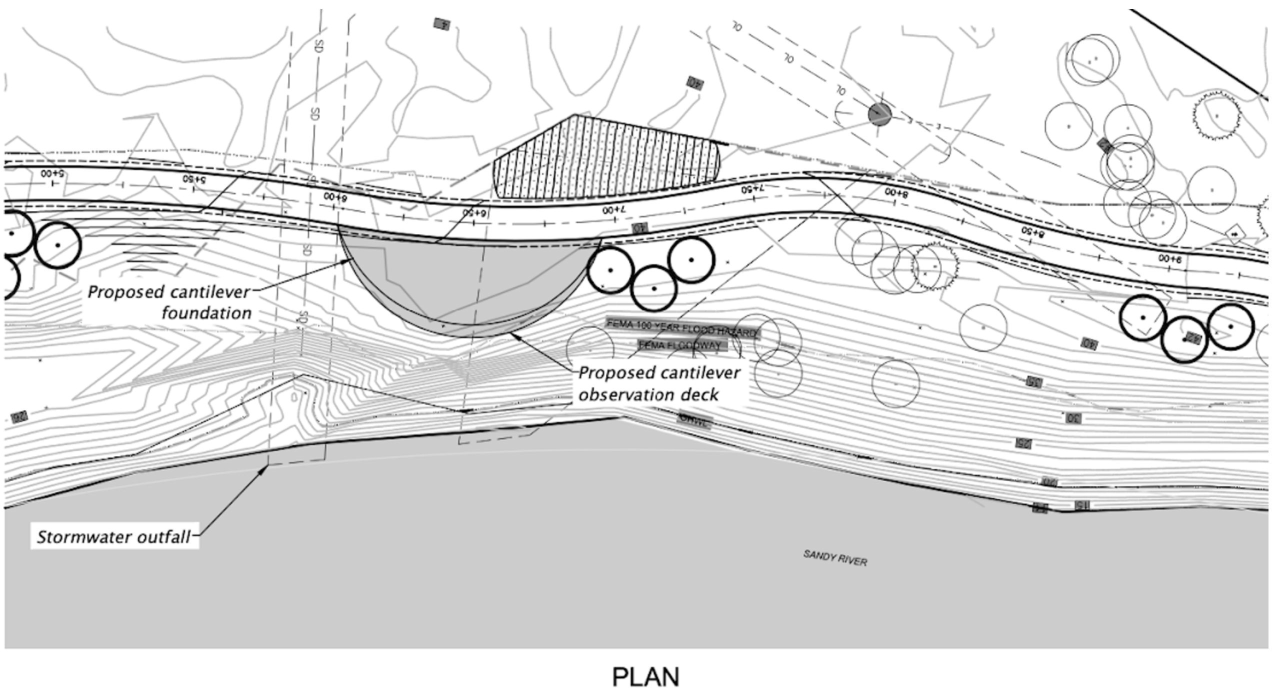

Figure 2.7: Plan view of the proposed wide and shallow deck design

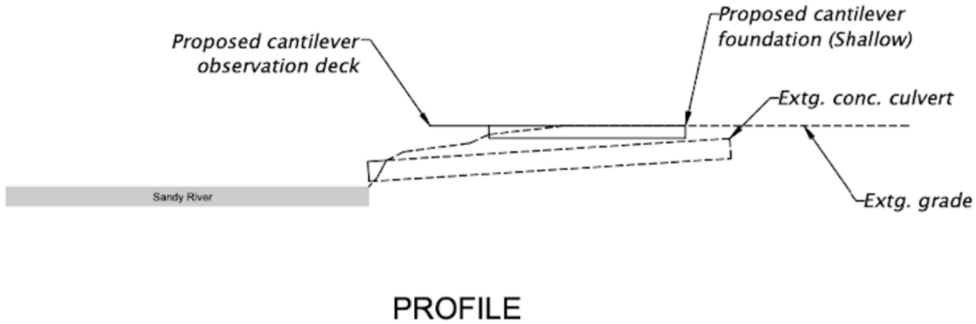

Figure 2.8: Profile view of the proposed wide and shallow deck design

2.1.5 No Build Option

This alternative aims at keeping the site in its current condition without any further design. See Figures 2.9 and 2.10 below for current site conditions.

Figure 2.9: Drone photo of current site conditions from above Sandy River looking southeast

Figure 2.10: Aerial view of current site conditions

2.2 Criteria Descriptions

The criteria development started out with engineering proposals in the form of a Pugh Matrix. These criteria focused on representing the client's requests for the design. The final criteria descriptions were presented to and approved by the client before officially being included in this report.

2.2.1 Cost

This criteria refers to the overall cost of the structure, including the costs of construction, permits, and materials. Based on the City of Troutdale's request, cost is an important deciding factor in the design of the structure. The costs of each design is important to consider due to the public nature of the funding for the project. A higher construction cost will result in a lower score for this criteria (Table 1), and this criteria was assigned a weight of 9.

Table 1: Cost criteria scoring and descriptions

Score	Criteria
1	Most expensive design
2	Very expensive design
3	Moderately expensive design
4	Less expensive design
5	Least expensive design

2.2.2 Constructability

The project's constructability refers to the probability of significant challenges arising during construction. Simpler designs lead to easier and faster builds, whereas complex designs can create challenges that delay construction schedules and increase costs. This can lead to issues that the client and project team need to resolve. Extra earthwork may also be needed for different designs. Earthwork includes permeability, corrosion & erosion protection, and foundation work. Additional earthwork on a design will result in changes to the schedule and increased complexity of construction. An easier design construction process will produce a higher constructability score (Table 2), and this criteria was assigned a weight of 6.

Table 2: Constructibility criteria scoring and descriptions

Score	Criteria
1	Design is very intricate and complex with overwhelming construction complications.
2	Design is intricate and complex with many complications in the construction.
3	Design is moderately complex with several complications in the construction.
4	Design is mildly intricate with minor complications in the construction.
5	Very simple and straightforward design with no complications in the construction.

2.2.3 Environmental Impact

Sustainability is important in the design, including the preservation of the surrounding natural environment and existing soil quality. It is vital to minimize ground disturbance, erosion, runoff, and removal of trees, as well as floodplain impact. This can be accomplished by minimal-disturbance designs and consideration of the design's location. Designs with lower environmental impact will receive a higher score (Table 3), and this criteria was assigned a weight of 5.

Table 3: Environmental impact criteria scoring and descriptions

Score	Criteria
1	Severe environmental disturbance. All or majority of trees removed from the site.
2	High environmental disturbance. Substantial tree removal from site.
3	Moderate environmental disturbance. Multiple trees removed from the site.
4	Mild environmental disturbance. Low overall local environment disruption.
5	No impact or disturbance of the local environment.

2.2.4 User Experience

The user experience score will be based upon the flow of the structure within the surrounding park and trails, the ease of access to the trails and structure, and the sound pollution from both the nearby freeway and nearby railroad bridge. For the purposes of scoring, "engagement" will be defined by the level of positive interaction from the public and the volume of visitors. An aesthetic design is crucial for drawing visitors to the park. This portion of the criteria will be met by designs with spatial aesthetics and appealing geometry and size. Alternatives with an appealing aesthetic and good user experience will receive a higher score (Table 4), and this criteria was assigned a weight of 7.

Table 4: User experience criteria scoring and descriptions

Score	Criteria
1	No engagement
2	Mild engagement
3	Moderate engagement
4	Substantial engagement
5	High engagement

2.2.5 Resiliency & Strength

The resiliency & strength criteria will depend on the length of the structure's estimated lifespan, as well as the seismic and structural capacity of the structure. Any additional reinforcement that is required after completion of the structure will lead to increased costs and extended construction time. The structure's ability to withstand floods, landslides, and wind and seismic loads will also significantly contribute to its score in this criteria. Designs with less required additional reinforcement and longer lifespans will receive a higher score (Table 5), and this criteria was assigned a weight of 8.

Table 5: Resiliency and strength criteria scoring and descriptions

Score	Criteria
1	Shortest lifespan/requires most additional reinforcement
2	Short lifespan/requires more additional reinforcement
3	Average lifespan/requires some additional reinforcement
4	Long lifespan/requires little additional reinforcement
5	Longest lifespan/requires no additional reinforcement

2.2.6 Maintenance

The client has made it very clear that the long-term maintenance of the structure is an important part of choosing an alternative. The maintenance score will be based on how often each alternative will need to be replaced and/or cleaned. This score will also take into account how intensive the maintenance will be. Alternatives with high maintenance will receive lower scores (Table 6), and this criteria was assigned a weight of 9.

Table 6: Maintenance criteria scoring and descriptions

Score	Criteria
1	High Maintenance
2	Substantial Maintenance
3	Moderate Maintenance
4	Mild Maintenance
5	No Maintenance

2.2.7 Permitting

The complexity of the designs will determine the permitting that is necessary for each different alternative. Increased permitting requirements could significantly raise the cost and duration of a project. The designs with simpler permitting requirements will receive a higher score (Table 7), and this criteria was assigned a weight of 8.

Table 7: Permitting criteria scoring and descriptions

Score	Criteria
1	High Permitting
2	Substantial Permitting
3	Moderate Permitting
4	Mild Permitting
5	No Permitting

2.3 Alternative Scoring

Each of the alternatives were scored based on their cost, constructability, environmental impact, user experience, resilience & strength, maintenance, and permitting. The scoring was completed by comparing the criteria descriptions above with each alternative's proposed design.

2.3.1 Pugh Matrix

Table 8: Pugh Matrix Alternative Analysis

	CRITERIA						
ALTERNATIVE TITLE & DESCRIPTION	**Cost**	**Constructability**	**Environmental Impact**	**User Experience**	**Resiliency and Strength**	**Maintenance**	**Permitting**
1) Large Deck, Cable-Stayed	1	1	3	5	5	4	3
2) Large Deck, Cantilevered	2	2	3	4	2	1	3
3) Small Cantilever Deck	4	3	3	2	3	2	4
4) Small Deck, Wide and Shallow	3	4	4	2	4	3	4
5) No-Build	5	5	5	1	5	5	5
CRITERIA WEIGHTS	***9***	***6***	***5***	***7***	***8***	***9***	***8***

Table 9: Pugh Matrix Analysis Results

ALTERNATIVE TITLE & DESCRIPTION	TOTAL SCORE	Order by score (high-low)
1) Large Deck, Cable-Stayed	165	2nd
2) Large Deck, Cantilevered	122	4th
3) Small Cantilever Deck	157	3rd
4) Wide and Shallow Cantilever	176	1st
5) No-Build	232	N/A

2.3.2 Large Cable-stayed Deck

The cable-stayed deck design is more unique and ambitious than the other designs. The cable-stayed aspect of the design means that it has a costly and complicated construction, which is reflected in very low scores for the cost and constructability criteria. However, the increased cost and complexity of the design results in a more resilient structure than the other alternatives. It also has a substantially better-proposed user experience because the design will allow for the deck to be suspended over the river. This, combined with the post-tensioned deck, will contribute to an impressive visual experience. Because the design requires more space, its impact on the surrounding environment will be greater than the other alternatives. Maintenance is expected to be moderately difficult because special equipment will be required to access the vertical elements of the structure. The amount of permitting required for the project is significant and also comparable to that of the large cantilevered deck.

2.3.3 Large Cantilever Deck

This design consists of a large deck with deep foundations. The cost of construction and design complexity is significant, which results in this alternative's cost and constructability scores coming in second to the cable-stayed deck. However, the larger deck size and proximity to the river contribute to a higher user experience score. This design's site footprint is on par with that of the cable-stayed deck, leading to a similar score in environmental impact. As the structure is supported solely by a cantilever, additional reinforcement, frequent inspections, and routine repairs are to be expected. The amount of permitting needed is similar to the cable-stayed deck, resulting in a tie between the two designs' scores.

2.3.4 Small Cantilever Deck

The small size of this cantilever deck design emphasizes the structure's ease of construction and maintenance. Fewer materials, smaller construction costs, and less site impact are also a result of the structure's smaller size. The simple structure is also forecasted to require fewer permits and less frequent maintenance. However, the small size is less capable of hosting visitors than the larger alternatives considered and will not extend over the water.

2.3.5 Wide and Shallow Cantilever

This design features a short but wide cantilever deck contouring along the trail alignment. The wide structure lends less to an impressive user experience but its proposed location compliments a rest area directly across the trail. Its simplicity and short cantilevered length make this alternative much easier to build, resulting in a higher constructability score. The quantity of materials required for this structure is greater than the other small cantilever design. The degree of environmental disturbance is less than the other alternatives, which leaves room for future landscaping to assimilate the deck into the park's landscape.

2.3.6 No Build

The no-build option intuitively scored the greatest. These scores reflect the fact that if we simply leave the site as it is then there will be no cost, no constructability score, and no foundational work or environmental impact. On the other side of the spectrum, this option scored poorly in the aesthetics and capacity criteria. Without making changes to the site it will remain as an empty lot. The maintenance score is a nine due to the fact that currently, the city does try to maintain the site to some degree by planting grass seed and keeping pathways clear of debris. Currently, the site has a low user experience simply because it is being used as a frisbee golf course and leaving the site as it does not affect the floodplain at all.

2.4 Preferred Alternative

After calculating the weighted total for each alternative, design Alternative #4, the Wide and Shallow Cantilever, scored highest behind the No Build option. The final recommendation for the client is the Wide and Shallow Cantilever design because they are not considering the No Build option at this time.

The client presented the Pugh Matrix and the recommended design to stakeholders. The preferred alternative chosen by the stakeholders was Alternative #4, the Wide and Shallow Cantilever because it is small and aesthetically complements the planned trail design.

After presenting the Alternative Analysis from PSU Capstone Team to the Public Committee of the City of Troutdale. The City of Troutdale decided to proceed with this alternative to the 30% design phase.

3.0 Facility Design

The following subsections outline the different elements comprising this proposed 30% design. These sections include Design Summary (Section 3.1), Structural Design (Section 3.2), Standards and Specifications (Section 3.3), Geotechnical Design (Section 3.4), Calculations (Section 3.5), AutoCAD (Section 3.6), and Construction (Section 3.7).

3.1 Design Summary

The proposed design Alternative #4 (Small Deck Wide and Shallow) will be constructed of pultruded fiberglass decking (Fibergrate's Safe-T-Span® Pultruded Grating or equivalent). The deck will be cantilevered 17' from its support and have an overall width of 18'. The fiberglass decking will be supported by six steel girders placed perpendicular to the cantilever length and spanning the full 18' width. These steel girders will then be supported by two reinforced concrete beams parallel to the cantilever length and located at opposite sides of the deck. These beams span the 17' cantilever length, as well as a back span of 1.5 times the cantilever length - equalling 25.5'. The back span will be underground with the purpose of counterbalancing a portion of the weight on the cantilever side of the deck.

The design will have its centerline located at station 6+30 along the planned trail alignment. This trail is featured in the Marianne Zarkin Landscape Architects 30% Design Plan and contains the base files utilized for drafting.

3.2 Standards and Specifications

The specifications and standards used for calculations and construction will be included in this section. This includes ORSS, ASTM, AASHTO, TDT and ODOT Bridge Design.

3.2.1 ORSS (2019)

The Oregon Structural Specialty Code Section 1607 contains Table 1607.1, which features a series of different uniform and concentrated live loads to be applied to a structure based on its occupancy or use.
This project utilizes the loading for Exterior Foot Bridge, with 100 psf and 1000-pound pedestrian live loads. These loads were selected to align with the applied vehicle loading from the AASHTO Pedestrian Bridge Design.

3.2.2 ASTM A6

ASTM A6 contains dimensions and parameters for wide flange steel W beams. This section is utilized in the steel stringer design.

3.2.3 AASHTO

The 2009 edition of the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges was used to incorporate maintenance vehicle loads into the structural design. Section 3.2 contains discussions on vehicle loading, and Table 3.2.1 contains the vehicle axle loads and geometry. There were two options for design loads based on the clear deck width. For this design with a clear width of 18’, the H10 design maintenance truck geometry and loads were utilized.

3.2.4 Troutdale Development Code (TDC)

The Troutdale Development Code is a set of standard details and guidelines to follow when installing or constructing something in the City of Troutdale. The TDC (Troutdale Development Code, 2019) is primarily used by construction workers and is often referred to in plan sets.

Flood management codes need to be met due to the structure’s location on the bank of the Sandy River, which may be affected during flood storms. These codes ensure that public health, safety, and general welfare are maintained during flood conditions (Troutdale Development Code, 2019).

3.2.5 ODOT Bridge Design

The Oregon Department of Transportation provides standard drawings for bridge design, and the BR700 series features retaining wall standards. For the purpose of this 30% design, the BR709 Cast-In-Place Semi Gravity Retaining Wall standard drawing.

3.3 Structural Design

Structural design of Observation Deck includes: concrete girder design, steel stringer design, and fiberglass pultruded decking. A retaining wall is recommended and a standard design by Oregon Department of Transportation is also included. The design criteria satisfy safety requirements, aesthetics, and long-term ease of access maintenance. Design criteria follow stipulated specifications as required by the State of Oregon and the City of Troutdale. Detailed design criteria are described in the following sections. For the general load calculations applied to the deck, pedestrian live loads were selected from ORSS Table 1607.1 and a maintenance vehicle load from Section 3.2 in AASHTO Bridge Design. For these deck load calculations, see Appendix D1.

3.3.1 Concrete Girder Design

The concrete girders were designed to resist the loading from the steel stringers and the live loads. For the live loads, a moving load analysis was performed of a 100 psf pedestrian load from and a vehicular load of an H10 design vehicle. The loadings were analyzed in a structural analysis program called SAP2000 to obtain a maximum bending moment and a maximum shear. In order to provide the strength to resist the loading, a 30” by 18” beam was chosen with 6 #10 bars in the top steel, 2 #10 bars in the bottom steel, and #4 stirrups spaced at 12 inches. The girder provides a demand to capacity ratio of 0.73 for the bending moment and 0.69 for the shear. The girder's stirrup detailing needs to be further examined; the 30% design only considered designing for shear capacity and did not consider the stirrup spacing design. See Appendix D2 for the associated calculations sheet.

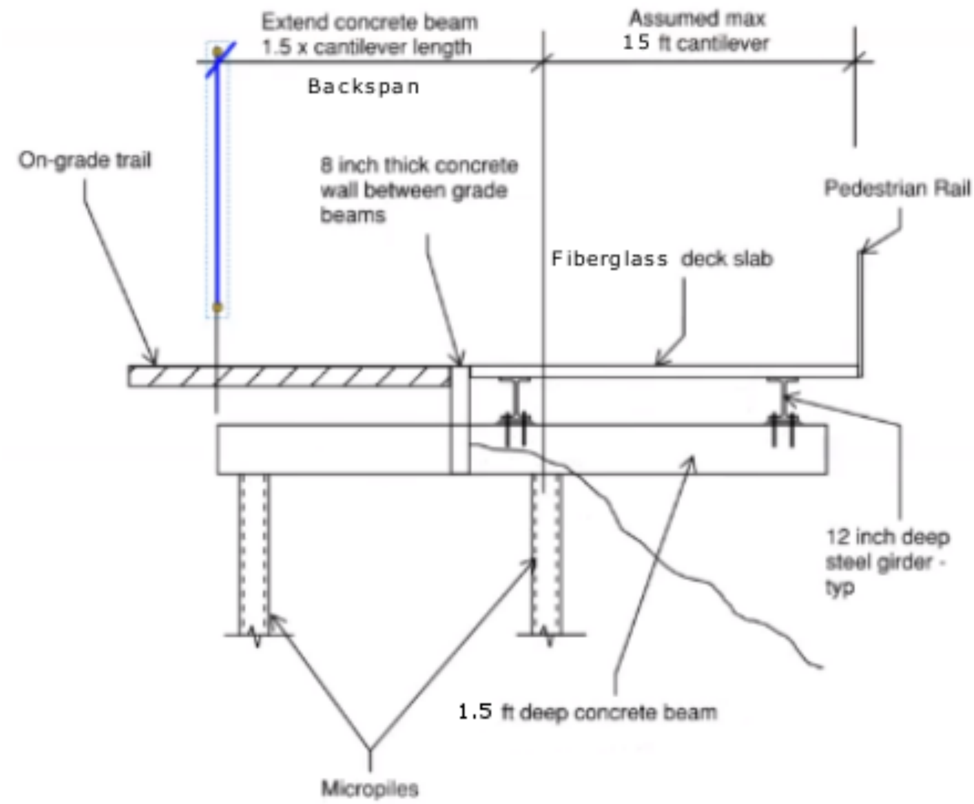

Figure 3.1: Schematic of structural design

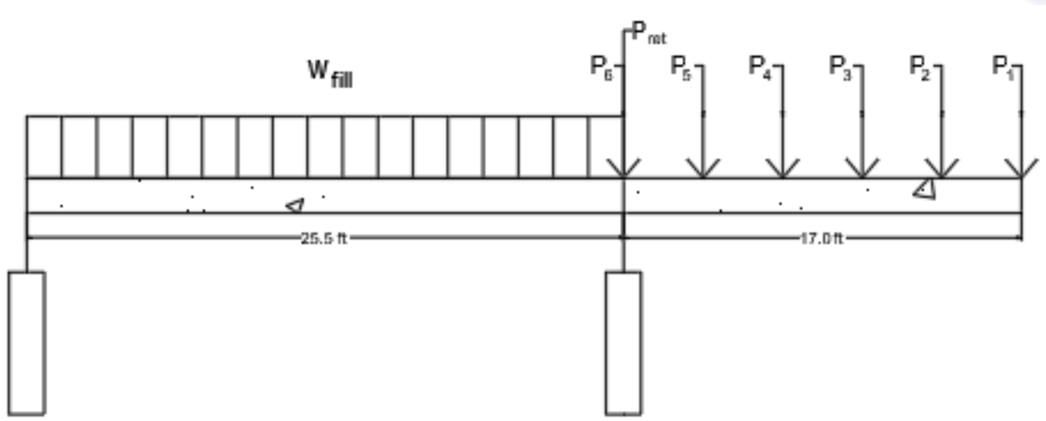

Figure 3.2: Design load distribution

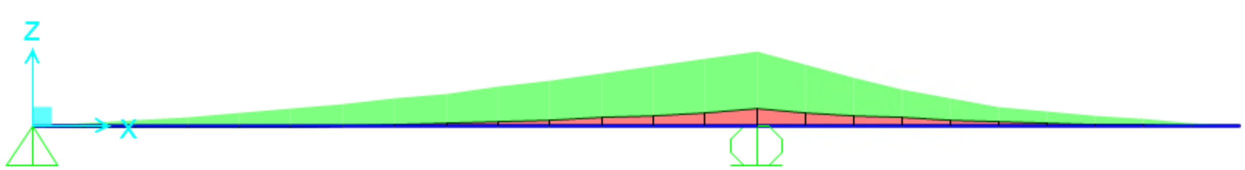

Figure 3.3: Loading distribution modeled in SAP 2000

3.3.2 Concrete Retaining Wall Design

The BR709 Cast-In-Place Semi Gravity Retaining Wall standard drawing will be utilized in the design. The wall will be a standalone structure and placed just behind the beginning of the cantilever. The design is in compliance with ODOT Bridge Design Standard BR705 and BR706.

3.3.3 Steel Stringer Design

The steel stringers are designed assuming six 18 ft long steel girders, spaced 3.4 ft on center. Under this geometry and worst-case H10 design vehicular loading, the factored loading includes a distributed load of 302 plf, a point load of 14.4 kips, and a second point load of 12.8 kips. The placement of the point loads varies with each limit state to maximize internal girder forces or deflection. The specified W10X54 provides a demand to capacity ratio (D/C) of 0.92 for flexural torsional buckling. Shear and bending do not control the design and provide D/Cs of 0.31 and 0.47, respectively. Unfactored service loads meet serviceability deflection criteria per ORSS 1604.3.3. Please see Appendix D3 for further details.

3.2.4 Pultruded Fiberglass Decking

The material chosen for the decking is the HI3730 pultruded fiberglass. This is the high load capacity grating offered by fibergrate that is capable of supporting AASHTO vehicle loads. The material chosen by our team is able to withstand loads of an H10 vehicle at a span of 3’-6” with a 30% increased impact rate and a factor of safety of 3.0. The deflection under max loading conditions is below 0.25 inches which is below the deflection code limits. On top of that, it is ADA compliant with an open area of only 37%. For deflection calculation, see Appendix D4

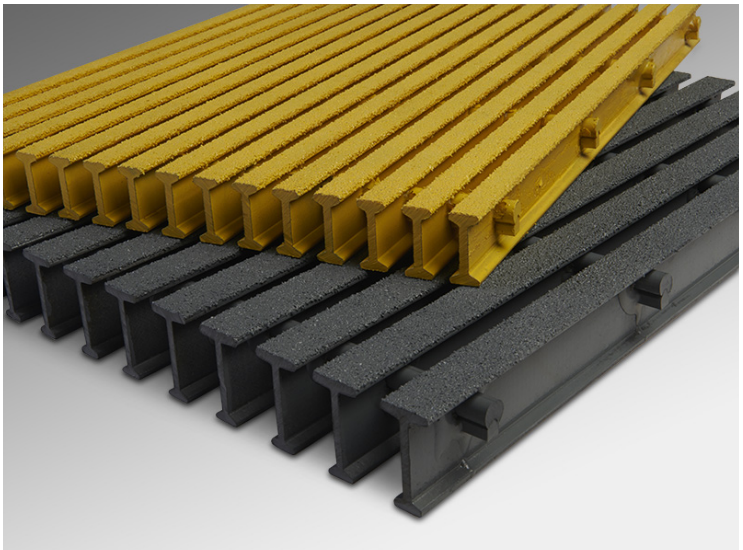

Figure 3.4: Pultruded Fiberglass Material

3.4 Geotechnical Design

The geotechnical assumptions, data, methods of calculation, and results are included in this section, along with a description of the site's geotechnical conditions and design foundation recommendations. See Appendix E for calculations, figures, and plan set.

3.4.1 Current Site Conditions

The scope of the current site's soil information has been created using a nearby hand auger and boring logs from the GRI *Geotechnical Investigation for the Sandy Riverfront Park*. The proposed location for the cantilevered overlook falls between 2 sets of auger locations and some distance from one of the boring logs, hand auger locations 4/5 and 6/7, and boring log B-1. This means that the foundation design for the project was completed using data that is not completely representative of the soil profile at the exact location of the overlook. For the 30% design work found in this report, this was determined to be acceptable. However, for a complete design of the Sandy Riverfront Overlook, a new hand auger and boring samples should be taken in the location of the project site. CPT and SPT testing methods should also be considered.

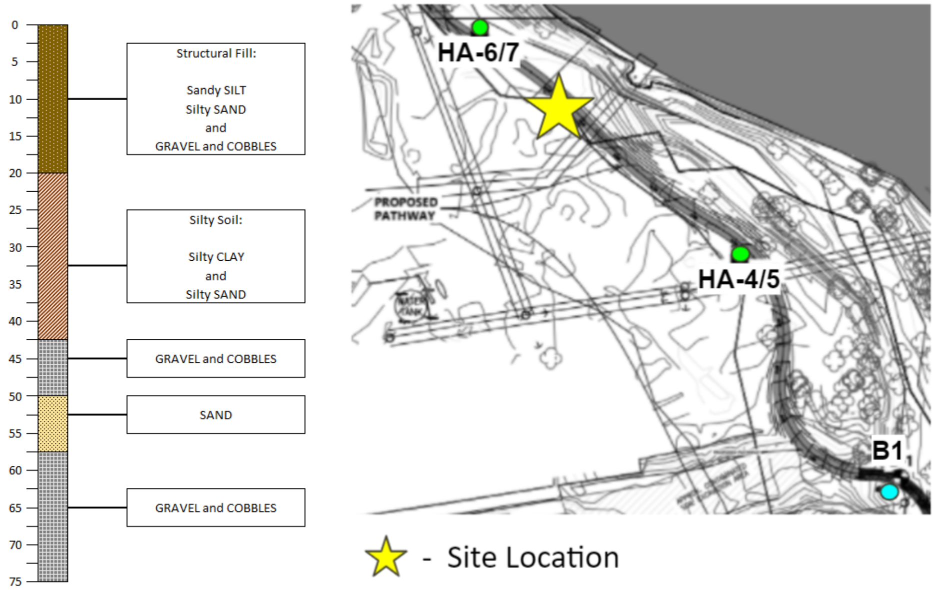

Figure 3.5: Current site condition soil conditions groundwork for geotechnical design

The site was found to have a variable fill top-layer, clay/sand/silt mid-layer, and a gravel/cobbles bottom-layer using the available soil information. The focus of the foundation design of this project is on these three layers of the soil profile from boring log B1. The upper variable fill layer reaches a depth of twenty feet and consists of different structural fills including silty sands containing organic materials as well as gravel and cobbles. The middle layer is made up of 22 feet of silty clay and sand, this layer and the silty fill portions of the upper layer are moisture sensitive and therefore easily disturbed during construction in wet weather. The final layer is made up of 33 feet of gravel and cobbles which is what we used as a reference of how deep our pile foundation would need to go given the stability of the layer. The GRI report recommends the use of a spread footing foundation for the cantilevered portion of the overlook. This design was looked into initially but deemed insufficient for our design. This led us towards the use of deep piles which could reach the lower and more stable soil layers.

The GRI geotechnical report brought up a significant concern related to the soil profile for the project site. Based on the report, the silty soils in this area are extremely moisture dependent and could be unsuitable fill for the project. This would require extra soil excavation to replace the silty soil fill with a more stable structural fill. This issue depends heavily on the time and weather conditions during construction. If construction took place in drier months, it would pose less of an issue than building during the wetter months later in the year.

3.4.2 Deep Pile Design Assumptions and Methods

In calculating the dimensions needed for the deep pile foundation, the following assumptions were made: The load on the cantilevered section of the overlook is a uniform area load, there is no bearing capacity in the horizontal direction, there is a factor of safety of three, and that the soil profile from boring B-1 of the GRI geotechnical report is similar to the soil profile at the project site. The final assumption made regarding the soil profile was used because the project site is approximately five hundred feet from the closest boring site, B-1. To make up for any differences in the soil profile of the project site and the boring log used for the design, the calculations for the deep piles were done conservatively.

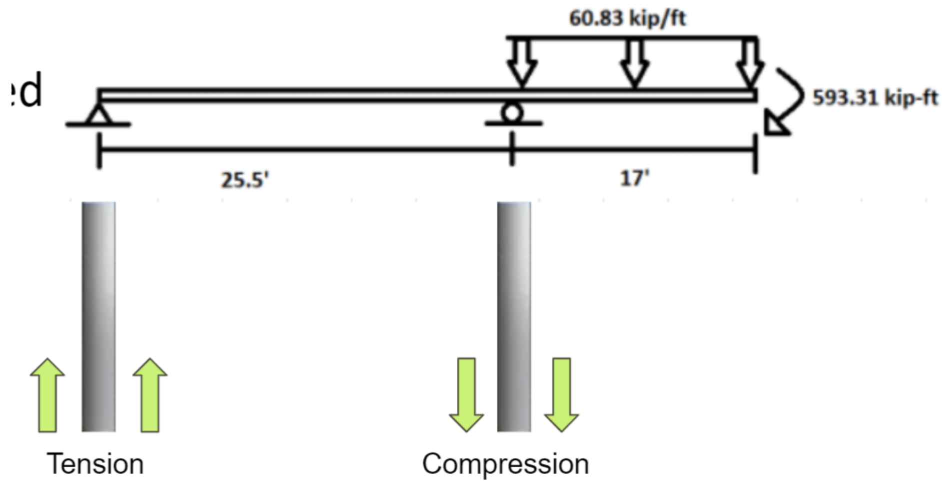

Figure 3.6: Schematic of the deep pile design for Observation Deck

The current method is using the bearing capacity of deep piles in the lowest layer of cobbles and gravel beginning at a depth of forty two feet. This takes into account the loading and moments on the structure, the effective bearing angle, the unit weight of the soil, and many other factors that can be seen on the table.

3.4.3 Recommendations for Future Development

Based on the available data, we recommend that further subsurface exploration be conducted at the site. CPT and SPT sampling should be considered. The current design is based on information provided by the GRI Geotechnical report, where the most relevant data was from the B1 boring log.

Collecting samples for laboratory analysis is also recommended in order to provide further information about the local soil’s engineering properties. Laboratory results can help to determine if the native soils are suitable for use in construction or not.

3.5 Calculations

Structural calculations done for Observation Deck took into account the stability of the structure under design loads as well as service life and maintenance ease-of-access. PSU Capstone Team used the Oregon Structural Specialty Code for allowable deflections (ORSS 1604.3.3) and applied pedestrian live loads (ORSS 1607.1-36), the 2009 AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges for vehicular loading (AASHTO 3.2-1, 2009), American Society for Testing and Materials specifications for wide flange steel beams (W beams) that offers high flexural strength (ASTM A6), AASHTO Soil Classifications system, and The Troutdale Development Code (TDC). Please see Appendix E for detailed calculations.

3.6 Visual Aids and Construction Drawings

Visual aids are instructive images including sketches, aerial photos, and drone photos with minimal mark-ups to show details. The PSU Capstone Team used the sketching software SketchUp to showcase the conceptual design and presented it to the City for approval. Construction drawings for the design were drafted using AutoCAD Civil 3D. Please see Appendix C and D for more information.

3.6.1 AutoCAD Civil 3D

Planning design drawings were done using AutoCAD Civil 3D. The purpose of the drawings was to specify detailed views of the structure for approval and construction. Please see Appendix D for the plan sets.

3.6.2 SketchUp

SketchUp Pro 2021 was the 3D modeling software used to draft a conceptual overview of the proposed design, including the cantilever deck and the surrounding landscape after construction. The version of SketchUp used was a trial version, and as such there was limited access to complex tools and features. These led to difficulties that the SketchUp drafting team faced when modeling the structure and adding more realistic graphics. Accurately representing the landscape of the site, acquiring ideal material textures, and laying in conceptual entities like planters and pedestrians were the key modeling components that were impacted by trial version challenges. The process of becoming familiar with SketchUp, drawing, and then designing this project, took over 15 hours until a complete structure model was finalized.

3.7 Construction

The construction scheduling process and cost estimate of the proposed design is heavily dependent on the permitting process. The permitting process requires a longer processing timeline due to an extensive pre-application process for municipal land use and building permits. Any changes relating to site grade, contours, floodway boundaries, and overall design will further lengthen the construction schedule.

3.7.1 Construction Cost Estimate

The detailed construction cost estimate summary can be found in the appendices and includes project coordination, surveying, geotechnical investigation, substructure and superstructure materials, sediment control during construction, and final stabilization. Preliminary construction cost estimates sum to $546,180.00, not including general contractors overhead and profit. Please see the Cost Estimates spreadsheet in the Appendix for more information.

3.7.2 Construction Schedule

The construction schedule was estimated to take approximately seven months to complete. This process includes: permitting, earthwork, foundation works, deck installation, and inspection. The permitting process requires The State of Oregon and City of Troutdale's approval. The permitting process could take between two and four months due to land use and building permit pre-application and submittal review processes, which can be complicated by any floodplain management requirements. Please see the Construction Schedule in Appendix B for more information.

4.0 Regulatory Compliance and Permitting

The Observation Deck design and construction involve the following permitting: construction stormwater general permit, flood hazard permit (FEMA floodplain management), land use application, wetlands/waterway removal-fill. This is due to the Observation Deck location belonging to the public land and near a FEMA line. The requirement of permitting is subject to change in accordance with the design of the structure and foundation. The processing time for each organization is as follows, Oregon DEQ (48 days), Troutdale (63 days) and Oregon DSL (120 days).

4.1 Oregon DEQ: Construction Stormwater General Permit

The Observation Deck structure is an outside structure with rainwater directly falling off from the structure to the stormwater inlet. A permit is required for any outside structure with water conveying through. The permit has an application process through the Department of Environmental Quality located in Portland, Oregon.

4.2 Troutdale: Flood Hazard Permit, Land Use Permit

The location of the Observation Deck is within the Flood Management Area mapped by the Federal Emergency Management Agency (FEMA). The design team used the FEMA's maps Flood Insurance Rate Maps (FIRMs) as one of the base maps for design. The Flood Hazard Permit is issued by the City of Troutdale. A member of the City's representative was also in charge of FHP of the City of Troutdale. The design aimed for Type I Permit for general construction without triggering any further types of the type.

The Land Use Application permit involves all projects within the limit of the City of Troutdale. This permit involves a flood hazard permit, development permit, site development review, tree removal permit, temporary use permit, etc. The Planning Division of the City of Troutdale issues the Land Use Application permit.

4.3 Oregon DSL: Wetlands/Waterway Removal-Fill

The State of Oregon requires any waterways and wetland construction projects to obtain permits and authorizations prior to construction. The authorizations include Removal-Fill permits and Proprietary waterway authorizations. The Removal-Fill permits allow the removal or fill activity in waterways and wetlands over fifty cubic yards. Observation Deck construction shall require removing and filling into the construction site. The Proprietary waterway authorizations for use of state-owned waterways which are the Sandy River and Storm outlets. The Oregon Department of State Lands is in charge of issuing these permits.

5.0 Conclusion

The proposed design has an 18' wide by 17' cantilever deck, constructed out of pultruded fiberglass grating panels. The substructure consists of six steel W10X54 beams spaced 3.4' on-center and supporting the deck, with two reinforced concrete girders dimensioned at 18" wide and 30" in depth. The two girders are placed at both ends of the 18' width and span the 17' cantilever and 25.5'backspan. A standalone retaining wall is placed behind the beginning of the cantilever and in front of the spread footing foundation, which is attached to the reinforced concrete girder backspan.

This design benefits from its simplicity manifested in its $546,180.00 cost to construct. The structural calculations utilized in this design report include a cushion of extra capacity in the structure, allowing for future additions and design changes to take place without requiring a total redesign.

There are some key limitations that inhibit this design in its 30% phase and will impact future work to be done. The greatest limitation is the need for extensive soil data near the site. Boring data further to the south of the park is available, but the distance between the borings and the project location is too great to depend on the boring results. For a more advanced and accurate foundation recommendation, further subsurface exploration in the immediate vicinity of the site is critical.

Another limitation considers the maintenance vehicle loads on the structure. AASHTO's H10 design maintenance truck specifies a rear axle load of 16 kips and a front axle load of 4 kips. These vehicular loads are the controlling element in determining the model of pultruded fiberglass decking, the spacing of steel stringers to mitigate deck deflection, and the design of the steel stringers, reinforced concrete girders, and spread footing. To prevent such conservatism, future designers should consider permanent bollards to obstruct vehicular entry to the deck, thereby disqualifying the H10 maintenance truck loads.

The limitations described above should be the focus of future designers to ensure confidence in foundations and structural efficiency.

Aside from the above mentioned design work and the completion of this 30% Design Report by the PSU Capstone Team, the City of Troutdale and related stakeholders are to provide suitable management arrangements for this project; select and appoint suitable personnels; notify relevant parties and agree to the cost projected for the project.

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State of Oregon (2021). “Department of State Removal-Fill Permit.” <https://www.oregon.gov/DSL/WW/Pages/Permits.aspx >

Geotechnical Investigation Sandy Riverfront Park, GRI. https://drive.google.com/drive/folders/1Hy34eEb7w4HGe9keZruBVLsw5fhpmluo

Appendices

The following appendices are attached.

A. Construction Cost Estimate

B. Construction Schedule

C. Drawings

D. Site Photos

E. Calculations

APPENDIX A

CONSTRUCTION COST ESTIMATE

Cost Estimate Report

Date: 05/20/2021

City of Troutdale

Troutdale, OR

Troutdale Observation Deck

Year 2021 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Matthew Stewart Portland State University

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
01 General Requirements						
013113000000	Project coordination	0.00		$0.00	0.00	0.00
013113200140	Field personnel, field engineer, senior engineer, maximum	26.00	Week	$3,625.00	94,250.00	0.00
01 General Requirements Subtotal					**94,250.00**	**0.00**
02 Existing Conditions						
022113000000	Site surveys	0.00		$0.00	0.00	0.00
022113090010	Topographical surveys	0.00		$0.00	0.00	0.00
022113090020	Topographical survey, conventional, minimum	0.00	Acre	$695.00	0.00	0.00
022113130010	Boundary & survey markers	0.00		$0.00	0.00	0.00
022113130300	Boundary & survey markers, lot location and lines, for large quantities, minimum	10.00	Acre	$1,131.95	11,319.50	0.00
022113160010	Aerial surveys	0.00		$0.00	0.00	0.00
022113161500	Aerial surveys, 10 acres, incl. ground control, minimum fee	10.00	Total	$4,700.00	47,000.00	0.00
022113161600	Aerial surveys, 2' contours, 10 acres, incl. ground control	10.00	Acre	$470.00	4,700.00	0.00
023200000000	Geotechnical investigations	0.00		$0.00	0.00	0.00
023213100010	Boring and exploratory drilling	0.00		$0.00	0.00	0.00
023213100020	Subsurface investigation, boring and exploratory drilling, initial field stake out & determination of elevations, for borings	1.00	Day	$1,363.00	1,363.00	0.00
02 Existing Conditions Subtotal					**64,382.50**	**0.00**

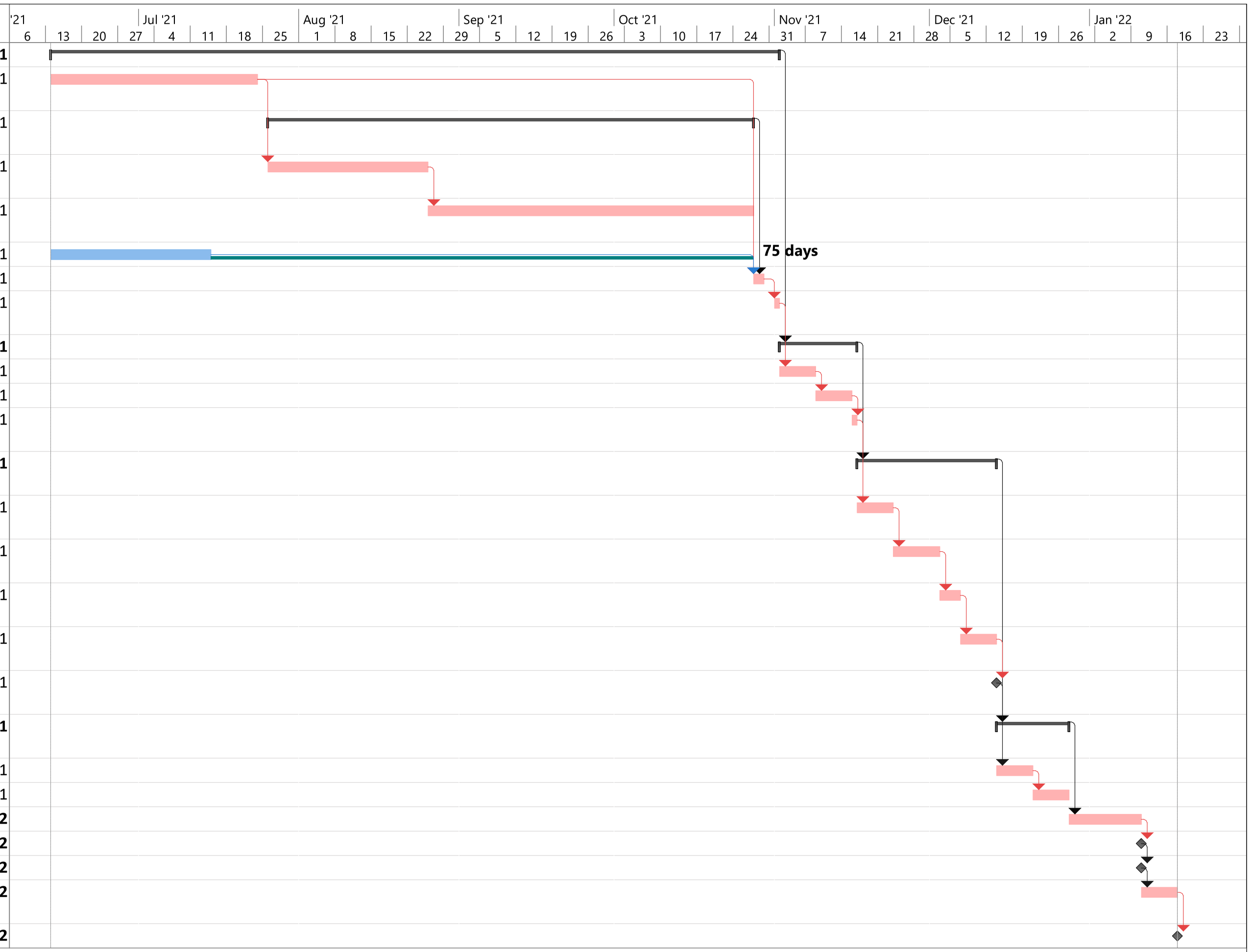
Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
03 Concrete						
032111600100	Reinforcing steel, in place, beams and girders, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	1.00	Ton	$3,125.00	3,125.00	0.00
032111600150	Reinforcing steel, in place, beams and girders, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	1.00	Ton	$2,425.00	2,425.00	0.00
032111600500	Reinforcing steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	1.00	Ton	$2,725.00	2,725.00	0.00
032111600550	Reinforcing steel, in place, footings, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	1.00	Ton	$2,160.00	2,160.00	0.00
033000000000	Cast-in-place concrete	0.00		$0.00	0.00	0.00
033053400020	Structural concrete, in place, includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), placing and finishing	0.00		$0.00	0.00	0.00
033053400050	Structural concrete, in place, includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), placing and finishing	0.00		$0.00	0.00	0.00
033053400300	Structural concrete, in place, beam (3500 psi), 5 kip/LF, 10' span, includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), placing and finishing	20.00	C.Y.	$1,547.00	30,940.00	0.00
033053403800	Structural concrete, in place, spread footing (3000 psi), under 1 C.Y., includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), placing and finishing	50.00	C.Y.	$540.08	27,004.00	0.00
03 Concrete Subtotal					**68,379.00**	**0.00**
05 Metals						
052100000000	Steel joist framing	0.00		$0.00	0.00	0.00
052113503040	Deep longspan joist, DLH Series, 40-ton job lots, spans to 144', shop fabricated, (shipped in 2 pieces), incl shop primer, bolted cross bridging	1.00	Ton	$3,465.00	3,465.00	0.00
055200000000	Railing, metal	0.00		$0.00	0.00	0.00
055213500580	Railing, pipe, steel, primed, 3 rails, 3'-6" high, posts @ 5' OC, 1-1/4" diameter, shop fabricated	75.00	L.F.	$79.69	5,976.75	0.00
05 Metals Subtotal					**9,441.75**	**0.00**
06 Wood, Plastics and Composites						
067300000000	Composite fabrications, woodgrained decking	0.00		$0.00	0.00	0.00
067313100140	Composite fabrications, encased woodgrained decking, 1" x 6", grooved edge	450.00	L.F.	$7.43	3,343.50	0.00
06 Wood, Plastics and Composites Subtotal					**3,343.50**	**0.00**
31 Earthwork						
312319000000	Dewatering	0.00		$0.00	0.00	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312319200800	Dewatering, pumping 8 hours, attended 2 hours per day, 2" diaphragm pump, includes 20 LF of suction hose and 100 LF of discharge hose	90.00	Day	$1,079.00	97,110.00	0.00
312319201600	Dewatering, sump hole construction, includes excavation and gravel pit	50.00	C.F.	$2.81	140.50	0.00
312319400410	Wellpoints, pump operation, 4 @ 6 hour shifts, per 24 hour day	90.00	Day	$2,075.00	186,750.00	0.00
312323140010	Backfill, structural	0.00		$0.00	0.00	0.00
312323140011	Backfill, dozer or F.E. loader	0.00		$0.00	0.00	0.00
312323142000	Backfill, structural, sand and gravel, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction	25.00	L.C.Y.	$1.29	32.25	0.00
312323240010	Compaction, structural	0.00		$0.00	0.00	0.00
312323240600	Compaction, structural, common fill, 8" lifts, vibratory plate	50.00	E.C.Y.	$2.83	141.50	0.00
312500000000	Erosion and sedimentation controls	0.00		$0.00	0.00	0.00
312514160710	Compost or Mulch Filter Sock, 9" diam	250.00	L.F.	$5.71	1,427.50	0.00
312514161000	Synthetic erosion control, silt fence, install and remove, 3' high	500.00	L.F.	$3.43	1,715.00	0.00
313700000000	Riprap	0.00		$0.00	0.00	0.00
313713100100	Rip-rap and rock lining, random, broken stone, machine placed for slope protection	15.00	L.C.Y.	$71.10	1,066.50	0.00
315200000000	Cofferdams	0.00		$0.00	0.00	0.00
315216100100	Cofferdams, soldier beams & lagging, H-piles with wood sheeting horizontal between piles, no hydrostatic head, 1 line of braces, 3" wood sheeting, 15' deep, includes removal of wales & braces, minimum	500.00	S.F.	$36.00	18,000.00	0.00
31 Earthwork Subtotal					**306,383.25**	**0.00**

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
Subtotal					546,180.00	0.00
General Contractor's Markup on Subs				0.00%		$0.00
Subtotal					$546,180.00	$0.00
General Conditions				0.00%	$0.00	$0.00
Subtotal					$546,180.00	$0.00
General Contractor's Overhead and Profit				0.00%	$0.00	$0.00
Subtotal					$546,180.00	$0.00
Grand Total						**$546,180.00**

Appendix B
Construction Schedule

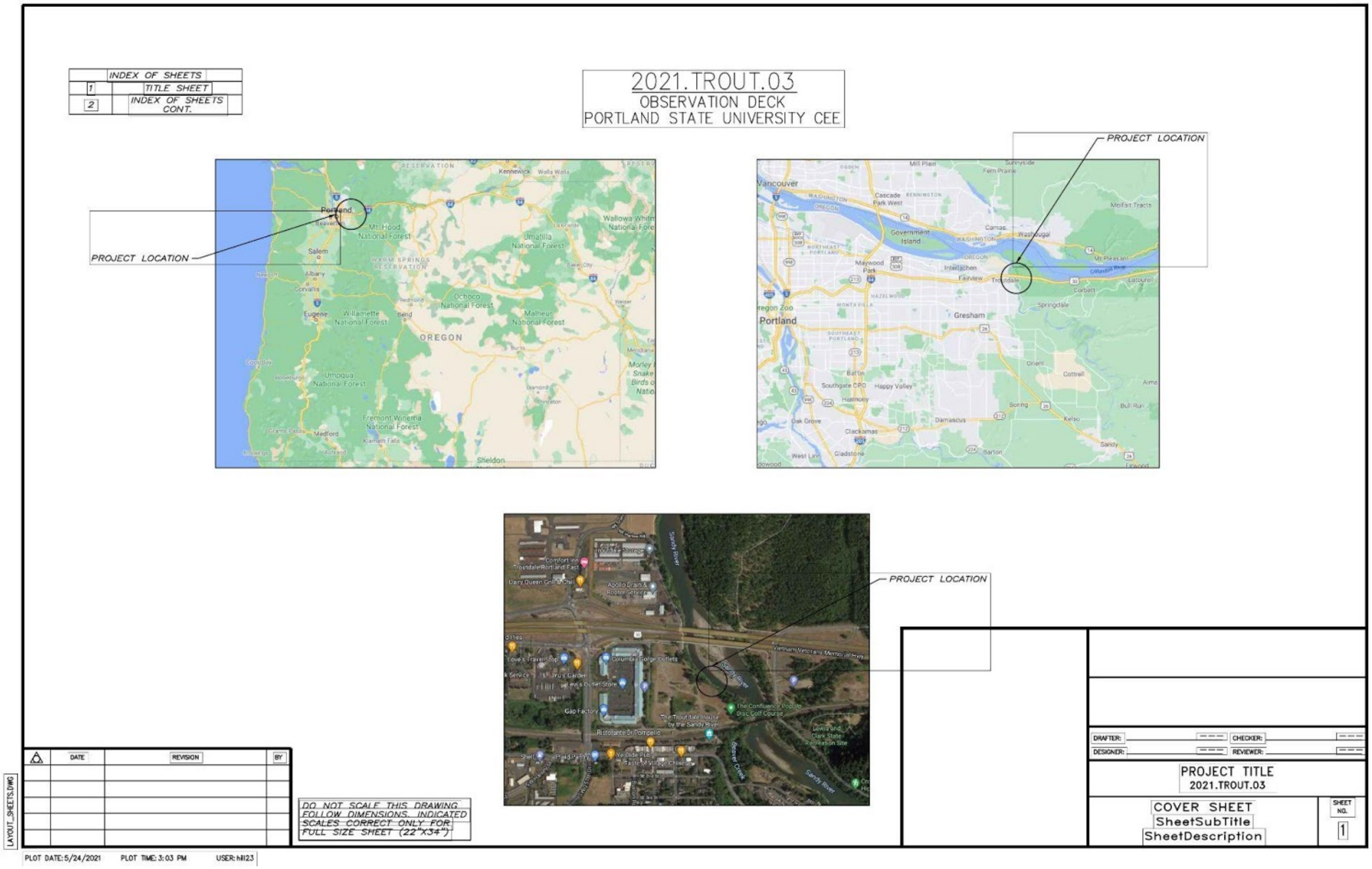
WBS	Task Description	Duration	Start	Finish
1	**Site Prep**	**101 days**	**Mon 6/14/21**	**Mon 11/1/21**
1.1	Permitting/Submittal approval	30 days	Mon 6/14/21	Fri 7/23/21
1.2	City of Troutdale Permitting	68 days	Mon 7/26/21	Wed 10/27/21
1.2.1	Pre-application Process	23 days	Mon 7/26/21	Wed 8/25/21
1.2.2	Land Use/Flood Hazard Permits	45 days	Thu 8/26/21	Wed 10/27/21
1.3	State of OR Permitting	23 days	Mon 6/14/21	Wed 7/14/21
1.4	Erosion Control	2 days	Thu 10/28/21	Fri 10/29/21
1.5	Construction Survey - Staking	1 day	Mon 11/1/21	Mon 11/1/21
2	**Earthwork**	**11 days**	**Tue 11/2/21**	**Tue 11/16/21**
2.1	Earth excavation	5 days	Tue 11/2/21	Mon 11/8/21
2.2	Pile installation	5 days	Tue 11/9/21	Mon 11/15/21
2.3	Construction Survey - Verify	1 day	Tue 11/16/21	Tue 11/16/21
3	**Deck installation - Structural**	**19 days**	**Wed 11/17/21**	**Mon 12/13/21**
3.1	Concrete form and rebar	5 days	Wed 11/17/21	Tue 11/23/21
3.2	Concrete pour and cure	7 days	Wed 11/24/21	Thu 12/2/21
3.3	Concrete form removal and surface work	2 days	Fri 12/3/21	Mon 12/6/21
3.4	Steel girder installation	1 wk	Tue 12/7/21	Mon 12/13/21
3.5	Concrete beam inspection	0 days	Mon 12/13/21	Mon 12/13/21
4	**Deck installation - Final**	**10 days**	**Tue 12/14/21**	**Mon 12/27/21**
4.1	Install FRP decking	1 wk	Tue 12/14/21	Mon 12/20/21
4.2	Install railing	1 wk	Tue 12/21/21	Mon 12/27/21
5	**Punch list items**	**2 wks**	**Tue 12/28/21**	**Mon 1/10/22**
6	**Final inspection**	**0 wks**	**Mon 1/10/22**	**Mon 1/10/22**
7	**Event day/Grand open**	**0 days**	**Mon 1/10/22**	**Mon 1/10/22**
8	**As built survey and plans**	**1 wk**	**Tue 1/11/22**	**Mon 1/17/22**
9	**Project Closeout**	**0 days**	**Mon 1/17/22**	**Mon 1/17/22**

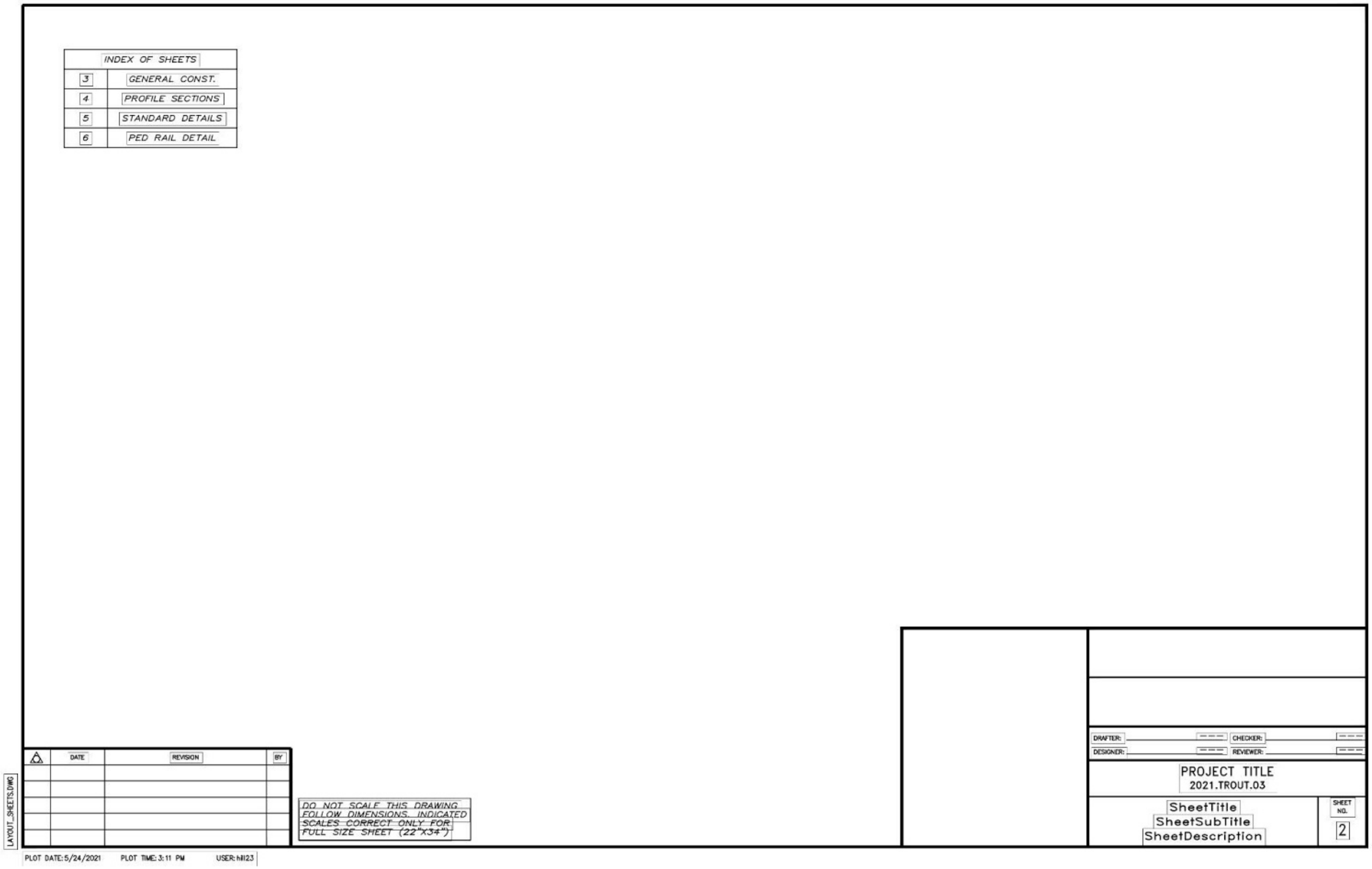


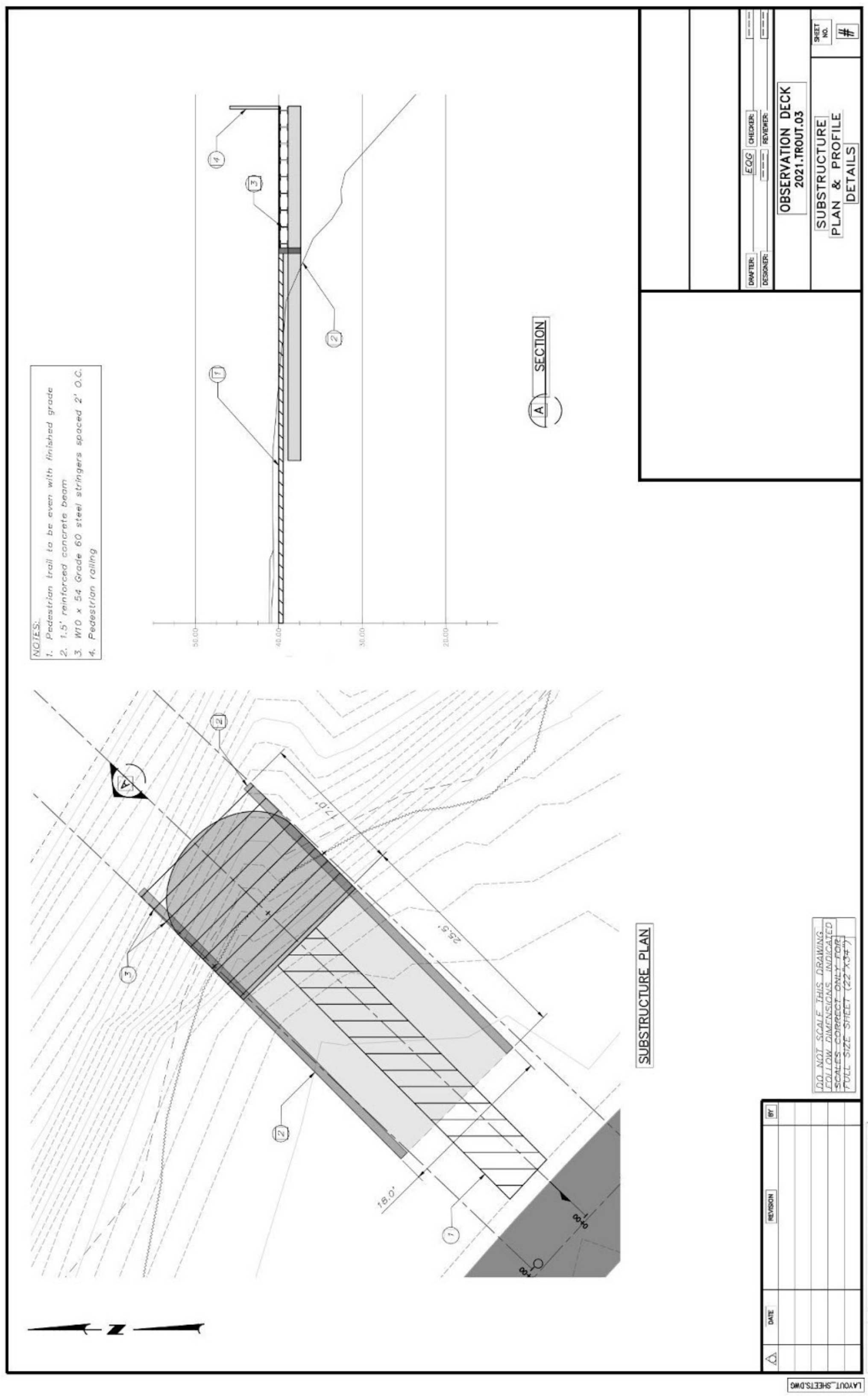
Critical	Slack	Rolled Up Critical Split	Duration-only	External Tasks	
Critical Split	Slippage	Inactive Task	Manual Summary Rollup	External Milestone	
Task	Summary	Inactive Milestone	Manual Summary	Deadline	
Split	Project Summary	Inactive Summary	Start-only	Progress	
Milestone	Rolled Up Critical	Manual Task	Finish-only		

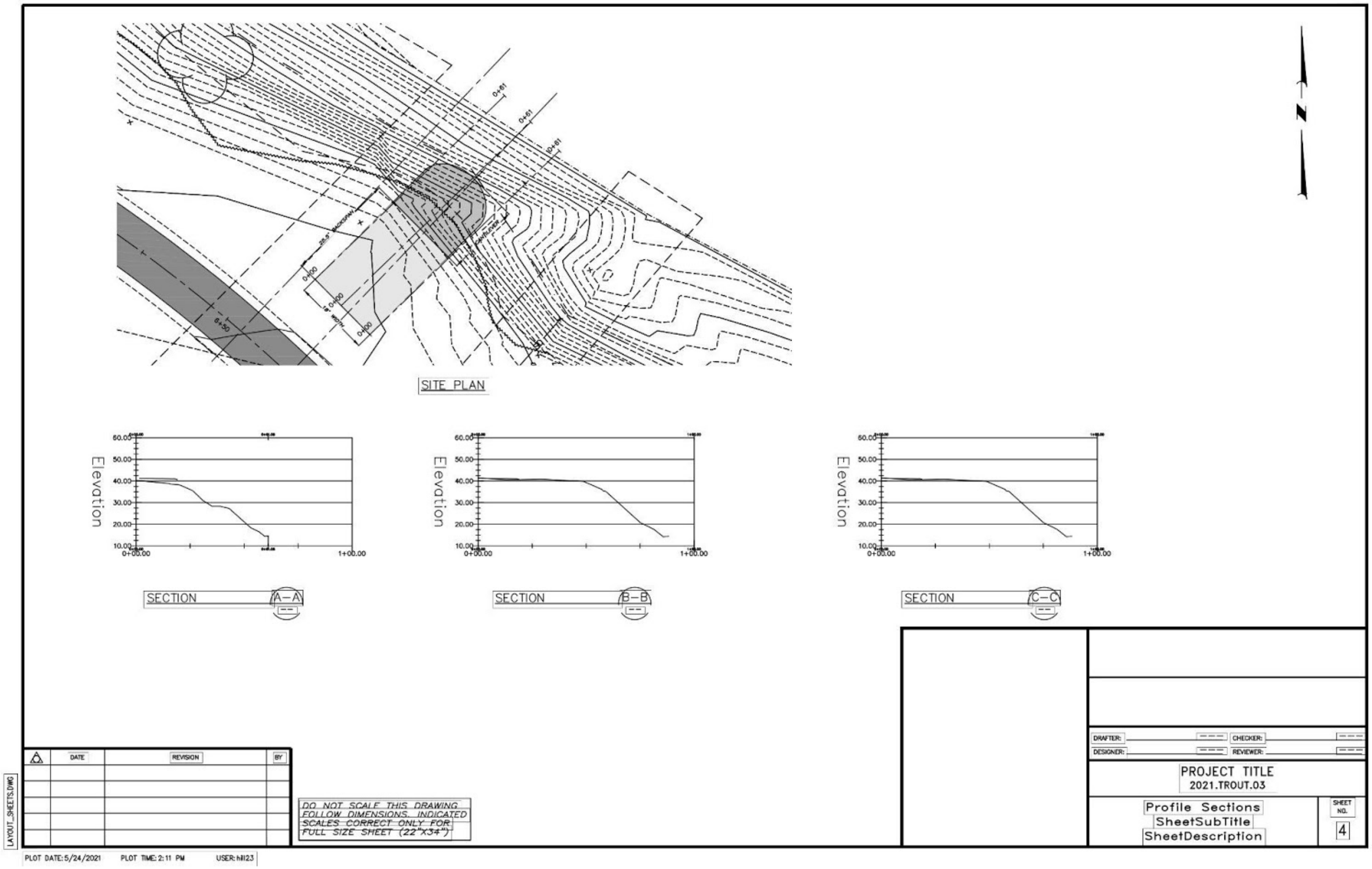
APPENDIX C

DRAWINGS


INDEX OF SHEETS
1 TITLE SHEET
2 INDEX OF SHEETS CONT.
2021.TROUT.03
OBSERVATION DECK
PORTLAND STATE UNIVERSITY CEE
PROJECT LOCATION
PROJECT LOCATION
PROJECT LOCATION
DATE
REVISION
BY
LAYOUT_SHEETS.DWG
PLOT DATE: 5/24/2021
PLOT TIME: 3:03 PM
USER: hil23
DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")
DRAFTER:
CHECKER:
DESIGNER:
REVIEWER:
PROJECT TITLE
2021.TROUT.03
COVER SHEET
SheetSubTitle
SheetDescription
SHEET NO.
1


INDEX OF SHEETS
3 GENERAL CONST.
4 PROFILE SECTIONS
5 STANDARD DETAILS
6 PED RAIL DETAIL
DATE
REVISION
BY
DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")
DRAFTER:
CHECKER:
DESIGNER:
REVIEWER:
PROJECT TITLE
2021.TROUT.03
SheetTitle
SheetSubTitle
SheetDescription
SHEET NO.
2
LAYOUT_SHEETS.DWG
PLOT DATE: 5/24/2021
PLOT TIME: 3:11 PM
USER: hll23


NOTES:
1. Pedestrian trail to be even with finished grade
2. 1.5' reinforced concrete beam
3. W10 x 54 Grade 60 steel stringers spaced 2' O.C.
4. Pedestrian railing
50.00
40.00
30.00
20.00
A SECTION
17.0'
25.5'
18.0'
SUBSTRUCTURE PLAN
DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")
DATE
REVISION
BY
PLOT DATE: 5/24/2021
PLOT TIME: 3:44 PM
USER: Elizabeth
LAYOUT_SHEETS.DWG
DRAFTER: EQG
CHECKER:
DESIGNER:
REVIEWER:
OBSERVATION DECK
2021.TROUT.03
SUBSTRUCTURE
PLAN & PROFILE
DETAILS
SHEET NO.
#



N
SITE PLAN
Elevation
60.00
50.00
40.00
30.00
20.00
10.00
0+00.00
1+00.00
SECTION A–A
SECTION B–B
SECTION C–C
DATE
REVISION
BY
DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")
DRAFTER:
CHECKER:
DESIGNER:
REVIEWER:
PROJECT TITLE
2021.TROUT.03
Profile Sections
SheetSubTitle
SheetDescription
SHEET NO.
4
LAYOUT_SHEETS.DWG
PLOT DATE: 5/24/2021
PLOT TIME: 2:11 PM
USER: hll23

DETAILS TO BE INCLUDED IN 30% SUBMITTAL

△	DATE	REVISION	BY

DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")

DRAFTER: --- CHECKER: ---
DESIGNER: --- REVIEWER: ---

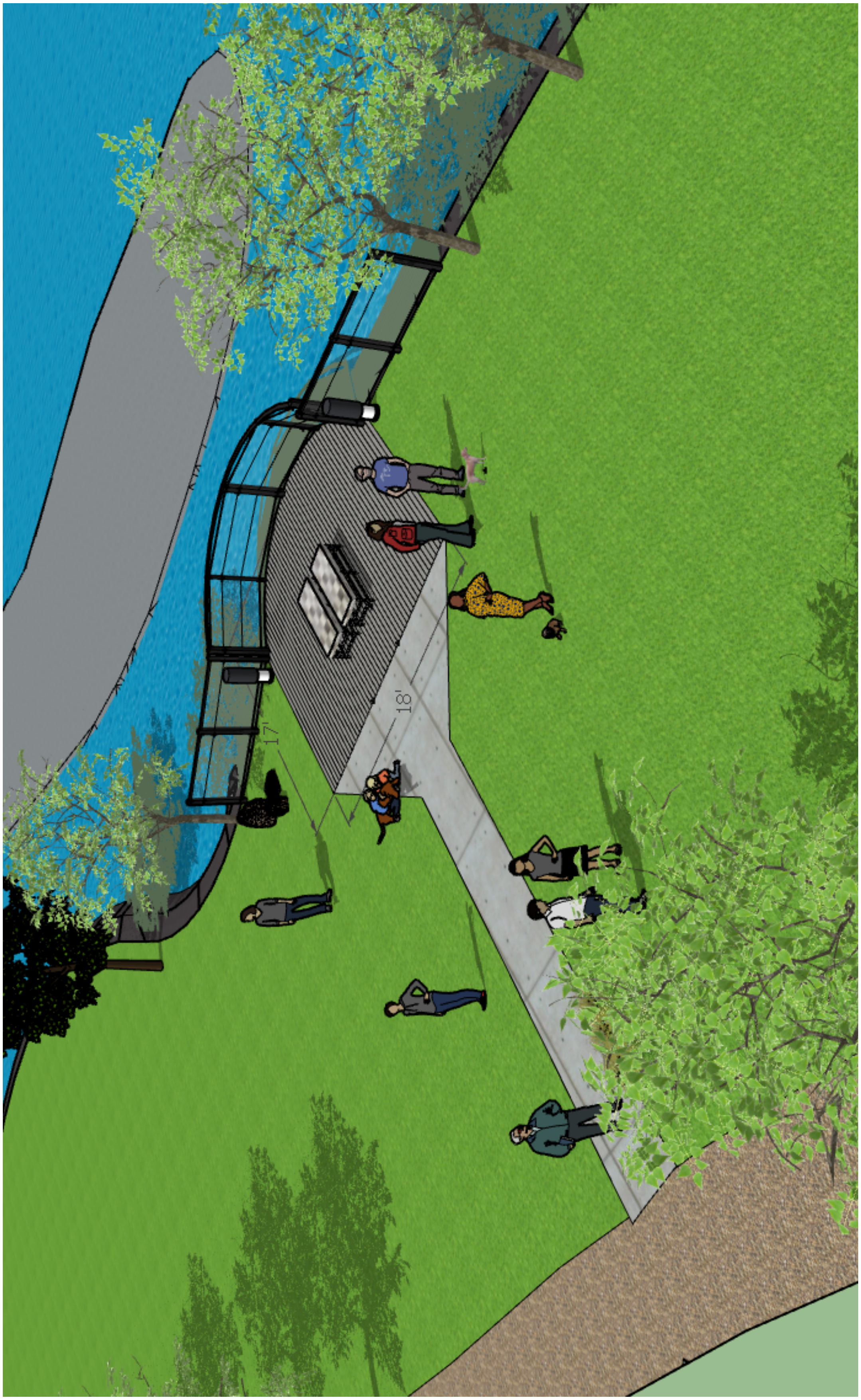
PROJECT TITLE
2021.TROUT.03

SheetTitle
SheetSubTitle
SheetDescription

SHEET NO. 5

LAYOUT_SHEETS.DWG

PLOT DATE: 5/24/2021 PLOT TIME: 9:15 PM USER: hll23


17'
18'

APPENDIX D
CALCULATIONS

DESIGN INPUTS

Key Assumptions

$n_{R/C}$	2	[-]	*Number of R/C Girders*

Geometry

Deck Dimensions

B_{deck}	18	[ft]	*Deck width*
L_{deck}	17	[ft]	*Deck cantilever length*
L_{back}	25.5	[ft]	*Deck backspan length*
d_{deck}	3	[in]	*Pultruded Fiberglass decking depth*

Steel Stringer Dimensions

$L_{stringer}$	18	[ft]	*Length of steel stringers supporting the decking*
$d_{stringer}$	10.1	[in]	*Depth of steel stringers supporting the decking*
S_{center}	3.4	[ft]	*Center-to-center span between steel stringers (from Steel Stringer Design)*

Reinforced Conrete (R/C) Beams

$L_{R/C}$	42.5	[ft]	*Length of R/C Girder ($L_{deck} + L_{back}$)*
$b_{R/C}$	18	[in]	*Width of R/C Girder (from R/C Girder Design)*
$b_{R/C}$	1.5	[ft]	*Width of R/C Girder*

$h_{R/C}$	30	[in]	*Height of R/C Girder (from R/C Girder Design)*
$h_{R/C}$	2.5	[ft]	*Height of R/C Girder*

AASHTO Design Vehicle Geometry

L_{veh}	14	[ft]	*Axle-to-axle length of the vehicle*
b_{veh}	6	[ft]	*Tire-to-tire width of the vehicle*

Material Properties

p_{deck}	17.7	[psf]	*Pultruded Fiberglass area weight (Model HI3730)*

$\gamma_{asphalt}$	145	[pcf]	*Asphalt overlay unit weight*
$t_{asphalt}$	0.5	[in]	*Asphalt overlay thickness (0.5" - 1")*
$w_{asphalt}$	6.04	[psf]	*Asphalt overlay weight*

w_{steel}	54	[plf]	*Steel stringer linear weight (from Steel Stringer Design)*
γ_{conc}	150	[pcf]	*Reinforced concrete unit weight*

Live Loads

AASHTO Design Vehicle Load

Locations measured parallel to the cantilever length, origin at the end of cantilever

P_{veh}	20	[kip]	*Total design H10 vehicle load (AASHTO Ped Bridge Design Table 3.2-1)*
$P_{veh.f}$	4	[kip]	*Vehicle load distributed to front axle*
$P_{veh.r}$	16	[kip]	*Vehicle load distributed to rear axle*
$x_{veh.f}$	14.0	[ft]	*Vehicle front axle load location*
$x_{veh.r}$	0	[ft]	*Vehicle rear axle load location*

Location measured perpendicular to the cantilever length, origin at longitudinal centerline of deck

y_{veh}	3	[+/- ft]	*Vehicle load location*

ORSS Live Loads

Locations measured parallel to the cantilever length, origin at the end of cantilever

p_L	100	[psf]	*Pedestrian area live load via ORSS Table 1607.1 36. "Exterior foot bridge"*
P_L	1	[kip]	*Pedestrian point live load via ORSS Table 1607.1 36. Exterior foot bridge*
x_L	0.5	[ft]	*Pedestrian concentrated live load location*

Location measured perpendicular to the cantilever length, origin at longitudinal centerline of deck

y_L	0	[+/- ft]	*Pedestrian concentrated live load location*

CALCULATED STEEL STRINGER LOADS

Dead Loads

Exterior Stringers, @ 0' from cantilever end, affected by vehicle load

$B_{Trib.steel}$	1.7	[ft]	*Tributary width (end stringer)*

$w_{d.steel}$	94.36	[plf]	*Total dead load acting on steel stringers*
$R_{d.steel}$	0.85	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Interior Stringers (3, unaffected by vehicle load)

$B_{Trib.steel}$	3.4	[ft]	*Tributary width*
$w_{d.steel}$	134.72	[plf]	*Total dead load acting on steel stringers*
$R_{d.steel}$	1.21	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Interior Stringer, @ 13.6', affected by vehicle load

$B_{Trib.steel}$	3.4	[ft]	*Tributary width*
$w_{d.steel}$	134.72	[plf]	*Total dead load acting on steel stringers*
$R_{d.steel}$	1.21	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Exterior Stringers, @ 17' from cantilever end, affected by vehicle load

$B_{Trib.steel}$	1.7	[ft]	*Tributary width (end stringer)*
$w_{d.steel}$	94.36	[plf]	*Total dead load acting on steel stringers*
$R_{d.steel}$	0.85	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Live Loads

Exterior Stringer, @ 0' from cantilever start

$B_{Trib.steel}$	1.7	[ft]	*Tributary width (end stringer)*
$w_{l.steel}$	170.00	[plf]	*Lineal live load acting on steel stringers*
$P_{l.steel}$	17.00	[kip]	*Concentrated live load acting on steel stringers*
$R_{l.steel}$	10.03	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Interior Stringers (3 of them, unaffected by vehicle load)

$B_{Trib.steel}$	3.4	[ft]	*Tributary width*
$w_{l.steel}$	340.00	[plf]	*Lineal live load acting on steel stringers*
$R_{l.steel}$	3.06	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Interior Stringer, @ 13.6' affected by vehicle load

$B_{Trib.steel}$	3.4	[ft]	*Tributary width*
$w_{l.steel}$	340.00	[plf]	*Lineal live load acting on steel stringers*
$P_{l.steel}$	3.53	[kip]	*Concentrated live load acting on steel stringers (front axle vehicle loads)*
$R_{l.steel}$	4.82	[kip]	*Reactions at either R/C Girder (symmetrical loading pattern)*

Exterior Stringer, @ 17' affected by vehicle load

$B_{Trib.steel}$	1.7	[ft]	*Tributary width (end stringer)*
$w_{l.steel}$	170.00	[plf]	*Lineal live load on steel stringers (pedestrian uniformly distributed load)*
$P_{l.steel}$	0.47	[kip]	*Concentrated live load acting on steel stringers (front axle vehicle loads)*
$R_{l.steel}$	1.53	[kip]	*Reactions at one R/C Girder (symmetrical for both girders)*

Ultimate Factored Reactions

All locations measured parallel to the cantilever length, origin at the end of cantilever

Exterior Stringer, @ 0' from cantilever start

$R_{d.steel}$	0.85	[kip]	*Dead load reaction*
$R_{l.steel}$	10.03	[kip]	*Live load reaction*
R_{u1}	1.19	[kip]	*LRFD combo #1:* $P_u = 1.4P_D$
R_{u2}	17.07	[kip]	*LRFD combo #2:* $P_u = 1.2P_D + 1.6P_L$

R_u	17.07	[kip]	*Ultimate Reaction (max of the two combos)*

x	0.00	[ft]	*Steel stringer location*

Interior Stringers (3 of them, unaffected by vehicle load)

$R_{d.steel}$	1.21	[kip]	*Dead load reaction (same for all 3 stringers)*
$R_{l.steel}$	3.06	[kip]	*Live load reaction (same for all 3 stringers)*
R_{u1}	1.70	[kip]	*LRFD combo #1:* $P_u = 1.4P_D$
R_{u2}	6.35	[kip]	*LRFD combo #2:* $P_u = 1.2P_D + 1.6P_L$

R_u	6.35	[kip]	*Ultimate Reaction (max of the two combos)*

x_1	3.40	[ft]	*Interior steel stringer 1 location*

x_2	6.80	[ft]	*Interior steel stringer 2 location*

x_3	10.20	[ft]	*Interior steel stringer 3 location*

Interior Stringer, @ 13.6' impacted by vehicle load

$R_{d.steel}$	1.21	[kip]	*Dead load reaction*
$R_{l.steel}$	4.82	[kip]	*Live load reaction*
R_{u1}	1.70	[kip]	*LRFD combo #1:* $P_u = 1.4P_D$
R_{u2}	9.17	[kip]	*LRFD combo #2:* $P_u = 1.2P_D + 1.6P_L$

R_u	9.17	[kip]	*Ultimate Reaction (max of the two combos)*

x	13.60	[ft]	*Steel stringer location*

Exterior Stringer, @ 17'

$R_{d.steel}$	0.85	[kip]	*Dead load reaction*
$R_{l.steel}$	1.53	[kip]	*Live load reaction*
R_{u1}	1.19	[kip]	*LRFD combo #1:* $P_u = 1.4P_D$
R_{u2}	3.47	[kip]	*LRFD combo #2:* $P_u = 1.2P_D + 1.6P_L$

R_u	3.47	[kip]	*Ultimate Reaction (max of the two combos)*

x	17.00	[ft]	*Steel stringer location*

DESIGN INPUTS

Loading

$M_{u\text{-}pos}$	0	[kip ft]	*Max. positive moment obtained from SAP2000 Model*
$M_{u\text{-}neg}$	660	[kip ft]	*Max. negative moment obtained from SAP2000 Model*
V_u	77	[kips]	*Max. shear obtained from SAP2000 Model*

Concrete Detail

Concrete Dimensions and Properties

b	22	[in]	*Girder thickness*
h	32.5	[in]	*Girder depth*
L_1	25.5	[ft]	*Length of backspan*
L_2	17	[ft]	*Length of cantilever*
f'_c	4	[ksi]	*Concrete strength*
w_c	150	[pcf]	*Weight of concrete*
Conc. Cover	3	[in]	*Concrete cover*
β_1	0.85	[-]	*ACI Table 22.2.2.4.3*
w_{self}	744.79	[plf]	*Lineal self-weight of the girder*

Reinforcement Details

Steel Properties

f_y	60	[ksi]	*ACI Table 22.2.2.4.3*
E_s	29000	[ksi]	*Modulus of Elasticity for Steel*

Bottom Steel

Bar No.	#10	[-]	*Bar size*
A_{bar}	1.27	[in^2]	*Bar area*
d_{bar}	1.27	[in]	*Bar diameter*
# of Bars	2	[-]	

Top Steel

Bar No.	#10	[-]	*Bar size*

A_{bar}	1.27	[in^2]	*Bar area*
d_{bar}	1.27	[in]	*Bar diameter*
# of Bars	6	[-]	

Shear Steel

Bar No.	#4	[-]	*Bar size*
A_{bar}	0.2	[in^2]	*Bar area*
d_{bar}	0.5	[in]	*Bar diameter*
s	10	[in]	*Stirrup spacing*

GIRDER CALCULATIONS

Negative Moment Girder Design

Effective Depth

d	29.5	[in]	*Effective depth to tension steel centroid*
d'	3.00	[in]	*Effective depth to compression steel centroid*

Area of Steel

A'_s	2.54	[in^2]	*Area of compression steel*
A_s	7.62	[in^2]	*Area of tension steel*

Stress Block Depth

Case 1: If $\varepsilon_s' < \varepsilon_y$

c	7.19	[in]	*Compression zone depth ACI 22.2.2.4.1*
ε_y	0.00207	[in/in]	*Longitudinal reinforcement tensile yield strain ACI 21.2.2*
ε_s'	0.00175	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*
$\varepsilon_s' < \varepsilon_y$	CASE 1	[-]	*Check if steel is yielding, if steel has yielded than assumption is valid, if steel has not yielded, Case 2 is valid.*

Case 2: If $\varepsilon_s' > \varepsilon_y$

c	5.58	[in]	*Compression zone depth ACI 22.2.2.4.1*
ε_s'	0.00139	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*

ε_t	0.0129	[in/in]	*Longitudinal reinforcement tensile strain @ Ult. (in/in)*

Moment Capacity

a	6.11	[in]	*Stress block depth*
ε_s'	0.00175	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*
ε_t	0.0129	[in/in]	*Longitudinal reinforcement tensile strain @ Ult. (in/in)*
f'_s	60.0	[ksi]	*Longitudinal reinforcement compression stress*
A_{s1}	5.08	[in^2]	
A_{s2}	2.54	[in^2]	

M_{n1}	8060	[kip in]	*Nominal moment for A_{s1}*
M_{n2}	4039	[kip in]	*Nominal moment for A_{s2}*
φ_b	0.90	[-]	*Strength reduction factor for moment ACI 21.2.2*
$\varphi_b M_n$	10889	[kip in]	*Factored nominal moment*

Demand to Capacity Ratio

$M_{u\text{-}neg}$	660	[kip ft]	*Max. negative moment*
$\varphi_b M_n$	907	[kip ft]	*Factored nominal moment*
$M_u/\varphi_b M_n$	0.73	[-]	*Demand-capacity ratio*

$M_u < \varphi_b M_n$	OK	[-]	*Factored nominal moment strength check*

Positive Moment Girder Design

Effective Depth

d	29.50	[in]	*Effective depth to tension steel centroid*
d'	3.00	[in]	*Effective depth to compression steel centroid*

Area of Steel

A'_s	7.62	[in^2]	*Area of compression steel*
A_s	2.54	[in^2]	*Area of tension steel*

Stress Block Depth

Case 1: If $\varepsilon_s' < \varepsilon_y$

c	2.40	[in]	*Compression zone depth ACI 22.2.2.4.1*
ε_y	0.00207	[in/in]	*Longitudinal reinforcement tensile yield strain ACI 21.2.2*
ε_s'	-0.00075	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*
$\varepsilon_s' < \varepsilon_y$	CASE 2	[-]	*Check if steel is yielding, if steel has yielded than assumption is valid, if steel has not yielded, Case 2 is valid.*

Case 2: If $\varepsilon_s' > \varepsilon_y$

c	2.87	[in]	*Compression zone depth ACI 22.2.2.4.1*
ε_s'	0.00014	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*
ε_t	0.0278	[in/in]	*Longitudinal reinforcement tensile strain @ Ult. (in/in)*

Moment Capacity

a	2.04	[in]	*Stress block depth*
ε_s'	0.00014	[in/in]	*Longitudinal reinforcement compression strain @ Ult. ACI 21.2.2*
ε_t	0.0278	[in/in]	*Longitudinal reinforcement tensile strain @ Ult. (in/in)*
f'_s	3.9	[ksi]	*Longitudinal reinforcement compression stress*
A_{s1}	2.04	[in^2]	
A_{s2}	0.50	[in^2]	

M_{n1}	3484	[kip in]	*Nominal moment for* A_{s1}
M_{n2}	797	[kip in]	*Nominal moment for* A_{s2}
φ_b	0.90	[-]	*Strength reduction factor for moment ACI 21.2.2*
$\varphi_b M_n$	3853	[kip in]	*Factored nominal moment*

$M_{u\text{-}pos}$	0	[kip ft]	*Max. positive moment*
$\varphi_b M_n$	321	[kip ft]	*Factored nominal moment*
$M_u/\varphi_b M_n$	0	[-]	*Demand-capacity ratio*

$M_u < \varphi_b M_n$	OK	[-]	*Factored nominal moment strength check*

Shear Design

V_c	82.1	[kips]	*Shear strength of concrete*
V_s	70.8	[kips]	*Shear strength of steel*
V_n	152.9	[kips]	*Nominal shear strength*

φ_v	0.75	[-]	*Strength reduction factor for shear ACI 21.2.1*
$\varphi_v V_n$	114.7	[kips]	*Factored nominal shear*

$V_u/\varphi_v V_n$	0.67	[-]	*Demand-capacity ratio*
$V_u < \varphi_v V_n$	OK	[-]	*Factored nominal shear strength check*

DESIGN CHECKS

Min. Girder Thickness

Backspan

$\ell/16$	19.1	[in]	*Min. thickness for length of backspan*

Cantilever

$\ell/8$	25.5	[in]	*Min. thickness for length of cantilever*

Design Check

$h \geq h_{min}$	OK	[-]	*Girder thickness must be greater than min. thickness*

Steel Reinforcement Ratio Check

ρ_{max}	0.021	[-]	*Max. reinforcing ratio*
ρ_{min}	0.1	[-]	*Min. reinforcing ratio*
ρ	0.016	[-]	*Reinforcing ratio*

$\rho_{min} < \rho < \rho_{ma}$	OK	[-]	*Reinforcing ratio check*

Bar Spacing

b_{min}	15.0	[in]	*Minimum width for bars need to be spaced properly ACI 25.2.1*
$b > b_{min}$	OK	[-]	*Bar spacing check*

STEEL STRINGER ANALYSIS AND DESIGN

Assumptions

Cross-Sectional Properties and Geometry

Designation	W10 X 54		
F_y	60	[ksi]	*Grade of steel*
A	15.80	[in^2]	*Gross cross sectional area*
d	10.10	[in]	*Actual beam depth*
t_f	0.62	[in]	*Flange thickness*
b_f	10.00	[in]	*Flange width*
t_w	0.37	[in]	*Web thickness*
I_x	303.00	[in^4]	*Moment of inertia about lateral axis*
r_x	4.37	[in]	*Radius of gyration about lateral axis*
I_y	103.00	[in^4]	*Moment of inertia about vertical axis*
r_y	2.56	[in]	*Radius of gyration about vertical axis*
Z_x	60	[in^3]	*Plastic section modulus*
A_{web}	3.28	[in^2]	*Area of web*
J	1.71	[in^4]	*Torsion Constant [note formula used in this sheet is **ONLY** for a W beam]*
w_{self}	54	[plf]	*Self weight*

Overall Stringer Dimensions

Braces	0	[-]	*Number of equally spaced braces to prevent flexural torsional buckling*
L	18	[ft]	*Beam length*
S	3.4	[ft]	*Beam OC spacing*

Structural Analysis

Loads

w_{D1}	17.70	[psf]	*Dead load from pultruded fiberglass decking*
w_{D2}	6.04	[psf]	*Dead load from asphalt overlay*
w_L	100	[psf]	*Pedestrian area live load via ORSS Table 1607.1 36. Exterior foot bridge*
P_L	1000	[lbs]	*Pedestrian concentrated live load via ORSS Table 1607.1 36. Exterior foot bridge*
$P_{HL10(Rear)}$	8	[kips]	*Vehicular point load*
w_u	301.66	[plf]	*Ultimate uniform load*
P_{u1}	14.4	[kips]	*Ultimate point load 1 includes P_L and $P_{H10(Rear)}$*

P_{u2}	12.8	[kips]	*Ultimate point load 2 includes $P_{H10(Rear)}$*

Reactions and Governing Internal Forces

Assuming stringer is simply supported

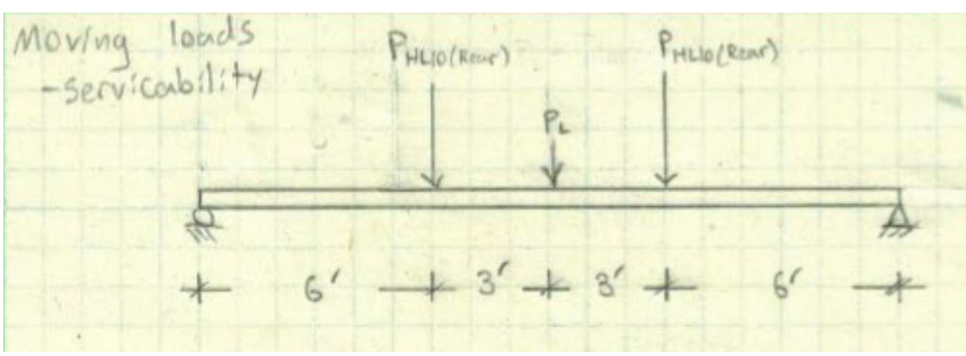
R_y	25.65	[kips]	*Vertical Reaction*
V_u	25.65	[kips]	*Max Shear*
M_u	1190.75	[kip in]	*Max Moment*

Structural Design

Servicability

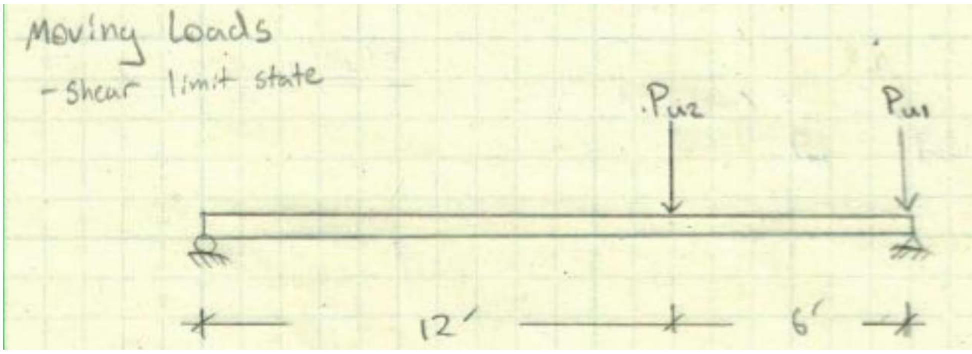
$\Delta_{max(D+L)}$	0.90	[in]	*Maximum deflection limit per ORSS 1604.3.3*
Δ_{D+L}	0.48	[in]	*Deflection of designated beam under service loads $W_D + W_L$ and $P_L + P_{HL10(Rear)}$*
$\Delta_{D+L} < \Delta_{max(D+L)}$?	Pass	[-]	*Check serviceability of Dead + Live*

$\Delta_{max(L)}$	0.60	[in]	*Maximum deflection limit per ORSS 1604.3.3*
Δ_L	0.44	[in]	*Deflection of designated beam under service loads W_L and $P_L + P_{HL10(Rear)}$*
$\Delta_L < \Delta_{max(L)}$?	Pass	[-]	*Check serviceability of Live*



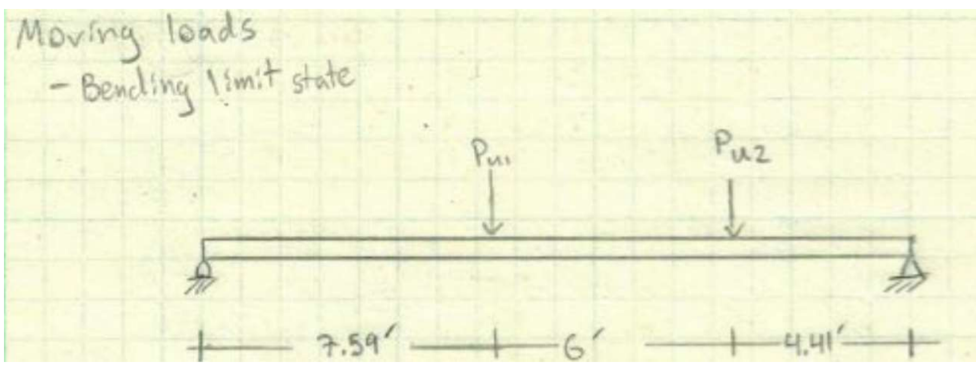
Shear Strength Limit State

φ_v	0.7	[-]	*Reduction factor for shear*
V_n	118.15	[kips]	*Nominal shear strength*
$V_u < \varphi_v V_n$?	Pass	[-]	*Test shear*
$(D/C)_V$	0.31	[-]	*Demand to capacity ratio for shear*



Bending Strength Limit State

φ_b	0.7	[-]	*Reduction factor for bending (flexure)*
M_n	3600	[kip in]	*Nominal moment strength*
$M_u < \varphi_b M_n$?	Pass	[-]	*Test bending*
$(D/C)_b$	0.47	[-]	*Demand to capacity ratio for bending*



Flexural Buckling Limit State

F_e	117.15	[ksi]	*Eulerian Buckling Stress*
$L_c/r<4.71(E/F_y)^{0.5}$	Eq E3-2	[-]	*Determine if buckling is Eulerian*
F_{cr}	102.74	[ksi]	*Critical Buckling Stress*
P_n	1623.34	[kips]	*Nominal internal buckling force capacity*

Flexural-Torsional Buckling Limit State

$r_0^{\ 2}$	51.10	[in^2]	
H	0.91	[in^{-1}]	
F_{ey}	40.20	[ksi]	*Eulerian Buckling Stress in y direction*
F_{ez}	23.73	[ksi]	*Eulerian Buckling Stress in z direction*
F_e	21.45	[ksi]	*Eulerian Buckling Stress*

$F_y/F_e < 2.25$?	Eq E3-3	[-]	*Determine if buckling is Eulerian*
F_{cr}	18.81	[ksi]	*Critical Buckling Stress*
P_n	297.27	[kips]	*Nominal internal buckling force capacity*

Buckling Checks

L_{eff}	18	[ft]	*Effective buckling length with bracing*
φ	0.7	[-]	*Buckling reduction factor*
P_u	191.60	[kips]	*Maximum internal force in beam flange calculated from extreme fiber stress*
$P_u < \varphi*min(P_n)$	Pass	[-]	*Testing Buckling*
DCR	0.92	[-]	*Demand to capacity ratio for buckling*

DESIGN INPUTS

Assumptions

Modulus of Elasticity

Calculated using different fiberglass decking models from the same manufacturer

E	4107143	[psi]	*E value used for 2" deep T3320*
E	631313	[psi]	*E value used for 1" deep I4010*
E	1458333	[psi]	*E value used for 1-1/2" deep I4015*

E	4107143	[psi]	*E value providing most conservative deflections*

Loading

P	10400	[lb]	*1/2 AASHTO H-10 Truck + 1.3 Upscale for Impact*

Deflection Calculations

1" Deep HI3710

S_{max}	40	in	*Max allowable span from manufacturer*
FS	3	[-]	*Factor of safety*
S	1.1	[ft]	

1-1/2" Deep HI3715

S_{max}	55	in	*Max allowable span from manufacturer*
FS	3	[-]	*Factor of safety*
S	1.5	[ft]	

2" Deep HI3720

S_{max}	68	in	*Max allowable span from manufacturer*
FS	3	[-]	*Factor of safety*
S	1.9	[ft]	

2-1/2" Deep HI3725

S_{max}	81	in	*Max allowable span from manufacturer*
FS	3	[-]	*Factor of safety*
S	2.2	[ft]	

3" Deep HI3730

S_{max}	92	in	*Max allowable span from manufacturer*
FS	3	[-]	*Factor of safety*
S	2.6	[ft]	

Use 3" Deep HI3730

Provides the greatest span

COMPRESSION PILE DESIGN

Site Soil Engineering Properties

Layer 1:

Soil Type	Fill	[-]	
z_1	52 to 15	[ft]	*Layer Depth*
γ_1	130.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_1	40.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Layer 2:

Soil Type	;and + Grave	[-]	
z_2	15 to - 5	[ft]	*Layer Depth*
γ_2	125.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_2	38.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Layer 3:

Only measuring to the bottom of the pile. This layer continues.

Soil Type	Silty Clay	[-]	
z_3	-5 to -8	[ft]	*Layer Depth*
γ_3	120.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_3	34.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Skin Friction Calculations

u, eff. vert stress, qs, and Qs are calculated based only on the depth of each layer. These values are added in a cumulative fashion to calculate Total Qs

Layer 1:

Soil Type	Fill	[-]	
t_1	37	[ft]	*Layer thickness*
u_1	748.80	[psf]	*Pore Water Pressure, u*
γ_1	130.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,1}$	4061.20	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_1	0.643	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_1	26.00	[deg]	*Friction Angle for Pile Material δ*
δ_1	0.454	[rad]	
q_{s1}	177125	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	37.00	[ft]	*Pile length*
Q_{s1}	20588785	[lb]	*Total Skin Friction, Qs = qs*π*D*L*

Layer 2:

Soil Type	and + Grave	[-]	
t_2	20	[ft]	*Layer thickness*
u_2	1248.00	[psf]	*Pore Water Pressure, u*
γ_2	125.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,2}$	1252.00	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_2	0.692	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_2	24.70	[deg]	*Friction Angle for Pile Material δ*
δ_2	0.431	[rad]	
q_{s2}	2071	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	20.00	[ft]	*Pile length*
Q_{s2}	130122	[lb]	*Total Skin Friction, Qs = qs*π*D*L*

Layer 3:

Soil Type	Silty Clay	[-]

t_3	3	[ft]	*Layer thickness*
u_3	187.20	[psf]	*Pore Water Pressure, u*
γ_3	120.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,3}$	5212.80	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_2	0.793	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_3	22.10	[deg]	*Friction Angle for Pile Material δ*
δ_3	0.052	[rad]	
q_{s3}	73289	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	3.00	[ft]	*Pile length*
Q_{s3}	53690	[lb	*Total Skin Friction, Qs = qs*π*D*L*
Q_s	20772597	[lb]	*Total Skin Friction Qs (lb)*

End Bearing Calculations

Soil Type	Silty Clay	[-]	*Total End Bearing (lb)*
φ'	34	[deg]	*Friction Angle φ'*
φ'	0.593	[rad]	*Friction Angle φ'*
N_q	29.40	[-]	
q_p	19.83	[psf]	*Unit End Bearing* $q_p = \sigma'_{v0} * N_q * 50 \leq (\tan\varphi') * N_q$
A_{base}	0.785	[ft^2]	*Area of the pile base*
Q_p	15.60	[lb]	*Total End Bearing (lb)* $Q_p = q_p * A_{base}$

Bearing Capacities: Q ultimate, Q allowable, # of Piles

Q_{ult}	2072613	[lb]	*Qult = Qp + Qs*
FS	3	[-]	
Q_{all}	6924204	[lb]	*Qall = Qult/FS*
Factored load	30181140	[lb]	
# of piles	4.00	[-]	

TENSION PILE DESIGN

Site Soil Engineering Properties

Layer 1:

Soil Type	Fill	[-]	
z_1	52 to 15	[ft]	*Layer Depth*
γ_1	130.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_1	40.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Layer 2:

Soil Type	Sand + Grave	[-]	
z_2	15 to - 5	[ft]	*Layer Depth*
γ_2	125.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_2	38.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Layer 3:

Only measuring to the bottom of the pile. This layer continues.

Soil Type	Silty Clay	[-]	
z_3	-5 to -8	[ft]	*Layer Depth*
γ_3	120.00	[pcf]	*Soil Unit Weight*
Strength Type	M-C	[-]	*Strength Type (M-C = Mohr-Coulomb)*
c	0.00	[psf]	*Cohesion*
φ_3	34.00	[deg]	*Friction Angle φ*
z_w	25.00	[ft]	*Water Table Depth*

Skin Friction Calculations

u, eff. vert stress, qs, and Qs are calculated based only on the depth of each layer. These values are added in a cumulative fashion to calculate Total Qs

Layer 1:

Soil Type	Fill	[-]	
t_1	37	[ft]	*Layer thickness*
u_1	748.80	[psf]	*Pore Water Pressure, u*
γ_1	130.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,1}$	4061.20	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_1	0.643	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_1	26.00	[deg]	*Friction Angle for Pile Material δ*
δ_1	0.454	[rad]	
q_{s1}	177125	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	37.00	[ft]	*Pile length*
Q_{s1}	8519017	[lb]	*Total Skin Friction, Qs = qs*π*D*L*

Layer 2:

Soil Type	Sand + Grave	[-]	
t_2	20	[ft]	*Layer thickness*
u_2	1248.00	[psf]	*Pore Water Pressure, u*
γ_2	125.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,2}$	1252.00	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_2	0.692	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_2	24.70	[deg]	*Friction Angle for Pile Material δ*
δ_2	0.431	[rad]	
q_{s2}	11517	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	20.00	[ft]	*Pile length*
Q_{s2}	723642	[lb]	*Total Skin Friction, Qs = qs*π*D*L*

Layer 3:

Soil Type	Silty Clay	[-]

t_3	3	[ft]	*Layer thickness*
u_3	187.20	[psf]	*Pore Water Pressure, u*
γ_3	120.00	[pcf]	*Soil Unit Weight*
$\sigma'_{v0,3}$	5212.80	[psf]	*Effective Vertical Stress for Layer σ'v0*
K_2	0.793	[-]	*Lateral Earth Pressure Coefficient K = (1.8)*(Ko)*
δ_3	22.10	[deg]	*Friction Angle for Pile Material δ*
δ_3	0.385	[rad]	
q_{s3}	6350	[psf)	*Unit Skin Friction, qs = K*σ'v0*tanδ*
D	1.00	[ft]	*Pile diameter*
P	3.14	[ft]	*Pile perimeter*
L	3.00	[ft]	*Pile length*
Q_{s3}	59848	[lb	*Total Skin Friction, Qs = qs*π*D*L*

Q_s	20772597	[lb]	*Total Skin Friction Qs (lb)*

End Bearing Calculations

End bearing not considered for tension piles

Q_p	0.00	[lb]	*Total End Bearing (lb)*

Bearing Capacities: Q ultimate, Q allowable, # of Piles

Q_{ult}	9302507	[lb]	$Q_{ult} = Q_p + Q_s$
FS	3	[-]	*Factor of Safety*
Q_{all}	3100836	[lb]	$Q_{all} = Q_{ult}/FS$
Factored load	111826000	[lb]	
# of piles	4.00	[-]	

<u>APPENDIX E</u>

SITE PHOTOS

Sandy River Observation Deck

Group: 2021.TROUT.03

Project Purpose and Background

- **Location:**
  - Sandy Riverfront Park in Troutdale, OR
  - South of I-84, north of downtown Troutdale, east of the Columbia Gorge Outlets

Figure 1: Project location

- **Objectives:**
  - Design a cantilevered observation deck with a scenic view of the Sandy River
  - The deck must blend with the flow of the nearby planned trail
  - Provide a space for local trail users to slow down and enjoy the scenic riverfront
  - Orient the deck to face the railroad bridge across a scenic bluff to the southeast

Existing Site Conditions

- Site use and layout has changed several times in the last 100 years
  - In that time, the river course has remained unchanged
- Soil is mostly fill, loose and gravelly
- Moderately vegetated with grass, blackberry, and several species of trees
- Stormwater drainage pipe with an easement south of the site

Figure 2: Aerial view of the project location, retrieved via drone

Alternatives Analysis

TABLE 1: Pugh Matrix used in the Alternative Analysis

ALTERNATIVE TITLE & DESCRIPTION	CRITERIA Cost	Constructability	Environmental Impact	User Experience	Resiliency and Strength	Maintenance	Permitting
1) Large Deck, Cable-Stayed	1	1	3	5	5	4	3
2) Large Deck, Cantilevered	2	2	3	4	2	1	3
3) Small Cantilever Deck	4	3	3	2	3	2	4
4) Small Deck, Wide and Shallow	3	4	4	2	4	3	4
5) No-Build	5	5	5	1	5	5	5
CRITERIA WEIGHTS	*9*	*6*	*5*	*7*	*8*	*9*	*8*

Alternative Design Solution

TABLE 2: Alternative Scoring

ALTERNATIVE TITLE & DESCRIPTION	TOTAL SCORE	Order by high-score to low
1) Large Deck, Cable-Stayed	165	2nd
2) Large Deck, Cantilevered	122	4th
3) Small Cantilever Deck	157	3rd
4) Small Deck, Wide and Shallow	176	1st
5) No-Build	232	N/A

- **Key Criteria:**
  - Maintenance, Cost and Strength
  - Higher total scores indicate the alternative is preferable
- Design must optimize user experience and comply with regulations
- Provide aesthetic views to the Sandy River

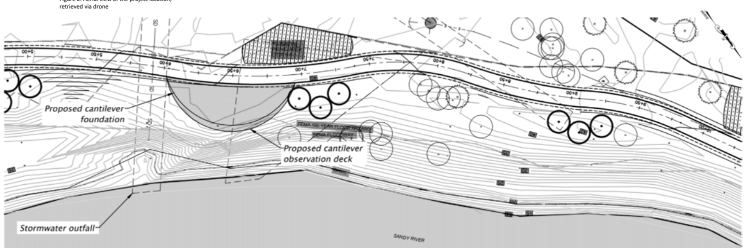


Figure 5: Alternative 4 Small Deck, Wide and Shallow

Aerial View and Drone Pictures

- Accurate aerials for conceptual design and drafting
- 2D orthomosaic imaging for large, high-resolution photos
- Required FAA authorization to fly in local airport airspace

Figure 3: View of the site facing southeast towards the scenic bluff, retrieved via drone

Consideration for Professional Practice

- This capstone team is split up into different departments:
  - Geotechnical Design
  - Structural Design
  - CAD Team
  - General Civil
- Each team is managed by an APM

Figure 4: Organizational Chart outlining the structure of the team

Stakeholders

- City of Troutdale Urban Renewal Agency
- Eastwinds Development, LLC
- Oregon Metro
- Sandy River Basin Watershed Council
- Troutdale Parks and Facilities
- End user: the general public

Prepared by:

Casey Keller
Anh Le
Ezra Albright
Ian Buslach
Elijah Kling
Leen Qwider
Marie Roza
Tran Tran
Savko Zagaryuk
Drew Hill
Jillian Pfeifer
Brooke Annotti
Elizabeth Gartner
Justin Potts
Jordan Real
Matthew Stewart
Arthur Yurov

Sandy River Observation Deck

Group: 2021.TROUT.03

Proposed Design Description

**Note*: Deck dimensions have changed as of the client meeting on Friday (04/23). The dimensions below are the updated dimensions.

- **Dimensions:**
  - Cantilever length = 15'
  - Back Span length = 22.5'
  - Deck width = 12'
- **Design Elements:**
  - Rounded deck for natural feel
  - Deck surrounded by plaza
  - Setback from FEMA 100-year event line
  - At Finished Grade of nearby trail

Decking and Structural Framing

- **Decking Material: Pultruded Fiberglass**

  Pros:
  - Lightweight and durable
  - Low maintenance

  Cons:
  - Moderate upfront cost
- **Decking Support: Steel Girders**

  Pros:
  - High strength-to-weight ratio
  - Low construction costs

  Cons:
  - Initial cost is higher (compared to concrete and timber)
- **Girder Support: Reinforced Concrete Beams**

  Pros:
  - Resistant to weathering
  - Low maintenance
  - Durable

  Cons:
  - Weaker in tension

Structure Foundation

- Deep piles supporting the above reinforced concrete beams
  - Site soil is relatively unstable fill
  - Piles provide friction from soil to stabilize structure

Proposed Design Drafts

**Note*: Deck dimensions have changed as of the client meeting on Friday (04/23). Drafted designs featured in this poster are based on the previous proposed width of 24'

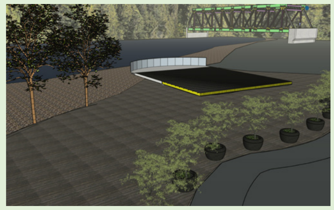


Figure 5: Southeast view of the deck design, drafted using SketchUp

Figure 6: Legend for the drafted plan view (see Figure 7)

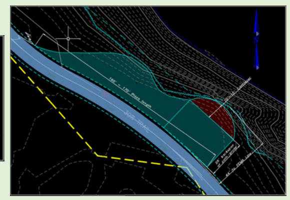


Figure 7: Plan view of the proposed design, drafted using Autodesk Civil 3D

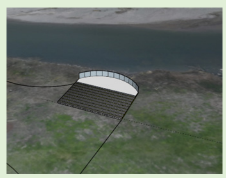


Figure 8: East-facing view of the deck design, drafted using SketchUp

Design Assumptions, Codes, and Permits

- **Key Design Assumptions:**
  - Deck is effectively rectangular for structural calculations
  - Modeling the deck this way provides more conservative load estimates
- **Codes:**
  - Oregon Structural Specialty Code (ORSS)
  - PROWAG ADA-Compliance
- **Permits:**
  - Permit for Floodplain Development – FEMA
  - Flood Hazard Permit – City of Troutdale
  - Basic Public Works Permit – City of Troutdale

Next Steps

- Refine Deep Foundation (Pile) Design
- Refine Structural Framing Design
- Cost Estimating
- Final Permit Checks
- Polished CAD and SketchUp views

Prepared by:

Casey Keller
Anh Le
Ezra Albright
Ian Buslach
Elijah Kling
Leen Qwider
Marie Roza
Tran Tran
Savko Zagaryuk
Drew Hill
Jillian Pfeifer
Brooke Annotti
Elizabeth Gartner
Justin Potts
Jordan Real
Matthew Stewart
Arthur Yurov

APPENDIX F

FINAL PRESENTATION

City of Troutdale Observation Deck

(2021.Trout.03)

2021 CEE Capstone: Final Design Presentation

Prepared by:

Casey Keller
Andrew Hill
Jillian Pfeifer
Anh Le

Ian Buslach
Elijah Kling
Leen Qwider

Marie Roza
Tran Tran
Savko Zagaryuk

Brooke Annotti
Justin Potts
Ezra Albright

Elizabeth Gartner
Jordan Real
Matthew Stewart
Arthur Yurov

Portland State University

Portland State University

Acknowledgements

City of Troutdale:

- *Chris Damgen, Community Development Director*
- *Arini Farrell, Associate Planner/Floodplain Manager*

THE CITY OF TROUTDALE OREGON

Design Professionals:

- *Stuart Finney, KPFF*
- *Marianne Zarkin, MZLA*
- *Kelli Grover, Firwood Design Group*

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Acknowledgements

Portland State University:

- *Evan Kristof, BSCE, Senior Instructor*
- *Dr. Arash Khosravifar, BSCE, PhD*
- *PSU CEE Department*

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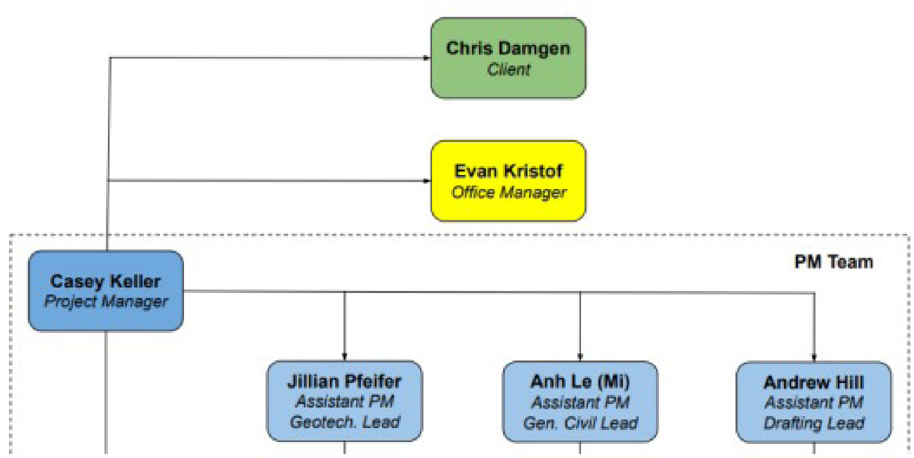
Project Team Organization - Project Management

2021 Troutdale Observation Deck Team



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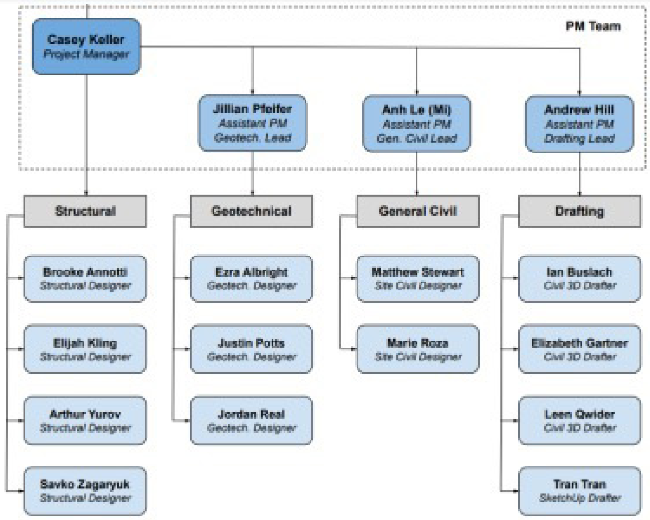
Project Team Organization - Specialty Groups



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Project Background

- Projects objective: 30% Design of Observation Deck
- Sandy River in Troutdale, OR
- Future Sandy Riverfront Park
- Part of the Sandy Riverfront Access plan and URA program

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Existing Conditions

View looking west from above the Sandy River

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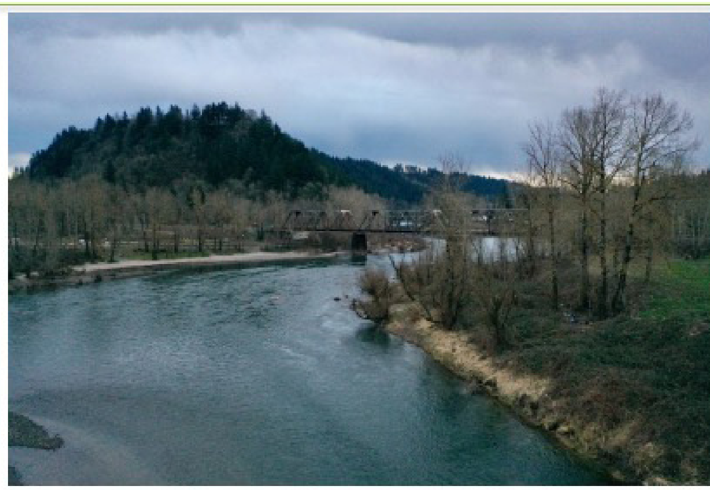
Existing Conditions



View looking southeast from above Sandy River

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Stakeholders

The City of Troutdale- Sandy River Access Plan initiator/Main stakeholder

Oregon Metro - provides funds to maintain sustainable access to Oregon natural areas

Eastwinds Development, LLC - Landowner & Major Project Sponsor

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Stakeholders

Sandy River Basin Watershed Council - Sandy River restoration and resources/habitat conservation

Troutdale Parks and Facilities - Maintenance agency of Park

End Users - pedestrians, hikers, bikers and visitors

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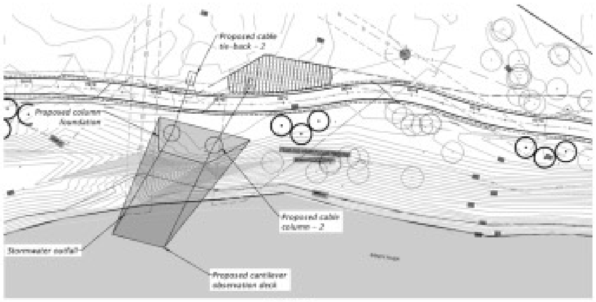
Proposed Design Alternatives

Alternative 1: Large Cable-Stayed Deck



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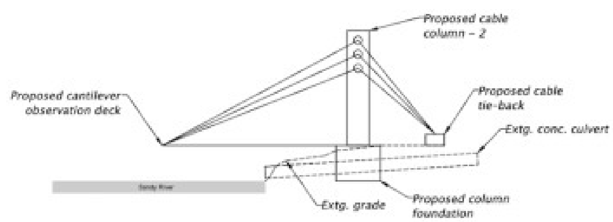

PROFILE

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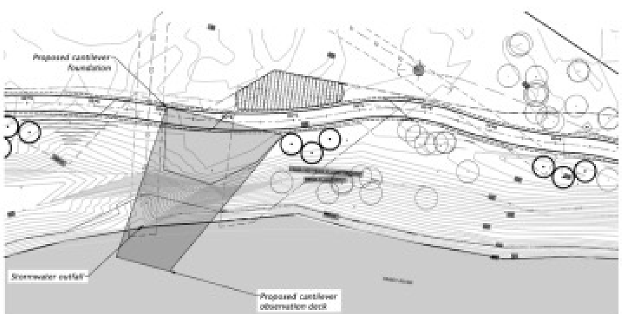
Proposed Design Alternatives

Alternative 2: Large Deck Cantilevered



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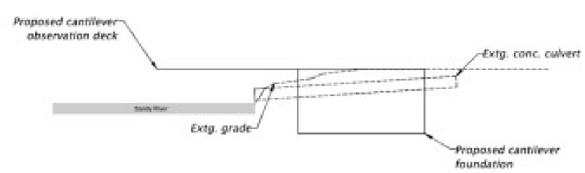

PROFILE

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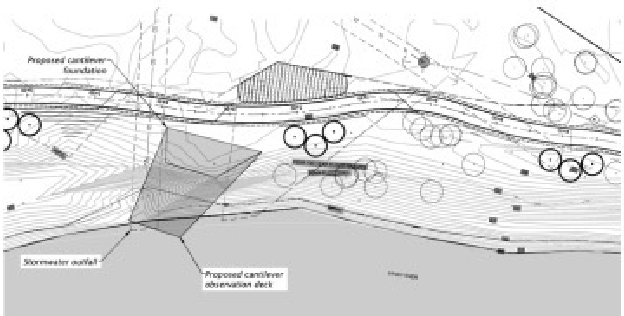
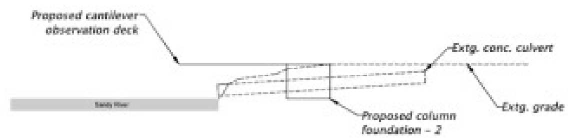
Proposed Design Alternatives

Alternative 3: Small Cantilever Deck



PLAN



PROFILE

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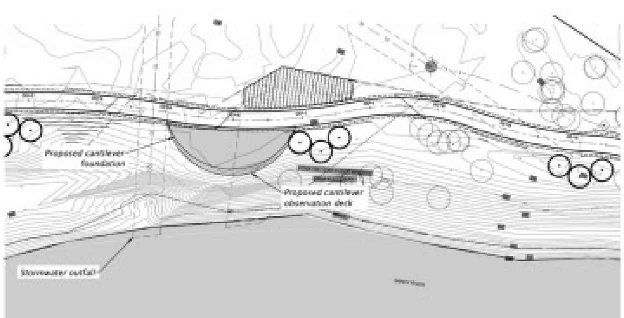
Proposed Design Alternatives

Alternative 4: Small Deck, Wide and Shallow



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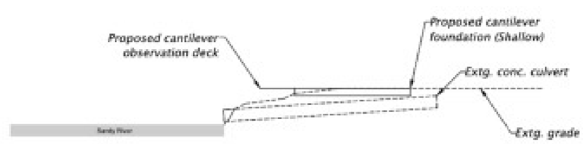

PROFILE

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Proposed Design Alternatives

Alternative 5: No Build

View Looking Southeast

Aerial View

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Pugh Matrix Criteria

- **Cost -** construction, permits, materials
- **Constructability -** risk of construction challenges
- **Environmental Impact -** sustainability of design

ALTERNATIVE TITLE & DESCRIPTION	CRITERIA Cost *Relative cost of design and construction*	Constructability *Simplicity and ease of construction*	Environmental Impact *Degree of disturbance to the site*
1) Large Deck, Cable-Stayed	1	1	3
2) Large Deck, Cantilevered	2	2	3
3) Small Cantilever Deck	4	3	3
4) Small Deck, Wide and Shallow	3	4	4
5) No-Build	5	5	5
CRITERIA WEIGHTS	*9*	*6*	*5*

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Pugh Matrix Criteria

- **User Experience -** visitor interaction
- **Resiliency & Strength -** lifespan
- **Maintenance -** upkeep
- **Permitting -** costs, requirements

CRITERIA				
ALTERNATIVE TITLE & DESCRIPTION	User Experience *Aesthetics and flow with planned trailed*	Resiliency and Strength *Long-term resilience of the structure*	Maintenance *Ease of maintenance and inspection*	Permitting *Relative degree of required permitting*
1) Large Deck, Cable-Stayed	5	5	4	3
2) Large Deck, Cantilevered	4	2	1	3
3) Small Cantilever Deck	2	3	2	4
4) Small Deck, Wide and Shallow	2	4	3	4
5) No-Build	1	5	5	5
CRITERIA WEIGHTS	*7*	*8*	*9*	*8*

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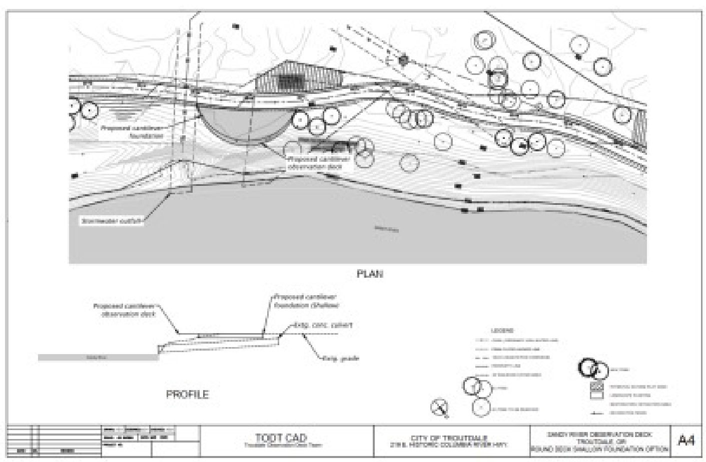
Preferred Alternative

- **Small Cantilevered Deck, Wide and Shallow**
  - Wide and short cantilevered deck that follows the riverwalk contours
  - Moderately cost effective
  - Least amount of environmental disturbance



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Preferred Alternative Scoring

- **Cost: 3/5**
  - Moderately expensive due to the amount of materials required
- **Constructability: 4/5**
  - Mildly intricate and minimal construction complications anticipated
- **Environmental Impact: 4/5**
  - Minimal disruption to the local environment
- **User Experience: 2/5**
  - Mild user engagement due to less impressive dimensions

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Preferred Alternative Scoring

- **Resiliency and Strength: 4/5**
  - Long structure lifespan and minimal additional reinforcement
- **Maintenance: 3/5**
  - Moderate amount of maintenance required
- **Permitting: 4/5**
  - Mild permitting required; does not encroach on flood lines
- **TOTAL WEIGHTED SCORE: 176**

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Facility Design

- **Design Summary**
- **Structural Design**
- **Standards and Specifications**
- **Geotechnical Design**
- **Calculations**
- **AutoCAD**
- **Construction**

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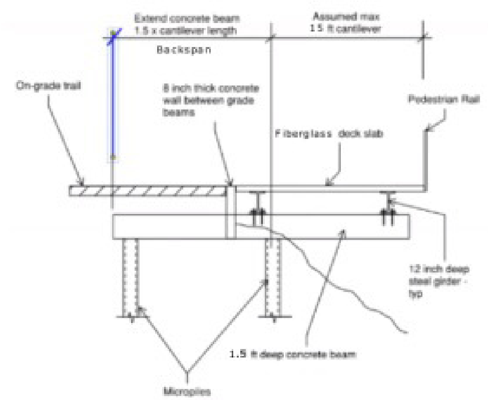
Design Summary

- **Alternative #4 Small Deck Wide and Shallow**
- Pultruded Fiberglass
- Supported by steel stringers
- Steel stringers supported by RC
- Backspan= 1.5 times the cantilever length


Grating Pacific, 2021



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Structural Design

- **Structural Elements**
  - Reinforced Concrete Girders
  - Retaining Wall
  - Steel Stringers
  - Decking
- **Design Philosophy**
  - Strength Design
  - Deflections
  - Demand to Capacity Ratio

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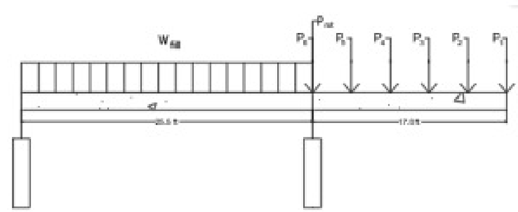
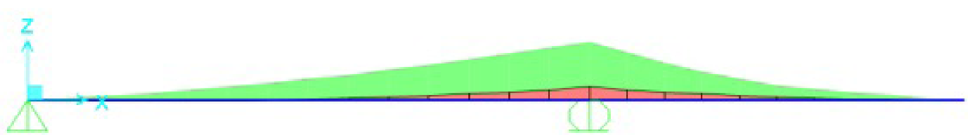
Concrete Girder Design

- **Design Requirements**
  - Cantilever Beam
  - Loading
    - *Dead and Live loads*
    - *Moving Load Analysis*
  - AASHTO Strength Design





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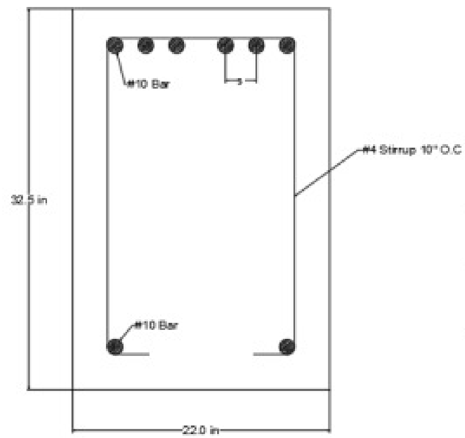
Concrete Girder Design

- **Design Solution**
  - Dimensions
    - *22" x 32.5" x 42.5' Girder*
  - Steel Reinforcement
    - *Top Steel - 6 #10 Bars*
    - *Bottom Steel - 2 #10 Bars*
    - *Shear Steel - #4 Bars 10" O.C*
  - Demand to Capacity
    - *Strength Capacity*
    - *Demand to Capacity*
    - *Steel Reinforcement Ratio*



$(D/C)_{b(+)}$	0
$(D/C)_{b(-)}$	0.73
$(D/C)_{v}$	0.67

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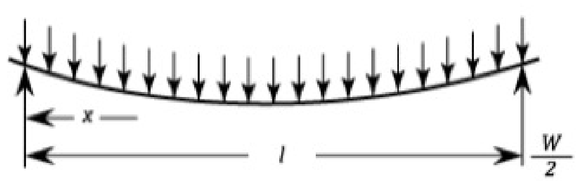
Steel Stringer Design

- **Requirements**
  - Design for each strength limit state
    - *Simply supported beam*
    - *Consider dead loads (gravity) and live loads (people and vehicular)*
    - *Use a strength reduction factor of 0.7*



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Steel Stringer Design

- **Solution: 6 W10X54 beams, 3.4 feet on center, 60 grade steel**
  - Strength limit states

- *Shear demand to capacity ratio*	*0.31*
- *Moment demand to capacity ratio*	*0.47*
- *Lateral torsional buckling demand to capacity ratio*	*0.92*

  - Serviceability deflection criteria

- *Dead plus live load deflection is less than 0.90 inches*	*0.48 inches*
- *Live load deflection is less than 0.60 inches*	*0.44 inches*

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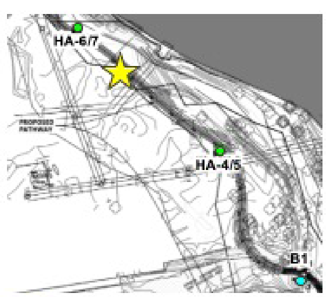
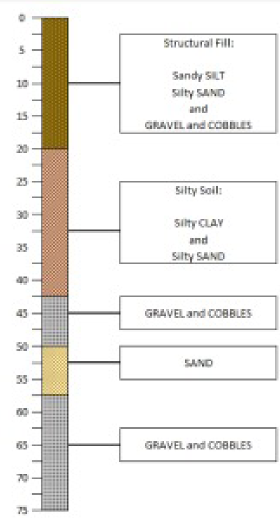
Geotechnical Design I

- **Geotechnical Site Soil Conditions**
  - Soil profile from Boring log B-1 (≈ 500 ft from project site)
    - *Structural Fill contains organic material*
    - *Silt layers are moisture dependent*
    - *GRAVEL and COBBLES layer ideal for piles*
  - Hand Auger Logs HA-4/5 and HA-6/7
    - *Reach a depth of 3-4 ft*
    - *Fill through all samples*
    - *Silty Soils*



☆ - Site Location



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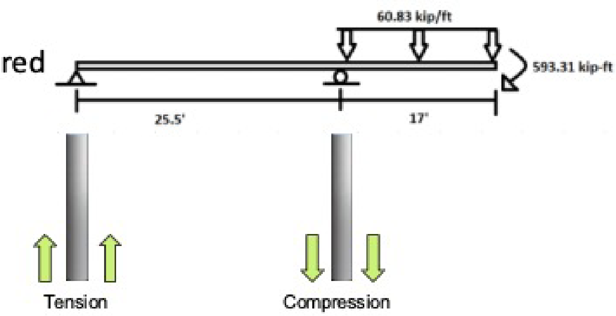
Geotechnical Design II

- **Spread Footings**
  - The preliminary geotechnical report from GRI recommended spread footings
  - Design calculations revealed this was not viable for the observation deck
- **Deep piles**
  - As an alternative, deep piles were considered
  - Skin friction and end bearing analysis
  - 1 row in tension, 1 row in compression
  - 4 piles each row
  - 60 ft. long
  - 1 ft. diameter



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Visuals and Drawings - SketchUp

- **Cantilever Deck**
  - Using SketchUp Pro 2021
    - *30 days trial version*
    - *Limited complex tools and features*
    - *Time-consuming when creating components with accurate dimensions (benches are not to scale)*

SketchUp Conceptual Drawing

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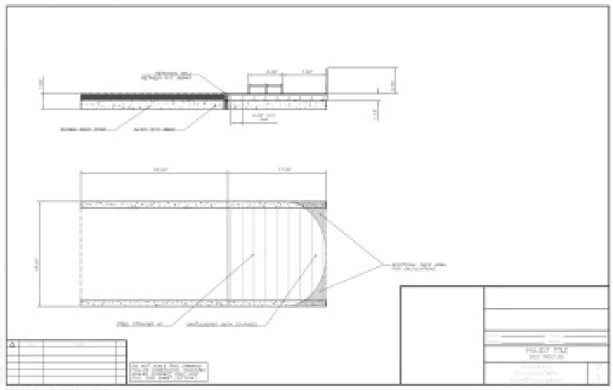
Visuals and Drawings - AutoCAD Civil 3D

- **Base files**
  - Trail alignment from Marianne Zarkin Landscape Architects
  - City survey files
- **Alignments**
  - Create Profile Views
- **Details**
  - Railing From KPFF
  - Bench sizing
  - Decking
  - Retaining Wall



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Cost Estimates

[redacted]

- **Estimate Total of $546,180**
  - without Contingency
  - without General Contractors Overhead, Profit, or Markup on Subs
- **Grand Total of $791,961**
  - with 15% Contingency
  - with General Contractors 20% O&P and 10% Markup on Subs
- **Total for 5 years out $985,991**
  - with 124.5% increase (RSMeans)

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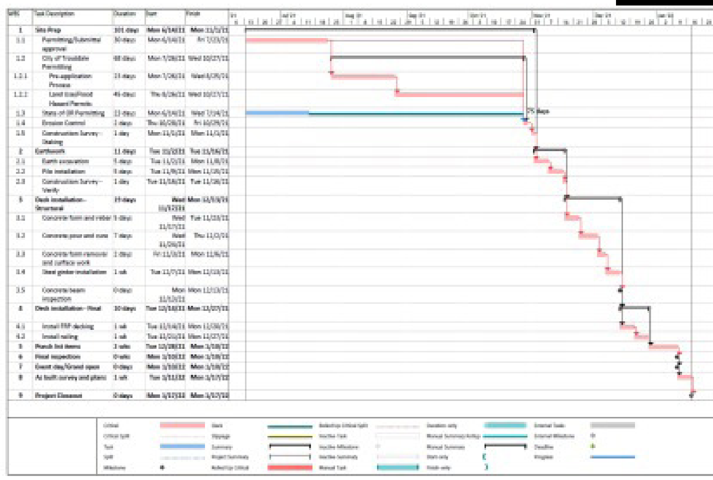
Construction Schedule

[redacted]

- **7 months, 3 days (217 days total) for Project Completion**
  - Permitting makes up over half (121 days) with City of Troutdale Permitting estimated at 68 days
  - Onsite Construction takes place over 40 days
  - Punchlist, As-Builts and Final Inspection can overlap in 2 weeks



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Regulation Compliance + Permitting

- **Oregon DEQ**
  - Construction stormwater general permit
- **Troutdale**
  - Flood hazard permit
  - Land use permit
- **Oregon Department of State Lands**
  - Wetlands/waterway removal-fill

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Conclusion

- **Proposed Design**
  - 18' x 17' Cantilever Deck
    - Pultruded Fiberglass for weather resistance and drainage
  - (6) W10X54 steel beams span between (2) 22" x 32.5" reinforced concrete girders
  - 25.5' backspan (buried) with exposed concrete pedestrian path to main trail.
- **Cost**
  - Estimated at $791,961 to construct with conservative D/C
- Limitations
  - Boring Data
  - Vehicular loading
- **Q&A?**

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SCI Directors and Staff

Marc Schlossberg	SCI Co-Director, and Professor of Planning, Public Policy and Management, University of Oregon
Nico Larco	SCI Co-Director, and Professor of Architecture, University of Oregon
Megan Banks	SCYP Director, University of Oregon
Nat Kataoka	Report Coordinator
Danielle Lewis	Graphic Designer