Guidelines for trail planning, design and management - Designing sustainable trails

The International Mountain Bicycling Association (IMBA) identifies core elements for a sustainable trail which are successfully applied to a range of trail types. The core elements need to be balanced equally in the development a trail and if any one element is overemphasised at the expense of the other there could be significant damage to the environment, provide an unsafe or negative experience, or impact financially or practically on trail maintenance. Sustainable trails should have very little impact on the environment; resist erosion through proper design, construction and maintenance and blend with the surrounding area.

Maximum sustainable trail grades

Generally, an average trail grade of 10% or less is most sustainable and this is known as the 10% Average Guideline. Maximum grade is the steepest section of trail that is more than about 3 meters in length. When designing a trail, it is essential to determine early in the process the precise maximum trail grades the trail will be able to sustain in the local conditions. This target figure will help guide the layout and ensure sustainability. Although maximum sustainable grade is typically about 15 to 20 percent, it is site specific and fluctuates based on several factors. The variables to be considered when setting the maximum trail grade include:

- **Half Rule** – A trail's grade shouldn't exceed half the grade of the sideslope, otherwise it is considered a fall line trail.
- **Soil Type** – There are many types of soil and each has different qualities of cohesion and drainage. Some soils will support steeper trail grades than others.
- **Rock** – Trail grades can be steeper on solid rock. However, steep earthen sections between rocks may need to be fortified or armoured to prevent soil loosening and erosion.
- **Annual Rainfall Amount** – Trails in regions with either very high or very low annual rainfall may need to be designed with gentler trail grades. Lots of rain can lead to water-caused erosion. Low rain levels can lead to very dry and loose tread surfaces.
- **Grade Reversals** – A grade reversal is a short dip followed by a rise, forcing water to drain off the trail. It is an essential technique for preventing water from channelling down the trail. Frequent grade reversals will allow for slightly steeper trail grades (refer to image below).
- **Types of Users** – Trails restricted to relatively low-impact visitors such as hikers and mountain bikers can sustain maximum grades as high as 15 to 25% for short distances depending on soil and rainfall. Trails open to visitors with higher impact, such as horses or motorised users should have more gentle maximum grades.
- **Numbers of Users** – Trails with high anticipated use may need shallower maximum trail grades.
- **Difficulty Levels** – Trails with a higher level of technical challenge may incorporate steeper grades, but construction techniques such as frequent grade reversals and armouring may be necessary to ensure sustainability.

Calculating the maximum sustainable trail grade is a complicated process that requires a high level of trail building knowledge and experience. When in doubt, design trails with conservative grades until you have had the opportunity to observe the effect of a variety of trail grades in your location.

Gathering information

Prior to commencing the design process, it is important to collect as much information as possible about the land. Typically, this will include and involve:

- maps showing cadastral boundaries, topographic features such as drainage lines and contours
- land ownership and adjacent land uses, including opportunities for linkages to surrounding areas
- location and type of vegetation, soils and other natural features (e.g. rare or threatened species, important habitat, cultural heritage areas, Phytophthora risk areas, etc.)
- aerial photographs
- planning control provisions

Identifying control points

This information can then be used to identify control points. These are places of interest that trail users will be attracted to (desirable) or should avoid (inappropriate). They will dictate where the trail should commence and finish, the location of parking areas, structures, slopes for turns or switchbacks, and road or watercourse crossings.

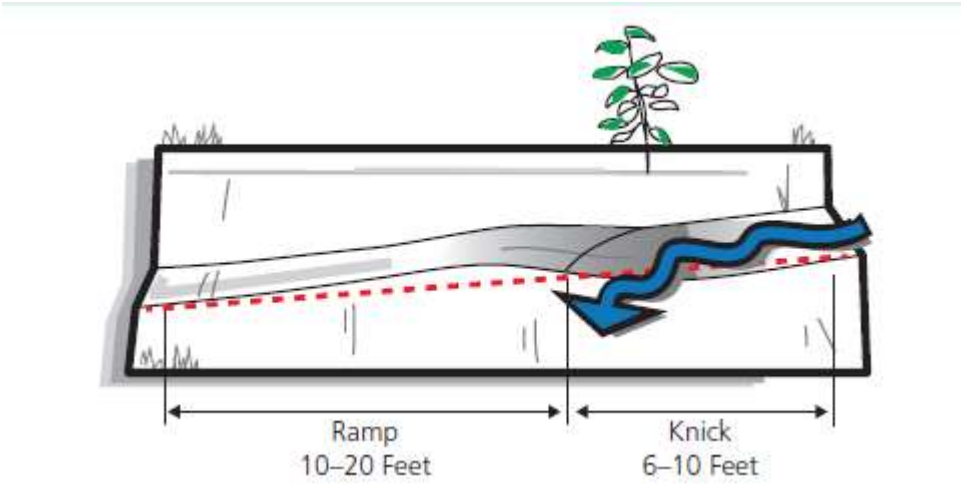
Sustainable trails follow the contours

The most sustainable trails are those that have a low overall grade (less than 10%, or a one in 10 change in elevation) to minimise the potential for water erosion. Combined with an outslope, or 'crossfall' on the trail path which slopes gently away from the high side, and regular grade reversals or undulations, this will ensure that water flows across and not along the trail.

If steeper sections are unavoidable they should be as short as possible (not exceeding 20 metres in length) and have a maximum gradient no more than 50% of the fall line gradient. Steep sections should be preceded and followed by a grade reversal to shed water away from the trail. Consider armouring the trail tread with rock to minimise the potential for erosion.

Grade reversals

A grade reversal is where the trail has to be briefly reversed (i.e. a climb briefly goes down, or a descent briefly goes up) to help divert water off the trail. A trail along a steep slope may require grade reversals every 10-15 metres, depending on soil type and rainfall. Incorporating grade reversals will avoid the need to build water-diversion devices later. They also break up a climb or descent and can provide recovery sections for users. Regular changes in grade will also assist in controlling excessive speeds by mountain bike riders. Grade reversals are also beneficial before and after steep sections, with smooth transitions between different grades; and at the approach to a watercourse, to disperse water and silt away from the watercourse.



Trail flow

Mountain bike riders tend to travel faster than walkers and horse riders and therefore trails designed for them should have a certain tempo or rhythm (referred to as flow). Contour trail designs can have three basic types of flow: open and flowing, tight and technical or hybrid (a combination of both).

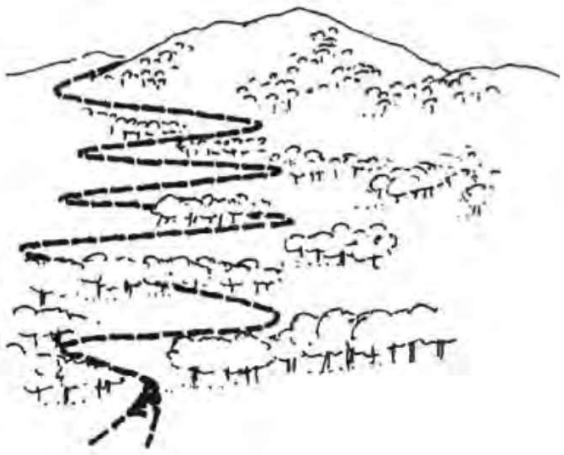
- Open and flowing trails have wide smoother surfaces, long sight lines, sweeping turns and appeal to less skilled cyclists or those who enjoy travelling fast.
- Tight and technical trails have sharper turns, narrower and rougher surfaces, and sometimes include obstacles. By their very design these trails dictate that users slow down.

- Hybrid trails blend the features of both with transitions between the different sections. Transitions should occur gradually with good sightlines or on top of hills to minimise the need for heavy braking and skidding.

The trail flow should be planned to suit the host environment. In grassland and open woodland areas users are likely to short-cut tight corners, so open and flowing trails are preferable. In more densely vegetated areas sight lines are more limited, so it's best to keep user speeds down with tight and technical trails. In wooded areas open and flowing trails can safely be incorporated if gradients are shallower and/or trails are single direction and single use. Many mountain bike trails are in densely wooded areas and are fast flowing trails, and it is important to consider this in the detailed design stage.

Incorporating turns on hillsides

Where it's necessary to gain elevation in a short distance it will be necessary to incorporate a turn into the trail alignment. Two types of turns are possible: a climbing turn or a switchback turn. Both are relatively difficult, expensive and time consuming to construct so it's best to plan trails with a minimum number of turns if possible. Avoid 'stacking' turns up a hill by using the full available width of the hill. Always seek the flattest site to construct a turn and in the planning stage identify such sites as control points.



Trail surface

While a natural surface for recreational trails may be appropriate in many situations, the application of an artificial trail surface (e.g. bitumen, crushed rock, sand) may be required if anticipated user numbers are high or sections of the natural surface is loose or prone to instability. The type of surface will also depend on who the primary users will be. For example, for more technical trails, it may be preferable to leave natural obstacles such as rocks and tree roots provided that they are not safety hazards or will contribute to erosion.

On bench-cut trails, it's usually preferable to remove rocks on the inside edge of the tread, otherwise users will be forced to the outside edge, possibly resulting in tread widening or break down (see image below). Large, rounded, flat and stable rocks should generally be kept in place to assist with tread stability.

If a trail is to be surfaced with gravel then angular fragments (e.g. crushed rock) is recommended over rounded fragments (e.g. naturally formed gravel) as the angular fragments will typically bed in and form a more secure surface, whereas the rounded fragments will become loose and 'skatey'.

Ultimately, the trail should be the 'path of least resistance' even in difficult terrain. This will ensure that users do not leave the trail and form new, easier routes.

Surface water control

Diverting surface water off the trail is of the highest priority in achieving sustainable trails. Running water will erode the tread and support structures and result in the deposition of sedimentation.

Standing water can result in soft boggy conditions, and tread and support structure failure. The most effective way to address these risks is through designing contour trails and frequently outsloping the tread. Other drainage treatments include grade or drain dips and waterbars.

Low lying and boggy terrain

Low lying and boggy sections should be avoided if possible because surface water will not adequately drain away from the tread. If there is no other option then consider the need for a boardwalk or a raised reinforced tread, such as armouring.

Another alternative is to consider the use of geo-textile materials that allow drainage, separate the underlying soil from the tread surface and reinforce the trail tread. In some circumstances, rubber mats may be an appropriate, relatively inexpensive alternative which keeps the surface of the trail solid without intensifying erosion.

Critical Trail Tip – Contour trails

A contour trail is a path that gently traverses a hill or sideslope. It's characterized by a gentle grade, undulations called grade reversals, and a tread that usually tilts or outslopes slightly toward the outer edge at the low points in the trail, i.e. that usually tilts or outslopes slightly towards the outer edge at the low points in the trail.. These features minimize tread erosion by allowing water to drain in a gentle, non-erosive manner called sheet flow. When water drains in thin, dispersed sheets, dirt stays where it belongs - on the trail.

1. Do everything you can to keep the water off the tread, and users on it
2. Build on the contour and use frequent grade reversals - surf the hillside
3. Follow the half-rule: A trail's grade shouldn't exceed half the grade of the sideslope
4. Maximum grade should be 15 percent (except for natural or built rock structures)
5. Average grade should stay under 10 percent (with grade reversals)
6. Route trails to positive control points (viewpoints, water, other attractions)
7. Use bench-cut construction, and excavate soil from the hillside
8. For reroutes, reclaim old trail thoroughly - the visual corridor as well as the trail tread
9. For highly technical trails where grade will sometimes exceed 15 percent, use natural rock, rock armouring or other rock features to add challenge and improve sustainability.

Hillside before trail:
Vegetation keeps water sheeting slowly downhill

Incomplete Full Bench:
Left with unfinished vertical cut, soil will slough off, making tread narrower.

Obtrusive back cut also forces rider to outside of 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.

The above information was obtained from 2 main sources, each utilising trail building guideline information developed by the International Mountain Bicycling Association (IMBA):

1. "Guidelines for trail planning, design and management" prepared with the support of the nine local governments within Barwon South West Region, Great Ocean Road Regional Tourism as well as the Regional Development Australia, Regional Development Victoria and Parks Victoria, including assistance from TRC Tourism Pty Ltd.
2. "Guidelines for the Planning, Design, Construction And Maintenance Of Recreational Trails in South Australia" (Revised 2016) Recreation Sa

For further information go to https://www.imba.com/resources/trail-building/designing-and-building-sustainable-trails.