The University of Iowa

Neste Park Recreational Trails

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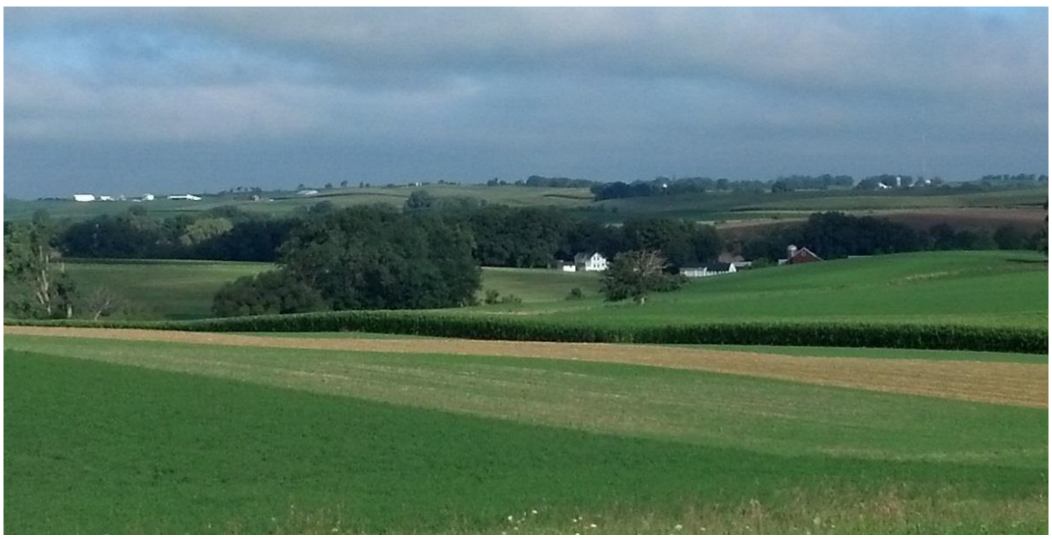

THE UNIVERSITY OF IOWA
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

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THE UNIVERSITY OF IOWA
Department of Civil and Environmental Engineering

Executive Summary

A 240-acre area just two miles south of Decorah, Iowa was recently donated by owners Ingrid and Mary Neste and Michele Stefanick. The Neste acreage is composed of mature native woodland, remnant oak savannah, and farmland that will soon be converted to dry and mesic prairie. The vision of Neste Park includes land and habitat restoration, public education, and recreational opportunities for visitors along the way. A trail has been created along Dry Run Creek within Neste Park to give visitors access to all areas of the acreage. After completion, the Dry Run Trail will establish a 43-mile regional trail in northeast Iowa for cyclists, hikers, and cross-country skiers.

The construction and design of the Dry Run Trail within Neste Park will generate an 8-mile path linking Trout Run Trail in Decorah to Prairie Farmer Recreational Trail near Calmar. In addition to the Dry Run Trail, internal walkways throughout Neste Park will give guests the chance to explore remarkable Iowan landscapes. The walkways will begin at the Neste Nature Center and tour historic structures inside the park. The walkways will also serve as a link from the Nature Center to the Dry Run Trail, giving visitors the opportunity to discover significant Iowan culture and countless native species.

Iowa Department of Transportation (IDOT), Americans with Disabilities Act (ADA), and American Association of State Highway and Transportation Officials (AASHTO) standards were considered in the design process. An optimal trail design was created using AutoCAD Civil 3D. Adequate grading and frequent rest stops will provide a safe and enjoyable environment for all trail guests while guaranteeing compliance with regulations. Sustainable trail design is offered through our services to minimize environmental impact, ensure low maintenance, and provide educational and recreational benefits for the public.

The final design offered for the Neste Park area includes a 10-foot wide concrete trail and various permeable pavement walkways for exploration. A 60-foot steel bridge will span Dry Run Creek and establish the northeast Iowa regional trail. Ancillary structures including kiosks, informative pedestals, and seating have been included in the final design to ensure sustainable public interaction. The total cost for the Neste Recreational Trail System is $530,000, including materials, labor, and infrastructure.

Hawk-Trek Trails Inc. is an innovative group that focuses on effective, sustainable trail design. We are confident that our proposal for Neste Park Trail offers safe, reliable, and gratifying recreational opportunities for visitors of the area. Our focus on safety, regulatory compliance, education, and low maintenance has created a final design that offers visitors an unparalleled experience and ensures a long-lasting, successful trail system.

1 Introduction

Hawk-Trek Trails Inc. has created an innovative trail design for Neste Park, consisting of a regional trail system and internal walkways to promote education and recreation in Winneshiek County. Safety, education, and sustainability were the main focus of the project, creating a lasting and appealing opportunity for visitors. AutoCAD Civil 3D was used to determine safe and compliant gradients, while minimizing project costs. Ancillary structures including kiosks, seating, and a steel pedestrian bridge over Dry Run Creek have been included in the proposal. Our final design compliments the vision of Neste Park, including minimal environmental impact, public education, and exciting recreational opportunities.

2 Problem Statement

The Neste Park Recreational Trail will establish a 43-mile regional trail in northeast Iowa. The trail will require minimal maintenance while providing informative recreational opportunities for guests. The portion of the regional trail shall be a concrete surface, accessible for walking, bicycling, and cross-country skiing. Internal walkways throughout the Neste Park will link the Nature Center to the regional trail and allow visitors to explore the area's historic buildings and landscapes. ADA, AASHTO, and IDOT compliance must be considered for gradients, curvature, and bridge design. A focus on safety and sustainability will ensure that the Neste Park Trail and walkways attract visitors with minimal upkeep and environmental impact.

2.1 Design Objectives

A recreational trail will be designed for the Neste Park property that will include a paved regional trail and internal walkways with a natural/minimal environmental impact surface, such as mowed grass. The layout of both the regional trail and internal walkways will be assessed and designed. Cross sections of both the regional trail and internal walkways will also be constructed.

The paved regional trail is designated for pedestrian and bicycle use, while the internal walkways are designed to aid in pedestrian exploration of the park and its scenic views. The paved regional trail and walkways will be designed for four-season use.

Ancillary structures will be included along the trail and walkways to support trail activity. The ancillary structures to be designed will include a rest/picnic area for the public and a nearby playground. Benches will be placed along the trail to overlook sites and comply with state recommendations. Restrooms and drinking fountains will be designed and included in the proposed Nature Center. Sustainable design will be utilized to reduce environmental impact at the site and promote species diversity and land restoration.

Signage will be displayed along the trail as a navigational tool. Additional kiosks will be located along the regional trail and walkways, providing educational benefits for the public.

A prefabricated bridge(s) will be designed where necessary to cross creeks or ravines in the area.

Cost estimates for the construction of the regional trail and walkways as well as for the ancillary structures, signage, and bridge construction will be included.

2.2 Approaches

For the design of the Neste Park Trail, the design requirements are coordinated with the Iowa Department of Transportation Design Manual chapter 12B-2. Iowa has also released the Iowa Trails 2000 guide which shows both the design requirements as well as the recommended approaches to the design of a trail. Both manuals often reference the American Association of State Highway and Transportation (AASHTO) for various requirements and in areas where requirements are not set forth by IDOT, AASHTO requirements are to be used. All three of these manuals are referred to and closely followed in the design process for this trail.

The approach taken for the design of this trail initially included following design requirements set forth by IDOT and AASHTO (when needed). The design process then focused on creating the most aesthetically pleasing trail while also keeping in mind the cost of construction. The objective of the design would be to limit cut and fill costs for construction while also designing a trail that abides by design requirements and remains close to the current elevation of land in order to create a trail that is visually appealing to users while complementing the Nature and Recreation Center that will be constructed.

2.3 Constraints

Various constraints exist for the Neste Park trail design, including: cost, space, design guide requirements, environmental considerations, and societal impacts. Of these, our only “strict constraints” are the design guide requirements. The design guide requirements come from the Iowa Department of Transportation (IDOT), the American Association of State Highway and Transportation Organization (AASHTO), and the Americans with Disabilities Act (ADA). The IDOT and AASHTO guidelines incorporate the ADA rules for our trail design.

The initial requirements for the design of the trail discuss parameters including the width of trail, pavement type (with material depth), vertical clearance of the trail, and lateral clearance of the trail. IDOT requires that the width of a shared use path (bicycle and pedestrian trail) be 8 feet; however, also states the typical path should be 10 feet. Larger widths are considered if the amount of users exceeds 300 within the peak hour, if large maintenance vehicles are required, or if three lanes of traffic is desired. The walking trails are required to be only 4 feet wide, but, are recommended to be 5 feet. The walking trails should also maintain an 8 foot vertical clearance and the regional shared use trail requires a vertical clearance of 10 feet. IDOT also requires a lateral clearance of 2 feet from any obstruction including trees and signs which will be the main considerations for this shared use trail layout. The type of pavement for the shared use trail is recommended to be concrete with a required minimum depth of 4 inches and a recommended depth of 5 inches.

The next requirements set forth involve the various slopes of the trail and the horizontal curves of the trail. In order to drain the water off of the trail, which lengthens the life of the pavement, IDOT requires a cross-slope with a maximum at 2% for both the shared use trail and pedestrian walkways. The maximum cross slope of the shoulder or lateral clearance of the shared use trail set forth by IDOT is 6:1. Safety rails are required if the slope is too large or if there is a steep drop off. The maximum vertical slope set forth by ADA is 5% for any trail, however, IDOT allows this to be exceeded according to the grade length. IDOT requires that AASHTO be referenced for the grade restrictions for a shared use trail. Table 1 shows the allowed vertical slope with the maximum horizontal distance for the shared use path.

Table 1: Grade restrictions set forth by AASHTO for shared use trail.

Vertical Slope (%)	Horizontal Distance (ft)
5-6%	for up to 800 ft
7%	for up to 400 ft
8%	for up to 300 ft
9%	for up to 200 ft
10%	for up to 100 ft
11+%	for up to 50 ft

Table 2 shows the same requirements set forth by IDOT but for the design of pedestrian walkways. IDOT also references AASHTO for the maximum radius on horizontal curves for the shared use trail. AASHTO gives a general table to follow, however, also gives equations to calculate the minimum horizontal radius depending on conditions specific to each project such as friction, design speed, and superelevation. The minimum required design speed set forth by AASHTO is 18 mph for a shared use trail with a recommended speed of 25 mph. The minimum horizontal radius for a design speed of 18 mph is 70 feet and the minimum horizontal radius for a design speed of 25 mph is 130 feet. Pedestrian only trails have no restrictions for horizontal curves. Refer to Appendix A for sample calculations of the horizontal curves.

Table 2: Grade restrictions set forth by IDOT for pedestrian trail.

Vertical Slope (%)	Horizontal Distance (ft)
8.3%	for up to 200 ft
10%	for up to 30 ft
12.5%	for up to 10 ft

As for the remaining constraints, cost is essential and must be considered. Our goal is to keep cost down as much as we can without compromising the project goals and trail opportunities. To control cost, we have designed our pathways to follow slopes that require the least amount of cut and fill. Space is an additional constraint. The trails must be designed to complement the proposed Nature Center that will be constructed along with camping and hunting areas.

Dry Run Creek runs down along the proposed regional trail, Dry Run Trail. Placement of this trail must not only comply with regulations, but prevent the risk of damage due to flooding. The trail will have to be designed outside of the stream floodplain to ensure an extended life. Figure 1 shows the 100-yr floodplain associated with Dry Run Creek, with the pink line indicating the centerline of the creek. Lastly, IDOT sets forth recommendations to cut down the fewest amount of trees as possible, which brings up one of our "soft" constraints in working to design the trail around the bordering trees of the creek. As for construction, no official permit is required for the completion of the Neste Recreational Trail, though Winneshiek County is required to approve the project plans prior to the start of construction.

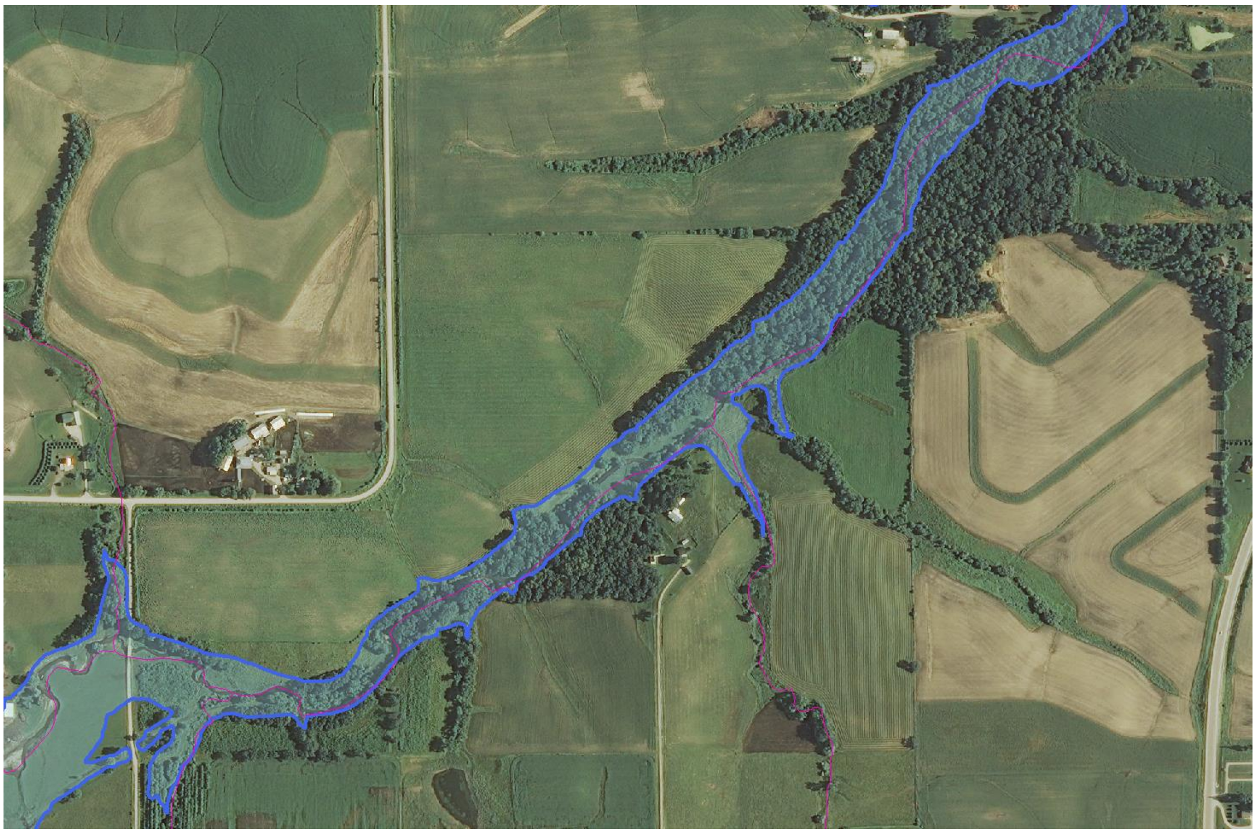

Figure 1: 100-year floodplain near Dry Run Creek within the Neste acreage.

2.4 Challenges

Challenges may present themselves in the design of this trail as to not negatively impact the environment. Design of the layout of the trail may result in removal of trees which may be in the negative opinion of the public as well as ecosystem alteration. Also, with the wetland area nearby, the trail must abide by Iowa Department of Transportation standards that require the trail location to be an appropriate distance away from the wetland.

Designing a trail near a creek will require that the trail not lie in the floodplain of the area, however, a trail near a creek is much more appealing for the users. Finally, the Iowa Department of Transportation has regulations for maximum slopes on a trail which will bring about a challenge when designing a trail that runs through the hills in Neste Park. Other regulations set forth by the Iowa Department of Transportation are explained previously in the constraints section.

One major challenge discovered while designing the regional trail was due to a steep hill that leads to the northern part of Neste acreage. This steep hill was challenging to design a trail while staying consistent with the AASHTO and ADA trail specifications. While keeping the cost at a minimum was crucial, the majority of our cut and fill was allocated to complying with AASHTO and the ADA along this steep hill.

2.5 Societal Impacts

Construction of the Dry Run Trail within Neste Park will attract visitors from the local area as well as neighboring communities. The Dry Run Trail will establish a 43-mile regional trail, giving Iowans and other Midwest travelers access to the Winneshiek County landscapes and local businesses. The trails will attract visitors to the Decorah and Calmar area and help support the local community with economic contributions.

Visitors will also have an opportunity to explore the Neste acreage, which offers education and countless recreational activities. Both the regional trail and internal walkways will encourage public exploration and appreciation for the natural landscape. Education will be highlighted throughout the walkways, allowing society to learn about the history of the area and the importance of the environment. Many aspects of the trails will be designed for all ages in order to keep the trail interesting and informative for various crowds.

The recreational activities offered through the trails of Neste Park include hiking, bicycling, cross-country skiing, running, and nature observation. These activities promote healthy living, societal bonding, and gratitude for the environment. It is important for communities to have areas to gather and share to improve the culture within their society. The Neste trail system will offer the community an enjoyable area to coexist and strengthen their society.

The farmland within the Neste area will soon become natural Iowa prairie and improve the habitat and species diversity within the acreage. Altering landscapes affects the native species but also has an indirect impact on society. Converting farmland to prairie will improve soil quality and in turn help society manage resources for a growing population.

A sustainable balance appears when economic, environmental, and societal factors are each met. That is, a healthy society cannot exist without proper environmental and economic success. Construction of the Neste Recreational Trails will improve the environmental conditions and give attention to the importance of nature. The trails will also attract visitors to the local area and support the local economy. Education, recreation, tourism, and land restoration are just a few of the impressions that will support a productive society due to the implementation of the Neste Trails.

3 Preliminary Development of Alternative Solutions

Several factors contributed to the development of our organization's alternative designs. While the time constraint of the project was first and foremost, the Client expressed a great interest in numerous other factors. While the Client had great interest in the sustainability of the new trail, they conveyed their concern over their unknown budget. For this reason the Client hoped to limit the cost of the recreational trail, in anticipation that the budget would not delay or cancel the vision they had for Neste Park. Likewise, the Client deemed the scenic views provided by Neste Park as an important deciding factor in the layout of the trail, as well as any ancillary structures to be added to the Park. While our organization placed the highest interest in delivering an ideal trail, the varying trail layouts and designs would be out ruled by the strong prior vision our Client had in mind. Ultimately, it would be decided that the trail layout previously established by the Client would be the starting point for our final trail design. Nonetheless, the following is an outline of our preliminary design solutions.

Our organization's first alternative design was aimed at minimizing the amount of cut and fill required to construct the trail. By doing so, our organization hoped to reduce the final cost, as idealized by the Client. The trail would follow an existing historic trail once used by horse and buggy located in the north-eastern corner of the acreage on the south side of Dry Run Creek for approximately half a mile. Once the trail approached the Neste acreage, a prefabricated bridge would provide access to the north side of Dry Run Creek. On this side of the Creek, the contours were far more gradual, and provided a more ideal trail layout. In fact, an old railway known as the Chicago, Milwaukee, St. Paul and Pacific Railroad once resided on this stretch of the future Neste Recreational Trail, thus providing us with a pre-graded land. As the trail approached the southwest end of the Neste acreage, an additional prefabricated bridge would once again cross the Dry Run Creek back to the south side, following the previously described abandoned rail bed. By utilizing prefabricated bridges, our group aimed to reduce project costs, all while maintaining the aesthetics of the rustic, barn appearance of the Neste acreage. Additional walkways would be provided to allow visitors to the adjacent Nature Center access to the Neste Park, as well as additional scenic routes throughout the landscape. While this alternative design looked to aim at reducing cut and fill quantities, the addition of a second prefabricated bridge eventually outweighed the benefits.

The second alternative our organization developed looked to encompass all aspects our Client envisioned into one. While this design is not budget-friendly, it incorporates the expanded vision and aesthetical pleasure the Client sought in Neste Park. Once again our organization looked to minimize the cut and fill quantities necessary to complete the project. Thus, the second alternative followed the same trail path outlined in the first alternative, but with added features. The Client envisioned a small wetland to the southwest of the Neste acreage as an ideal location for a trail boardwalk. Branching off from the regional, a concrete trail would provide access to a scenic boardwalk passing through the wetland. Additional extended footpaths would be provided to allow hikers and/or visitors the chance to visit the boardwalk. Due to concern for trail users safety over the wetland, as well as future possible maintenance issues associated with the wetland, this design was never truly possible. Likewise, the additional cost associated with the boardwalk made this alternative design a far-fetched idea envisioned by the Client.

Our organization's last design followed the ideas set out by the Board in a simple straightforward trail. The trail would immediately cross Dry Run Creek in the north-eastern most section of Neste acreage. Once on the south side of the Creek, the trail would continue along the pre-existing historic pathway described previously. Utilizing the rolling hills along the south side of the Creek, the trail would cross past the existing historic structures on the Neste acreage, intertwined with mowed grass footpaths. While these hills provided for a scenic user route, our organization had slight concern over the possible cut and fill needed to meet the AASHTO and ADA vertical slope requirements. Nonetheless, this route was chosen by our organization due to the Clients strongly established vision associated with this layout. The benefits of only using one prefabricated bridge versus additional cut and fill were analyzed by our organization, and our presented below. All three preliminary design layouts can be seen in Appendix C.

Our organization also weighed the advantages versus disadvantages of different prefabricated bridge materials, as well as trail constructional materials, to provide the Client with a long lasting, low cost, ideal design. Each material was analyzed for various constituents to provide the Client with the finest recommendation.

4 Selection Process

Upon successful selection of the trail layout, our organization provided the following analysis to deliver the Client an optimal design. The regional trail design involved navigating AutoCAD Civil 3D to minimize cut and fill requirements, while exploring different routes to comply with regulations and reduce overall project costs. Similarly, the walkway designs were chosen to effectively connect the Nature Center to the regional trail and explore the main area, while reducing the environmental impact and material costs associated with the paths. In addition to alternative routes, materials for the regional trail and walkways were also evaluated to ensure a low-maintenance, sustainable, and cost-effective trail. Three bridge materials were analyzed for the Dry Run crossing, where the decision was based on capital cost, maintenance, aesthetics, and sustainability.

4.1 Materials Selection

A paved surface was essential for the Dry Run Trail, as specified by the Client. A paved surface would make the trail aesthetically pleasing and most importantly, minimize the degradation of the trail and promote longevity. Both asphalt and concrete were considered as potential materials for surfacing the regional trail. Ultimately, concrete was selected as the optimal surface due to its low maintenance requirements, high aesthetic appeal, and long life-span. Although concrete costs exceed that of asphalt, the low maintenance and durability of concrete reduce future upkeep costs of the trail and prove to outweigh its associated capital cost.

The internal walkways were initially requested to be mowed grass, however this surface will quickly degrade under heavy foot-traffic. For this reason, we have selected permeable pavement to serve as the path connecting the Nature Center to the regional trail, as well as walkways around the historic buildings. The permeable pavement will offer high aesthetic appeal as it comes in natural colors, while also minimizing runoff and environmental impact. This pavement will prevent visitors from veering off-path and widening the walkway, and keep the trail accessible during rain events and muddy conditions. In addition, less maintenance will be required for pavement when compared to the labor associated with mowed grass.

A grass path will however be better suited for the east-side walkway (access from the eastern end of the Nature Center) because this is a much more indirect route to the buildings and regional trail. As less foot-traffic is expected, combined with the fact that this path is not completely necessary to connect the walkways to the regional trail, it is concluded that mowed grass would be a more realistic material for this portion of the walkway.

4.2 Bridge Selection

Aluminum, steel, and timber were analyzed to determine which material would be best-suited for the Dry Run Bridge within Neste Park. Each material was ranked between 1 and 3, with 1 being the best option and 3 being the least suitable. In addition, each constraint was weighted between 1 and 5, with 5 having the most significance to the decision and 1 having the least significance. Table 3 shows the score for each material depending on capital cost, maintenance, aesthetics, and sustainability.

Table 3: Bridge decision matrix

	Importance	Aluminum	Steel	Timber
Capital Cost	5	3	**1**	2
Maintenance	4	1	**2**	3
Aesthetics	3	3	**2**	1
Sustainability	1	1	**3**	2
Total		29	**22**	27

Steel, with the lowest score, would be considered the most suitable bridge material for the Neste Recreational Trail System. This is due to the high aesthetic appeal, low capital cost and low maintenance qualities of steel.

Capital Cost: Steel would initially be the least expensive choice ($35,200), followed by timber ($42,300) and aluminum ($45,300), respectively. Prices include delivery cost.

Maintenance: Aluminum would require the least maintenance, while steel would require periodic corrosion control, and timber would need frequent upkeep to prevent decay and weakened integrity.

Aesthetics: Timber would offer the most natural look, yet steel would have a weathered finish to also provide an aesthetically pleasing bridge. The aluminum would appear as a shiny-silver material and may not provide a natural look.

Sustainability: The aluminum bridge is comprised of 80% recycled aluminum and does not require any toxic coatings, as steel would for corrosion control. The timber would also require some toxic sealing to prevent decay that could be harmful to aquatic life, and soil/water quality.

Constructability was initially considered in the decision process until further investigation revealed that each bridge had similar transport and installation requirements. Each bridge is prefabricated in close proximity to the project and shipped by truck in a single piece (Wheeler, 2015). Due to the equality in transport and installation for all three materials, constructability was left out of the matrix because it would not add any additional worth to the final decision.

5 Final Design Details

Specific aspects of the Neste Recreational Trail design include a regional trail and internal walkways, bridge foundation, signage, and ancillary structures. The final design for the regional trail will border the Dry Run Creek with countless exciting turns along the way. Durability, safety, and regulatory compliance were the focus of the trail design, creating a stimulating recreational opportunity while optimizing project costs. A discussion of the final walkway design is also presented in this section, where sustainability, education, and feasibility were the primary focus. The final walkway design offers several explorative pathways that provide both history and recreation alike. A detailed discussion of the specific ancillary structures and signage throughout the regional trail and walkways is offered in the closing of this section.

5.1 Regional Trail Design

The final design for the regional trail was made with the use of AutoCAD Civil 3D and ArcMaps following the design requirements set forth by both IDOT and AASHTO. All constraints of the construction of this trail can be seen in Section 2.3 of this report. The width of the regional shared-use trail will be 10 feet with a shoulder width of at least 2 feet per side. The pavement to be used, as requested by the client, will be concrete with a depth of 5 inches and a subbase depth of 4 inches. The shoulder will be made of gravel and past the shoulder there will be a small ditch, where necessary, in order to properly drain the trail. The cross-slope of the trail is 2% and the horizontal slope of the shoulder is set to a maximum at 6:1. These dimensions were chosen to comply with IDOT and AASHTO while also allowing for emergency vehicles, whose width is 8 feet, to use the trail, as requested by the Client. The general cross-section of the trail can be seen in Figure 2. The cross section of the trail is also shown with the surrounding contours at various points along the trail, located in Appendix D.

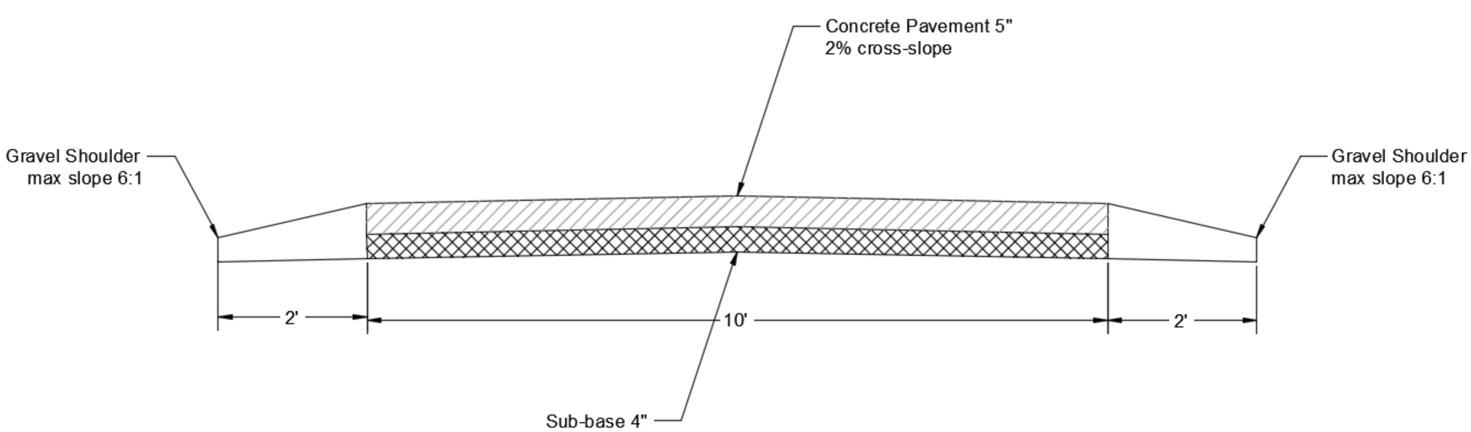

Figure 2: Cross section of final regional shared use trail design.

Once the cross-section of the trail was designed, the final layout design of the trail was created based off of the Client's preferred trail layout. This layout was then taken into AutoCAD Civil 3D and designed according to the requirements made by IDOT and AASHTO. After laying out the Client's trail design, there were multiple areas found that did not comply with the minimum horizontal radius set forth by AASHTO. The minimum horizontal curve radius was calculated to be 130 feet using the equations given by AASHTO for a design speed of 25 mph. The minimum horizontal curve radius was also calculated to be 70 feet at a design speed of 18 mph, in compliance with the AASHTO horizontal curve requirements. A new layout design was constructed in AutoCAD Civil 3D to comply with these horizontal curve radii. After the horizontal layout of the trail was finished, the profile view of the trail in Civil 3D was used in conjunction with the AASHTO guidelines for maximum vertical slopes shown in Section 2.3, Table 1 of this report, to finalize appropriate vertical slopes and horizontal distances that comply with AASHTO. The final AASHTO-compliant trail layout can be seen in yellow in Figure 3. The red layout was the Client's original proposed layout.

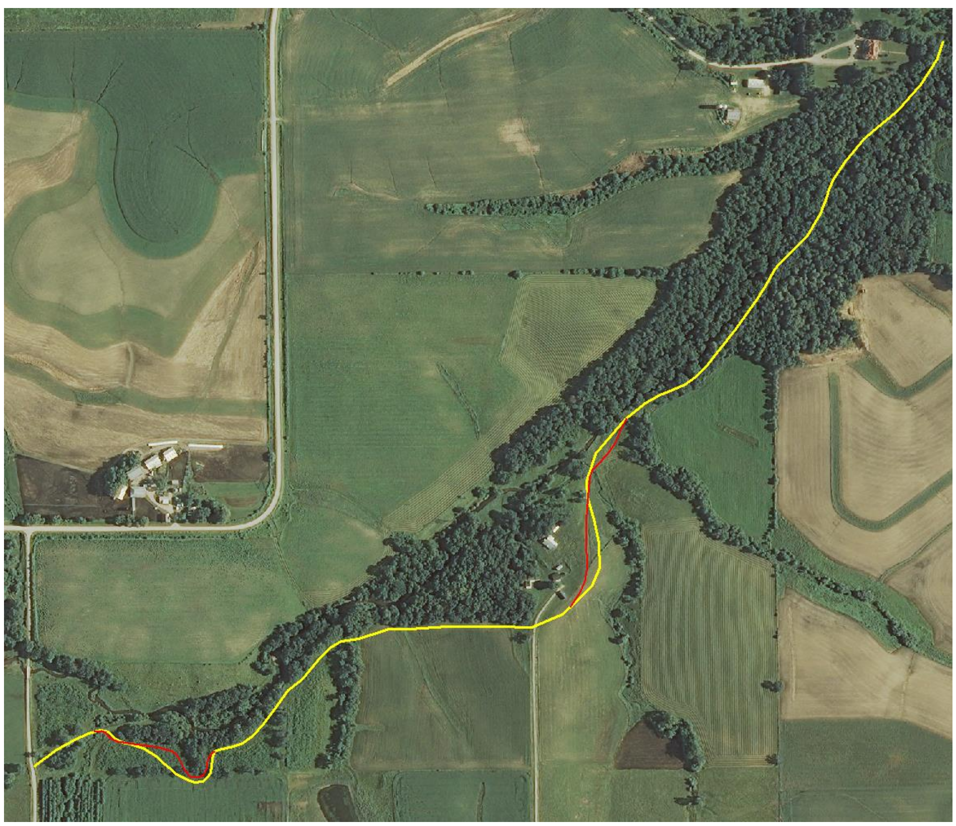

Figure 3: Regional trail route with AASHTO compliance.

The cut and fill amounts were determined using the volume analysis capabilities of AutoCAD Civil 3D. The difference in cut and fill was adjusted by working with the profile view in AutoCAD Civil 3D to bring the value as close to zero in order to save costs. When adjusting the trail for cut and fill purposes, the vertical alignment of the trail changed, therefore the vertical slopes still needed to comply with AASHTO. Refer to Appendix A for vertical slopes greater than 5% located along the trail. All vertical slopes comply with the standards set forth by AASHTO. Also, the goal was to keep the trail as close to the current elevation as possible in order to create an aesthetically pleasing, cost efficient trail as requested by the Client. The finalized profile view of the trail can be seen in Appendix D which shows the vertical layout of the trail as it complies with AASHTO requirements, simultaneously attempting to minimize the cut and fill volumes.

A steel pedestrian bridge was selected for the Dry Run Creek crossing, as described in Section 4.3. The Steadfast Express Pedestrian Bridge by Contech Engineered Solutions offers a pre-engineered steel truss bridge that is ready for shipment within six weeks of finalized drawings. Specifically, this bridge will be 60-feet long and 10-feet wide with a weathering steel finish, douglas fir wood deck, horizontal safety rails, and meets AISC design code specification. The final bridge will have a design weight of 13,300 pounds and a price of $35,200 delivered F.O.B. Figure 4 shows an example of a Contech Steadfast Pedestrian Bridge with a weathering steel finish and horizontal rails. Figures 5 and 6 also offer an example of the safety hand rails and wood decking offered by Contech ES for the proposed bridge.

Figure 4: Contech ES Steadfast Express Pedestrian Bridge.

Figure 5: Safety hand rails by Contech ES.

Figure 6: Wood decking by Contech ES

Our organization analyzed the constructability of the steel prefabricated bridge and presents the following recommendations to our Client. Upon arrival of the single-piece, 60-foot span bridge, the freight delivery vehicle should approach the trail from S Bear Rd located off of Dry Run Rd. The existing roadway will provide cost efficient access to the desired bridge location. The neighboring property owner has previously complied with the construction of the Neste Recreational Trail, thus will allow access via his property at the end of S Bear Rd. Our organization recommends delivering the 60-foot span bridge to an adjacent mobile crane along the south side of the existing property where the existing grade is no greater than 10%. If the freight delivery vehicle is not confident in this route, our organization recommends delivering the bridge just north of the existing property structure, where the grade is no greater than 7%, then backing the bridge span to an adjacent mobile crane nearest to the desired bridge location. Both routes will require minimal tree removal for proper installation. The maximum distance the mobile crane should be located from the bridge or freight delivery vehicles is 160 feet. See Figure 7 below for a map of the two recommended routes.

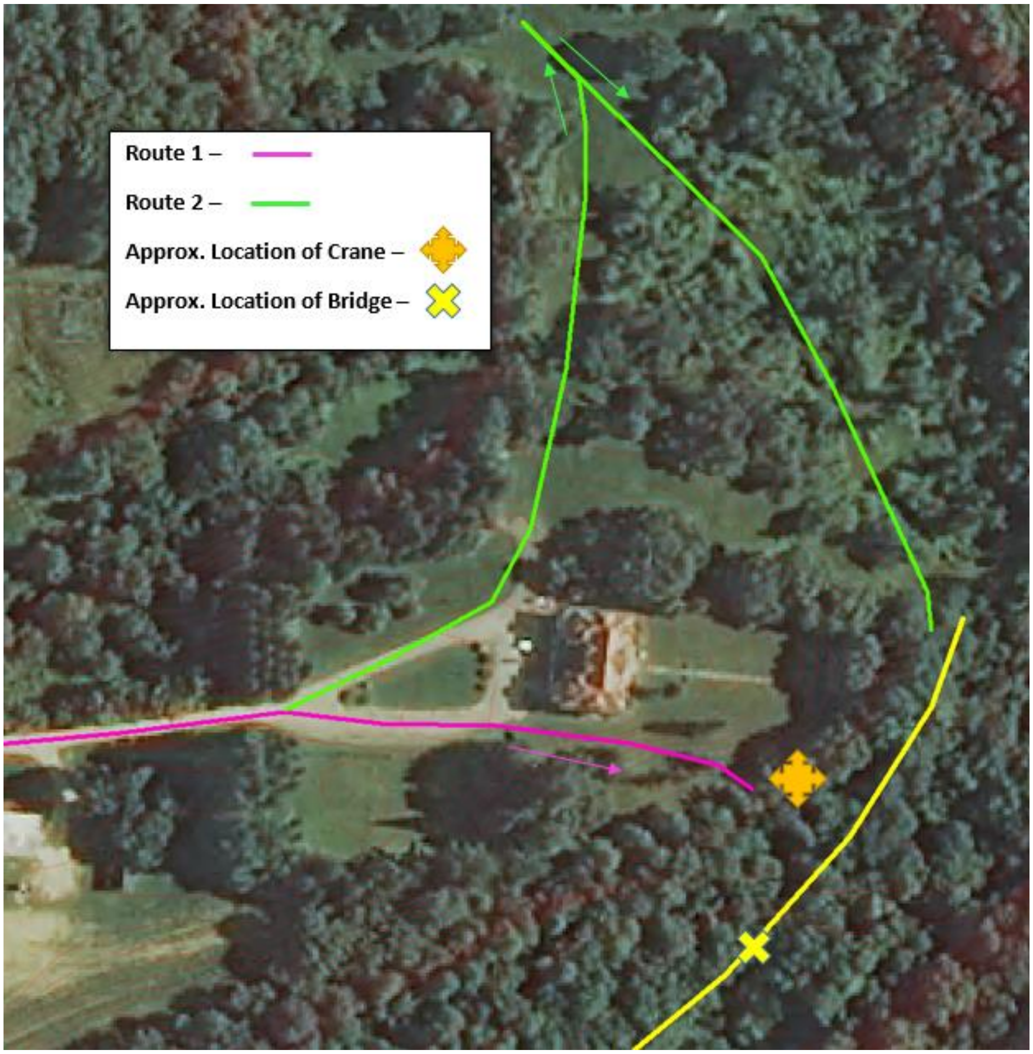

Figure 7: Potential routes for bridge installation.

5.2 Walkway Design

The walkways throughout Neste Park will provide a means of connection for the Nature Center and the regional trail. More so, they will tour the historic buildings near the Nature Center and allow visitors to explore the main area. The walkways will begin at both ends of the Nature Center to allow north and south access for visitors entering the walkway at different locations. There will also be a walkway beginning at the parking lot for visitors who wish to go directly to the walkway upon arrival.

The walkways will directly connect to the regional trail, encouraging the regional trail guests to visit the internal walkways and vice-versa. The walkways loop around the historic buildings and offer various paths for visitors, depending on how long they would like to explore. The walkway also goes through the forest to a scenic overlook of Dry

Run Creek. A seating area (potentially a gazebo) will be provided for visitors who choose to take this route for exploration. The walkways will be constructed with permeable pavement, a sustainable option that minimizes environmental impact and trail degradation, all while complimenting the natural aesthetics of the area. Additionally, a minor portion of the trail will be composed of mowed grass to reduce unnecessary costs.

A map of the walkway relative to the Nature Center is displayed in Figure 8 below, with the permeable pavement walkway shown in white, mowed walkway in light blue, and regional trail in yellow.

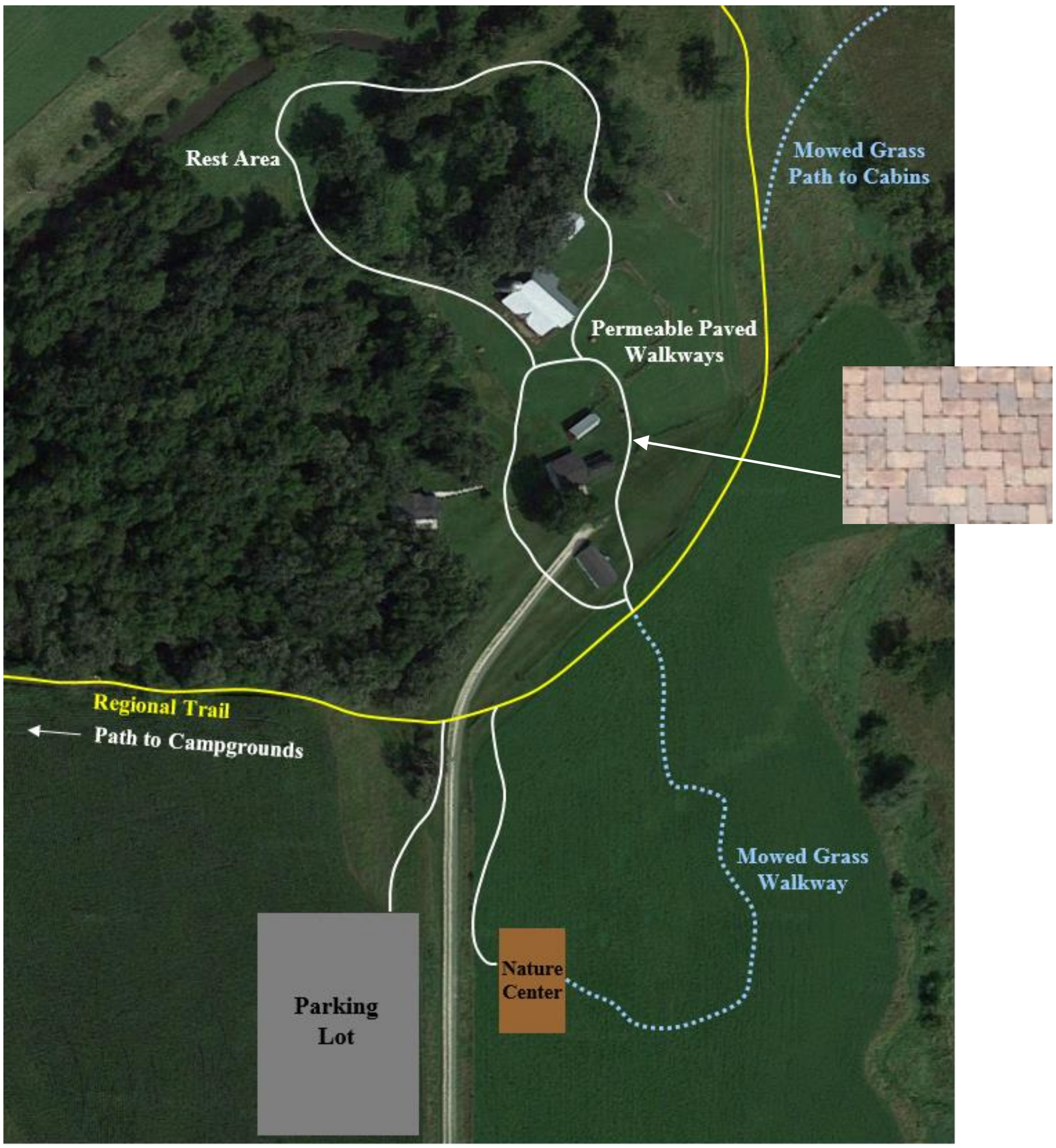

Figure 8: Internal walkways in Neste Park.

5.3 Bridge & Kiosk Foundation

To ensure the previously described Contech steel bridge is safely installed, as well as to extend the expected life of the pedestrian bridge, a proper foundation is needed for the structure. According to Contech, the bridge design weight is 13,300 lbs. Likewise, the pedestrian live load will be 90 lb/ft^2. The maximum LRFD factored loading based on load case 2 will then be 51.2 kips per foundation, or 5,120 lb/ft of wall based on the 10' width of the bridge. The foundation was designed as a retaining wall where the factor of safety against overturning, sliding, and bearing capacity was analyzed. If our proportioned structure met a factor of safety against overturning of 3, a factor of safety against sliding of 1.5, and a factor of safety for bearing capacity of 3, the design could be deemed acceptable. In most cases, the factor of safety against sliding dictates the design, but due to the low bearing capacity of the silty loam soil located at the desired bridge location, the factor of safety for bearing capacity was the designs ultimate limit state.

After several iterations, the foundation was determined to be 10'-6" tall with a 1'-0" stem, 11'-0" long. The base of the foundation had a 1'-2" toe, 1'-6" heel, and should be 1'-0" thick. At this depth, the foundation would successfully avoid abutment scour caused by Dry Run Creek at its 100-yr flood level. To protect the abutment during extreme conditions, several other features are recommended. A 45^o wingwall, 4'-0" long, and with the same foundation base dimensions should be included on each side of the abutment. To reduce unnecessary concrete, the wingwall will have a 4:1 sloped top extending from the main abutment to the end of the wingwall. Our organization also recommends the addition of riprap lining around the base abutment to alleviate the possibility of abutment scour. Riprap with an average diameter of 6" is recommended. The riprap skirt surrounding the abutment should extend 8 feet out from the base of the abutment, and should be 9" thick when above the average water depth and 12" thick when beneath the average water depth due to uncertainties in flow. A schematic of our design can be seen in Figure 9. Refer to Appendix A for detailed design calculations used for both the bridge foundation, and riprap sizing. Also included in Appendix A is detailed dimensions of the bridge abutment.

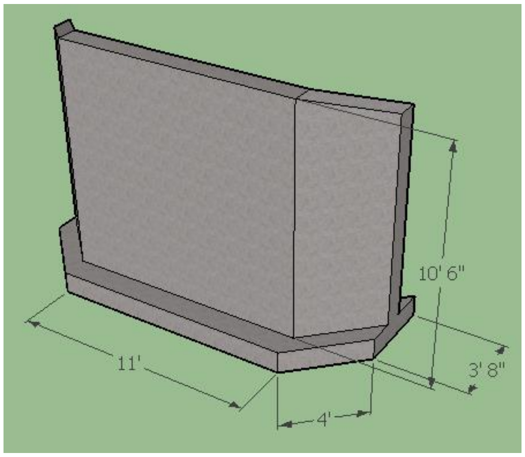

Figure 9: 3D rendering of pedestrian bridge abutment

Complete calculations for the design of a trail head kiosk foundation can be found in Appendix A. After analyzing both the downward force and potential uplift from extreme wind velocities, our organization found the trail head kiosk foundation to only be a 1’-0” square cross-section. In fact, assuming the trail head kiosk is anchored by 2 legs, a 1’-0” square foundation per leg would provide more than needed design strength. Due to the minimal size of this foundation, our organization does not recommend requiring a lengthy, expensive installation process for this foundation. Though, the foundation for the kiosk is recommended to be no smaller than a 1’-0 square concrete foundation, 9” or more thick.

5.4 Signage

Signage throughout the Neste Recreational Trail will offer directional and educational services to the public. To maintain our focus in safety and sustainability, marker posts, trail maps, and informative pedestals will be placed along the trail. Vacker Inc. creates signs for trails and parks and were selected for their environmentally-friendly and aesthetically pleasing products.

Recycled plastic lumber trail marker posts will be placed every 0.1-miles along the regional trail to let visitors know how far they have traveled and mark the trail edges during the winter with heavy snowfall. The posts will be 4” x 4” x 6’ with labels marking the trail distance on each side of the post. Each post will also contain vandal resistant stainless steel fasteners. Figure 10 displays the mile marker and optional symbols.

Figure 10: Recycled plastic lumber mile marker posts, courtesy of Vacker Signs Inc.

A kiosk will be located where the walkway at the Nature Center connects to the regional trail. This kiosk will show a map of the Neste Park and trails with additional information provided by the Winneshiek County Conservation Board. Kiosks serve to welcome visitors and provide them with information that may be essential to their safety and enjoyment on the trail. Kiosks typically give visitors information that results in less waste around the trail and an understanding of volunteer efforts. In addition to creating a visible map of the trails, hikers traveling along the trail may find information at kiosks helpful in understanding their location in relation to area surroundings, such as their proximity to a nearby town's available services.

To implement these ideas, a two-sided pitched roof kiosk have been selected from Vacker Signs Inc. The kiosk will also come with a cedar wood underlayment and steel roof that provide a natural look to compliment the area. Figure 11 shows an example of the kiosk for Neste Park.

Figure 11: Kiosk near park entrance courtesy of Vacker Signs Inc.

Figure 12: Informative pedestal courtesy of Vacker Signs Inc.

Angle mount frameless pedestals will also be placed along the trail to serve as educational and directional placards. This pedestals will have information about the original landowners, historic landscapes, native species, and additional information to guide visitors along the trail. Figure 12 shows an example of one of the many pedestals to be placed throughout the trail and walkways.

5.5 Ancillary Structures

To comply with ADA Standards and offer rest areas along the trail, recycled plastic benches will be placed every one-tenth of a mile on the regional trail, well within the ADA requirements. Each bench is 6' long and offers a natural look that compliments the area. Figure 13 shows an example of the recycled plastic bench proposed for the Dry Run Trail.

Figure 13: Recycled plastic bench courtesy of The Park Catalog.

There are many scenic views throughout the Dry Run Trail within Neste Park. To highlight these areas and encourage visitors to spend the day at the park, Hawk-Trek Trails Inc. proposes adding at least one gazebo at the north-side of the internal walkway, where a beautiful overlook of the Dry Run Creek can be viewed while visitors stop to rest or eat. Figure 14 displays an example of the proposed picnic area for Dry Run Trail.

Figure 14: Picnic area proposed for southwest corner of Dry Run Trail.

A natural playground near the Nature Center is also recommended, as it would attract more families and promote outdoor exercise. Figure 15 shows an example of a natural playground that would complement the surrounding area.

Figure 15: Proposed playground near the Nature Center to attract visitors and promote outdoor recreation.

6 Cost and Construction Estimates

Cost estimations for the entire project are located in Table B1 of Appendix B. The final costs are divided into five categories, including the regional trail, walkways, structures, signage, and additional options.

The regional trail budget consisted of clearing and grubbing, grading, granular subbase fill, concrete, seeding and mulching, excavation, soil fill, labor, equipment, transportation, and construction services. A basic excavation cost of $3 per cubic yard was used to estimate the excavation costs for the regional trail. Similarly, a cost of $5 per cubic yard was used to estimate the cost to fill areas that required soil (Walker, 2012). The cut and fill volumes were provided by AutoCAD Civil 3D, where the volume was multiplied by the unit price for excavation and fill to come up with a final estimate. A price of $54,000 was calculated for cut and fill volumes of 8,300 cubic yards and 5,800 cubic yards, respectively. The cost to fill land should be slightly more than excavation because compaction equipment and additional labor are required. Cut and fill costs were considered minor for the internal walkways because they were placed specifically along the grade lines to minimize cut and fill entirely.

These costs do not take labor (planning, equipment, material acquisition, area preparation, and setup/cleanup), disposal costs, and equipment allowance (specialty equipment, demolition) into consideration. For that reason, the Iowa Trails 2000 cost estimates were used to determine prices for clearing and grubbing, grading, subbase, concrete, seeding and mulching, and construction services. The unit price for each of these tasks is located in Table B1, Appendix B. Additionally, inflation was considered to alter the costs from year 2000 to realistic costs for the year 2015.

The total cost for clearing and grubbing was found by multiplying the unit price by a length and width of 6,200 feet and 14 feet, respectively. A width of 14 feet was used by assuming that the width of the trail (10 feet) and an additional two feet on each side would need to be cleared for accessibility. Equation 1, Appendix A describes this calculation. The cost for grading was determined by multiplying the unit price by the length of the trail, shown in Equation 2, Appendix A. The granular subbase cost was found by multiplying the unit price by the length of the trail and a width of 14 feet, assuming an additional 2 feet of fill on each side of the trail. The subbase cost is calculated in Equation 3, Appendix A. A concrete price for the regional trail was estimated by multiplying the unit price by the length of the trail and a ten foot width, shown in Equation 4, Appendix A. Lastly, seeding and mulching prices were determined by multiplying the unit price by the length of the trail and an assumed width of 4 feet. Seeding and mulching calculations are given in Equation 5, Appendix A.

The final items to be considered for the regional trail are labor, equipment, and transport. The costs were calculated by assuming that each person can handle 100 cubic yards each hour and each person makes roughly $30 an hour. The labor calculation can be found in Equation 6, Appendix A. Similarly, an equipment cost is calculated in Equation 7, Appendix A, where it is assumed that one dozer can handle 300 cubic yards an hour at an operation cost of $90 per hour. A transportation cost was estimated in Equation 8, Appendix A, where it is estimated that a dump truck can hold 18 cubic yards per trip with a price of $100 per trip (Assakkaf, 2003). Only the extra soil left over (cut volume minus fill volume) was considered in the transport costs because the remaining soil would remain onsite. By adding each of these subtotals, a total cost for the 1.2 mile-long regional trail through Neste Park is $380,000.

Costs for the internal walkways were estimated using the average unit price of permeable pavement at $5.55 per square foot (Walker, 2012). The area of the permeable pathway was estimated by multiplying the length of the walkway at 1,650 feet by a width of 6 feet. This area was then multiplied by $5.55 to come up with a total cost of $55,000 for the walkway material. Similar to that of the regional trail, clearing and grubbing, grading, labor, equipment, and construction services were estimated using the Iowa Trails 2000 manual. Values from Iowa Trails 2000 were inflated for the year 2015 and multiplied by the length and width of the walkway at 1,650 feet and 6 feet, respectively.

Structures for the Neste Park include a steel bridge, foundations for the bridge and kiosk, and benches. The bridge was discussed in Section 5.1 (Regional Trail Design) and has a total cost of $35,200 delivered F.O.B. Both foundations will be constructed with concrete, having an average price of $90 per cubic yard (CN, 2015). Volumes of these foundations were multiplied by the unit price of concrete to find a total price of $1,800. Rip-rap unit cost was found to be $25 per cubic yard for a D_{50} of 6” (Rolfe, 2014). The volume of riprap necessary to protect the Dry Run Creek from erosion was calculated in Appendix A. The kiosk foundation was found to be less than $5 and was left out of the total cost table for clarity.

Benches were a necessary addition to the regional trail to provide a resting area for visitors. Recycled plastic benches were selected with a price of $664 each (The Park Catalog, 2014). Benches will be placed frequently along the regional trail to provide rest opportunities that exceed ADA standards. As the trail is 1.2 miles in length, this would require a minimum of two benches according to ADA standards. To provide further seating, eight additional benches will be placed throughout the regional trail and highlight scenic areas. The mile markers, kiosk, and informative pedestals were discussed in detail in Section 5.5. Each mile marker and pedestal has a unit price of $221 and $162, respectively. The trail head kiosk will cost $2,743 (Osterberg, 2015).

A bonus of $45,000 is included in the cost estimation to allow for additional structures such as a gazebo/pavilion and playground within the Neste Park area. We highly recommend each of these additions as they will attract visitors and enhance the overall experience.

A final project cost of $530,000 is estimated for the Neste Park Recreational Trails. This price includes materials and labor for the regional trail and walkways, a steel bridge, foundations, signage, seating, and optional structures.

For the construction of the regional trail, bridge, and internal walkways it will take approximately seven months to complete, starting in 2019 as requested by the Client. The majority of the time will be taking up grading and excavating the land to our desired shape. Actual construction is planned to not begin until the middle of March so that there is enough time for snow to melt. Our hope is to have the project completed before the beginning of October, as seen in Figure 16 below.

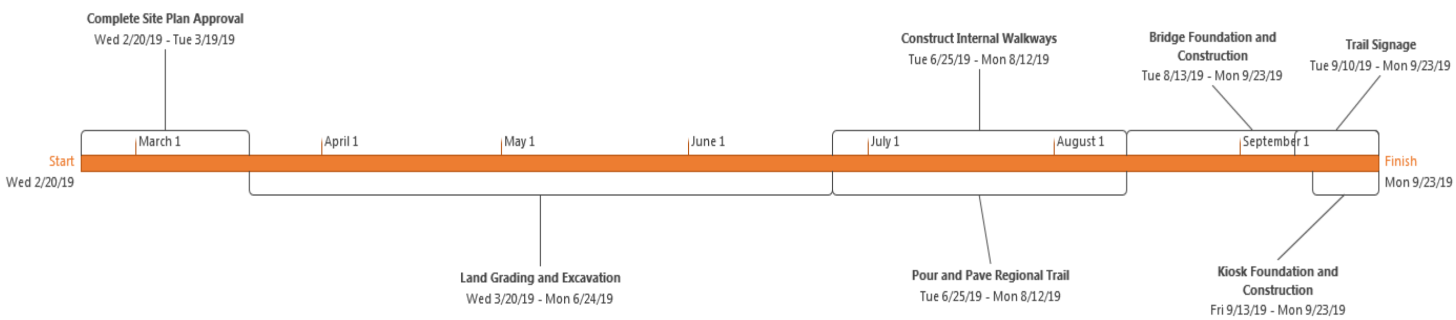

Figure 16: Project timeline

7 Conclusions

At Hawk-Trek Trails Inc., we pride ourselves on our ability to create sustainable yet feasible trail designs. Our final design for the Neste Park Recreational Trail offers safe, reliable, and educational recreation opportunities for visitors. Our focus on regulatory compliance, minimal environmental impact, and low maintenance has created a final design that ensures a long-lasting, successful trail system. The final design offered for the Neste Park area includes a 10-foot wide concrete trail and various permeable walkways for exploration. A 60-foot steel bridge will span Dry Run Creek and establish the northeast Iowa regional trail. Ancillary structures including kiosks, informative pedestals, and seating have been included in the final design to ensure sustainable public interaction. The total cost for the Neste Recreational Trail System is $530,000, including materials, labor and infrastructure. We are confident that our trail design will provide visitors with an unparalleled experience while enhancing the unique features of Neste Park.

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Appendix A: Relevant Calculations

Clearing/Grubbing Cost: $\frac{\$2960}{acre} * (14\ ft.) * (6200\ ft.) * \frac{acre}{43560\ ft.} = \$5{,}898$ **(1)**

Grading Cost: $\frac{\$4440}{mile} * (6200\ ft.) * \frac{mile}{5280\ ft.} = \$5{,}214$ **(2)**

Granular Subbase Cost: $\frac{\$0.60}{sq.ft.} * (14\ ft.) * (6200\ ft.) = \$52{,}080$ **(3)**

Concrete Cost (regional trail): $\frac{\$3.33}{sq.ft.} * (10\ ft.) * (6200\ ft.) = \$206{,}460$ **(4)**

Seeding/Mulching Cost: $\frac{\$2368}{acre} * (4\ ft.) * (6200\ ft.) * \frac{acre}{43560\ ft.} = \$1{,}348$ **(5)**

Labor Cost: $\frac{1\ hr}{100\ CY} * \frac{\$30}{person} * 5\ people = \$1.5/CY$ **(6)**

Equipment Cost: $\frac{\$90}{hr-dozer} * \frac{hr}{300\ CY} * 2\ dozers = \$0.6/CY$ **(7)**

Transport Cost: $\frac{trip}{18\ CY} * \frac{\$100}{trip} = \$5.55/CY$ **(8)**

Riprap Cost: $\left(19\ feet\ long * 8\ feet\ out * \frac{\mathbf{10.5\ in}}{\mathbf{12\frac{in}{ft}}}\right) * \frac{\mathbf{yd^3}}{\mathbf{27\ ft^3}} * \frac{\mathbf{\$25}}{\mathbf{yd^3}} * 2\ abutments = \$246$ **(9)**

Trail Head Foundation Design

The size of the foundation for the main trail head kiosk/map will be governed by the wind loads applied to the structure. ASCE/SEI 7-10 Directional Procedure was used to determine the forces. To begin, the trail head kiosk was assumed to be an open building with monoslope, pitched, or troughed free roofs. The velocity pressure was estimated using the following equation.

$$q_z = 0.00256 K_z K_{zt} K_d V^2 = 13.67\ lb/ft^2$$

where, K_d *= wind directionality factor = 0.85 (solid freestanding and attached sign)*

K_z *= velocity pressure exposure coefficient = 0.57 (Exposure B)*

K_{zt} *= topographic factor = 1.0 (conservatively)*

V = basic wind speed = 105 mph (Building Risk Category I)

q_z *= velocity pressure calculated at height z*

q_h *= velocity pressure at mean roof (equivalent to* q_h *in our case due to the limited height of the trail head kiosk.)*

The wind pressure is found using the subsequent equation.

$$p = q_h G C_N$$

where, *G = gust-effect factor = 0.85*

C_N *=net pressure coefficient*

C_N varies based on several factors. Analyzing the roof angle, load case A or B, wind direction, as well as clear wind flow versus obstructed flow, the most severe case was determined. At a roof angle of 30°, monosloped, the following C_N values were analyzed for both Load Case A and B, as required by the building code. Note, negative values correspond to uplift caused by the wind pressure.

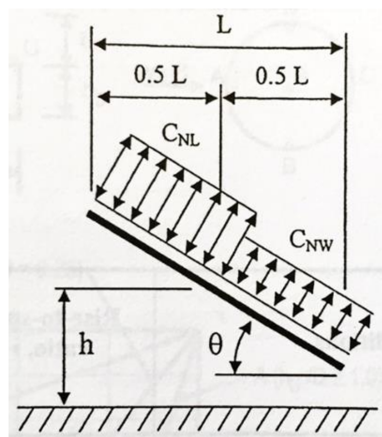


Figure A1: Roof wind loading

Case A: $C_{NW} = 2.1$ $C_{NL} = 2.1$

Case B: $C_{NW} = -2.3$ $C_{NL} = -1.1$

- $p_{A(NW)} = 24.4\ lb/ft^2$ $p_{A(NL)} = 24.4\ lb/ft^2$
- $p_{B(NW)} = -26.72\ lb/ft^2$ $p_{B(NL)} = -12.78\ lb/ft^2$

The following 2 LRFD load combinations apply to the trail head kiosk. Note, load combination 6 applies only in cases where the lateral force counteracts gravity. Assuming the trail head weighs approximately 500 lbs, and the roof area is 10 ft by 5 ft.

$$4. \quad P = 1.2DL + 1.0W + LL + 0.5(L_r \; or \; S \; or \; R)$$

$$= 1.2(500\; lb) + 1.0(24.2\; lb/ft^2 x[10\; ft\; x\; 5\; ft]) = 1.82\; kips$$

$$6. \quad P = 0.9DL + 1.0W$$

$$= 0.9(500\; lb) + 1.0(-26.72\; lb/ft^2 x\;[10\; ft\; x\; 2.5\; ft] - 12.78\; lb/ft^2 x[10\; ft\; x\; 2.5\; ft]) = -0.54\; kips$$

where, DL = deal load

LL = live load

W = wind load

L_r = roof live load

R = rain load

From Table 1806.2 from the IBC text, for a silty loam soil, the vertical foundation pressure is 1,500 psf. Note, this value takes into consideration foundation settlement, thus will not need to be considered.

$$Required\; Foundation\; Area = \frac{1{,}820\; lb}{1500\; psf} = 1.21\; ft^2$$

- Try a 1'-0" square foundation per footing (2 footings total)

Next, LRFD load case 6 needs to be analyzed for potential uplift. Assume a silty loam soil weight of 97.3 lb/ft^3. The frost line, and thus minimum foundation depth, for Decorah, IA will be taken as 48". The soil above the 1'-0" sq. foundation and weight of the trail head kiosk must outweigh the uplift load in order to satisfy this condition.

$$wt\; of\; soil + DL = 97.3\; \frac{lb}{ft^3}\left(([1.0\; ft]^2 - [0.5\; ft]^2)x4\; ft\right) + 500\; lb = 791\; lb\; per\; footing$$

- The weight of the combined soil and trail head kiosk is far greater than the total 540 lb uplift force, and thus the foundation size of 1'-0" is OK. Use a foundation thickness no less than 9". Monosloped or pitched roof is allowed with a 1'-0" sq. by 9" thick foundation.

Pedestrian Bridge Abutment Calculations

Bridge Loads:

- Pedestrian = 90 psf
- Bridge Weight = 13,300 lb

LRFD (per abutment):

2. $P = 1.2DL + 1.6LL = 1.2\left(\frac{13{,}300\ lb}{2}\right) + 1.6\left(90\ psf\ x\ \left\{\frac{60\ ft\ x\ 10\ ft}{2}\right\}\right) = 51.2\ kips$

where, DL = dead load

LL = live load

➢ *Knowing that the bridge is 10 ft wide, this equates to 5120 lb/ft of wall*

Soil Properties:

- Unit weight of soil, γ = 97.3 lb/ft^3 (Silty Loam soil)
- Soil friction angle, φ' = 30^o
- Cohesion, c' = 31.3 lb/ft^2

Using Table 1806.2 from the IBC text, the highly conservative vertical foundation pressure of a silty loam is 1500 psf. Knowing this value, the initial foundation cross-sectional area can be estimated. Note, this value takes into consideration settlement. All foundations larger than the required cross-sectional area satisfy the foundation settlement limit state.

$$Required\ Foundation\ Area = \frac{51{,}200\ lbs}{1500\ psf} = 34.1\ ft^2$$

➢ *Start with a 2.5 ft by 15 ft cross-sectional area*

To determine the required depth of the foundation, the Dry Run Creek scour depth needs to be determined. The max velocity, v_{max} = 3.9 ft/s and flood depth, y_a = 7 ft. Using Froehlich's abutment scour equation, the scour depth was determined.

$$\frac{y_s}{y_a} = 2.27K_1K_2\left(\frac{L'}{y_a}\right)^{0.43} Fr^{0.61} + 1$$

where, y_s *= scour depth, ft*

K_1 *= coefficient for abutment shape = 0.82 (45° wing wall)*

$K2 = \left(\frac{\theta}{90}\right)^{0.13} = 1\ (conservatively)$

θ = angle of abutment wall to upstream flow (θ<90 for a wingwall)

L' = length of active flow obstructed by embankment = 15 ft

y_a = average depth of flow in floodplain = 7 ft

$$Fr = \sqrt{\frac{v_{max}}{g y_a}} = \sqrt{\frac{3.9\ ft/s}{32.2\frac{ft^2}{s}\ (7\ ft)}} = 0.1315$$

- *From the Froehlich equation, scour depth, y_s = 1.10 ft. Therefore, set the depth of the foundation, D_f = 8.5 ft.*

The abutment will be analyzed as a retaining wall. The abutment must satisfy a factor of safety against overturning of 3, a factor of safety against sliding of 1.5, and a factor of safety for bearing capacity of 3.

Factor of Safety against Overturning:

$$FS_o = \frac{\Sigma M_R}{\Sigma M_o} = 4.58 > 3$$

where, ΣM_R = sum of the moments resisting overturning

$$\Sigma M_R = wt\ of\ concrete\ x\ moment\ arm + wt\ of\ soil\ applied\ to\ abutment\ heel\ x\ moment\ arm + additional\ loads\ x\ moment\ arm = 14.99\ kip - ft/ft$$

ΣM_o = sum of the moments causing overturning

$$\Sigma M_o = P_a\left(\frac{H}{3}\right) = \frac{1}{2}\gamma\ H^2 K_a = 3.28\ kip - ft/ft$$

K_a was determined from Table 7.3 of Braja's *Principles of Foundation Engineering*, assuming the soils angle of inclination, $\alpha = 0^o$.

Factor of Safety against Sliding:

$$FS_s = \frac{\Sigma F_{R'}}{\Sigma F_d} = 3.23 > 1.5$$

where, $\Sigma F_{R'}$ = sum of the forces resisting sliding

$$\Sigma F_{R'} = \Sigma V tan\delta' + Bc'_a + P_p = 3.73\ kips$$

ΣF_d = sum of the driving forces

$$\Sigma F_d = P_a = 1.156\ kip/ft$$

δ' was taken as 2/3 of φ'. P_p was conservatively ignored.

Factor of Safety for Bearing Capacity:

$$FS_{BC} = \frac{q_u}{q_{max}} = 3.38 > 3$$

where, q_{max} *= larger of* q_{toe} *or* q_{heel}

$$q_{toe} = \frac{\Sigma V}{B}\left(1+\frac{6e}{B}\right) = 3.662\ kip/ft^2$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1-\frac{6e}{B}\right) = 0.783\ kip/ft^2$$

$$e = \frac{B}{2} - \frac{\Sigma M_R - \Sigma M_O}{\Sigma V} = 0.396 < \frac{B}{6} = 0.611\ \ OK.$$

$$q_u = c'N_cF_{cd}F_{ci} + qN_qF_{qd}F_{qi} + \frac{1}{2}\gamma B'N_\gamma F_{\gamma d}F_{\gamma i}\ = 12.262\ kip/ft^2$$

$N_c = 30.14$ $\qquad q = \gamma D = 0.141\ kip/ft^2$

$N_q = 18.40$ $\qquad B' = B - 2e = 2.88\ ft$

$N_\gamma = 22.40$ $\qquad F_{xi} = 1\ (no\ inclination)$

All shape factor values, N, were taken from Table 3.3 of Braja's *Principles of Foundation Engineering*. Note, if *e* had been greater than B/6, the soil at the heel of the base would be in tension. Because soil cannot withstand tension, the dimensions should have been re-proportioned.

Riprap Sizing

With the Froude number less than 0.80, the following equation can be used to determine the D_{50} for the abutment riprap. Note, this equation applies for SI units.

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]$$

where, *K = 1.02 for vertical wall abutment*

S_s *= specific gravity of rock riprap = 2.65*

y = flow depth at flood level = 7 ft = 2.134 m

V = maximum velocity at flood level = 3.9 ft/s = 1.189 m/s

- The D_{50} required for the bridge abutment is 0.0891 m, or 3.5 in. Due to the lower max velocity, Hawk-Trek Trails Inc. recommends increasing the riprap D_{50} size to a minimum of 6 inches.

The riprap should extend 2 times the average flow depth into the bridge waterway, or approximately 8 feet. Likewise, the thickness required should be 1.5 times the D_{50} size while above the average depth water level (approximately 9”), and 2.0 times the D_{50} size when under the water level due to flow uncertainties (approximately 14”).

Horizontal Curve Calculations

The minimum radius of curvature, R, is derived from equation (x)

$$R_{min} = \frac{V^2}{15(\frac{e}{100} + f)}$$

Where V (mph) is the design speed, e (%) is the super elevation and f is the coefficient of friction. From the IDOT trail design standards bike trials design speed ranges from 18 to 30 mph. We chose to use two design speeds of 18 and 25 mph, with our superelevation as 2%, and assuming a friction coefficient of 0.3 between the pavement and bicycle wheel we found our minimum horizontal curve radius to be 130 and 67 feet for design speeds of 25 and 18 mph respectively.

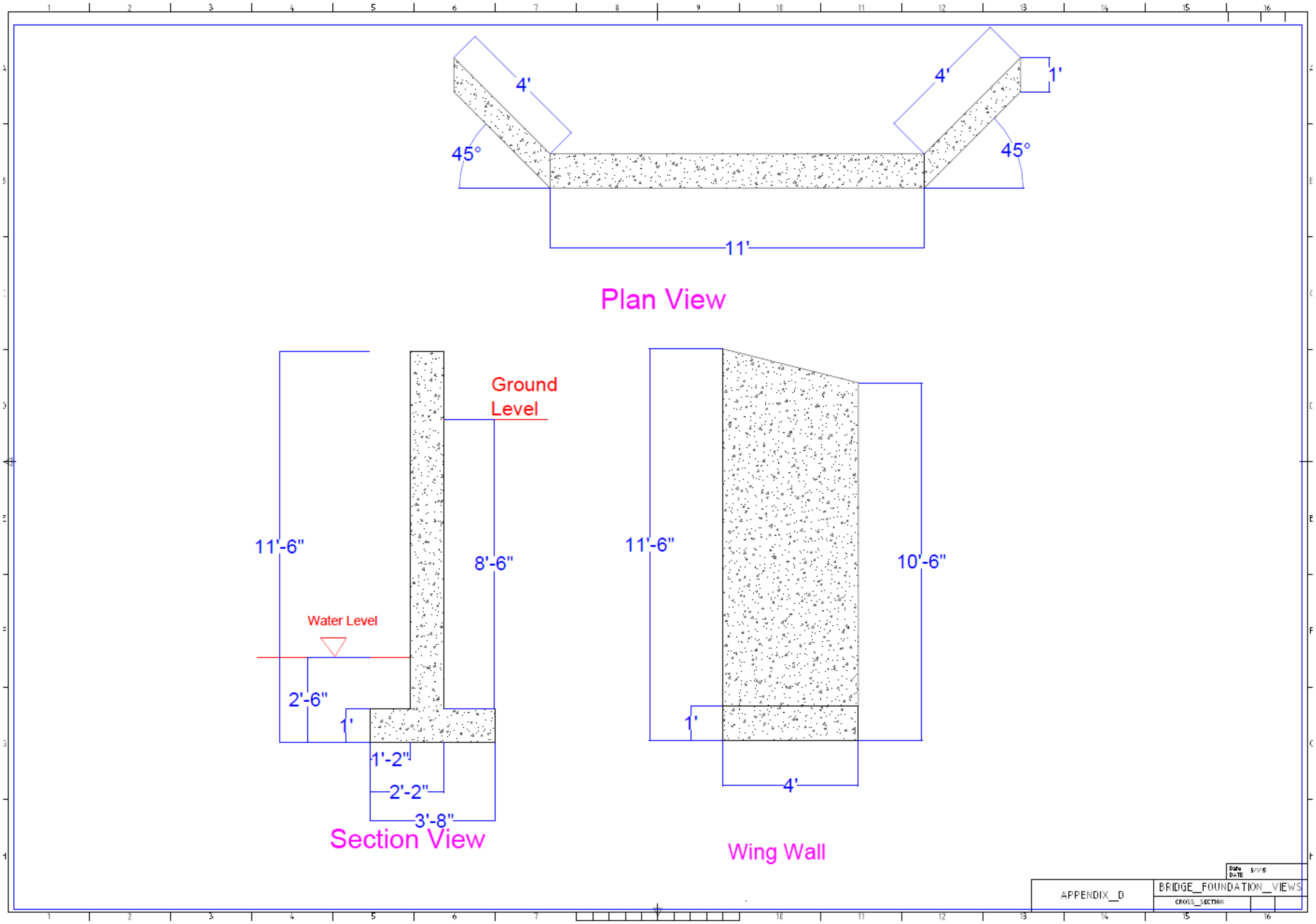
$$R_{min} = \frac{25^2}{15\left(\frac{2}{100} + 0.3\right)} = 130'$$

$$R_{min} = \frac{18^2}{15(\frac{2}{100} + 0.3)} = 68\,'$$

Neste Trail Max Vertical Slopes

Table A1: AASHTO compliant vertical slopes

Station 1	Station 2	Curve Length (ft)	Grade of Curve	Maximum Curve Length at Current Grade (ft)
11+00	13+00	200'	< 7%	400'
17+00	19+00	200'	<6%	800'
25+00	27+00	200'	<9%	200'
29+00	30+00	100'	<7%	400'
32+00	34+00	200'	<8%	300'
38+00	40+50	250'	<7%	400'
41+00	42+00	100'	<10%	100'
43+50	44+50	100'	<7%	400'
45+00	46+00	100'	<6%	800'
50+00	51+00	100'	<8%	300'
52+00	53+00	100'	<6%	800'
57+00	58+00	100'	<7%	400'
62+50	63+00	150'	<7%	400'


4'
4'
1'
45°
45°
11'
Plan View
11'-6"
Ground
Level
8'-6"
Water Level
2'-6"
1'
1'-2"
2'-2"
3'-8"
Section View
11'-6"
10'-6"
1'
4'
Wing Wall
APPENDIX_D
BRIDGE_FOUNDATION_VIEWS

Appendix B: Cost Information

Table B1: Cost estimation for regional trail and internal walkways in Neste Park.

Item	Unit Cost	Total Cost
REGIONAL TRAIL		
Clearing, grubbing	$2,960/ac	$5,898
Grading	$4,440/mi	$5,214
Granular sub base	$0.60/ft^2	$52,080
Concrete	$3.33/ft^2	$206,460
Seeding, mulching	$2368/ac	$1,348
Excavation	$3/yd^3	$24,900
Fill	$5/yd^3	$29,000
Labor, equipment	$2.1/yd^3	$29,610
Transport	$5.55/yd^3	$13,875
Construction services	5% of trail cost	$18,047
Subtotal		$381,742
WALKWAYS		
Permeable pavement	$5.5/ft^2	$39,600
Clearing, grubbing	$2,960/ac	$673
Grading	$4,440/mi	$1,388
Labor, equipment	$2.1/yd^3	$216
Construction services	5% of trail cost	$2,826
Subtotal		$44,703
STRUCTURES		
Bridge	$35,200	$35,200
Bridge Foundation	$90/yd^3	$1,773
Riprap	$25/yd^3	$246
Benches	$664	$6,640
Subtotal		$43,859
SIGNAGE		
Kiosk	$2,743	$2,743
Trail posts	$221	$2,652
Informative pedestal	$162	$2,430
Subtotal		$7,825
ADDITIONAL		
Gazebo	$5,000	$5,000
Playground	$40,000	$40,000
Subtotal		$45,000
TOTAL		**$527,819**

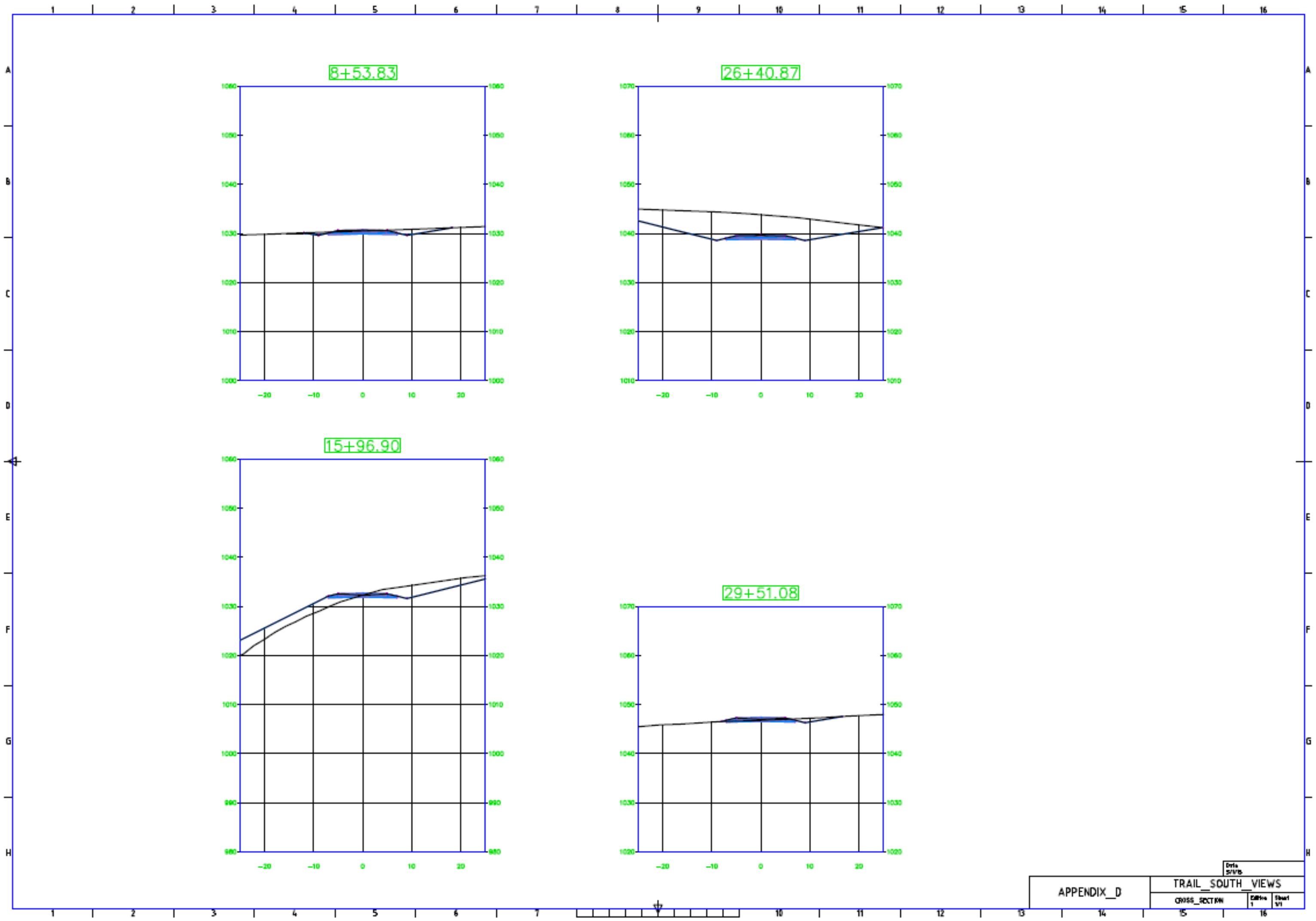
Appendix C: Neste Park Preliminary Designs

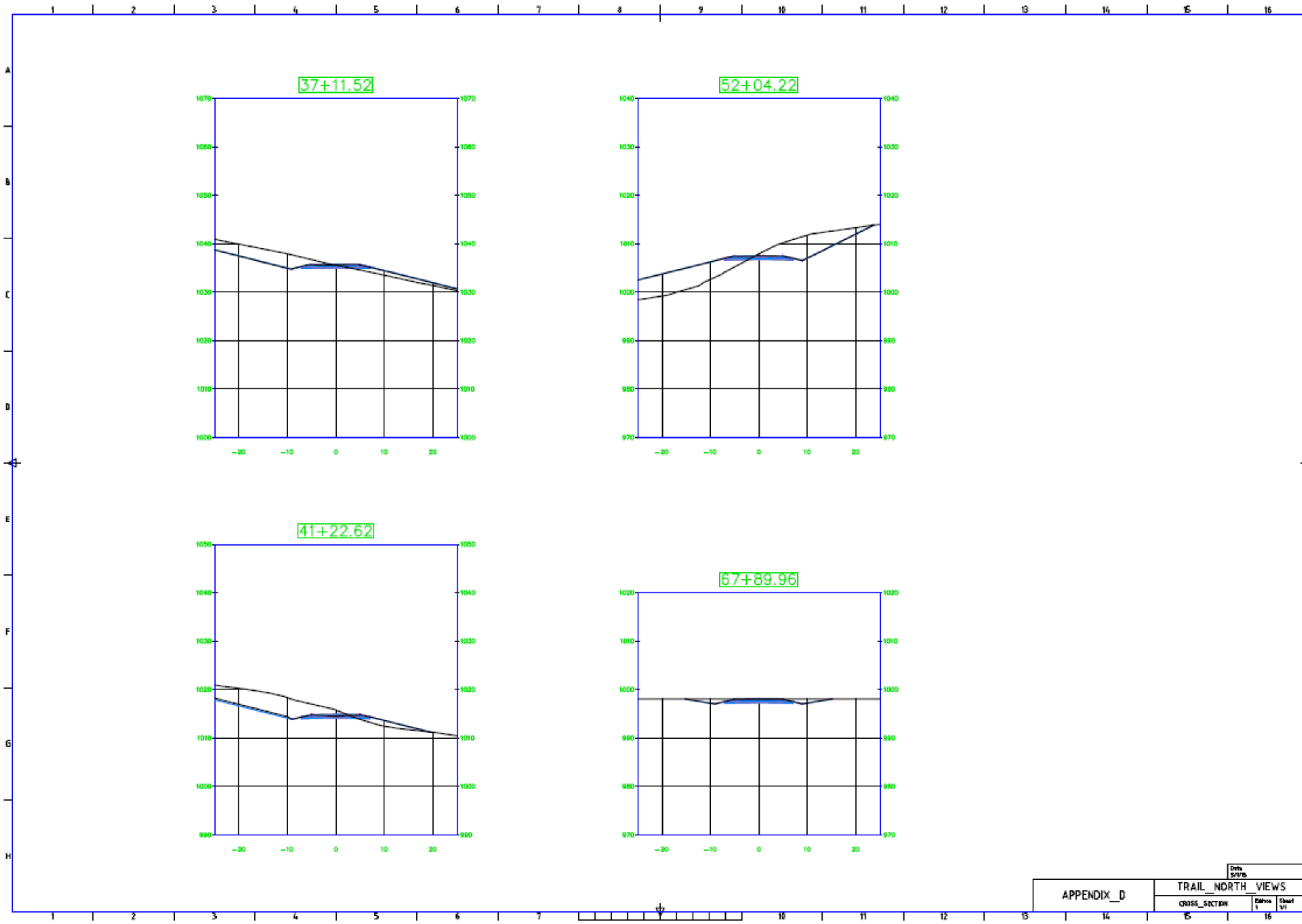
Figure C1: Preliminary Design Option 1

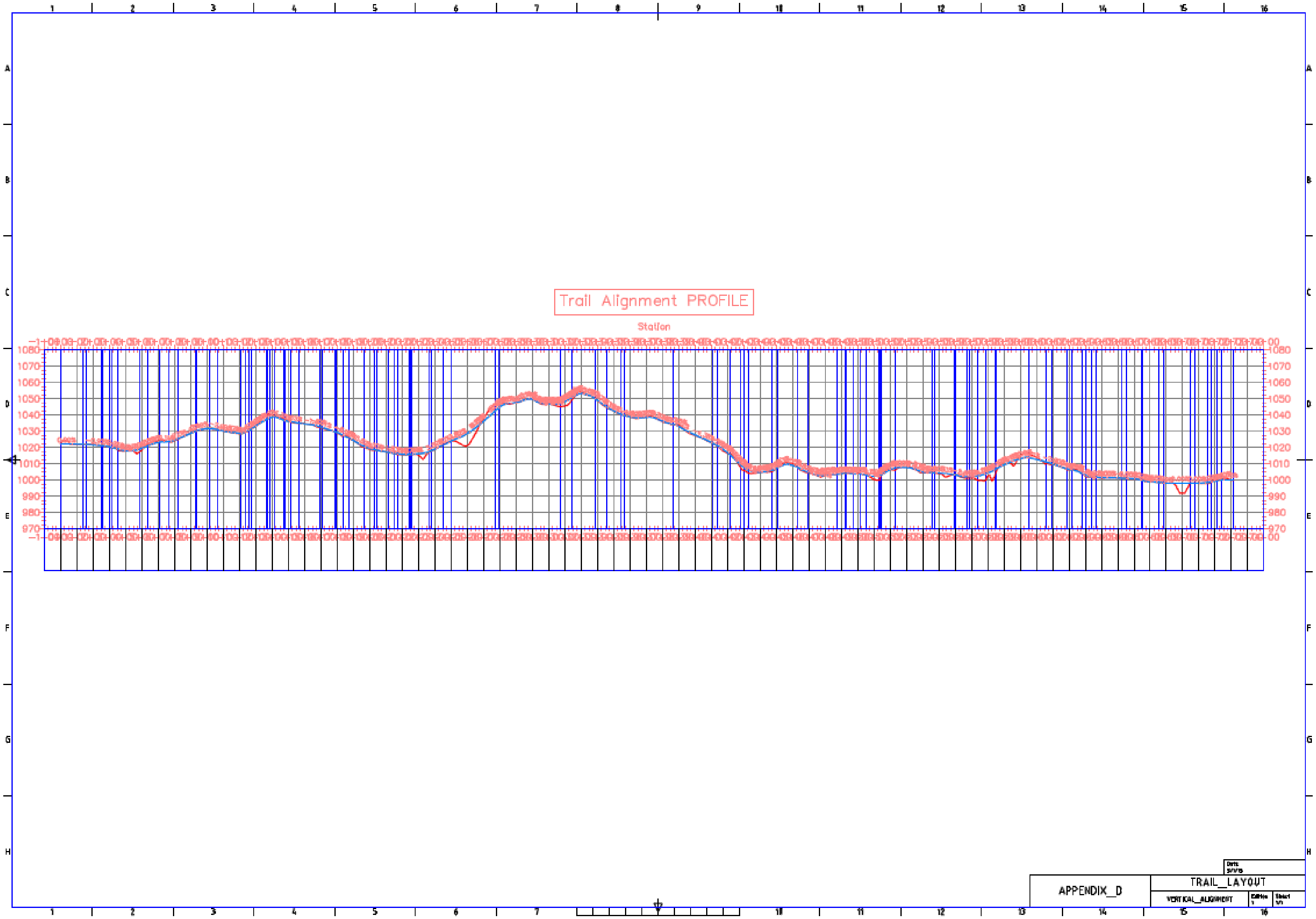
Figure C2: Preliminary Design Option 2

Figure C3: Preliminary Design Option 3

Appendix D: Trail Design Views




37+11.52
52+04.22
41+22.62
67+89.96
APPENDIX_D
TRAIL_NORTH_VIEWS
CROSS_SECTION
Edition
1
Sheet
1/1


Trail Alignment PROFILE
Station
APPENDIX_D
TRAIL_LAYOUT
VERTICAL_ALIGNMENT