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Design Requirements for Sustainable Trails

Once you have completed the initial planning, and before proceeding with construction, you need to establish the details of the design. The design process builds upon the work completed during the planning phase and results in defining the specific locations, details, and specifications that will guide the construction of the trail. Further, you must consider requirements for designing sustainable trails, trail amenities, and support facilities. These requirements apply to all trail types. When designing trails, you must also consider and address the requirements of all applicable permits as discussed in Chapter 1 - Planning.

With an understanding of the site gained during the planning process, your designer refines the trail alignment based on the trail's design requirements, users' needs, and sustainable design practices. The design requirements for your trail are based on the uses you desire to accommodate.

Your ultimate goal during the design phase is to develop plans and specifications that will communicate all aspects of the design to those responsible for building trails, trail amenities, and support facilities in a sustainable manner.



Dr. J Skills Park
Hardened tread
North Park, Allegheny County

Photo Credit: Jon Pratt



Allegrippis Trails
Huntingdon County

Photo Credit: Leslie Kehmeier



Unsustainable Trails

Photo Credits:
Steve Bloser, Director
PSU Center for Dirt & Gravel Road
Studies



Design Requirements for Sustainable Trails

To be successful, a trail must be designed to be physically, ecologically, and economically sustainable. This includes:

- Physical Sustainability**
 Designing trails to retain their structure and form over years of use and under forces of humans and nature is a key factor in sustainability. Trail use promotes change, so trails must be designed in anticipation of change to ensure that they remain physically stable with appropriate maintenance and management.
- Ecological Sustainability**
 Minimizing the ecological impacts of trails, and protecting sensitive natural and cultural resources is fundamental in sustainable trail design and development.
- Economic Sustainability**
 For any trail to be sustainable, the implementing agency or advocacy group must have the capacity to economically support it over its life cycle. Developing and committing to a long-term maintenance strategy is a critical aspect of a successful trail program.

How Does this Translate on the Ground?

While there are many factors that can influence the sustainability of trails, when you design them, they should achieve the following objectives.

Connect Positive, and Avoid Negative, Control Points

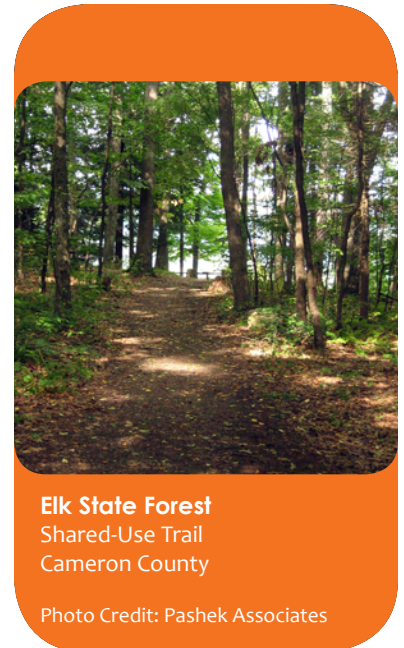
Sustainable trails lead users to desired destinations such as water features, historic sites, vistas, interesting landforms and user facilities; while avoiding wet areas, steep slopes, critical habitats, and other culturally or environmentally sensitive areas.

Keep Water Off the Trail

Erosion is the number one problem for sustainable trails. It damages trails, is expensive to repair and diminishes the user experiences. Water is the primary erosive force. Trails that collect water or channel water will be both environmentally and economically un-sustainable.

Follow Natural Contours

Trails lie on the land in three ways: 1) Fall Line Trail - along a fall-line, parallel with the direction of the slope, 2) Flat Trail - on flat ground with little slope or cross slope, and 3) Contour Trail - along the contour with subtle elevation changes. Of these types of trails, only the contour trail easily sheds water and is thus sustainable.



Elk State Forest
 Shared-Use Trail
 Cameron County

Photo Credit: Pashek Associates



Hillside Before Trail

Vegetation stabilizes the slope, slows down stormwater runoff, thereby preventing erosion.



Wintergreen Gorge
Braided Trail
Erie County

Photo Credit: Pashek Associates

Keep Users on the Trail

When users leave the trail tread, they widen it, create braided trails, and create social trails. These can cause environmental damage and raise maintenance costs. Users leave the trail when it becomes eroded or wet, or when the trail does not meet their needs or expectations.

Ultimately, a sustainable trail design will most often be a contour trail that connects desired control points by contouring along the sides of slopes while making subtle changes in grade.

Upon establishing your Trail Management Objectives (see Chapter 5 – Management) and referring to the user characteristics and design requirements for the respective trail type (as detailed in Chapter 2 - Design Requirements for Specific Trail Users), you are ready to begin the design of your trail.

Important considerations in sustainable trail design include:

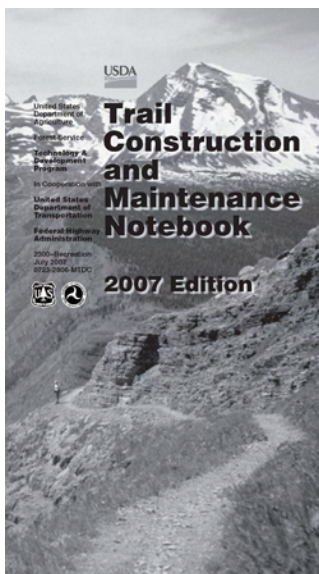
- Trail Corridor
- Tread Design
- Tread Drainage
- Changes in Trail Grade
- Drainage Solutions
- Tread Reinforcement & Trail Structures
- Trailhead Design
- Signage and Markings
- Trail Gates and Barriers
- Bridges
- Landscaping with Native Plants

Each of these considerations are described in this Chapter.

Trail Corridor¹

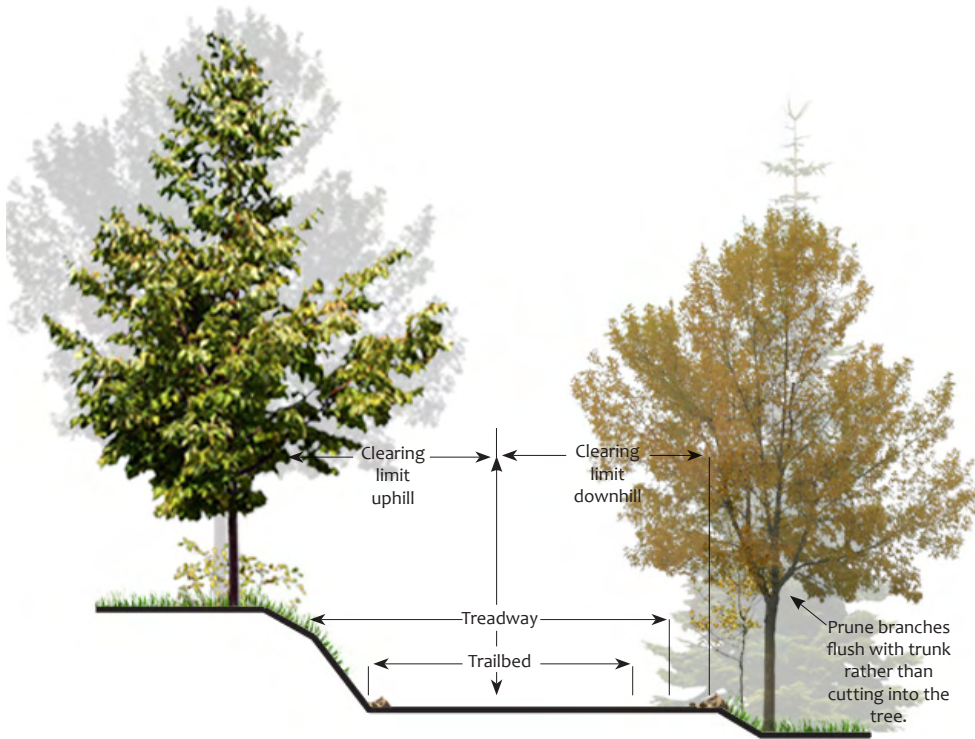
The trail corridor is the area that your trail will pass through. The trail corridor includes the trail's tread and the area above, below, and to the sides of the tread. Trail standards typically define the edges of the trail corridor as the clearing limits. Vegetation is trimmed back, and obstacles, such as boulders, fallen trees, and branches, are removed from the trail corridor to make it possible to walk or ride on the tread.

The dimensions for the trail tread, shoulders, upper clearing limits, lower clearing limits, and the clearing height are determined by the needs of the target users and the level of difficulty established for the trail.



Trail Construction and Maintenance Notebook
U.S. Forest Service

¹ Trail Construction and Maintenance Notebook, U.S. Forest Service: 2007



Typical Trail Corridor Elevation

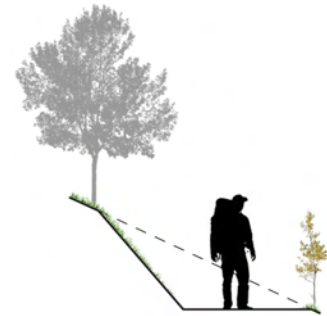
Tread Design

After clearing the trail corridor, clear the treadway of organic material and then shape into a slightly outsloped walking surface. In most cases your work will occur on a slope, so excavation will occur across the side of a hill. A “sidehill” trail has a near level, slightly outsloping bench for the trail surface. In many cases this type of design allows for trail construction to occur without manmade structures. There are two ways to build a sidehill trail: full bench and partial bench.

Full Bench Trail Tread²

A full bench trail tread has its entire width excavated into the hillside. Trail designers generally prefer a full bench tread for most trails, especially on steeper terrain with poor soils. The steeper the side slope, the closer the construction will resemble a full bench.

Use full bench tread construction where possible. If not possible, construct a partial bench tread and reinforce it with a retaining wall on the downslope side of the fill, if necessary. Typically it is more costly and time consuming to construct a partial bench tread as compared to constructing a full bench tread.



Full Bench Cut

Entire tread width is cut into firm mineral soil. Tread compacts uniformly and is sustainable. 5% outslope ensures water sheets across tread. Back cut is blended into back slope. Proper back slope, out slope, and full bench cut minimize maintenance.



Incomplete Full Bench

Left with unfinished vertical back cut, soil will slough off, making tread narrower. Obtrusive back cut also forces rider to outside of tread.



Partial Bench

Relatively easy to construct, but fill soil may collapse and creep downslope, requiring excessive maintenance.



Partial Bench with Cribwall

In some cases, tread must be supported by a cribwall. Wall holds fill soil in place and tread is outsloped over top of wall.



Partial Bench Trail Tread³

Partial bench construction is when part of the tread is excavated and the soil that is removed is placed on the lower edge of the trail corridor to fill and build up the tread. The fill should make up no more than half of the tread width. Remove all organic material from the tread to mineral soil and place organic soil on the outside of the bench.

Common failures resulting from improper construction of trail treads include:

- Fill material slipping downhill resulting in sliding of the trail.
- Fill material compacting and creating a berm on the downslope side of the trail.

Trail Tread and Materials

Selecting the tread surface is one of the most important decisions when designing your trail. When several different types of users will use the trail the surface material selected must meet the needs of all users.

Various Considerations

Loading

Designing and selecting trail surfaces is similar to designing and selecting highway pavement sections. Consideration must be given to the loads being placed on the surface. Conduct a soils investigation to determine the load bearing capabilities of the native soil, or former railroad bed (if ballast has been removed), and the need for any special treatments. A soils investigation will also help determine whether subsurface drainage may be applicable and how freeze-thaw cycles may affect a trail. Consider using geotextile fabrics to reinforce weak sub-grades or subsoils.

While loads on trails will be much less than roadways, trail managers may require the tread design to sustain the wheel loads of occasional emergency, patrol, maintenance and other motor vehicles that may travel on or cross the trail.

When motor vehicles drive on trails, their wheels often will be at, or very near, the edges of the trail. This can cause edge damage that, in turn, will reduce the effective operating width of the trail. Therefore, when designing a trail to accommodate emergency response vehicles, construct it wide enough and with adequate edge support to accommodate vehicles. You can reinforce the edges of the tread by stabilizing the shoulders with geotextile and/or stabilizing products.

3 Ibid



Surface Texture

On shared use paths and rail trails, it is important to construct and maintain a smooth riding surface. Use machines to lay aggregate and asphalt pavements; use soil sterilizers where necessary to prevent vegetation from erupting through the pavement. On concrete pavements, saw cut the transverse joints necessary to control cracking, rather than tooling the joints to provide a smoother ride.

Do not sacrifice skid resistant qualities for the sake of smoothness. Users prefer a broom or burlap drag concrete finish. Where a shared use path crosses an unpaved road or driveway, pave the road or driveway a minimum of 20 feet on each side of the crossing to reduce the amount of gravel scattered onto or along the path by motor vehicles. The pavement cross section at the crossing should adequately sustain the expected loading at that location.

Accessibility

Upon construction the tread must be stable and firm. The following table lists commonly used tread surface materials and summarizes each surface's ability to provide a firm, stable, and slip resistant surface.

Tread Surface Options⁴

Surface Material	Firmness	Stability	Slip Resistance
Asphalt	Firm	Stable	Slip Resistant
Concrete, Broom finish	Firm	Stable	Slip Resistant
Soil with Stabilizer	Firm	Stable	Slip Resistant
Compacted Aggregate, 3/4" minus, with Stabilizer	Firm	Stable	Not Slip Resistant
Compacted Aggregate, 3/4" minus, without Stabilizer	Firm	Stable	Slip Resistant
Wood Planks	Firm	Stable	Not Slip Resistant
Grass or Vegetation/Groundcover	Soft	Moderately Stable	Not Slip Resistant

Reflectivity

When selecting the tread surface for a rail trail that will also accommodate cross-country skiing, consider constructing a compacted stone surface in lieu of asphalt. Dark asphalt surfaces absorb energy from the sun and therefore, tend to melt snow more quickly than a surface, such as compacted stone, which has a higher coefficient of reflection (albedo).

⁴ Designing Sidewalks and Trails for Access: Part I of II, US Department of Transportation, Federal Highway Administration: 1999



Construct the trail tread on stable and compacted soils to achieve structural stability. Trail treads can be constructed from a variety of materials. Materials should be selected based on:

- User needs
- Maintenance needs
- Construction costs

Natural Surface Trails

As noted in Chapter 1 – Planning, sustainable trail design begins in the planning phase and continues through the design, construction, and management of your trail. To design a natural surface trail you must have an understanding of:

- The characteristics of the soil where you will construct the trails;
- The grades of trail;
- The watershed above your trail and its impact on the trail; and,
- The trail users and how they will impact the trail tread.

Soil Characteristics and their Impact on Sustainability

Soil scientists use a soil texture triangle to classify the texture of soil. Soil is comprised of sandy, silt, and clay. To determine a soil's texture, soil scientists analyze the soil's make-up to determine the percentages of sand, silt and clay.

Soil Component	Particle Size
Clay	less than 0.002 mm
Silt	between 0.0002 mm and 0.05 mm
Sand	0.05 to 2 mm

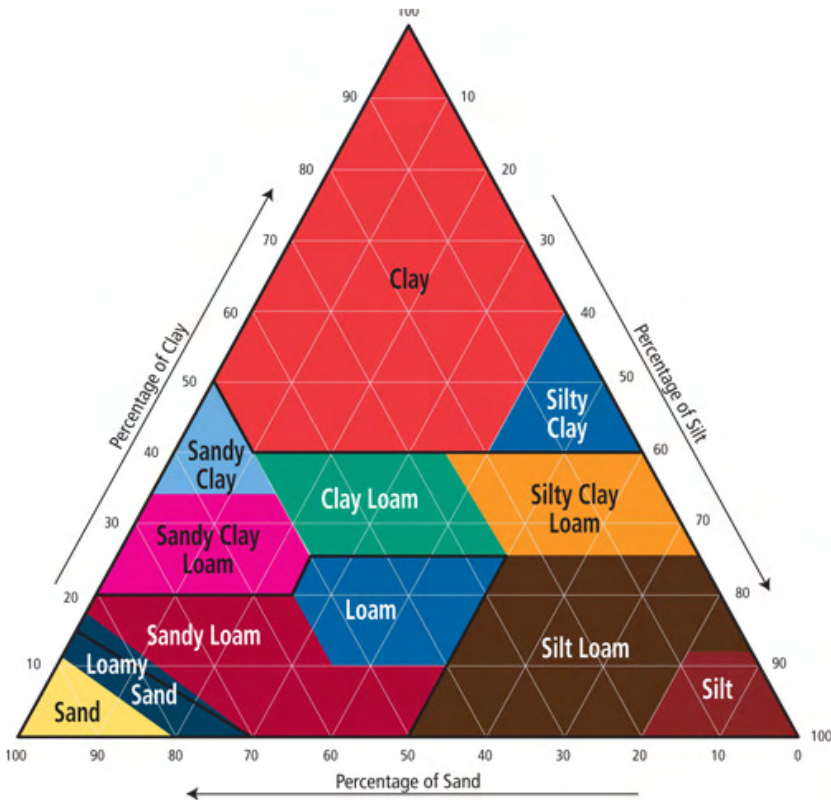
Components greater than 2 mm are further designated as gravel, stone, and boulders.

- Clay compacts easily, but holds water for long periods given the small void space between its fine particles.
- Silt drains well, can be easily compacted, and easily rutted.
- Sand has large pore spaces between particles and drains well, yet it does not compact easily.



USDA Soil Texture Triangle⁵

Soils as classified according to the percentage of clay, silt, and sand that they contain by plotting the percentages of each on the USDA Soil Texture Triangle.



Soils that are a combination of silt, sand, and clay are classified as loam soils. A loam soil comprised of equal parts clay, silt, and sand provides a better natural trail surface than a trail comprised of just clay, silt, or sand.

Soil texture can be estimated in several ways:

By Measurement

1. Spread soil on a newspaper to dry. Remove all rocks, trash, roots, etc. and crush lumps and clods.
2. Finely pulverize the soil.
3. Fill a tall, slender jar (like a quart canning jar) 1/4 full of soil.
4. Add water until the jar is 3/4 full.
5. Add a teaspoon of non-foaming dishwasher detergent.
6. Put on a tight fitting lid and shake hard for 10 to 15 minutes. This shaking breaks apart the soil aggregates and separates the soil into individual mineral particles.
7. Set the jar where it will not be disturbed for 2-3 days.

⁵ <http://soils.usda.gov/education/resources/lessons/texture/>

Soils Desktop Analysis

To determine the types of soil present in your trail corridor, begin by reviewing your site on-line through the USGS' Web Soil Survey on-line [HERE](#).

Here you will find information related to soil limitations, soil stability, and many more factors important to trail designers. Once you complete the desktop analysis you must then evaluate the trail corridor's soils in the field.



8. Soil particles will settle out according to size. After 1 minute, mark on the jar the depth of the sand.
9. After 2 hours, mark on the jar the depth of the silt.
10. When the water clears mark on the jar the clay level. This typically takes 1 to 3 days, but some soils may take weeks.
11. Measure the thickness of the sand, silt, and clay layers.
 - a. Thickness of sand deposit ____
 - b. Thickness of silt deposit ____
 - c. Thickness of clay deposit ____
 - d. Thickness of total deposit ____
12. Calculate the percentage of sand, silt, and clay.
 - a. Clay thickness / total thickness = ____ percent clay
 - b. Silt thickness / total thickness = ____ percent silt
 - c. Sand thickness / total thickness = ____ percent sand
13. Plot the values on the soil texture triangle to determine the soil texture class.

By Feel

Feel test - rub some moist soil between fingers.

- Sand feels gritty.
- Silt feels smooth.
- Clays feel sticky.

Ball squeeze test – Squeeze a moistened ball of soil in the hand.

- Coarse texture soils (sand or loamy sands) break with slight pressure.
- Medium texture soils (sandy loams and silt loams) stay together but change shape easily.
- Fine textured soils (clayey or clayey loam) resist breaking.

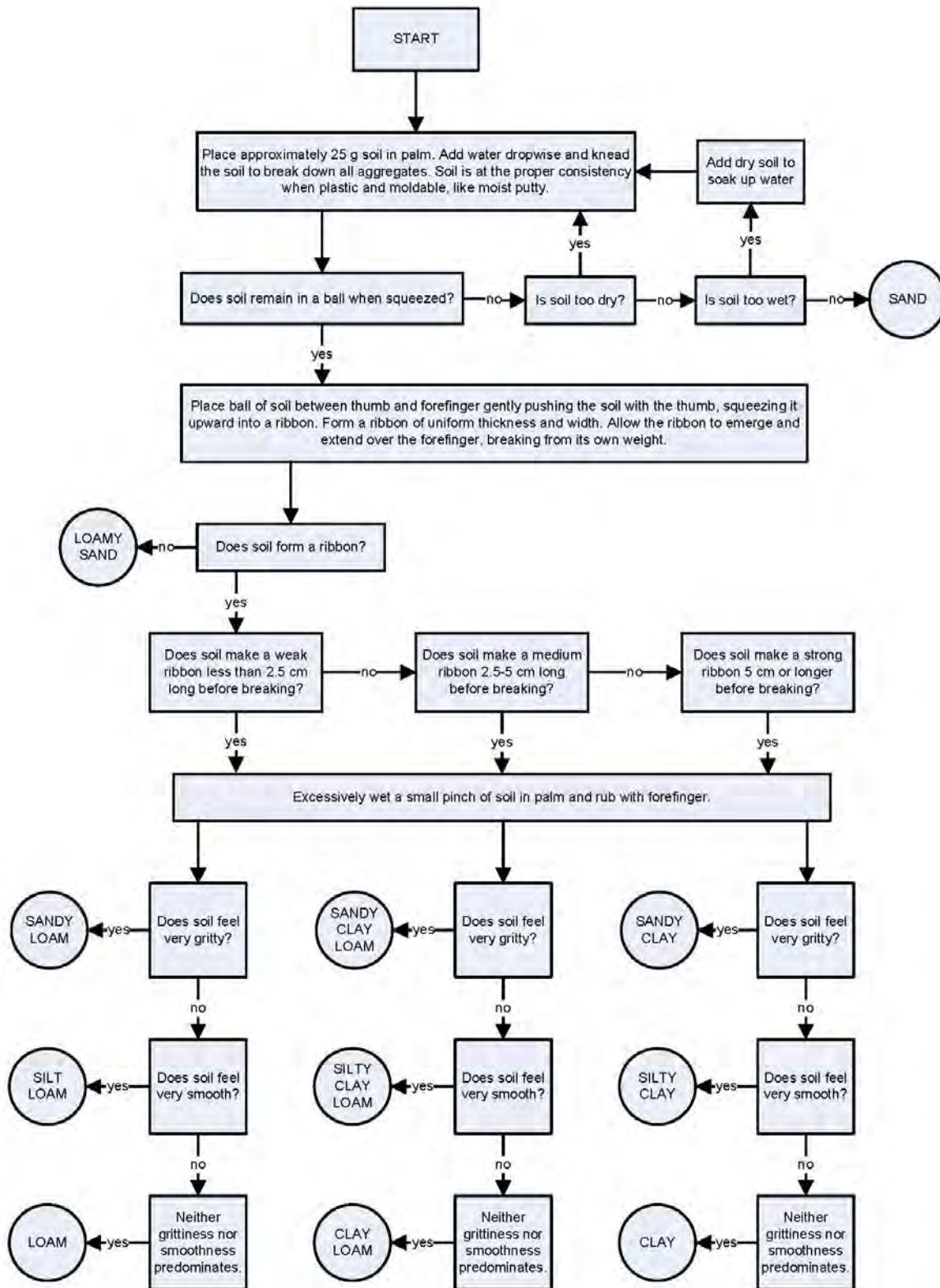
Ribbon test – Squeeze a moistened ball of soil out between thumb and fingers.

Ribbons less than 1"

- Feels gritty = coarse texture (sandy) soil
- Not gritty feeling = medium texture soil high in silt

Ribbons 1-2"

- Feels gritty = medium texture soil
- Not gritty feeling = fine texture soil
- Ribbons greater than 2" = fine texture (clayey) soil





It is important for you to know the texture of your soils, so you can understand the limitations of the soils along your trail. Understanding these limitations will allow you to align the trail and design features to respond to these limitations.

The properties desired in soils as a base for trails include:

- Adequate strength
- Resistance to frost action
- Acceptable compression and expansion
- Adequate drainage
- Good compaction

Soils that do not exhibit all of these properties may still be suitable for trails if the missing properties can be supplied through proper construction methods. For instance, materials having good drainage characteristics are desirable, but if such materials are not available locally, adequate drainage may be obtained by diverting water away from the trail and by providing a base layer of aggregate. Another example is increasing low strengths in subgrade materials by increasing the thickness of overlying base materials or using geotextile products.

For example, a loam soil with high clay content compacts well. However, it also tends to hold water. Therefore, it is likely that sections of a trail located on relatively flat terrain will not be sustainable. This is because relatively flat terrain does not provide enough slope for positive drainage, and the high clay content of the soil does not allow the water to infiltrate into the ground.

Soils containing gravel and stones, combined with loam soils are very sustainable. Rocky areas are the most sustainable, but are difficult to traverse because there usually are transitions between rocks.

Compacted Aggregate Trails

A compacted aggregate trail surface is considered to be an environmentally friendly alternative to an asphalt tread for the following reasons:

- The compacted aggregate trail has a higher rate of permeability than asphalt.
- The compacted aggregate trail has greater texture, and therefore, reduces the velocity of water run-off to a higher degree than asphalt.

In addition to the environmental incentives, a compacted aggregate trail is typically less expensive to install than an asphalt cross section. Another benefit of a compacted aggregate trail is that it provides the users with a more forgiving tread due to its resiliency under foot.



**Shaver's Creek
Environmental Center**
Centre County

Photo Credit: PSU Dirt & Gravel
Road Program



A popular tread material is a compacted aggregate surface. This material can be a practical solution popular when a tread cannot be constructed from natural soils, and on trails that need to support heavy loads. Many rail trails are constructed with a compacted aggregate cross section. Over the years, many formulas have tried to achieve the perfect mix of aggregate sizes to provide a stable, firm, and high-density trail surface. The Penn State Center for Dirt and Gravel Road Studies developed, and continues to refine a Trail Surface Aggregate (TSA) specification⁶ ideally suited for trail surfaces. For the current TSA specification visit the Center for Dirt and Gravel Roads [HERE](http://www.dirtandgravel.psu.edu/Trails/trails.html).

Properly placed and compacted TSA will meet the Americans with Disabilities Act requirements for a firm and stable trail surface.

The TSA specification allows trail surfaces to achieve very high densities that withstand traffic and erosion better than traditional aggregates. The Center designed the mix by “downsizing” its successful Driving Surface Aggregate (DSA) mix for use on roads. TSA functions as wearing surface for trails. It is different from traditional materials used to surface trails such as “number 10’s.” TSA has a uniform mixture of a range of rock sizes from 3/8-inch all the way down to fine material. This uniform mix allows excellent compaction to achieve a higher in-place aggregate density than commonly used aggregates to resist wear and erosion.

Asphalt Tread

Sometimes trail managers prefer hard, all-weather pavement surfaces over those of crushed aggregate, sand, clay, or stabilized earth, since these unpaved surfaces provide a lower level of service. On unpaved surfaces, bicyclists and other wheeled users must use a greater effort to travel at a given speed compared to a paved surface. Some users, such as in-line skaters cannot use compacted aggregate surfaces. In areas that experience frequent or even occasional flooding or drainage problems, or have moderate or steep terrain, compacted aggregate unpaved surfaces often erode.

Asphalt has many benefits. It is a durable material for trail surfaces. It can be placed on slopes and curves and remains stable where native soils or compacted aggregate trails can erode. Asphalt provides a more durable surface than compacted aggregate, requiring less maintenance and less frequent resurfacing. An asphalt surface eliminates the concerns over dust which can be associated with compacted aggregate trails. Further, asphalt’s smooth surface is quieter, enhancing wildlife viewing experiences.

One of the drawbacks to consider is asphalt’s dark color. Asphalt trails absorb the sun rather than reflect it, resulting in a increase in the “heat island” effect. The heat that reflects off the pavement increases temperatures on and near the trail.

⁶ <http://www.dirtandgravel.psu.edu/Trails/trails.html>



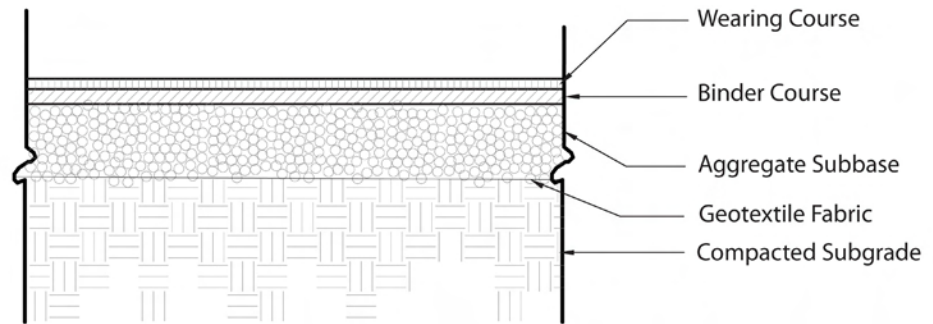
Centre Furnace Mansion
Centre County

Photo Credit: PSU Dirt & Gravel Road Program



D & L Trail
Lehigh County

Photo Credit: Delaware & Lehigh National Heritage Corridor



Asphalt Trail Tread

Porous Asphalt Tread

Porous asphalt is created by eliminating the smaller, graduated sizes of crushed rock and using a larger, uniform size, resulting in a rougher surface that has open voids. By maintaining pore space water will infiltrate through the tread surface instead of running off. Provided the trail's subbase has suitable infiltration rates, stormwater is conveyed through the tread and infiltrated into the ground. If the subgrade cannot provide adequate infiltration, then porous asphalt should not be used for the trail tread. Some subgrades of old railroad berms or gravel roads may be impervious, so runoff will drain to the side of the trail rather than infiltrate under the trail surface. Avoid using porous asphalt in areas that flood or where debris will clog the voids in the pavement.

Concrete Tread

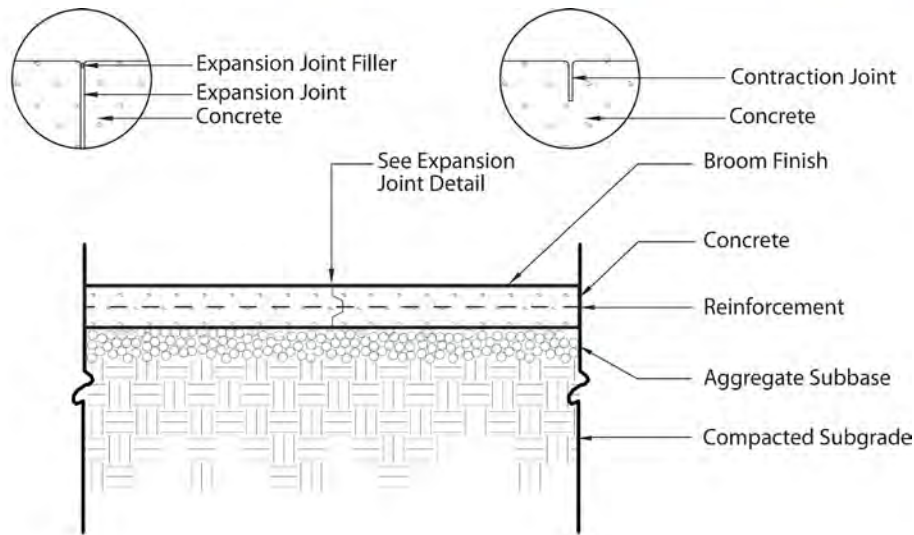
Concrete is the most durable material for trail surfaces, but it is the most costly. Concrete trail treads are used in urban environments. Advantages of concrete include longer service life, reduced susceptibility to cracking and deformation from roots and weeds, and a more consistent riding surface after years of use and exposure to the elements. The joints in concrete trail treads can degrade the experience of using the path for some wheeled users. In addition, users can see pavement markings more easily on asphalt than on concrete, particularly at night. Concrete's light color on a trail reflects the sun, rather than absorbing it, resulting in a reduction in the "heat island" effect.

The traditional concrete mix is impermeable. Like asphalt, porous concrete mixes are also available for consideration and have the same drainage qualities and concerns of porous asphalt.



Porous Asphalt
Asbury Woods Nature Center
Erie County

Photo Credit: Pashek Associates



Concrete Trail Tread

Tread Drainage

Drainage is the most important aspect of trail design, regardless of the trail tread material selected. Without sufficient drainage, a trail will require a high level of maintenance and may eventually fail. Although drainage improvements are designed on a case-by-case basis, some general rules of thumb apply.

Natural surface trails tend to catch and direct rain, as well as non-point-source runoff. When designing a trail system, it is important to consider all sources of water within the tread's immediate watershed. Some water sources may include rain or snowfall, seeps, springs, streams, ephemeral drainages, hanging or perched water tables, or floodplains.

Water typically drains on a treadway beginning at the top of the tread's immediate watershed and continues until water is directed away from the treadway. Therefore, the location of high points, such as crests, and dips in the tread further determine the length of the segment that drains between them. Since the locations of these features are not necessarily related to a site's topography, a tread's watershed size and location is flexible. Adding drainage dips, swales, waterbars, and other devices can reduce the length of drainage areas associated with the tread. The larger the drainage area and the steeper the slope above the tread, the more likely runoff will occur. A steeper slope is more likely to produce runoff.

Watershed Above the Trail and Its Impact on Sustainability

Water runoff is the one physical force that contributes most to erosion. When you design a trail to direct water away from or around the trail, you are reducing the amount of erosion potential along the trail.



Therefore, analyze and evaluate the watershed located above each segment of the trail to determine how to direct drainage away from the trail. A watershed is the land area that drains to a given location. Typically, this location is a body of water such as a wetland, stream, or river. Traditionally designers associate the term watershed with streams. All of the land between the ridgelines on either side of a stream is located within the stream's watershed.

In the case of trails, however, look at watersheds at a much smaller and more detailed scale. For a trail, the watershed is the amount of land above the trail between a high point above the trail, and low point along the trail.

During the planning and design phases, locate the trail to take advantage of the topography. Trails located at higher elevations typically have less watershed above them. Align the trail so undulations in the landscape can serve as drainage locations for grade reversals and dips. This type of alignment utilizes the topography to limit the maximum tread length.

Flat areas with little slope in either direction are poor locations for trails. There are fewer opportunities in flat areas to direct water away from the trail tread. Therefore, the tread becomes saturated; trail users go around the saturated areas, widening the tread, reducing vegetative cover, which in turn increases compaction and reduces infiltration. This typically results in a large mud puddle on the trail.

Trail Users and Their Impact on Sustainability

The volume and type of use your trail receives will affect the sustainability of the trail. A hiking trail with steeper grades but few users can be just as sustainable as a trail with less grade but many more users. Equestrian trails with few users can be unsustainable if the trail is located on soils that cannot support the load of the horses on the trail.

Design the trail to disperse use along the length of the trail and throughout the trail network, rather than concentrate use at specific locations.

Runoff and Erosion

Tree canopy, vegetative cover, and forest litter help reduce runoff and absorb rainwater. On the other hand, bare soil and rock surfaces produce more runoff and increase runoff speed. Therefore, both the amount of vegetative cover, and the amount of trail tread are important considerations. The amount of runoff will depend on the proportions of each type of materials present in the trail corridor. Without vegetative cover, heavy rainfall will dislodge fine particles and erode part of a tread. The steeper the slope of the treadway the higher the runoff velocities and therefore the greater the erosion potential of stormwater runoff.



Erosion from High Velocity of Concentrated Flow

Lower Trail, Huntingdon County

Photo Credit: PSU Dirt & Gravel Road Program



Weather, Climate, and Microclimate

When planning a trail consider the location's overall climate, seasons of use, and microclimates. Always assume intense rains or rapid snowmelt will occur and design trails to sustain these events. The only way to limit runoff caused by severe precipitation is to limit a tread's drainage area. On north facing slopes and in deep ravines, trails are generally cooler and wetter. These conditions affect an area's humidity, temperature, and speed of snowmelt.

Tread Grade and Length

A sustainable tread depends on its grade, length, tread texture, type, amount of use, and tread watershed factors. The steeper the tread grade, the more likely it is to erode. To prevent washouts on grades, install grade breaks into the trail alignment. Grade breaks should be integrated into the trail. The steeper the grade, the more often grade breaks are required. This further limits the continuous length of running grade on the trail reducing the tread's susceptibility to erosion. Grade breaks are described in further detail later in this Chapter.

Cross Slopes, Side Slopes, Swales, and Culverts

Every part of the trail surface should pitch water at a minimum slope of 2%. Typically, a surface pitches downhill. When the trail is constructed on land with a cross slope of 30% or greater, best practices recommend crowning the trail.

Side slopes, side swales, and culverts prevent water from reaching, and direct water away from, the trail surface and provide the water with a place to drain. Design side swales and culverts to correspond with a trail's grade and width, as well as the location's uphill watershed.

1. Where side slopes of the trail are less than 5%, the trail needs no swales unless construction occurs in a wet area.
2. Where side slopes are greater than 5% and/or when side slopes extend over 25 feet in length, these conditions typically require a swale on the uphill side of the trail to collect water, pipe it beneath the trail, and outlet the flow of water to daylight. Size all pipes to adequately contain a 10 year storm event, or as required by local ordinance.
3. Where trails are constructed on an embankment, designers need not incorporate swales, assuming trail runoff drains away from the trail.
4. When trails are constructed in cut, swales are typically required on both sides and piping installed as required to drain water to daylight.
5. Where swales are required along trails, pitch the trail surface toward the swale on the high side of the trail.

Culvert crossings take the water from side swales and crowned surfaces and route the water beneath the trail surface. Each culvert crossing should have a headwall and endwall to prevent erosion at pipe openings, prevent flowing water from damaging the trail structure, and provide structural support for



Natural Stone Endwall

Photo Credit: PSU Dirt & Gravel Road Program



the trail. Furthermore, headwalls and endwalls increase flow capacity of the pipe by reducing turbulence and directing flow, as well as visually identifying pipe openings to protect them from traffic and maintenance equipment.

Waterbars and Drainage Dips

Constructed waterbars and tread dips prove problematic and often need maintenance. Some of these problems include ponding water, clogging, and slow or poor drainage. The most sustainable dips, those requiring minimal maintenance, incorporate several key characteristics in their design. These include a wide outflow, sufficiently sized dip, substantial crest, quick drainage, minimal erosion, as well as resistance against tread compaction and displacement. If a trail lacks any number of these characteristics, the more likely the feature will fail. In short, when designing a trail ensure the dip's ability to handle both water and physical forces to minimize its need for maintenance. Further details concerning waterbars and dips follow later in this Chapter.

Contour Trails

The contour trail is the most sustainable design, but how does one lay out and create contour trails so they do not collect or channel water? As described in Chapter 1, sustainable contour trails should follow five best practices⁷:

1. **The Half Rule:** A trail's grade should not exceed the half grade of the hillside or sideslope that the trail traverses. If grade does exceed half of the sideslope, consider it a fall line trail that will be susceptible to erosion.
2. **The Ten Percent Average Grade Guideline:** Generally, a trail with an average grade of 10 percent or less is most sustainable. This does not mean all grades must be kept less than 10 percent. Many sections of trail will have short steep sections greater than 10 percent, and some unique situations will allow average grades of more than 10 percent.
3. **Maximum Sustainable Grade Trails:** Maximum sustainable grade equals the steepest section of trail that is more than ten feet in length. When designing a trail, it is essential to determine early in the process the maximum grades the trail will be able to sustain given local conditions. Variables that impact the maximum sustainable grade include:
 - Soil Type
 - Rock
 - Annual Rainfall Amount
 - Type of Users
 - Number of Users
 - Planned Level of Difficulty



Contour Trail
North Park
Allegheny County

Photo Credit: Pashek Associates

⁷ Trail Solutions: IMBA's Guide to Building Sweet Single Track: International Mountain Bicycling Association: 2004



4. **Grade Reversals/Dips:** A grade reversal occurs at a spot where a climbing trail levels out and then changes direction, dropping subtly for about 10 to 50 linear feet before rising again. This change in grade forces water to exit the trail at the low point before it can gain volume, velocity, and erosive power. Other names for grade reversals include dips, grade breaks, drainage dips, or rolling dips.
5. **Outslope:** As the trail contours across a hillside, the downhill or outer edge of the trail tread should typically tilt slightly down and away from the high side. This encourages water to flow across and off the trail.

When designing sustainable trails, consider the level of trail development required based upon the location, use, and other factors. Some trails will consist of a natural surface, while others will consist of more developed surfaces.

Changes in Trail Grade

Steep changes in grade prove difficult for both trail designers and builders to tackle, especially when they occur over short distances. Climbing turns, switchbacks, and grade reversals provide unique solutions for designers to accommodate trail users on challenging terrain. It is important to locate these design features in appropriate areas to maximize both their longevity and their ability to withstand the effects of erosion.

Trail Grades and their Impact on Sustainability

The grade of a trail also has a significant impact on the sustainability of the trail. As noted earlier steeper grades are less sustainable. Steeper grades also result in water runoff becoming concentrated in shorter distances, less water infiltration resulting in higher volumes of runoff, and water runoff flowing faster over the terrain. Each of these aspects contribute to soil erosion.

Climbing Turns

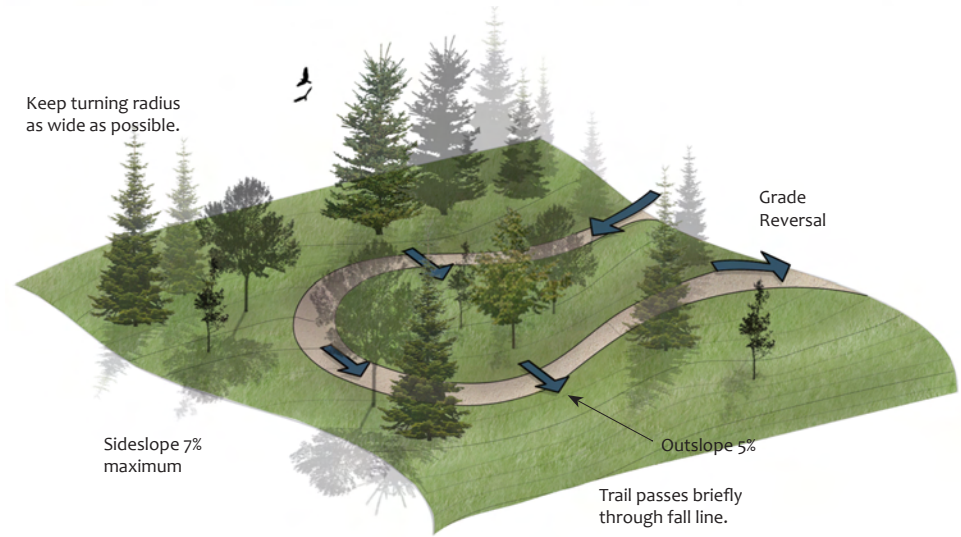
Climbing turns require trails to follow the fall line for a short segment. Therefore, in general, a climbing turn should only occur on cross slopes of no steeper than 7 to 10 percent. When constructing a climbing turn designers must locate a grade reversal just above, and after, a turn to divert water away from the fall line portion of the trail.

Constructing climbing turns on cross slopes greater than 10 percent typically results in erosion of the trail. This a common trail-building mistake.



Climbing Turn
Allegrippis Trails
 Huntingdon County

Credit: Leslie Kehmeier



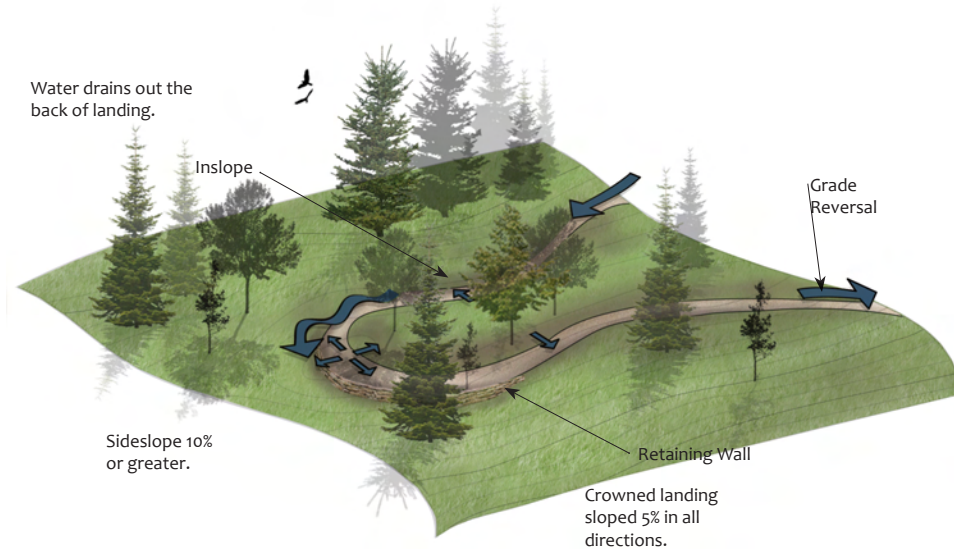
Climbing Turn

Switchbacks

A switchback reverses the trail's direction by constructing a relatively level landing between trail segments traveling opposite directions. They are difficult to build but are more durable on steep slopes than climbing turns, because the trail does not follow the fall line. Moreover, construct switchbacks in lieu of climbing turns when sideslopes of a climbing turn exceed 10 percent.

Key features to designing switchbacks:

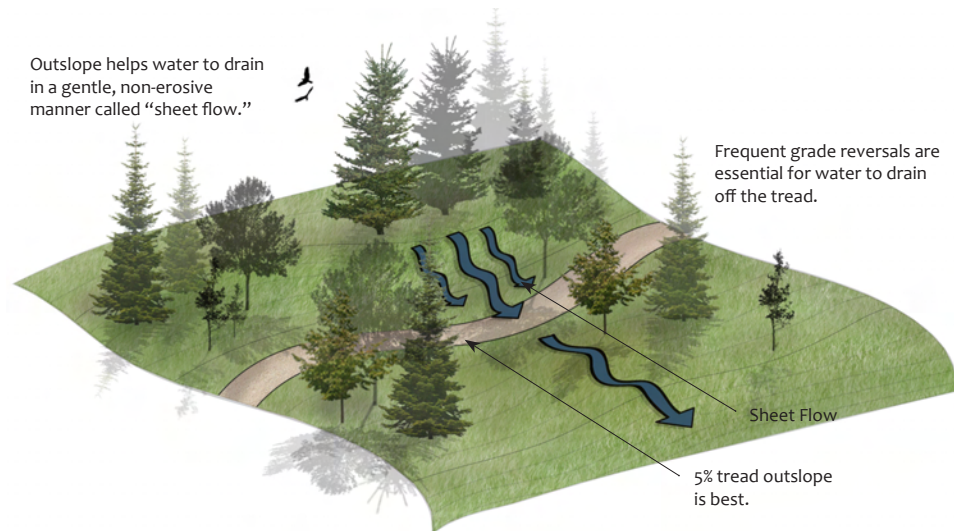
1. Drain water away from all sides of the turn.
2. Crown the platform slightly so that water drains in all directions.
3. Stay on contour for both approaches.
4. Combine bench cuts and retaining walls as needed to facilitate the change in grade.
5. Carefully construct retaining walls, when required, to ensure stability.
6. Use excavated material from the top leg as backfill behind the retaining wall along the bottom leg.
7. Inslope the upper leg to direct water away from the trail.
8. Outslope the lower leg to direct water off of the trail.
9. Design approaches to control user speed.
10. Construct grade reversals at the approaches to divert water.
11. Stagger switchbacks to prevent water accumulation.



Switchback

Outslope

Outsloping is a method of grading the tread where the downhill edge of a trail is lower than the uphill edge of the trail to shed water. This deflection of water prevents concentration of flows that produce rilling, gullying, and rutting on trail treads. Users should barely notice the outslope which is generally between 2 and 5 percent.



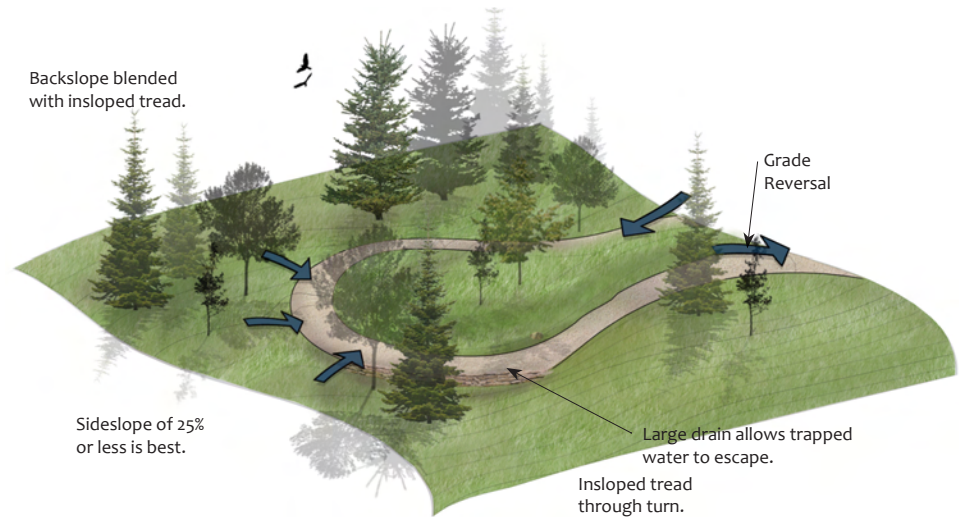
Outslope

Insloped Turn

Insloped turns can be constructed on either single use or shared use trails and provide a sustainable method of stabilizing turns on natural surface and compacted aggregate trails. Insloped turns reduce tread widening and



displacement that can occur on flat or outsloped turns. A 5 percent slope to the inside of the turn helps stabilize the turn. When sideslopes are steeper than 25 percent a platform and/or retaining wall may be required.



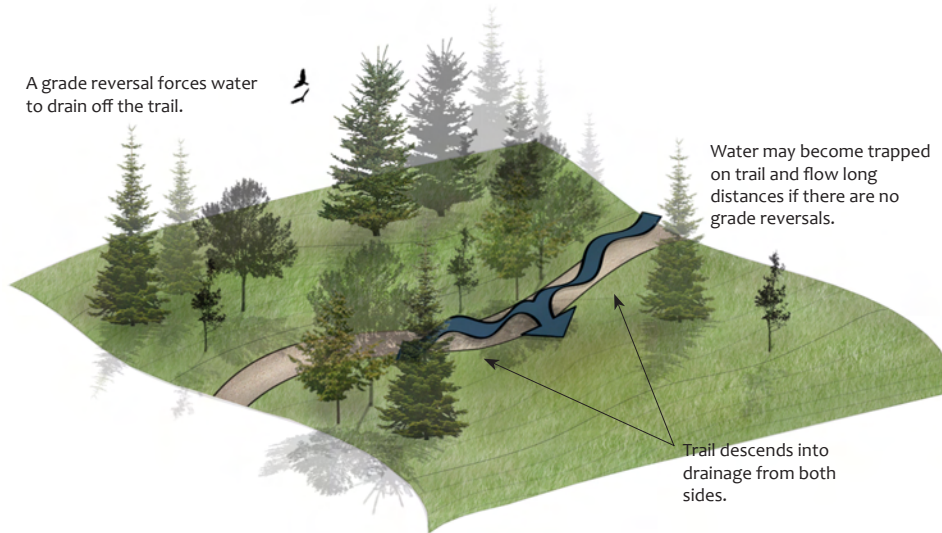
Insloped Turn

Drainage Solutions

Proper excavation, outsloping/insloping, and stabilization of a trail all contribute to create a stable treadway. However, even perfect construction cannot completely neutralize water's damaging effects on a trail over time. It is important to rely on contour trail construction to maximize a trail's sustainability. A well-constructed trail will incorporate a number of features into the construction of the trail to direct water away from and off of the trail. Consider installing more drainage than necessary to ensure proper water flow, in the event that one or more drainage methods fail.

Grade Reversals/Dips

A grade reversal is a reverse in the trail grade, usually a short dip followed by a rise, that forces water off the trail. Grade reversals are also referred to as grade dips, drainage dips, and/or rolling grade dips. Frequent grade reversals are a critical element of sustainable trail design. Most trails will benefit from grade reversals every 20 to 50 feet, depending on soil type and rainfall.



Grade Reversal

The table on the following page, adapted from *Natural Surface Trails By Design: Physical and Human Design Essentials of Sustainable Trails*⁸ provides rules of thumb for maximum tread lengths for various soil textures.

These guidelines are based on the following assumptions:

1. The trail's grade does not exceed the half grade of the hillside or sideslope that the trail traverses.
2. Water reaching the trail drains along the trail to a dip.
3. The tread is well compacted.
4. Trail receives moderate use.
5. Watershed above the trail has moderate runoff potential.
6. Little to no tree canopy above the trail tread.
7. Intense rain events are limited to a few times a year.
8. There are no other contributing water sources present, i.e. high water table, spring seeps, etc.

⁸ Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails, Troy Scott Parker: 2004

Dips Are In, Bars Are Out

For existing trails with water problems, we encourage the use of rolling grade dips or knicks instead of waterbars. Here's why.

By design, water hits the waterbar and is turned. The water slows down and sediment drops in the drain.

Waterbars commonly fail when sediment fills the drain. Water tops the waterbar and continues down the tread. The waterbar becomes useless.

A good dip can be built quicker than installing a waterbar, and a rolling grade dip works better.

USDA Trail Construction and Maintenance Notebook



Maximum Tread Length between Grade Reversals/Dips by Soil Texture <i>Rule of Thumb - based on running percentage of the trail grade</i>										
Soil Texture	0%	2%	4%	6%	8%	10%	12%	14%	16%	18%
Clay Loam with high quantity of gravel and stone	215'	160'	120'	90'	67'	50'	35'	24'	16'	10'
Gravelly clay	180'	132'	96'	69'	49'	34'	22'	14'	X	X
Loam with high quantity of gravel and stone	160'	117'	83'	57'	39'	26'	17'	10'	X	X
Clay	145'	104'	74'	51'	34'	22'	13'	X	X	X
Loam	135'	90'	57'	37'	23'	14'	X	X	X	X
Crushed stone, angular particles, 3/4" or less	125'	78'	49'	30'	17'	X	X	X	X	X
Organic soil	110'	68'	39'	22'	12'	X	X	X	X	X
Sand	100'	55'	30'	16'	X	X	X	X	X	X

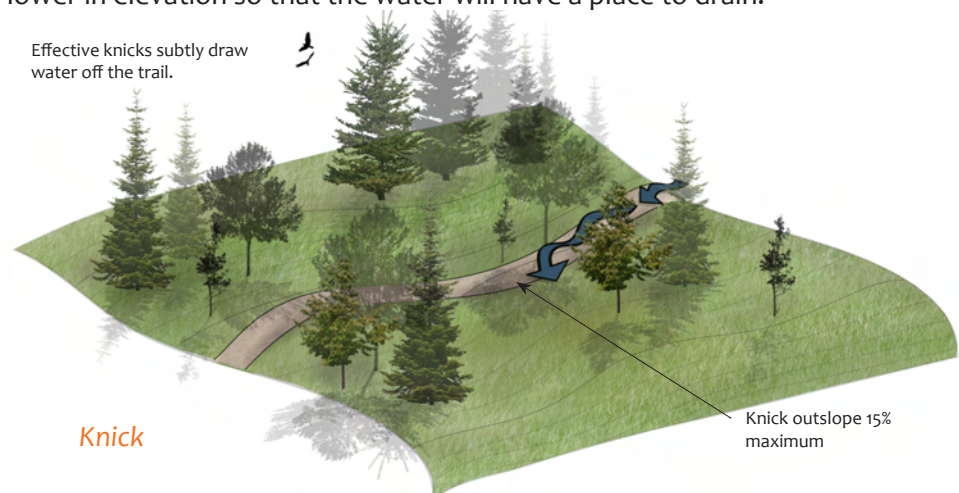
This Rule of Thumb is not only modified by soil texture, but should also be modified as required to respond to:

- Amount of stone and rock in the tread.
- Annual rainfall amount.
- Location and frequency of grade reversals and dips.
- Type of users and their impact on the tread.
- Number of users, more users = more impact to the tread.
- Desired level of difficulty for the trail.

Knicks

Knicks are tapered, semi-circular sections of a trail that measure approximately 10 feet in diameter. Knicks are usually built on gentle, smooth sections of a trail tread where water tends to puddle. For the knick to be effective, its center must be outsloped at least 15 percent towards an area lower in elevation so that the water will have a place to drain.

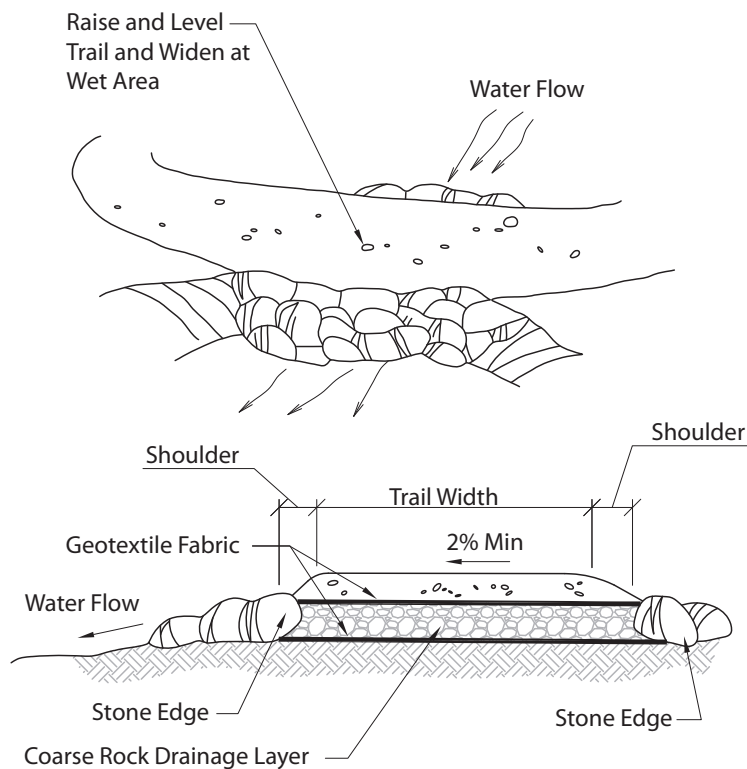
Effective knicks subtly draw water off the trail.





Drainage Lens

Low-volume water flow caused by spring seeps or cross swales can often be managed with a drainage lens. Beginning with a firm subbase, construct the drainage lens by placing large stone and progressively smaller stone capped with fine aggregate or suitable native fill. In wet areas, placing the drainage lens between two layers of geotextile material helps to stabilize the base. Perforated pipes can be placed at the base of the drainage lens to collect water that seeps through the stone, and outlet the water to daylight.



Drainage Lens

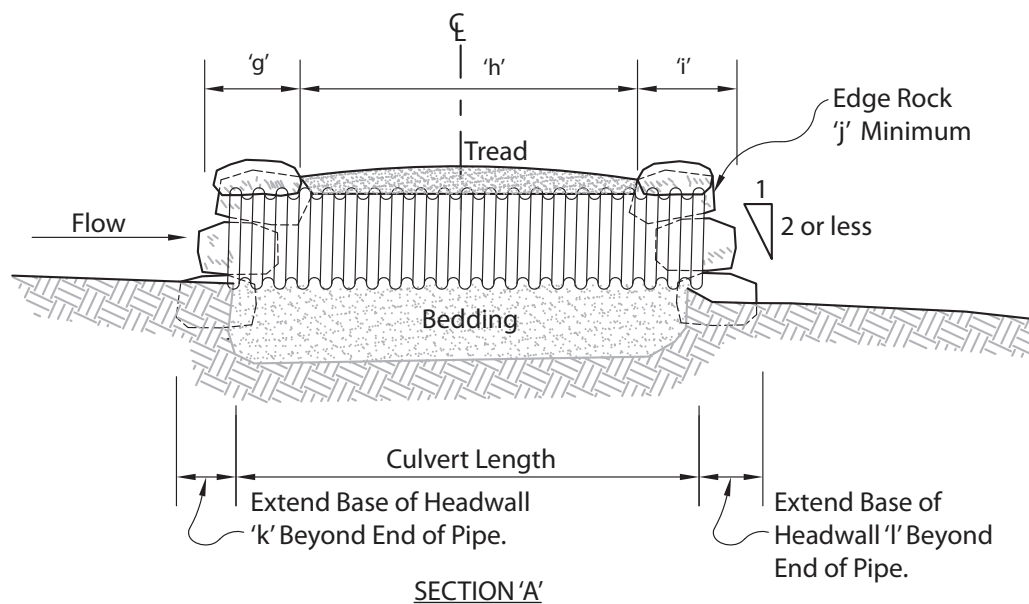
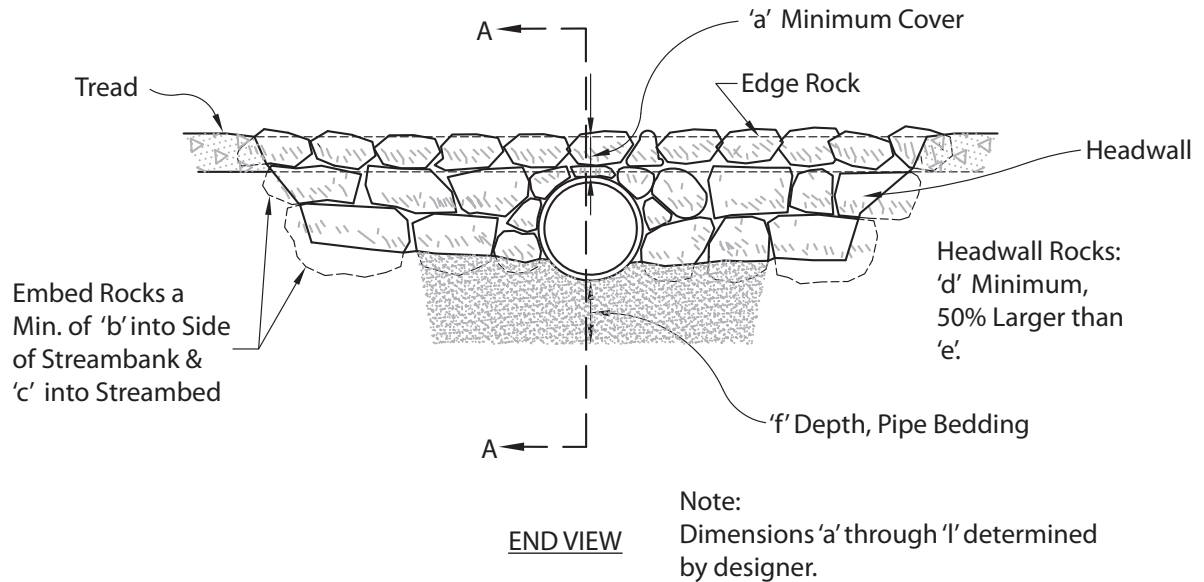
Bleeders

Bleeders are constructed swales angled to drain water off and away from the treadway. Build them by digging a shallow dip in the tread at a slant towards the outside edge of the treadway. Bleeders work best on sidehills, especially in spots where topography, roots, and rocks naturally facilitate drainage. Bleeders often work as effective backups where drainage dips will not fit. They also work well at the apex of turns and switchback corners. However, they work poorly along straight, unobstructed graded trails where they may clog with silt.



Culverts

Culverts are a form of drainage structure designed to convey water beneath a trail. Culverts can be constructed from natural rock, or plastic, metal, of concrete pipe. The fact that the trail tread extends across a culvert without interruption serves as an advantage over ditches and waterbars. They have relatively little visual impact on the trail, and are not easily displaced by trail users.



Culvert with Natural Stone Head/Endwalls



Culverts should be installed with a gentle down stream gradient of 2 percent and should be properly bedded to insure continued performance. Pipe diameters less than 12 inches may present frequent clogging and therefore are not recommended.

Tread Reinforcement and Trail Structures

Even well designed and constructed trails may need tread reinforcement or trail structures. Since these take a lot of time and effort to construct, they should be kept to a minimum in the initial trail design. However, in any trail section where the grade is steep enough to warrant concerns about erosion, tread reinforcement or trail structures can be constructed either preventatively or as erosion issues become apparent. In some cases, tread reinforcement or trail structures are creative solutions around obstacles on certain routes.

Geosynthetics

- **Geotextiles:** Geotextiles are fabric sheets of synthetic fibers that provide separation and reinforcement between soil and gravel surfaces. A single layer of geotextile fabric provides soil separation and encapsulates free-draining gravel that trail builders cover with a gravel drainage layer. A wrapped section, with two layers of geotextile, has more strength than the single-layer section alone. With the separation created by using geotextile fabric, the aggregate remains separated from the subgrade, providing a stronger surface that requires less gravel and resists rutting.
- **Geogrids/geocells:** Geogrids/geocells are three-dimensional, expandable panels made from high-density polyethylene, polyester or another polymer material which when backfilled with stone provide a stabilized surface. Trail builders install individual cells in an excavated section, fill with gravel, and then cover with an added layer of gravel. This confinement system reinforces and restores areas easily eroded and reduces the load stresses over a unit area. Some features or benefits of the system include increased soil strength, increased soil bearing capacity, ability to vegetate, ability to utilize local soils, as well as vertical and lateral porosity.



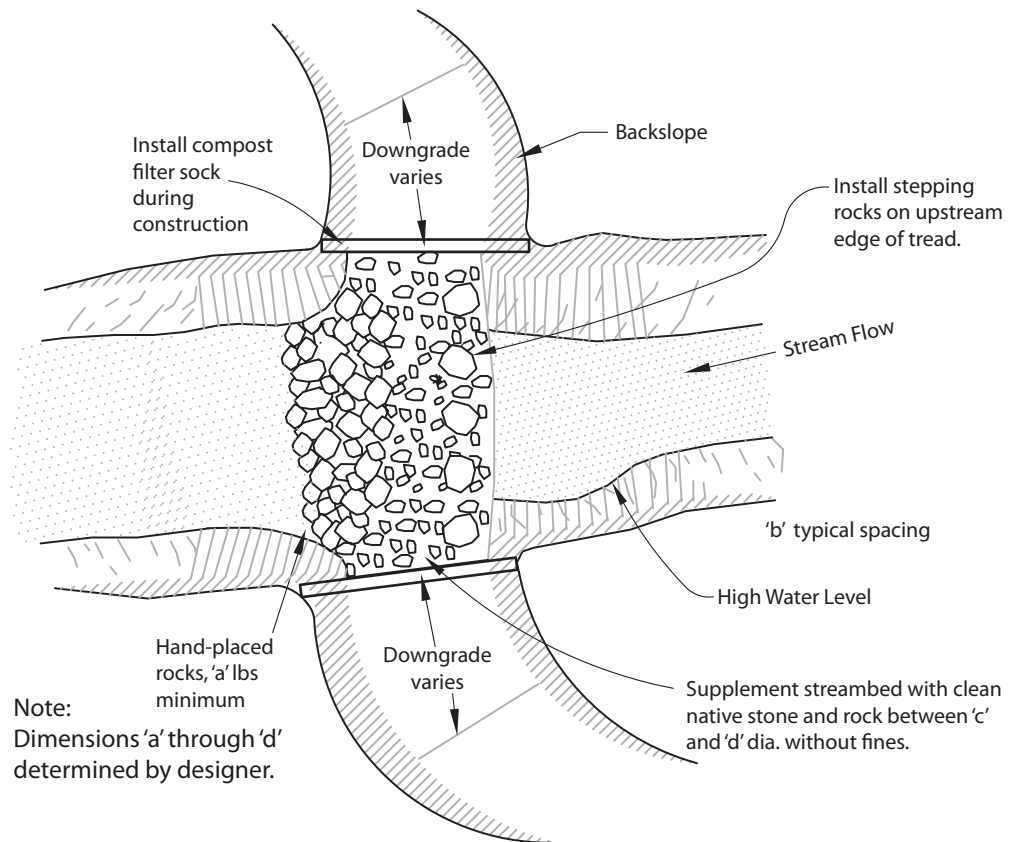
Geogrid Being Backfilled with Stone

Photo Credit: PA DCNR



Armoring and Footpaths

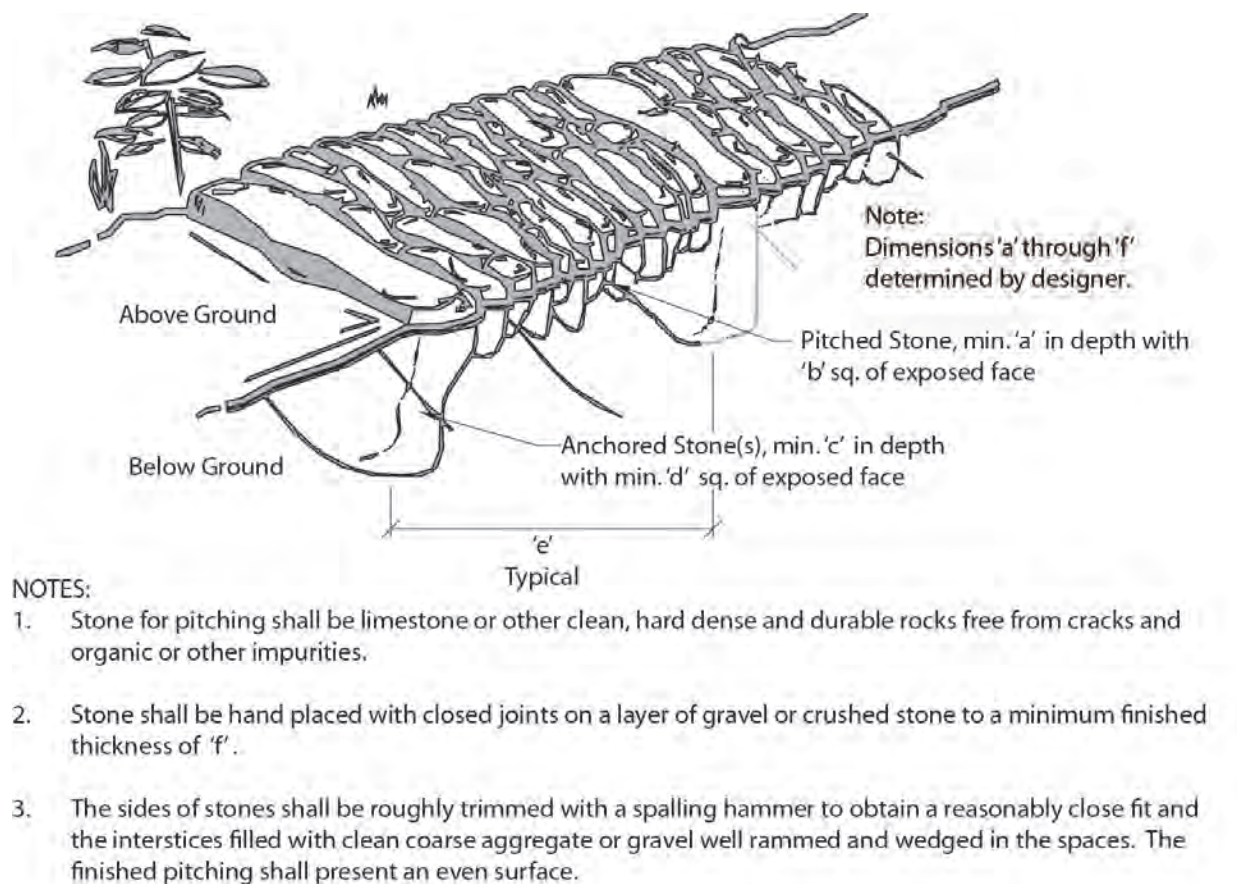
- Fords and Step Stones:** Fords are used on swifter flowing streams in upper watersheds with rocks available for step stones. Naturally occurring or secured stepping stones retain gravel at the ford and can provide an interesting way for hikers, mountain bikers, and equestrians to navigate a small stream. When fords are not sufficient or need to be augmented, use step stones.



Shallow Ford Crossing



- **Stone Pitching:** Stone pitching is used to create an elevated trail tread above soft terrain when no alternate route is available. Stone pitching provides a durable solution for hardening a section of a trail.



Stone Pitching

Retaining Walls

- **Cribbing/Rock Walls:** Rock and log cribbing, sometimes called retaining walls, support the treadway along steep side slopes. In areas difficult to drain, installing trail cribbing will allow regular drainage to occur. On steep sidehill cuts, cribbing stabilizes the upper or lower slopes along the trail. Rock cribbing functions as the most durable and aesthetically pleasing technique; however, designers may use logs to achieve the same effect.
- **Gabion Walls:** Gabion walls are retaining walls made of rectangular containers fabricated of thick, galvanized wire. They are filled with stone and stacked on one another, usually in tiers that step back with the slope, to stabilize slopes against erosion. Gabion baskets can be stacked in various shapes, resist being washed away by moving water, and drain



freely. Their strength and effectiveness may increase with time as silt and vegetation fill the voids and reinforce the structure.

- **Soldier Pile Walls:** Soldier pile retaining walls provide an effective solution to addressing deep, vertical cuts in elevation. Because there is minimal soil displacement, cut and fill requirements are reduced along the trail. Wood, pre-cast concrete panels, or steel plates are used as lagging to temporarily hold back the soil. Depending on the geometry of the wall and soil conditions, builders may install tiebacks to provide lateral resistance of the soil and load.

Trailhead Design

Locate trailheads in key locations where trail users will likely enter the trail system, at intervals that provide convenience, yet protect neighborhood privacy in urban and suburban areas. Typically, trail access points should be located at equal intervals along the trail corridor. The distance between access points is determined by the type of trail. Typically on rail trails through urban and suburban environments trail access points are located at intervals ranging between 5 and 8 miles. Access points for long distance trails, or rural trail systems are generally located further apart. Clustering of trail facilities provides for ease of maintenance, user convenience, and minimize vandalism. Be sure to locate trail access facilities in areas that are visible from adjacent roads, helping to provide basic security of the facilities.

Each access point should have enough parking to accommodate commuters or cyclists who may drive to trailheads to begin their journey. These areas should be well marked and provide a graphic map showing a trail user's location within the overall trail network.

Recommended trailhead facilities include:

- **Parking:** Consider the length of a trail, number of visitors, and proximity to population centers when determining the parking requirements for a trailhead. Also give consideration to the type of trail, and the typical vehicle used to transport persons and equipment to the trailhead. Visitors to equestrian trails need parking for their towing vehicles/trailers and prefer pull-through parking spaces when available.

Standard parking stalls can be either angled or 90 degrees to the travel lane, measuring 10' wide by 20' long or as established by local zoning. AASHTO states that the minimum inside turning radius of a car is about 6 1/2' and the maximum outside turning radius is 25'. Travel lanes in a one-way parking lot should be a minimum of 12' wide, and 24' wide when designed as a two-way lane.

Specialized parking areas for tow vehicle and trailer combinations are typically between 18 to 28' wide and between 55' to 78' long.



Ernst Trail
Crawford County

Photo Credit: Pashek Associates



- **Loading/Unloading:** Where horses are permitted provide loading and unloading areas for the horses. These areas should measure about 20' wide by 55 to 78' long and should be separate from other areas of the parking lot.
- **ADA Accessibility:** The 2010 ADA Standards for Accessible Design, available [HERE](#), establishes the design requirements to provide accessibility for individuals with disabilities as classified under the ADA. The ADAAG outlines requirements for the number and size of parking stalls and access isles, as well as ground surface conditions and slopes for the parking areas. At least one accessible route must be provided from accessible parking stalls to all accessible facilities. Further, the parking area must have a stable and firm surface. The minimum ratio of accessible parking spaces to standard parking spaces is one accessible parking space for every 25 spaces.
- **Bicycle Rack:** Choose a bicycle rack based on its ability to secure a bicycle while protecting it from vandalism. In addition, consider any potential damage that a bicycle may incur while it is in the rack. The preferred style of rack are those that secure the bike in two locations on the bicycle frame. Traditional bicycle racks, like the comb or toast racks, are also known as wheel benders because of the ease with which one can damage the bicycle by bending the rim. Where an aisle separates the bike racks a minimum width of 48 inches should be provided. Bike racks can be custom designed and fabricated to reflect local heritage or a local theme. The American Association of Pedestrian and Bicycle Professionals' *Bicycle Parking Guidelines*⁹, available [HERE](#), provides recommendations for choosing bicycle racks.
- **Air Station:** For the convenience of bicyclists consider providing an air station in urban and suburban locations, when and where restroom facilities are located, when feasible.
- **Security Lighting:** Limit trail to daylight hours unless the trail manager intends to light the trail corridor. Where feasible, provide at least one dawn-to-dusk security light at each trail access point. If electric service is not available, solar panels can be utilized to generate the electricity necessary for security lighting.
- **Drinking Water:** Select a cost effective frost-free design to provide a water source at all trailheads. Drinking fountains that include a pet fountain are desirable at trailheads when dog walking is a popular trail use. Where municipal water is not available, consider providing a well and hand pump with a water purification system. In these instances trail managers must have the staff and financial resources available to test the water supply for public use.

Characteristics of a Good Bike Rack

- Do not bend wheels or damage other bicycle parts.
- Accommodate high security U-shaped bicycle locks.
- Accommodate locks securing frame and both wheels.
- Do not impede or interfere with pedestrian traffic flow.
- Are easily accessed from the street and protected from motor vehicles.
- Are visible to promote usage and enhance security.
- Are covered in locations where users will leave their bikes for a long time.
- Have as few moving parts as possible.

9 Bicycle Parking Guidelines, Association of Pedestrian and Bicycle Professionals



- **Toilets:** Toilets are a necessary amenity and should be provided at trailheads when feasible. Construct restrooms from materials that are in character with the surrounding setting. In urban and suburban areas construct restrooms from vandal resistant materials, and connect them to municipal sewer and water lines when available. If budget is a concern provide one unisex unit. Regardless of the arrangement, all restrooms should comply with ADA accessibility standards. In suburban and rural areas consider sealed vault toilets and composting restrooms when a municipal sanitary sewer system is not available. Use agreements with adjoining facilities can allow trail users to access existing restrooms. Many modular restrooms can be monitored and secured remotely.
- **Benches:** The location of rest opportunities is crucial to ensuring a positive trail experience. Benches should have backrests and at least one armrest to provide support as a user returns to the standing position, as required by ADA. Benches, as well as drinking fountains, bike racks, and other amenities can be funded through dedicated donations/sponsors.
- **Picnic Shelters:** Locate picnic shelters at trailheads. The minimum size of a shelter should be 20' x 28', housing 4 accessible picnic tables, to provide adequate cover from wind and rain. Consider using laminated wood beam shelters, or shelters with a similar roof truss design, as they eliminate roosting opportunities for birds and subsequently are much easier to maintain.
- **Trash and Recycling Containers:** Trash and recycling containers should be located at trail heads, where volunteers or municipal services agree to empty them at regular intervals. Use a 50 gallon drum with a removable plastic liner, as they prove the most cost efficient. The trail's logo can be painted on the container. In areas near populations of black bears, install bear-safe lids on the containers as well.
- **Trail Information Kiosk:** Information kiosks should remain functional and provide enough room for an overall trail map, as well as rules and regulations of the trail, and a map box.
- **Landscaping:** Screening along the trail provides a finished appearance to a trail, as well as protects wildlife habitat, streamside buffers, erosion control, windbreaks, and separates areas of different uses. Limit landscaping along the corridor and at trailheads to the use of native plant species. When selecting trail amenities consider an item's required maintenance, quality, affordability, and construction details. Use high quality, yet affordable items of simple design, reflective of the heritage of the area.
- **Trail Barriers:** There are many options for installing barriers along a trail corridor to limit access. They include boulders, fences, and gates. They



can be ornate and functional by corresponding to the design aesthetic/theme of an urban/suburban rail trail, or they may be purely functional, such as a gate constructed of steel tubing, to prevent motorized access to a trail corridor. Barrier types are further discussed in AASHTO’s publication titled “Guide for the Planning, Design, and Operation of Bicycle Facilities.”

Kiosks

Kiosks introduce users to a trail. Signs and maps, as well as safety concerns are valuable to both inexperienced and experienced outdoor travelers and are typically posted at kiosks. The kiosk should provide a modest roof to eliminate glare and protect posted information from direct exposure to the elements. Maps and signs should be manufactured from weatherproof materials, designed for the intended use. Encouraging the responsible use of the outdoors conveys an important message for users, setting the stage for future generations utilizing public lands.

Well-designed information kiosks that communicate to persons of all skill levels are important for the continued enjoyment of outdoor recreation areas. It is important to have a common design for all kiosks and trail information signs along a trail corridor.

Kiosk Design

Kiosks can range from a simple, single panel containing a limited amount of information about an area, to three or more panels describing the location in more detail. Kiosks are constructed in either an angled or linear fashion. The size of the kiosk is determined based on the amount of information to be displayed, average number of visitors, and the type of use an area receives. Trail designers generally locate multi-sided kiosks with roofs at prominent trailheads. At less-visited trailheads, single-paneled kiosks relay key points and messages.

The design and materials of a kiosk must match the character of the location, feel of the trail, and the needs of the user group to contribute to a user’s overall experience. Use materials that fit the character of the landscape and meet the expectations of the user groups. It is also important to consider the potential for vandalism or theft when designing a kiosk. Select durable materials that anchor kiosks firmly in the ground. Use vandal-proof screws and bolts to secure the structure and information panels.





Sizerville Nature Trail
Kiosk, Elk State Forest
Potter County

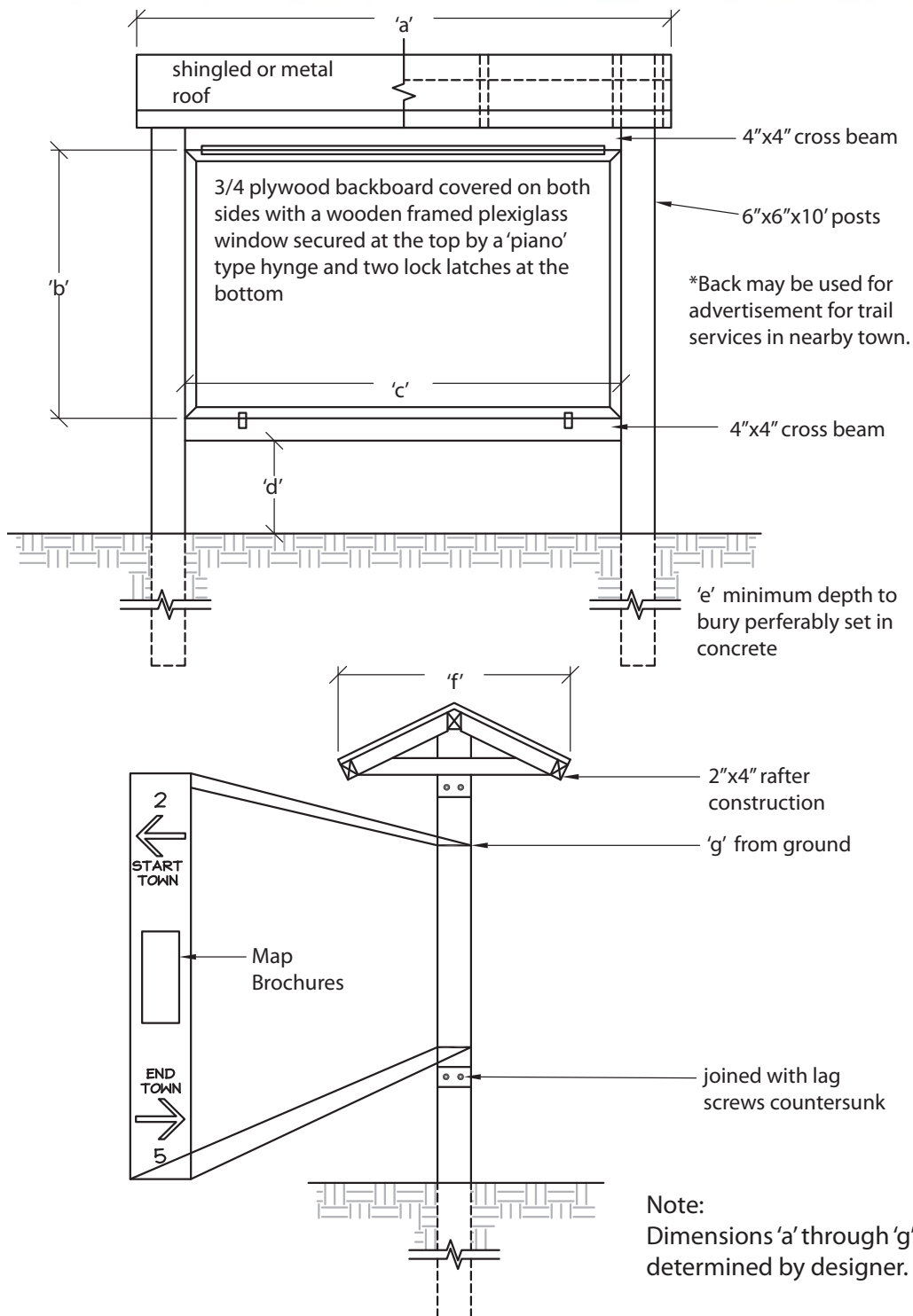
Photo Credit: PA DCNR

Place kiosks at all trailheads. Kiosks should include the following basic information:

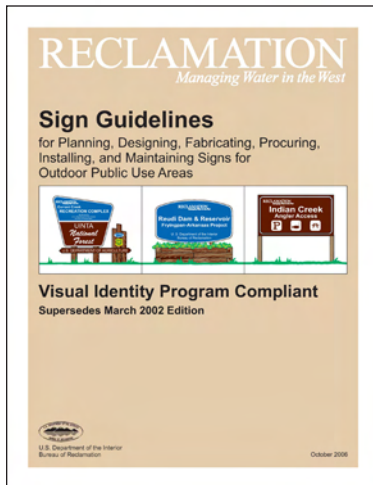
- Trail name and logo
- Map showing the location of the trail and associated trail amenities
- Trail distance (in time and mileage)
- Trail level of difficulty and special instructions
- Trail accessibility information
- Rules of the trail
- Warnings of dangers, safety messages and trail closures
- Contact phone numbers for trail manager and emergency services
- Statement indicating the information posted reflects the conditions of the trail when it was last evaluated, events beyond the control of the trail manager can present hazards and make the trails temporarily inaccessible

The kiosk/bulletin board trailhead sign may also include:

- Carry in/out, Leave No Trace principles that suggest ways to decrease user impact
- Hours trailhead is open, if applicable
- Trail map handouts
- Trail register
- Information about trail organization partners and/or trail care crews
- Information about how users can get involved in volunteering
- Information about agency partners
- Interpretive information
- Types of trail uses allowed
- Recognition of organizations providing volunteer services



Kiosk



Letter Size¹⁰

Determine the size of letters for pedestrian signs by considering the location, volume, and type of visitors using the area. If the sign is intended for people with disabilities, letter point size should comply with accessibility guidelines. To be easily read, the sign should have sufficient color contrast between letters and background.

The following rules of thumb pertain to the sign's primary message only. Letter size for a sign's secondary message will be two-thirds the height of the primary message.

1. Short messages to be read from some distance: lowercase height and thickness of arrow shaft, 2-1/2 inches.
2. Direction, distance, instructions, listings in moderate visitor use areas where pedestrian traffic is channeled by walks, etc.: lowercase height and thickness of arrow shaft, 2 inches.
3. Plaques, markers, and object identification: capital height, 1-1/2 inches; lowercase height and thickness of arrow shaft, 1 inch; 8-inch recreation symbol.
4. Description sign texts: capital height, 1 inch; lowercase height and thickness of arrow shaft, 5/8 inch; 8-inch recreation symbol.

As a rule, one inch of letter height can be read from a distance of 50 feet; 2 inches from 100 feet, and so on.

Construction and Installation

To begin the design and construction of a kiosk, first select its location. Common topics showcased in kiosks include local history, safety information, and maps. After determining its location consider the specific placement of the kiosk. Best practices include placing kiosks at trailheads, parking areas, or campgrounds to address a trail's user group before beginning their trip on the trail. Because the area around the kiosk will receive plenty of visitors, place stable and firm materials around the kiosk.

Next, construct detailed plans and an illustrated plan to determine the style, colors, and material choices that will work best for this location. Generally, trail designers will present construction drawings for kiosks to land managers for approval before construction.

User Education

Consider the information to be placed on the kiosk before finalizing its size and style. Since the trailhead indicates the beginning of the trail, it is important to introduce visitors to unique aspects of a location and quickly convey safety and stewardship information. Concise and interesting signs

Basic Kiosk Information

- A map or layout of the land, including trail descriptions if appropriate.
- A short description of unique historical, wildlife, and other characteristics that define the location.
- Safety information to warn visitors of dangers and suggestions for safe travel.
- Stewardship information of how visitors can get involved.
- Carry In/Carry Out and Leave No Trace principles that suggest ways to decrease user impact.
- Information on local services; eat, sleep, fuel, etc.
- Contact information for organizations and land managers.

¹⁰ Sign Guidelines for Planning, Designing, Fabricating, Procuring, Installing, and Maintaining Signs for Outdoor Public Use Areas, U.S. Department of the Interior Bureau of Reclamation: October 2006



attract the attention of all users. Incorporating artwork, photos, and maps can keep the attention of trail users. Consider what messages the kiosk will convey to users before they head out on the trail. The real challenge involves keeping the information simple, relevant, and interesting.

Trail designers and trail managers must take the time and give the consideration necessary to plan and construct a kiosk, as it will serve as a source of information for years to come. Further, the information contained at the kiosk should be regularly reviewed and updated to avoid creating any confusion on the part of the trail users.

Trail Access Information¹¹

Signs identifying trails and trail segments that have been officially assessed and designated as accessible to persons with disabilities should be placed at the trailhead and at all designated access points. Display the official symbol designating that the trail or trail segment is accessible, and include the total distance of the accessible trail or trail segment and the distance to the location of the first point of exception to accessible standards.

Use marker posts to display accessibility information at access points without trailhead signs. Decals are readily available to attach to marker posts.

The size of the trailhead sign should be such that both text and graphics are easily readable. The minimum size should be 12"x18". Background colors, margins, and sizes of text and images are subject to change.

Materials for Signs, Trail/Sign Markers, and Posts

Signs can be constructed from a wide range of materials, including cast aluminum, fiberglass, phenolic resin, porcelain enamel, and vinyl on aluminum. The following is a description of common sign materials, as well as the pros and cons for each.

- **Fiberglass:** Fiberglass panels imbed a digitally produced paper graphic into the sign's surface. These signs are generally easy to maintain and clean, but have a relatively short lifespan of 5 to 8 years. Fiberglass panels will fade and become brittle over time, but are low enough in price to be replaced as needed.
- **Phenolic Resin:** Phenolic resin panels are a high-pressure laminate that encapsulates a digital paper graphic. These panels are appropriate for all locations and require waxing once every year. These colorfast panels are an excellent choice for reproducing high-resolution photographs.
- **Porcelain Enamel:** Porcelain enamel markers are made by fusing glass

¹¹ Draft Final Accessibility Guidelines for Outdoor Developed Areas, U.S. Access Board: 2009

Mingo Creek Paved Trail

Trail Length	2.8 Miles
Trail Surface	Asphalt
Trail Width	10 feet
Typical Running Slope	2%
Maximum Running Slope	15%
Typical Cross Slope	2%
Maximum Cross Slope	5%

Trail Access Information Sign
Mingo Creek Park
Washington County

Photo Credit: PA DCNR

Trail Accessibility Information

When available, the following additional information should be included on trailhead signs:

- Trail-specific trail symbol
- Running slope (average and maximum grade)
- Cross slope (average and maximum)
- Cumulative elevation change (gain and loss)
- Profile of the trail grade showing changes in surface type and accessibility
- Clear tread width (minimum and average)
- Tread obstacles (magnitude and frequency)
- Any major height obstacle, such as boulders, in the trail tread



Cook Forest State Park
Bald Eagle Interpretive Sign

Photo Credit: Pashek Associates

to steel. They are durable and perform well in most environments such as zoos and aquariums. However, if damaged this material will rust and cause surface stains.

- **Vinyl on Aluminum:** Commonly used for highway markers, vinyl graphics on aluminum backers are ideal for semi-permanent wayfinding signs. This type of signage looks professional and offers flexibility, minimizing season-to-season costs.
- **Cast Aluminum:** Durable and heavy, cast aluminum signs require minimal maintenance and can withstand adverse weather conditions. Unfortunately, cast aluminum signs cannot be used for color photographs.

Fabricating the Posts and Frame

While the graphics are being produced, use the time to fabricate the posts and frames that will hold them. Plastic, wood, steel, aluminum, and steel can be used for posts and frames. The choice will depend on location of the signs, budget, and required annual maintenance.

- **Wood:** Wood signs and posts are visually appealing and the most readily available material for trail posts and frames. When choosing to use wood, select a rot-resistant form and consider using paints and sealers to protect it from the elements. Wood frames are the most easily damaged and require the most maintenance.
- **Steel:** Steel is a durable, strong material for fabricating posts and frames. However, it is prone to rusting and must be galvanized to resist corrosion.
- **Aluminum:** Aluminum frames and powder-coated finishes are more expensive at the outset but will require less maintenance over time. Furthermore, aluminum will not rust or stain when left outside and are usually half the weight of their steel counterparts.
- **Stone:** Stone is durable, but it limits the amount of information that can be carved into the sign. However, it can be a cost effective material to use if found on-site.
- **Plastics:** Plastics vary in quality and durability; therefore, it is important to research the various types before making an investment in them. Fiber-reinforced plastics are a popular choice for marking trails as they are durable and affordable.



Allegheny River Trail Map

Photo Credit: Pashek Associates



Signage and Markings

These trail signing guidelines provide standardization for signs and uniformity in the use of signs. Installing trail signs assists in managing trail use, warning trail users of trail conditions or characteristics, locating the trail, and providing general information to trail users.

Standardizing the size, shape, color, and content of signs improves recognition and safety through trail user familiarity, no matter what trail users visit.

Uniformity in the application of signs remains as important as standardization of sign design and placement. Always mark identical conditions with the same type of sign, regardless of where those conditions occur. Uniformity also enhances safety and the comfort level of trail users. Designers typically classify signs into one of the following groups:

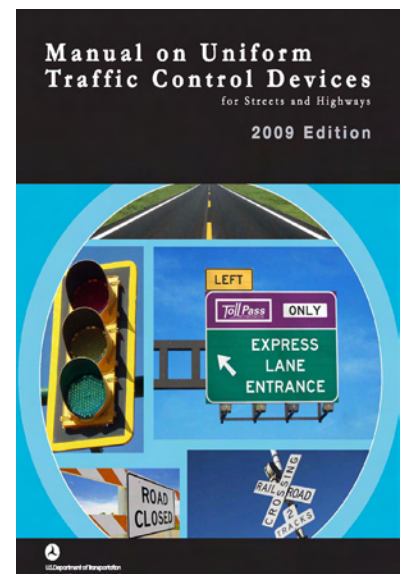
1. **Regulatory and Warning Signs:** Used when trail users must perform an action or to provide warning or caution and promote safety of users and property. Only place signs where potential conflicts are unclear, or to emphasize the significance of a potential conflict.
2. **Identifier Signs, Reassurance Blazes, and Trail Markers:** To identify the type of trail use permitted or prohibited as well as indicate the trail's level of difficulty. These signs reassure trail users that they are following the correct path and provide them with a point of reference along the trail. These signs provide a trail user with a level of comfort that adds to the enjoyment of the overall trail experience.
3. **Information Signs:** Used to indicate location, direction, and/or distance to a point of interest; wayfinding signs to direct trail users to features off the trail corridor; and interpretive signs to uncover points of interest along the trail such as cultural, historic, or environmental features.

Regulatory and Warning Signs

The *Manual on Uniform Traffic Control Devices*¹² (MUTCD), available [HERE](#), is recognized as the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel.

The MUTCD defines traffic control devices as all signs, signals, markings, and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, bikeway, or private road open to public travel by authority of a public agency or official having jurisdiction, or, in the case of a private road, by authority of the private owner or private official having jurisdiction. Chapter Nine of the MUTCD addresses traffic control for bicycle facilities.

¹² Manual on Uniform Traffic Control Devices, Federal Highway Administration: 2009



Manual on Uniform Traffic Control Devices
U.S. Department of Transportation



Common Regulatory Signs

Regulatory signs regulate movement of trail users along the trail in a safe and orderly fashion. Failure of trail users to obey these signs can lead to legal consequences.



Common Regulatory Signs, US Department of Transportation MUTCD



Common Warning Signs

Warning signs alert trail users to hazards or conditions requiring special attention. Signs are located at a distance suitable to provide ample time for the trail user to react.



* A fluorescent yellow-green background color may be used for this sign or plaque. The background color of the plaque should match the color of the warning sign that it supplements.

Common Warning Signs, US Department of Transportation MUTCD



Level of Difficulty Symbols



Identifier Symbols, Reassurance Blazes, and Trail Markers¹³

Identifier signs indicate the type of trail use permitted or prohibited, the trail's level of difficulty rating, the trail name or number, and the specific location along the trail. Use of these signs provides a trail user with a level of comfort and adds to the enjoyment of the overall trail experience.

Identifier Symbols

Use recreation symbols on trailhead signs, at trail junctions and road crossings, and on maps to indicate permitted and prohibited uses of the trail.

Permitted Use

Hiking

Equestrian

Biking

Cross-Country Skiing

Symbols



Level of difficulty ratings are based on the degree of challenge a trail presents to an average user's physical ability and skill by using trail condition and route location factors such as alignment, steepness of grades, gain and loss of elevation, and natural barriers that must be crossed. The sign should note that conditions are subject to change due to weather and other factors.

Trail Markers

The most basic trail signs are those that identify the trail. These signs may provide the name of the trail, mark the route of the trail, and include simple information, such as difficulty rating, mileage point, and symbols that show allowable uses of the trail. Where directional signs are used, identification of the trail is often incorporated into the directional sign.

Trails can be marked in many ways. Blazes can be painted on trees, stakes, or other objects, posts can be set into the ground, markers can be nailed to

¹³ Guidelines for Marking Recreational Trails, Pennsylvania Department of Conservation and Natural Resources; 2008



trees or posts, or cairns (piles of rocks) can be carefully erected. Regardless of the method used or type of trail being marked, each specific trail should be marked clearly and consistently and the marking should conform to a standard color, shape, and size. Where trail conditions prevent the use of the standard marker, an alternative can be used.

One method to mark trails is to use colored plastic or metal markers attached to posts. Plastic markers are less expensive but may not last as long as metal markers. Markers of various colors, shapes, and sizes are useful for distinguishing between multiple trails and between different types of trails. However, it should be noted that a large number of people are unable to distinguish between different colors; therefore, trail intersections should be well-labeled using different symbols or text (on markers or signs) to signify different trails. Use markers with arrows to indicate major changes in direction along a trail.

Use distance markers to show the mileage from either end of the trail or from a designated trailhead. These types of markers can be very useful in emergency situations and for maintenance purposes. Distance markers are often placed every quarter mile, although placement at tenth-mile intervals may be preferable.

Use of distance markers is encouraged along all trails and should include a unique identifier, such as the trail name. Where distance markers are used, other methods of marking the trail are usually unnecessary. Distance markers are often embedded in a post that is placed into the ground alongside the trail using vandal resistant hardware. Alternatively, distance markers can be metal or plastic markers nailed to trees or attached to posts; however, these types of specialized markers are prone to theft. Whichever method is used, the design of distance markers should be consistent along the entire length of the trail on which they are placed.

On long distance trails, it is not cost effective or desirable to use official trail markers as the sole method of marking a trail. Other less costly, less visually obtrusive, and more vandal-resistant methods should be used between widely-spaced markers. The preferred method is to use paint blazes, typically vertical rectangles painted on trees, posts, and other objects along the trail.

Blazes

Painted blazes along any given trail should eventually conform to a standard color, shape, and size, namely painted rectangles six inches in height and two inches in width. When painted neatly with sharp corners and clean edges, blazes remain visible to users at a distance and distinguish themselves from naturally occurring marks.

Place the blazes on trees at approximate eye height. Remember, the trail should be marked for the benefit of users traveling either way, so place

PA DCNR's
Guidelines for Marking
Recreational Trails,
available [HERE](#), provides
recommendations for
marking recreational trails
on State Forest and State
Park lands.



Trail Blaze
Mason Dixon Trail
York County

Photo Credit: Pashek Associates



blazes facing in both directions. If you can't find a suitable tree next to the trail, paint blazes on ledges or trail side rocks. Check with and receive permission from the land manager before painting blazes.

Keeping Blazing Primitive

Blaze Less

- Along well-defined trail
- Along highly constructed trail in dense vegetation (example: mountain laurel or rhododendron)
- Along sharp ridgelines

Blaze More

- At turns, both on and off roads
- Along obscure footpath
- In open forests
- In open areas

Other points to remember:

- When choosing a blaze tree, remember that one well-placed blaze is better than several that are poorly placed or partly hidden.
- Most importantly, avoid defacing trees and rocks that form distinctive and pleasing elements of the scenery.

Frequency

Blazing needs to be continuous, even along roads or unmistakable parts of the trail corridor. Immediately beyond any junction, paint a blaze even if there is a direction sign. Place a second "safety blaze" 50 to 100 feet beyond.

Normally, you should change blazing frequency naturally with changes in trail terrain, forest cover, or the clarity of the footpath. When the trail is conspicuous, place one blaze for every five minutes of hiking time, or about six per mile in each direction (800 to 1000 feet apart). Where you run into hard-to-follow sections, often in transitions between field, forest, balds, and other environments, blaze more frequently.

Be careful not to over blaze. Too many single and double blazes can mar the primitive character of a trail. This is a special concern in wild and natural areas, where blazing should remain minimal, or six per mile. Elsewhere, you should place blazes so that no more than one is visible in either direction. In other words, except near trail junctions, keep blazes at least 150 feet apart.

Double Blazes

A double blaze means "caution". Place a double blaze 25 to 50 feet before abrupt turns and highway or trail junctions. Remove painted arrows, or slanted blazes, and replace them with standard double blazes. Double blazes should be placed one over the other, and about one to two inches apart. Where the double blazes are alerting a trail user to a turn, the top blaze, tree size permitting, can be offset in the direction that the trail will turn.

As with the single blaze, place the blazes sparingly. They are unnecessary at most turns in the trail, and they become unsightly and meaningless with frequent use. Only use double blazes where necessary for the safety of trail users. On switchbacks, for example, use only single blazes, but paint them near the switchback corner, one above the corner and one below. If needed, pile brush, logs, or rocks at the corner to define the trail and guide users around the turn.

Where the route remains ambiguous even with blazes, avoid the urge to paint an arrow to direct the user. The extra, nonstandard paint may hurt the trail's primitive character, detract from the trail users' sense of exploration, or set a precedent for painted arrows. Try to use small directional signs, posts, or cairns, instead.

When Two Differently Marked Trails Share the Same Path

Sometimes two or more trails briefly share the same path or corridor. When blazing in these areas, avoid confusing over-blazing and consider combining different blaze colors into one blaze.



Placement

Paint blazes on trees that will easily be seen by trail users. Look down the trail to find a tree that will catch hikers' attention in all seasons. If the tree is far enough away, and within one to three feet of the right side of the trail, you've found your next blaze tree. Try to make sure that leafy summer growth or branches weighted with snow or rain will not later hide the blaze. Clear any interfering growth with lopping shears or hand pruners, if permitted by the land manager.

Suggested Paint Colors

The following paint colors are recommended in PA DCNR's *Guidelines for Marking Recreational Trails*. Following these recommendations provides uniformity and consistency when blazing trails. Each color includes the Pantone Color ID Number to maintain consistency when purchasing paint from various manufacturers.

- Red PMS 485 2X
- Orange PMS 165 2X
- Yellow PMS 102
- Blue PMS 300
- White
- Brown PMS 161

High quality latex paint is recommended. Enamel is not recommended as it may damage thin-barked trees.

Trail/Sign Markers

There are many materials that can be used to construct trail signs and markers. They include:

1. **High-Density Overlay (HDO) Plywood:** Marine-quality, 3/4-inch plywood with one side covered with a high density, slick material (the overlay), to which adhesives cling quite strongly. Commonly used as the substrate for pressed-on materials such as reflective vinyl. This substrate should be used extensively for the larger signs. It weathers well, and holes in the vinyl can be easily repaired.
2. **Medium-Density Overlay Plywood:** Marine-quality, 3/4-inch plywood, with one side covered with a smooth but more porous overlay than HDO. This substrate accepts paint much better than HDO. The porosity of the overlay allows the paint to bond with the substrate better.
3. **Medium-Density Fiberboard (MDF):** A pressed-particle board product that accepts paint (silk screening) very well and weathers well. MDF is gaining adherents among transportation departments for large highway signs (green, blue, and brown).

Pennsylvania Department of Conservation and Natural Resources

Guidelines for Marking Recreational Trails



July, 2008

**Guidelines for Marking
Recreational Trails**
PA DCNR

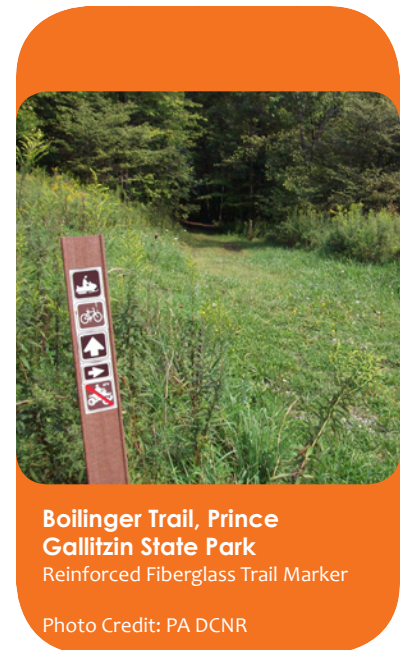
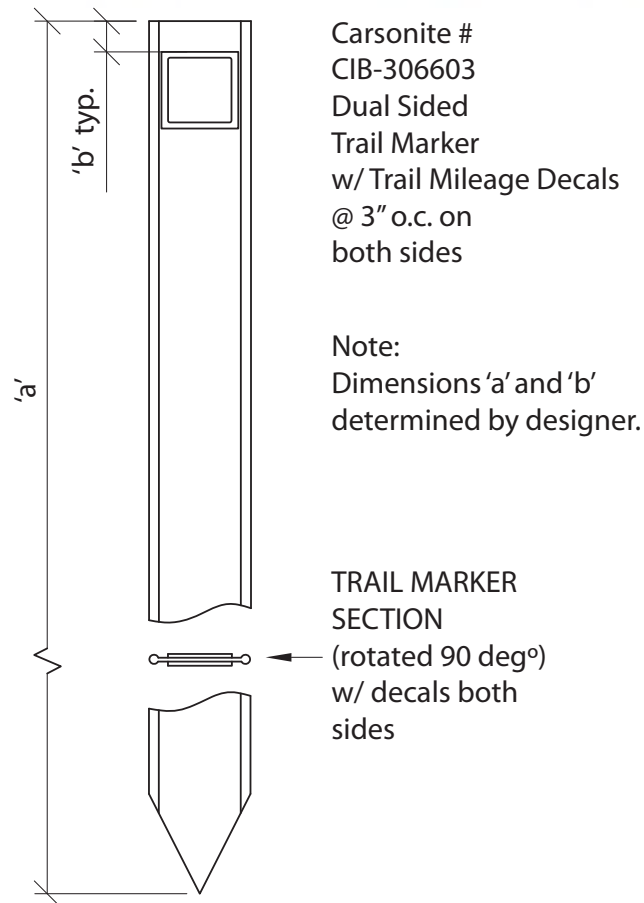


4. **Plastics:** Sign-making can involve a variety of plastics:

- Acrylic, or Plexiglas, is a hard, rigid material that withstands abrasion well but breaks easily. It is often used as a clear protective covering over another sign.
- Polycarbonate, or Lexan, is similar to the acrylic panel but is softer, with a greater flex. Its softness makes it more likely to be marred by dust and blowing sand.
- Polyethylene and polypropylene are fairly common materials that are suitable for most routine sign applications. They are soft materials that have sufficient rigidity to stand up as small signs, but not so rigid that they are easily broken.

They come in basic colors, and accept paint (silk screening) well. Generally, they weather well; however, their softness makes them easy prey to vandals wielding sharp or pointed instruments. Initial and replacement costs are low.

5. **Aluminum:** A long-used, common substrate for routine, smaller signs. Message usually silk screened onto substrate. Easily and significantly damaged by bullets and other forms of vandalism. It has good weather resistance. Moderate initial and replacement costs.
6. **Aluminum-clad plastic:** Similar in character to aluminum signs. The plastic core adds strength; this substrate is highly durable and light weight, making it ideal for kiosk panels or other signs mounted with a backing. The cost of this product is moderate.
7. **Aluminum-clad plywood:** Similar in character to aluminum signs. Plywood backing adds support to the aluminum to provide stability/rigidity for larger size signs. Initial and replacement costs are moderate to high.
8. **High-Density Foam Boards:** Three-dimensional signs made by cutting a matte and sandblasting to the desired depth. Sand blasting and mattes can also be used to make three-dimensional wood signs from 2-inch-thick material.
9. **Reinforced Fiberglass Trail Marker (RFT):** Recreational trails can be marked using dual sided reinforced fiberglass trail (RFT) marker posts with decals to identify type of trail (horse, hiking, etc.) and the individual trail identification (name, number, or color code).



Reinforced Fiberglass Trail Marker

Marking other Property and Recreational Facilities

You may use any color of RFT posts, with the following exceptions to mark other property facilities.

1. Red: traditionally used to identify safety zones or other danger areas.
2. Orange: traditionally used for boundary marking.
3. Yellow: traditionally used to identify survey marker locations (corner stones, etc.) with appropriate decal ("Survey Marker"). Survey markers may be on property lines or off line.
4. Blue: traditionally used for marking firewood cutting areas.



Split Rail Fence
Bellefonte Central Rail Trail
Centre County

Photo Credit: Pashek Associates

Trail Gates and Barriers

Barrier design depends on an area's intended use, native materials, and character. Consider vandalism as a factor in barrier planning. Generally, wooden barriers are more vandal prone because they can be carved or burned. Concrete and metal barriers are more durable, but still succumb to vehicular ramming.

Some barriers serve as a deterrent for access to a road or a trail, while others keep vehicles on a road or in a parking lot. Most visitors recognize and respond to design features such as a simple curb used to deter vehicles from driving off-road.

Use barriers or fabricate specialized barriers for areas where user or vehicle control problems exist.

To make barriers more difficult to remove, use:

- Steel instead of wood
- Large boulders
- Larger diameter posts
- Posts buried deeper
- Posts set in concrete
- Posts anchored with rebar spikes

Movement Barrier Types

Generally, there are five types of barriers: bollards, fences, gates, large rocks, and wooden guardrails. The barrier size and its materials vary depending on the problem's severity and the proper scale to fit with the site's resources.

Bollards

A bollard consists of a large post with no stringer or rail, commonly 1 to 4 feet tall, and used singly or grouped to block vehicle entry from pedestrian right-of-ways. Materials for bollards consist of wood, concrete, steel, or plastic lumber posts. Bollards should be identified with reflective tape.

Fences

A fence functions as a boundary or barrier, usually made of posts, boards, wire, or rails. Fences are designed to keep people and stock in or out of an area, but generally cannot withstand vehicular impact.

- **Split Rail Fence:** Split rail fences are desirable from a cost and aesthetic standpoint. However, in isolated locations they may be prone to vandalism.
- **Rolled Wire Boundary Fence:** A rolled wire boundary fence also is a cost effective solution. Generally, this fence disappears from sight from a distance. Therefore, when constructing this fence install appropriate



Schuylkill Trail
Montgomery County

Photo Credit: Montgomery County
Planning Commission



signage or flagging to ensure trail users recognize the location of the fence.

Gates

Gates made of wood or steel allow passage and may or may not swing open. Secure gates to a fence or a large natural feature to prevent people from navigating around them. Use gates to allow pedestrian and wheelchair access, while blocking stock, motorcycle, and ATV access.

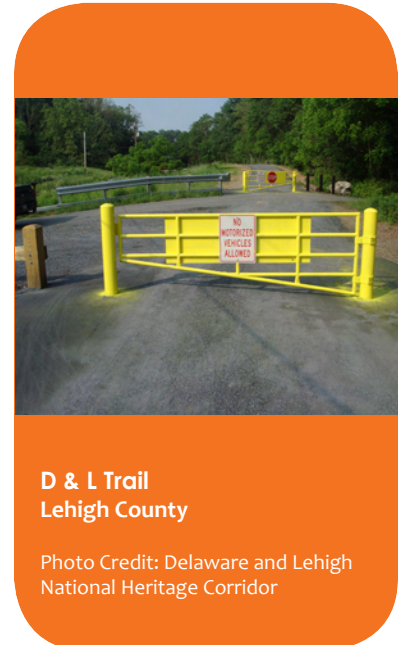
- **Right-Angle Gates:** A right-angle gate creates a passageway for pedestrians and stock. This type of gate is generally constructed from wooden or steel posts with wooden or pipe rails.
- **Steel Road Gates:** Steel road gates prevent vehicle or ATV entry to roads, trails, administrative roads, and campgrounds. Consider using large rocks and berms to block entry around the gate.
- **Steel Trail Gates:** Steel trail gates limit access of 4 wheel vehicles and ATVs while allowing motorcycle access. For safety reasons, this gate must be visible at the trailhead and as one approaches it while riding.
- **Non-motorized Trail Barrier Gate:** Non-motorized trail barrier gates are located at trail access points to allow pedestrian and stock access to pass through. Flank the gate with a steel rail fence to prevent people from skirting the gate.

Large Rocks

Rocks prove difficult to drive over in a standard automobile and generally deter trail users from navigating over them. Mimic nature by placing rocks, that weigh 200 to 400 pounds each, in groups and vary the space between them to create a natural looking barrier.

Wooden Guardrails

Wooden guardrails consist of a series of low posts tied together by wooden rails to block and control vehicular access. Combine guardrails with a curb, bumper stop, wheel stop, or shrubbery to increase effectiveness against vehicle intrusion.



D & L Trail
Lehigh County

Photo Credit: Delaware and Lehigh
National Heritage Corridor



Walter Dick Park
Jefferson County

Photo Credit: Pashek Associates



East Branch Trail
Crawford County

Photo Credit: Pashek Associates

Bridges

Building a bridge poses one of the biggest challenges to constructing a trail. It requires a strong understanding of engineering and hydrological principles, as well as sustainable design principles. The first step in determining the best way to handle a specific situation involves assessing likely users of the trail, its location, and alternative routes before concluding if a bridge is necessary. It is important to carefully plan and explore all options for a site during the design phase, and before construction begins. Further, the designer must be aware of permitting requirements and design the bridge to be compliant with them.

A wide range of bridge designs exist, from simple designs constructed on-site with native materials to expensive, factory-built models. Only the materials available and creativity of the builders involved in the project limit the variety of bridge designs possible. It remains important to base a bridge design on its aesthetic value, size, and the intended user experience proposed for the trail.

Nearly every trail crosses one or more waterways along its route. Narrow streams can be crossed in several ways depending on the size and the type of the stream. Appropriate crossings can include placement of flat stone along a narrow streambed or the use of culverts. For perennial streams, anchored bridges or culverts typically provide the user with the necessary means to cross the stream. By placing the trail above the water, the impact to the stream is decreased.

The thought that goes into the planning and design of a bridge remains every bit as important as the effort invested in its construction. Location is a key determinant of the durability and ease of construction for a bridge. Some important aspects to consider include: stable banks, banks close together, a sunny location, acceptable approach trails, and a bridge's potential environmental impact. Using the right size of lumber for the span and building supports, if necessary, remain important. Remember to build bridges to meet the needs of the intended users, and to prohibit other uses.

It also remains important to consider other aspects of a design before constructing a bridge or water crossing such as safe approaches and incorporating flat, skid-resistant surfaces. Designers should carefully select bridge types and construction materials for site conditions, building them to support emergency and maintenance vehicles where appropriate. It is also important to avoid sharp and blind curves, as well as drastic changes in elevation, on immediate approaches to minimize adverse effects on sight distance, drainage, and footing for users.



The USDA Forest Service identifies six general bridge types in their *Trail Bridge Catalog*¹⁴, available [HERE](#), typically used along non-motorized trails, including:

- **Cable Suspension Bridge:** Cable suspension bridges have two main steel cables for support. Builders create the deck of the bridge using sawn timber planks typically hung from suspended cables or steel rods. They anchor the cables into the streambanks and use intermediate towers for support when necessary.
- **Deck Girder/Truss Bridge:** Deck girder bridges are supported by two or more longitudinal girders (beams). Deck support comes from the tops of the girders and usually consists of timber (log, sawn, or glued laminated timber), but may be concrete or steel.
- **Side Girder/Truss Bridge:** Side girder bridges are supported by two longitudinal girders or beams. The deck hangs on the interior side of the girders on either the floor or ledger beams, attached to the main girders.
- **Arch Bridge:** Longitudinal beams or walls typically support the deck of an arch bridge. Designers use a variety of materials including timber, masonry, concrete-filled, and open spandrel concrete in the design of these bridges.
- **Single Unit Bridge:** Consists of a single, self-supporting bridge. A foot log, nailed or glued-laminated timber, and prestressed concrete are typically used to construct this type of bridge.
- **Covered Bridge:** Traditional covered bridges essentially use a side truss bridge design to span up to 300 feet. Most modern bridges use side girders or deck girders with the covering simply added to the top of the bridge.

Several other types of bridges that can be considered when designing a non-motorized trail include:

- **Puncheon Bridge:** Puncheon bridges consist of wooden walkways used to provide passage over small streams. A puncheon refers to two flattened logs nailed side by side on sills to form an elevated walking surface. Puncheon for a horse trail consists of a deck 48 inches in width with a minimum thickness of 4 inches, laid on stringers with a diameter of at least 10 inches. The design of these bridges accommodates both pedestrian and equestrian uses.

¹⁴ Trail Bridge Catalog, USDA Forest Service; 2008



Stringer Bridge
Nescopeck State Park
Luzerne County



Reinforced Fiberglass Bridge
Quehanna Shared Use Trail
Clearfield County



Suspension Bridge
Cook Forest State Park
Clarion County

Photo Credits: PA DCNR



Standard Dimensions of Puncheon and Bridge Decking

Trail Type	Deck Width	Deck Thickness
Hiker	36"	3"
Cross-Country Skier	60" minimum	3"
Equestrian	48" minimum	4"
Rail Trail	10' Clear, minimum	4"

* Nails- For 3-inch decking, use #50 to #60 galvanized nails.

** For 4-inch decking, use 3/8 inch x 8 inch galvanized spikes.

- **Stringer Bridge:** Similar to the USDA Forest Service's Single Unit Bridge, a stringer bridge typically uses a single log or a timber beam to cross a span. These bridges span crossings of 50 feet or less. Two-stringer bridges (the width of two logs or beams) usually prove sufficient for use by hikers, while bridges intended for livestock or cross-country skiers will have 3 or more stringers. Depending on user needs, designers can equip stringer bridges with railings stabilized by longer planks of decking.
- **Ladder Bridge:** A ladder bridge is an elevated boardwalk put in place to get over an obstacle or wet area, or simply to add an interesting trail feature to a mountain biking trail. Elevate these bridges using large rocks, strong tree stumps, or well-designed wooden posts. The trail surface at the entrance or exit of a ladder bridge will require hardening, especially on steeper grades and landing areas.
- **Reinforced Fiberglass Bridge:** A fiberglass bridge system offers significant design and construction advantages. Manufacturers ship components in sections that typically weigh less than 90 pounds, which trail crews can easily carry to any trail construction site. In a matter of a few days workers can easily assemble these bridges with hand tools. The material used to design these bridges withstands harsh weather that can quickly deteriorate traditional materials.



Landscaping with Native Plants¹⁵

When landscaping along trails, whether to stabilize recently graded areas, to create natural barriers, or for aesthetics, native plant materials should be used. A native plant is one which occurred within this region before settlement by the Europeans. Native plants include ferns and clubmosses; grasses, sedges, and rushes; perennial and annual wildflowers; and woody trees, shrubs, and vines which covered “Penn’s Woods” when the first settlers arrived. Over 2,100 native plant species occur in Pennsylvania.

An introduced or non-native plant species is one that travelers brought into the state and escaped cultivation to establish itself in the wild. About 1,300 species of non-native plants exist today in Pennsylvania outside of gardens, parks, and agricultural lands. That is 37 percent of Pennsylvania’s total wild plant flora, with more identified every year.

Basics of Plant Conservation

Protect native plant communities and minimize habitat destruction

The most important guideline involves conserving existing areas of native vegetation as a whole, functioning unit. The easiest, least expensive, and best way to conserve Pennsylvania’s plant heritage is to protect existing native plant communities from further disturbance. If disturbance must occur, strive for minimum habitat destruction. Some cases may require ecological restoration, which can include planting native species, removing invasive introduced species, controlling erosion, and loosening soil compaction.

Landscape with native plants

The destruction of native plant communities has occurred in many areas. Intelligent landscaping in parks, yards, and campuses can help redress this loss. Well-chosen native plants can flourish in these landscapes. The Department of Conservation and Natural Resources recommends avoiding rare, endangered, and threatened plants and instead choosing native plant species which grow commonly throughout the state. If you do not want all natives, select adapted introduced plants suited for the site, colorful annuals, or flowering plants that will not escape and become environmental weeds.

Buy nursery-propagated native plants

Most retail nurseries and mail-order catalogs now offer native plants. If you want guaranteed ornamental characteristics, in some cases cultivars (named varieties) are available; for instance, a cultivar of New England Aster named ‘Purple Dome’ was selected for shorter height and showier flowers. Cultivars have predictable attributes like height, color, blooming period, or absence of seed pods/thorns—qualities many gardeners want. If your goal is genetic diversity, however, ask for straight species, not cultivars, grown from local

Landscaping with Native Plants in Pennsylvania

This DCNR publication, available [HERE](#), is a good resource for identifying which native plants may be appropriate for your situation.

Additional information on:

- Rare, Threatened and Endangered Plants
- Common Trees of Pennsylvania
- Landscaping with Native Plants
- Invasive Plants
- Plant Communities
- Wild Plant Sanctuaries



Go Native Tree Farm
Lancaster, York County

Photo Credit: Go Native Tree Farm

¹⁵ Landscaping with Native Plants Brochure, Pennsylvania Department of Conservation and Natural Resources



seed sources. Plants grown from seeds have much more variety than cloned cultivars.

Do not remove native plants from the wild

Taking native plants from the wild depletes native populations. In addition, many wild-collected plants do not survive transplanting. Prevent wild collecting of plants by making sure a nursery propagates the plants that you buy, or by starting plants yourself from a local seed supply. Before you collect seeds always obtain the property owner's permission.

Practice responsible landscaping techniques

The first rule of responsible landscaping is planting the right plants in the correct environment: never introduce invasive plants to your landscape that will aggressively spread off your trail and invade native plant communities. They can drastically alter ecosystems and give you and your neighbors maintenance headaches for years to come.

When landscaping with native plants it is important to choose plants that will grow well at the site: wet or dry, shade or sun, acid or neutral soil. By noticing which native plants thrive nearby, you can use those clues to guide plant selection. Other information can be found from plant nurseries, catalogs, books, or the Internet.

Finalizing the Design

At this point you should have completed the planning inventory and analysis as described in Chapter 1 - Planning. Your trail designer has reviewed the map and identified anything that may have changed since the completion of the inventory that occurred in the planning phase.

You have also established the trail management objectives by completing the Trail Management Objective sheet(s) for your proposed trail during the planning phase, and as described in Chapter 5 - Management. This sheet provides your trail designer with the information needed to develop the preliminary alignments and prepare the specifications for each segment of trail.

During the planning phase, as described in Chapter 1, your designer has also identified potential corridors and control points the trail will pass including destinations, areas of interest, and general trailhead and trail access locations.

Based on all of the design factors covered in this chapter, your trail designer will then finalize the location of the horizontal alignment for your trail in the field, GPS it, and transfer it to the construction drawings. While refining the alignment in the field the designer adjusts the alignment to avoid obstacles and previously unidentified constraints, and flags the locations of specific



construction details, such as the locations of dips, climbing turns, and other features described earlier in this chapter. Your designer will also adjust the alignments to provide a flow for the trail and to take advantage of interesting visual features. These features may include rock outcrops, waterfalls, habitats, and scenic views.

Your designer should flag the trail alignments by placing flags no greater than 50 feet apart, at any change, such as horizontal curves, vertical grade, and cross section, and where the construction of specific trail features will occur. The designer should also flag the clearing limits, and any trees that need to be removed. If the designer cannot see adjacent flags along the alignment, your designer should place more flags along the alignment. Placing too few flags along the alignment is a common mistake in flagging trails. Your designer will document the final alignments on the base map.

Your trail designer will then revise the Trail Management Objective Sheets as necessary, based on the refinement of the preliminary alignments.

Once your trail designer is satisfied with the final alignments, they will record the alignment utilizing GPS equipment to ensure properly located trail alignments on the plans.

Trail design and construction may or may not require a detailed survey. Your trail designer will identify when you may need a property boundary survey. A property survey establishes the locations of the property boundaries and ensures that you build the trail on your property. You may also need to have a topographic survey prepared in certain situations. Generally, the use of topographic surveys occurs to show elevations and geometry when your trail will intersect with a state or local road. Further, topographic surveys prove useful when designing trailheads, and for designing structures, such as bridges and retaining walls.

Preparing Construction Documents

After completing the final alignment(s) and recording their locations, your designer will prepare the construction drawings. On these drawings, the designer identifies the locations and establishes the details for each section of the trail. This generally includes typical cross sections, horizontal and vertical trail alignments, tread materials, location of water control structures, location of other structures and specific details for trail facilities such as trailheads and amenities. The trail designer should prepare an opinion of probable construction cost to compare the projected cost of constructing the trail to the available funding.



If competitive bidding will occur on your project, your designer will prepare bid documents that also contain regulatory requirements, conditions of the contract, and technical specifications.

Construction drawings typically include:

- **Erosion and Sedimentation Control Plans:** These document the locations of temporary and permanent erosion and sedimentation control features.
- **Layout Plans:** These identify existing conditions with proposed improvements overlaid, GPS coordinates, stationing, and/or dimensions to locate the proposed improvements, detailed call-outs identifying locations of various construction requirements that a construction detail further defines.
- **Grading Plans:** These plans note the existing and proposed topography which indicates the amount of cut and fill needed to establish the trail bed. Grading plans also typically identify locations and the extent of permanent erosion and stormwater control features.
- **Planting or Landscaping Plan:** Plans identifying existing vegetation to remain; location, size, and quantity of proposed plant materials; and extent of seeding.
- **Construction Detail Plans:** These plans provide both graphic and written information about specific parts of the construction. These are drawings showing the area of construction at a larger scale in order to clearly show the materials, dimensions, method of building, and methods of attachment.

Depending on the size and scope of your project, designers can combine information on fewer plans, or separate it into more plans.

Standard Drawings & Specifications for Construction

The U.S. Forest Service (USFS) has *National Trail Drawings and Specifications*¹⁶, available for reference [HERE](#). These construction details and specifications are available for professional use by those qualified to adapt these drawings to local conditions. The user accepts full liability for their use. The USFS does not provide supporting data for these drawings and specifications. The USFS makes them available on an as-is basis.

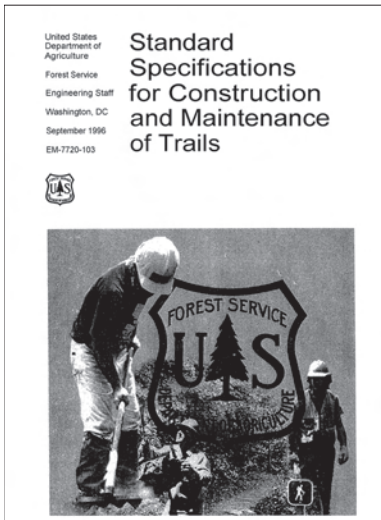
¹⁶ US Forest Service National Trail Drawings and Specifications, US Forest Service: 1998



USFS National Trail Drawings

These include fifty-three standardized set of model construction details that designers can adapt and modify to fit many trail situations.

- | | |
|---|--|
| 1. Clearing Limits | 28. Underdrain |
| 2. Typical Trail Cross Section | 29. Foot Log Trail Bridge with 2 Handrails – Side View |
| 3. Outsloped Climbing Turn | 30. Foot Log Trail Bridge with 2 Handrails – End View |
| 4. Trailbed and Slope Finish | 31. Optional Deck and Handrails |
| 5. Talus and Rubble Rock Section | 32. Puncheon without Decking |
| 6. Grade Dip | 33. Puncheon with Decking |
| 7. Rolling Dip | 34. Plank Stairway |
| 8. Turnout and Passing Sections | 35. Crib Ladder Stairway |
| 9. Shallow Stream Ford and Gully Crossing Rock Structure | 36. Rock Stairways |
| 10. Shallow Stream and Ford or Gully Crossing Log Structure | 37. Pinned Stairway |
| 11. Insloped Climbing Turn | 38. Log and Treated Timber Riser Stairway |
| 12. Turnpike - Type I | 39. Log Retaining Wall |
| 13. Turnpike - Type II | 40. Rock Retaining Wall |
| 14. Switchback - Type I | 41. Aggregate Surfacing |
| 15. Switchback - Type II | 42. Bituminous Surfacing |
| 16. Switchback - Type III | 43. Grid Pavement Units |
| 17. Existing Trail Restoration | 44. Sign and Post Installation |
| 18. Check Dams | 45. Rock Cairn Construction |
| 19. Culverts with Headwalls | 46. Log Barrier |
| 20. Culverts without Headwalls | 47. Log Barrier on Posts |
| 21. Rock Culverts | 48. Treated Timber Barrier |
| 22. Treated Timber Box Culvert | 49. Treated Timber Barrier on Posts |
| 23. Treated Timber Box Culvert Details | 50. Rock Barrier |
| 24. Rock Water Bar | 51. Trail Obliteration |
| 25. Log or Treated Timber Waterbar | 52. Seeding and Fertilizing |
| 26. Rubber Belting Waterbar | 53. Illustration of Trail Structure Terms |
| 27. Rock Spillway | |



**Standard Specifications
for the Construction and
Maintenance of Trails**
U.S. Forest Service

USFS Standard Specifications for the Construction and Maintenance of Trails

Further, the companion document *Standard Specifications for the Construction and Maintenance of Trails* provides the technical specifications for each item, along with maintenance specifications for existing trails. These specifications include the following sections:

General Specifications

- 901 Abbreviations, Acronyms, and Terms
- 902 Definitions
- 903 Intent of Contract
- 904 Maintenance for Traffic
- 905 Control of Materials
- 906 Measurement and Payment
- 907 Quality Assurance and Quantity Measurement
- 908 Staking, Flagging, and Cleanup

Construction Specifications

- 910 Earthwork
- 911 Clearing and Grubbing
- 912 Excavation and Embankment
- 913 Turnpike
- 914 Switchbacks
- 915 Existing Trail Restoration
- 916 Removal of Structures and Obstructions
- 920 Drainage
- 921 Culverts
- 922 Waterbars
- 923 Rock Spillways
- 924 Underdrain
- 930 Structures
- 931 Log Stringer Bridge
- 932 Puncheon
- 933 Trail Stairways
- 934 Log Retaining Walls
- 935 Rock Retaining Walls
- 936 Wire Baskets
- 940 Surfacing
- 941 Aggregate Surfacing and Base Course
- 942 Hot Bituminous Plant Mix Trail Surfacing

- 943 Cold Bituminous Mix Trail Surfacing
- 944 Grid Pavement Units
- 950 Incidental Construction
- 951 Mobilization
- 952 Sign, Post, and Cairn Installation
- 953 Barriers
- 954 Obliteration of Abandoned Trailways
- 955 Seeding and Mulching
- 960 Materials
- 961 Rock, Grid Pavement Units, and Aggregate
- 962 Material for Timber Structures
- 963 Drainage Pipe
- 964 Geosynthetics
- 965 Wire Baskets

Maintenance Specifications

- 981 Brush Cutting
- 982 Logging Out
- 983 Danger Tree Removal
- 984 Loose Rock Removal
- 985 Rock and Root Removal
- 986 Borrow
- 987 Slide Maintenance
- 988 Slough and Berm Removal
- 989 Turnpike Maintenance
- 990 Switchback Maintenance
- 991 Drainage Maintenance
- 992 Rock Retaining Wall
- 993 Sign Repair and Placement
- 994 Barrier Maintenance