

Outdoor Sport Institute – Online Trail Build School

Building Great Trail Experiences



INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION

IN PARTNERSHIP WITH



OSI
OUTDOOR SPORT
INSTITUTE



West Virginia University®

BRAD AND ALYS SMITH OUTDOOR ECONOMIC
DEVELOPMENT COLLABORATIVE



INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION

IMBA TRAIL UNIVERSITY - DESIGN



INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION

***IMBA's mission is to create, enhance and protect
great places to ride mountain bikes.***



TOC

- Recap – Trails Planning
- Trail design considerations
- Compliance (permitting)
- Sustainable trail fundamentals
- How to use a clinometer
- Minor control points
- Advanced topics



Traditional activity-based outdoor recreation management evolved to **outcomes-focused management:**

“...an approach to recreation management that centers on the positive outcomes gained from engaging in recreational experiences.”



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Trail Project Development Life Cycle

Feasibility Study

- Market & Demand Analysis
- Project Area Recon
- SWOT Assessment

Concept Plan

- Terrain Analysis - Development Zones
- Experience Objectives - Connectivity
- Key Control Points (positive and negative)

Master Plan

- Trail Corridors - Trail Specifications
- Phasing Plan - Construction Approach
- Cost Opinion - Permitting Requirements

Contracting

- RFP Development and Advertising
- Statement of Qualifications - Bids
- Proposal Evaluations - Award - Signed Contracts

Design Development

- Detailed Trail Alignments - Trail Segment Definitions
- Feature Locations/ID

Construction Documents

- Permitting - Engineering - Site Layout
- Erosion Control Measures

Construction

- Mobilization - Building - Flow Checking
- Project Management - Quality Control
- SWPPP Monitoring - Final Inspection

Post Build

- Management - Maintenance
- Assessment - Reporting



FROM PLAN TO DESIGN

Planning Phase

- Determine project opportunities
- Determine project objectives
- Outline a phased road map to operation
- Determine compliance and approval requirements
- 10,000' overview of project
- High level cost estimate (round numbers)
- Lots of unknown details
- Zones represented on maps

Design Phase

- Provide the details needed for successful a build and operation
- Produce the documentation required for compliance and permitting
- Provide the documentation needed to guide a build that meets the plan objectives
- Refined cost estimates
- Greatly reduced amount of unknown details
- Corridors represented by flaglines and maps



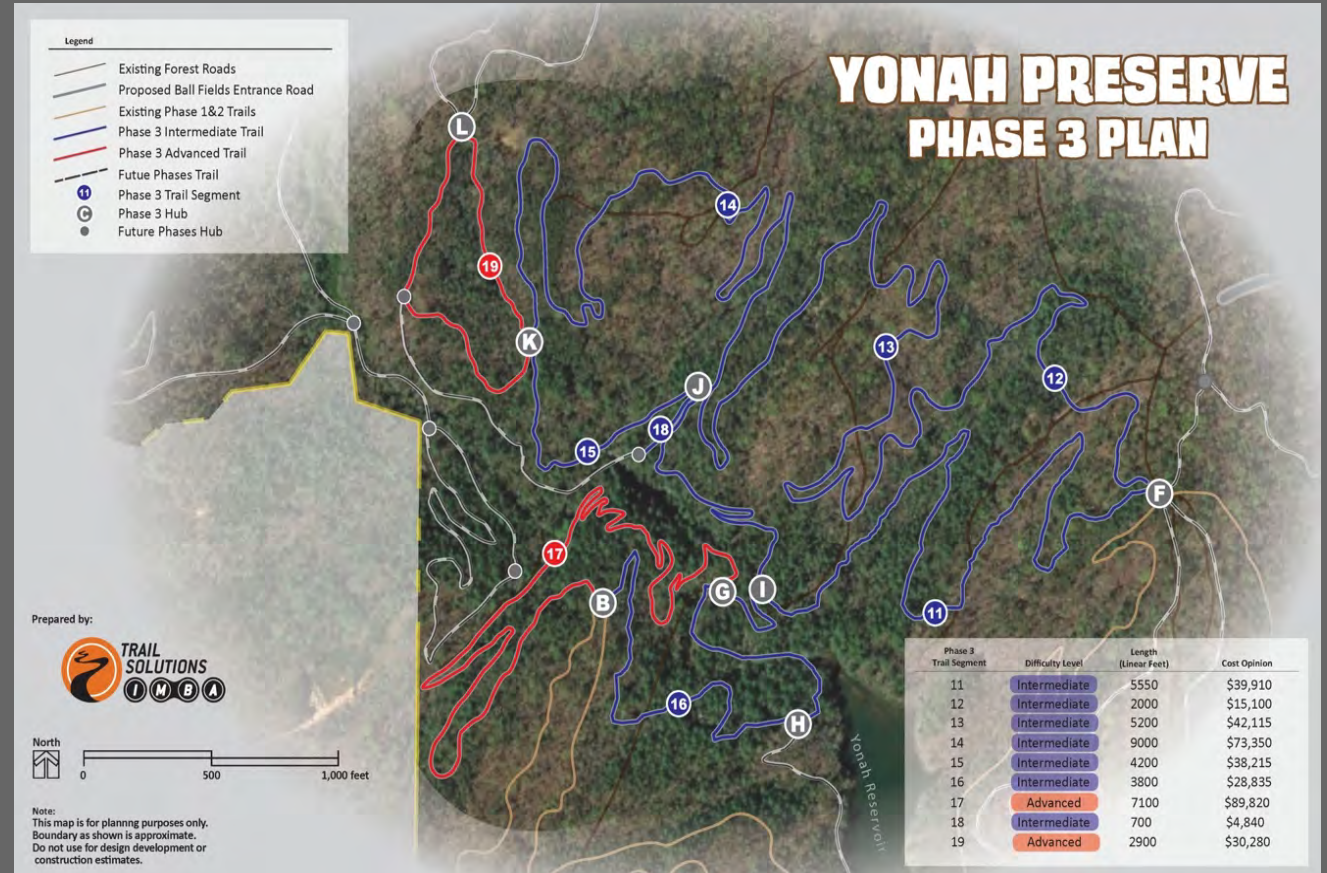
THE DESIGN PROCESS REFINES PLANS

- The plan informs the design. You don't decide you want a jump trail during the middle of flagging. The plan should identify the general vicinity for that jump trail. The design identifies where on the landscape that jump trail would be and what it would take (personnel, equipment, technique, material, etc.) to build it.
- Information and detail acquired during the design phase feeds into the planning documents and updates them.
- Increased site knowledge, stakeholder input, and better understanding of compliance constraints and funding streams will inform design output needs and may require modifying original plan objectives.
- Flexibility allows for embracing new opportunities or negotiating new constraints.



CONSIDERATIONS ON PROJECT PHASING

- Is there current support to approval the entire desired project?
- Are there multiple entities involved with varying degrees of support?
- Is there sufficient funds for the entire project?
- Does additional land need to be acquired or granted access to?
- Does the community require time to develop new skills or knowledge to achieve the entire project objectives?



DEVELOPING THE DESIGN SOW

Scope of Work (SOW) – the agreed upon amount, type, and details of work between two parties

You need to determine what you need in the design process to facilitate actual construction and operation. How much detail do you need? You need just enough to get clearance/approval and ensure the build meets the desired outcomes.

Extra unneeded detail can add cost!

Compliance requirements

- Land owner
- Jurisdiction with authority
- Funding source

Labor force

- Procurement
- Build management



DETERMINE COMPLIANCE NEEDS

Federal?

NEPA – archeological/biological (these are the two big resource groups most often encountered with trail plans)

Buy America?

Procurement? Competitive bid?

State? County? Municipality?

May have similar arc/bio

Stormwater? SWPPP? BMPs? Inspection?

Will builder need contractor's license?

Wetlands, streams, aquatic habitats?

Army Corps of Engineers (Clean Water Act 401/404) and other possibilities (state/local)

Corridor vs zone

Zone based resource review is similar to planning zones; it can approve large areas.

Corridor review is an alignment. What is the corridor width reviewed by specialists? 50-feet on center is much different than 100-ft O.C

Fit it into your compliance environment

Some places are more restrictive than others

Compliance may be triggered by landscape or funding stream



COMMON RESOURCE MITIGATION

Avoidance – the simplest and often best approach. Avoiding sensitive resources preserves them and can be most easily done during the planning/design phase. For instance a wetland may be best dealt with by going around it and keeping a good buffer to the edge.

Interpretative/Education – if the land manager and resource specialist want to showcase the resource, bringing the trail close is desired. This could take the form of a boardwalk or viewing platform at a wetland, possibly with informational signage.

IMPORTANT RESOURCE NOTES

Biological – can change, species can be listed or delisted and the natural environment can change. Species also move, what is sensitive may be seasonal.

Archeological – don't change, what is a resource will remain one. Time will add more resources, what is trash today may be cultural in a few decades.

They go stale – almost all reviews have a time limit; if a resource specialist has reviewed your design and given guidance, it is likely only valid for a few years.



AVOID RESOURCE IMPACT ISSUES

- Knowing and avoiding local resource concerns during design will reduce compliance cost and additional design costs.
- Research plans/data and meet with resource specialists for that agency to determine likely concerns and how to identify likely locations.

For instance, archeologists may inform you early on that all rock outcroppings are off limit due to cultural concerns

Or biologists and hydrologists may inform you crossing all “blue lines” is not allowed, even with bridges.

Most forested lands on the east coast have bat restrictions.

- This information may not be freely or easily available. Work with what you have.



BIOLOGICAL RESOURCES

Federal Laws

- Includes flora, fauna, and sometimes their important habitat. 46 states have endangered species legislation.
- Determine habitat and landscape types suitable for likely species of concern for that area or agency

Wetlands are one of the most unique and protected types of habitats.

- Avoid, if possible, those unique locations or habitats
- Surveys typically have a 5 year shelf life – Species of concern can change
- Include possible mitigation tactics in planning and design documents.

I.E. no standing dead trees will be cut during bat nesting season

From planning document:

Flora, Fauna, and Habitat

SNP is likely habitat for federally listed endangered bats, including the Indiana Bat (*Myotis sodalis*), the Northern Long-eared Bat (*Myotis septentrionalis*), and the Gray Bat (*Myotis grisescens*). Typical bat mitigation includes only cutting trees during certain seasons (often winter) and not cutting hazard or dead trees unless necessary for protection of human life. Eight species of migratory birds classified as Birds of Conservation Concern (BCC) potentially pass through the site and nest between the May and August. Identifying the locations of and avoiding impacts to active nests will reduce impact to migratory bird species.

The Green Pitcher-plant (*Sarracenia oreophila*), Small Whorled Pogonia (*Isotria medeoloides*), and the White Fringeless Orchid (*Platanthera integrilabia*) are endangered or threatened plant species that might be found in on site. The Green Pitcher-plant and White Fringeless Orchid area likely to occur wet, boggy areas. The Small Whorled Pogonia prefers drier ground and sun-lit canopy breaks and sparse to moderate groundcover. Avoiding trail development within boggy areas and carefully observing changes in the landscape and sunlight reduce impacts to these species.

CULTURAL RESOURCES

Federal Laws

- Includes both historic and pre historic resources. Cultural resources may be obvious or may be very tough to spot, unlike biological these resources don't move or change over time.

Examples

- Camp/home sites: likely locations are often south facing, flat, near water - especially if flat areas are in short supply . A good place to camp now was likely a good place in the past 25,000 years. Ridge tops and rock shelters are common.
- Old foundations, stone walls, cemeteries, and even "trash" piles.
- Other evidence of human activity – grading, stacked stones, hieroglyphics



PLAN TO DESIGN

Read the report! Look at the map!

Review the report to understand the objectives, opportunities and constraints.

What does the plan have? Zones or corridors?

Zones? → draw corridors within zones (more on that later) → ground truth them → repeat

Master plan with corridors (lines on map)? → are they ground truthed? do they make sense? still relevant?

What are the zone experience and skill level goals? Where are the major access points? How will loops and connectors circulate visitors? Where are the hubs? What should the clusters look like?

Review the major control points.

Planning/design are iterative; they will always feedback as you learn more you refine, then go learn more, refine, and continue...



REVIEW THE PLAN TO DETERMINE CORRIDOR NEEDS

What other system objectives?

Long descent

NICA practice or race loop

Gateway trail

Kids loop (sub mile)

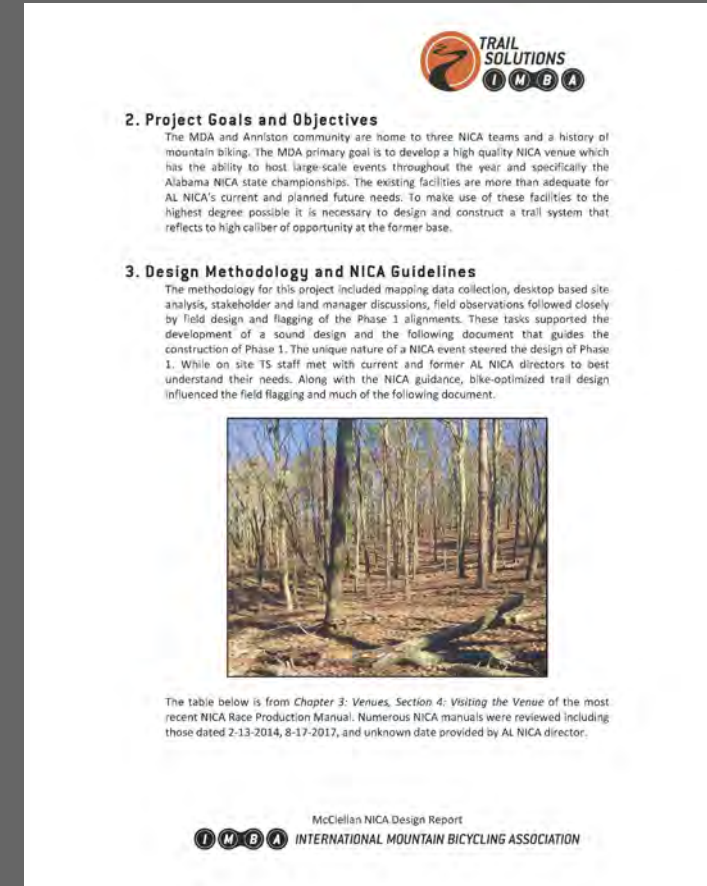
Shuttle or gravity options

Long section with no intersections (backcountry, remote)

Progressive flow/jump trails



INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION



ONE PAGE REVIEW OF TRAIL TYPES

Shared-Use

- Traditional
- Bike-optimized

Single-Use

- Bike gravity
- Hiking only
- Equestrian only



TRAIL TYPE INFORMS CORRIDOR



TRAIL SPECIFICATIONS BY TYPE






Corridor grades (average and maximum)

Turn radius

Obstacle height

Design speeds

Sightlines

| IMBA Trail Difficulty Rating System | | | | | |
|--|---|--|--|---|---|
| |  |  |  |  |  |
| | EASIEST WHITE CIRCLE | EASY GREEN CIRCLE | MORE DIFFICULT BLUE SQUARE | VERY DIFFICULT BLACK DIAMOND | EXTREMELY DIFFICULT DBL. BLACK DIAMOND |
| TRAIL WIDTH | 72" (1,800 mm) or more | 36" (900 mm) or more | 24" (600 mm) or more | 12" (300 mm) or more | 6" (150 mm) or more |
| TREAD SURFACE | Hardened or surfaced | Firm and stable | Mostly stable with some variability | Widely variable | Widely variable and unpredictable |
| AVERAGE TRAIL GRADE | Less than 5% | 5% or less | 10% or less | 15% or less | 20% or more |
| MAXIMUM TRAIL GRADE | Max 10% | Max 15% | Max 15% or greater | Max 15% or greater | Max 15% or greater |
| NATURAL OBSTACLES AND TECHNICAL TRAIL FEATURES (TTF) | None | Unavoidable obstacles 2" (50 mm) tall or less Avoidable obstacles may be present Unavoidable bridges 36" (900 mm) or wider | Unavoidable obstacles 8" (200 mm) tall or less Avoidable obstacles may be present Unavoidable bridges 24" (600 mm) or wider TTF's 24" (600 mm) high or less, width of deck is greater than 1/2 the height | Unavoidable obstacles 15" (380 mm) tall or less Avoidable obstacles may be present May include loose rocks Unavoidable bridges 24" (600 mm) or wider TTF's 48" (1,200 mm) high or less, width of deck is less than 1/2 the height Short sections may exceed criteria | Unavoidable obstacles 15" (380 mm) tall or less Avoidable obstacles may be present May include loose rocks Unavoidable bridges 24" (600 mm) or narrower TTF's 48" (1,200 mm) high or greater, width of deck is unpredictable Many sections may exceed criteria |



Trail Specifications
Duluth Traverse Trail System

Version: 1.2 (130220)

| Label | Working title | Difficulty Rating | Symbol ² | Use | Directional | Feature Frequency ² | Constructed Tread Width ^{2,4} | Ave Trail Grade per 1000' ³ | Max Trail Grade: climbing ³ | Max Trail Grade: descending ⁴ | Min Turn Radius | Max Turned Grade ² | Max Berm/Turn Camber ⁴ | Corridor Width (4' above tread) | Corridor Height Minimum | Exposure (without railing) | Unavoidable Obstacles | Avoidable Obstacles (over 50% of tread or less) | Rollable Feature Height (jumps, berms, etc.) | Roughness (surface texture) ⁵ | Tread and trail features | Notes |
|---------|---|-------------------|---------------------|-------------------|-------------|--------------------------------|--|--|--|--|-----------------|-------------------------------|-----------------------------------|---------------------------------|-------------------------|----------------------------|-----------------------|---|--|--|--|--|
| Spec 1 | Green Singletrack (Traditional shared-use singletrack) | Easier | Green Circle | bike, foot | Two-Way | Low | 48" | 5% | 20% | 20% | 10' | 10% | 15% | 48"-72" | 10-12' | less than 18" | less than 2" | less than 6" | 9" | low | Firm trail surface. May include rock armored section. | |
| Spec 2 | Blue Singletrack (Traditional bike-optimized singletrack) | More Difficult | Blue Square | bike, foot | Two-Way | Medium | 36" | 7% | 25% | 50% (armored over 25%) | 8' | 15% | 30% | 36"-72" | 8-12' | less than 48" | less than 8" | less than 24" | 24" | med | Modest rough tread is expected. May include steps and terraces. | May include features similar to those on easier "Bump and Pump" or "Jump" trails. |
| Spec 3 | Black Singletrack (Traditional technical singletrack) | Most Difficult | Black Diamond | bike, foot | Preferred | High | 18" | 10% | 50% (armored over 25%) | 100% (armored over 25%) | 6' | 15% | 50% | 36"-48" | 8-12' | no limit | less than 18" | less than 48" | 18" | high, some very high | Significant unavoidable obstacles are expected. May include steps, stairs, rock gardens, loose rock, and significantly | Seek out rocky ridges. Selective machine work to create very organic appearing rock strewn tread. Most rock and tread work is aimed at sustainability rather than ease of passage. Trails like |
| Spec 4 | Green Bump Pump | Easier | Green Circle | bike, foot | Preferred | High | 48" | 3-5% | 20% | 30% (armor as function of flow) | 15' | 10% | 30% | 48-72" | 8-10' | less than 36" | less than 2" | less than 6" | 12" | low | Firm trail surface. Rollers and berms. May include rock surfaced sections. | |
| Spec 5 | Blue Bump Pump | More Difficult | Blue Square | bike, foot | Preferred | High | 36" | 7-10% | 30% | 100% (armor as function of flow) | 10' | 15% | 50% | 36"-72" | 10"-12" | less than 60" | less than 2" | less than 24" | 24" | low | Firm trail surface. Rollers, roller doubles, berms predominate. May include significant armored sections. | Demonstration trail at Spirit Mtn is an example of the upper end of this spectrum. |
| Spec 6 | Black Bump Pump | Most Difficult | Black Diamond | bike | One-Way | High | 36" | 10-12% | n/a | 150% (armor as function of flow) | 7' | 25% | 150% | 36"-72" | 10"-12" | less than 120" | less than 8" | less than 48" | 36" | med | Firm trail surface. Rollers, roller doubles, berms predominate. May also include steps, stairs, rock gardens and exposed | |
| Spec 7 | Green Jump | Easier | Green Circle | bike | One-Way | Medium | 48"+ | 3-5% | n/a | 30% (armor as function of flow) | 20' | 10% | 150% | 48-72" | 10-12' | less than 36" | less than 2" | less than 6" | 18" | low | Smooth continuously cambered trail surface. Easily rollable jumps. | A green jump trail could fit within a stacked-loop system. Blue and Black are likely best done at a resort. |
| Spec 8 | Blue Jump | More Difficult | Orange Pill, medium | bike | One-Way | Low | 48"+ | 7-10% | n/a | 100% (armor as function of flow) | 15' | 15% | ∞% | 48-72" | 12"-15' | less than 60" | less than 2" | less than 24" | 30" | low | Smooth continuously cambered trail surface. May include significant armored sections. More complex jump | Complete berms, plan on extreme drainage solutions - sumps + culverts. |
| Spec 9 | Black Jump | Most Difficult | Orange Pill, large | bike | One-Way | Low | 48"+ | 10-12% | n/a | 150% (armor as function of flow) | 15' | 25% | ∞% | 48-72" | 12"-15' | less than 120" | less than 8" | less than 48" | 48" | med | Firm trail surface. May include rock surfaced sections. Some jumps may not be rollable. | Complete berms, plan on extreme drainage solutions - sumps + culverts. |
| Spec 10 | Green Gravity | Easier | Orange Pill, small | bike | One-way | Medium | 48" | 7-10% | n/a | 100% (armor as function of flow) | 20' | 15% | 150% | 48-72" | 12' | less than 36" | less than 18" | less than 24" | 18" | high | Entry level downhill course. Will include rocks, steps, and terraces. Drops will be rollable. | For all DH types, potentially only at Spirit Mtn. |
| Spec 11 | Blue Gravity | More Difficult | Orange Pill, medium | bike | One-way | Medium | 36" | 10-15% | n/a | ∞% (mandatory drops) | 15' | 25% | ∞% | 36"-72" | 12' | less than 60" | less than 48" | n/a | 30" | very high | Intermediate level downhill course. Mandatory drops. Will include significant steps, stairs, rock gardens and exposed | |
| Spec 12 | Black Gravity | Most Difficult | Orange Pill, large | bike | One-way | High | 24" | 15-20% | n/a | ∞% (mandatory drops) | 15' | 25% | ∞% | 36"-72" | 12' | less than 120" | less than 72" | n/a | 48" | very high | Advanced level downhill course. Significant mandatory drops. Will include extreme terrain that has a high penalty for failure. | |
| Spec 13 | Gateway trail | Easiest | Green Circle | bike, foot, horse | Two-Way | low | 48"+ | 3-5% | 10% | 15% | 12' | 10% | 10% | 10-12' | | | | | | | | Very front-country, likely connected to a recreation park. Typically under a mile. |
| Spec 14 | Accessible trail | Easiest | | bike, foot, horse | Two-Way | none | | | | | | | | | | | | | | | | AASHTO spec trail: |

O'Brien Watershed: Trail Guidelines by Difficulty Level

All values are approximate and should be used in aggregate to determine the appropriate skill level.

Values do not apply to technical trail features (TTFs) such as jumps, rollers, drops, whoopdees, etc.

| | Easiest (Green Circle) | More Difficult (Blue Square) | Most Difficult (Black Diamond) |
|---|---|---|--|
| Riding Surface (under typical conditions) | Firm tread, highly predictable traction | Mostly firm tread, predictable traction | Variably firm tread, mostly predictable traction |
| Average Trail Grade | | | |
| <i>Ascent</i> | 1% to 5% | 1% to 7% | 1% to 10% |
| <i>Descent</i> | -1% to -7% | -1% to -12% | -1% to -20% |
| Maximum Segment Grade | | | |
| <i>Climbing (segment cannot exceed 50' in length)</i> | +10% | +15% | +25% |
| <i>Descending (segment cannot exceed 150')</i> | -10% | -20% | -40% |
| Turn Diameter (min. >90 degrees) | 16' | 12' | 8' |
| Height of Unavoidable Obstacles (max.) | 2" | 10" | 20" |
| Tread Cambering (excludes turns, TTFs) | | | |
| <i>Outslope (avg.)</i> | 0% - 5% | 0% - 5% | 0% - 10% |
| <i>Outslope (max.)</i> | 5% | 10% | 20% |
| <i>Inslope (avg.)</i> | 0% - 5% | 0% - 5% | 0% - 10% |
| <i>Inslope (max.)</i> | 10% | 15% | 20% |
| Clearing Limits from Constructed Tread (greater above jumps) | 3' horz., 8' vert. | 2' horz., 10' vert. | 1' horz., 12' vert. |
| Constructed Tread Width | | | |
| <i>0% - 5% sideslope</i> | 12" - 24" | 8" - 24" | 6" - 18" |
| <i>6% - 25% sideslope</i> | 16" - 36" | 12" - 30" | 8" - 24" |
| <i>26% - 50% sideslope</i> | 24" - 42" | 16" - 36" | 12" - 30" |
| <i>51% - 75% sideslope</i> | Not recommended | 30" - 48" | 18" - 42" |
| <i>75+% sideslope</i> | Not recommended | Not recommended | 36" - 48" |

Standing Boy Trail Construction Guidelines by Trail Type

| | Cross-country (Multiuse) | Gravity (Bike optimized) |
|--|---|--|
| Intended Trail Users | Pedestrians, mountain bikers | Mountain bikers |
| Intended Travel Direction | Two-way | One-way, descending |
| Intended Experience Goals | | |
| <i>Pedestrians</i> | Enjoying nature, solitude, aerobic fitness, relaxation, connectivity | N/A |
| <i>Mountain Bikers</i> | Enjoying nature, solitude, aerobic fitness, relaxation, connectivity | Challenge, progression in mountain bike specific skills, specialized features for mountain bikes, sense of speed and flight, technically demanding |
| Maintenance Needs | General trail upkeep, ~10% of construction costs annually | General trail upkeep and regular specialized trail maintenance, ~20% of construction costs annually |
| Design Speeds | Low speed | Medium to High speed |
| Special Construction Considerations | | |
| <i>Intersections</i> | Trails should slow visitors speeds prior to the intersection. | Trails must slow visitors speeds prior to the intersection. |
| <i>Turns</i> | Turns should be platform in nature with slight inslopes, turns should be adequate radii to ensure good sightlines. | Turns should be downhill bike optimized, including wider radii and more elevation drop. Berms may be required. |
| <i>Sightlines</i> | Sightlines should be adequate for quickly moving visitors in both directions. | Sightlines must be adequate for quickly moving visitors in both directions. |
| <i>Trail Meander</i> | Trails should meander to provide rolling nature and slower speed potential. | Trails do not need to meander and should focus on trail visitor speed for experiential goals. |
| <i>Corridor width and height</i> | Corridor width and height should reflect appropriate skill level guidelines. | Corridor width and height should go above appropriate skill level guidelines where necessary, especially around trail features. |
| <i>Trail corrals and gateways</i> | Trails should be tight in nature, reflecting skill level guidelines. The use of native material and features to corral and slow riders is encouraged. | Trails may be wider or narrower than skill level guidelines to accommodate desired experiences. |



INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION

| Label ID | Difficulty Rating | Symbol ¹ | Summer Use | Winter Use | Trail Type | Direction | Approx. Trail Distance (Ft) | Constructed Tread Width ^{2, 3} | Ave Trail Grade | Max Trail Grade: climbing ⁴ | Max Trail Grade: descending ⁵ | Tread and trail features | Approx. Construction Cost per Linear Foot ⁶ | Recommended Phasing Approach |
|----------|-------------------|---------------------|------------|-------------------------------------|-------------------------|--------------------------------|-----------------------------|---|-----------------|--|--|--|--|------------------------------|
| 1 | Beginner | Green Circle | Hike, Bike | Fat Bike, Snowshoe, and Ski Touring | Traditional Singletrack | Two-way | 1,500 | 36-48" | 3% | 10% | 10% | Firm trail surface. May include rock armored section. | \$6-8 | Phase 1 |
| 2 | Beginner | Green Circle | Hike, Bike | Fat Bike, Snowshoe, and Ski Touring | Traditional Singletrack | Two-way | 3,825 | 36-48" | 3% | 10% | 10% | Firm trail surface. May include rock armored section. | \$6-8 | Phase 1 |
| 3 | Beginner | Green Circle | Hike, Bike | Fat Bike, Snowshoe, and Ski Touring | Flow Trail | Hike (uphill), Bike (downhill) | 3,325 | 36-48" | 3% | 10% | 10% | Firm trail surface. Rollers and berms. May need rock armored section. Include optional Intermediate trail features. | \$7-10 | Phase 1 |
| 4 | Beginner | Green Circle | Hike, Bike | Fat Bike, Snowshoe, and Ski Touring | Flow Trail | Hike (uphill), Bike (downhill) | 5,650 | 36-48" | 3% | 10% | 10% | Firm trail surface. Rollers and berms. May need rock armored section. Include optional Intermediate trail features. | \$7-10 | Phase 2 |
| 5 | Intermediate | Blue Square | Bike | Fat Bike | Flow Trail | One-Way (downhill) | 4,375 | 36-60" | 7% | 15% | 20% | Firm trail surface. Rollers, roller doubles, tabletops, berms, and trail features. Include optional Advanced trail features. | \$10-12 | Phase 2 |

Trail Specifications
O'Brien Watershed
Version: 1.3 200326

| Unit | Unit | Directional | Feature Frequency ¹ | Constructed Tread Width ^{2,3} | Ave Trail Grade per 100' ⁴ | Max Trail Grade: climbing ⁴ | Max Trail Grade: descending ⁴ | Min Turn Radius | Max Turnpad Grade ⁵ | Max Berm/Turn Camber ⁶ | Proposed Flagline Corridor Width | Corridor Width (4' above tread) | Corridor Height Minimum ⁷ | Exposure (without railing) | Avoidable Obstacles (over 50% of tread or less) | Rollable Feature Height (jumps, berms, etc.) | Rugosity (surface texture) ⁸ | Tread and trail features | Experience Notes |
|----------------|-------------|----------------------------|--------------------------------|--|---------------------------------------|--|--|-----------------|--------------------------------|-----------------------------------|----------------------------------|---------------------------------|--------------------------------------|----------------------------|---|--|---|--|--|
| Tread Type I | Linear Feet | Two-way (bike uphill only) | Low | 48" | 5% | 7% | 10% | N/A | N/A | N/A | 100' | 60"-72" | 8' | less than 24" | less than 8" | 6"-18" | Low | Firm trail surface. May include rock surfacing. | Typically specified for easiest trail difficulties and heavily used multi-use trails. Trail grades are gentle and set on shallow cross slopes with little to no exposure to trail side risks like steep slopes, cliffs, or external influences that require advanced bike handling moves to avoid. In general, the trail surface is relatively smooth with little to no obstacles (rocks and roots). Feature frequency is appropriate for the multi-use nature while keeping it engaging for beginner riders advancing their skills. |
| Tread Type II | Linear Feet | One-way (bike-only) | Medium-High | 30"-48" | 7% | 15% | 20% | N/A | N/A | N/A | 100' | 42"-58" | 8' | less than 36" | less than 16" | 12"-24" | Medium-High | Semi-firm trail surface. May include rock surfacing. | Specified for the intermediate and advanced bike-only trails. Trails are gravity-specific, with use in the downhill direction. These trails traverse side slopes ranging from 20%-120%, therefore users are exposed to steep hills and rocky drop offs. The trail surface is variable with the presence of rocks and roots. Feature frequency is determined by specific trail narratives. |
| Tread Type III | Linear Feet | Two-way (bike uphill only) | Low | 18" | 10% | 20% | 40% | N/A | N/A | N/A | 100' | 30"-42" | 8' | less than 48" | less than 24" | 24"-48" | High | Semi-firm to loose trail surface. Will include rock surfacing. Rocks will be uneven. | This trail type looks and feels like traditional singletrack and hiking trails, narrow tread with the presence of rocks, roots, and other obstacles. Grades are steeper than Type I and II and are used here to climb steep slopes efficiently and may exceed the physical climbing/descending limits of some hikers and riders. |
| Turn Type I | Each | N/A | N/A | N/A | N/A | N/A | N/A | 10' | 5% | 10% | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Firm trail surface. May include rock surfacing. | Sweeping long radius turns comfortable for many user types of all ability levels. In combination with good sight lines, these turns work well for multi-use trails. Generally these are climbing turns on mellow to moderate sideslopes and associated with Tread Type I. |
| Turn Type II | Each | N/A | N/A | N/A | N/A | N/A | N/A | 8' | 10% | 10% | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Semi-firm trail surface. May include rock surfacing. | Generally associated with the Tread Type II. Can be slightly tighter radius turns to be used on steeper cross slopes. The turn grades are steeper than Type I to allow for elevation gain or loss where needed to achieve key control points or for desired experience. |
| Turn Type III | Each | N/A | N/A | N/A | N/A | N/A | N/A | 4' | 12% | 15% | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Semi-firm trail surface. May include rock surfacing. | Used only on the Tread Type III trails located on steep side slopes where a small footprint is needed to fit turns on these slopes. Turn radius is tight and turn pad grades are steeper, therefore requiring advanced bike handling skills to successfully navigate, this challenge can be seen as a way to improve ones bike handling skills. |

Footnotes

- Feature Frequency is averaged over long distances. Per 100': "low" = 2-3 features, "med" = 3-5 features, "high" = 5-10 features.
- Constructed tread width may narrow over short distances to 50% of spec. Examples include rock or tree gateways.
- Tread width also applies to bridges and boardwalks. Check with local regulations for overriding guidelines on width or any other requirements (height restrictions, railings, etc.).
- Max grades climbing and descending refer to extremely short segments, 10 feet or less.
- Turnpad grade measures the rise/fall across the turning surface at the base of any inslope.
- Max camber is measured at the top of the inslope. Turns can not be outslped.
- Corridor height should be reduced in thick laurel or rhododendron where appropriate to provide a more natural "tunnel experience".
- Rugosity attempts to capture average tread coarseness. Tread area with obstacles: "low" = less than 5%, "med" = less than 20%, "high" = over 20%, "very high" = over 50%. Check Master Plan and Trail Guidelines by Difficulty Level for surface texture details.

General Notes

Sustainable trails guidelines provide the foundation for all design + construction decisions ("half rule", frequent grade reversals, max grades function of soils + use, etc.). All trails should have a minimum grade and camber (in/outslope) of 3% to ensure a well-drained tread. Trail Specifications should adhere to O'Brien Watershed Trails Master Plan dated March 2020 and the O'Brien Watershed Trail Guidelines by Difficulty Level table. Trail experience is determined by the O'Brien Watershed Trails Master Plan dated March 2020 trail segmetn descriptions.

ZONES TO CORRIDOR

Digital

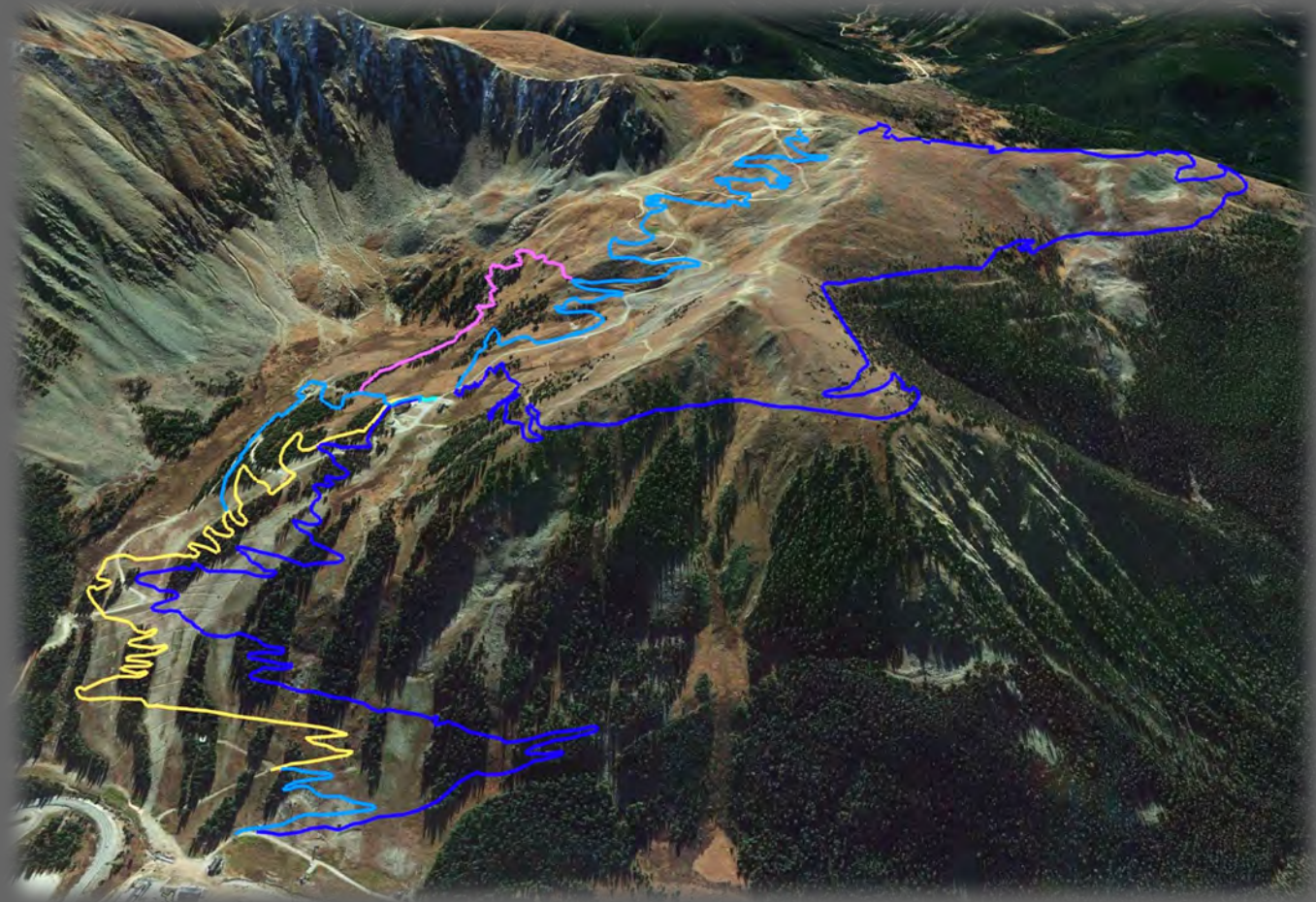
Google Earth

GIS

Avenza Maps

Analog

Sketching on maps



ZONES TO CORRIDOR

Google Earth

Free

Uses common KMLs, can also import SHP files

Easy to load outputs from fieldwork (often KMZs)

Easy to learn and use

How-To

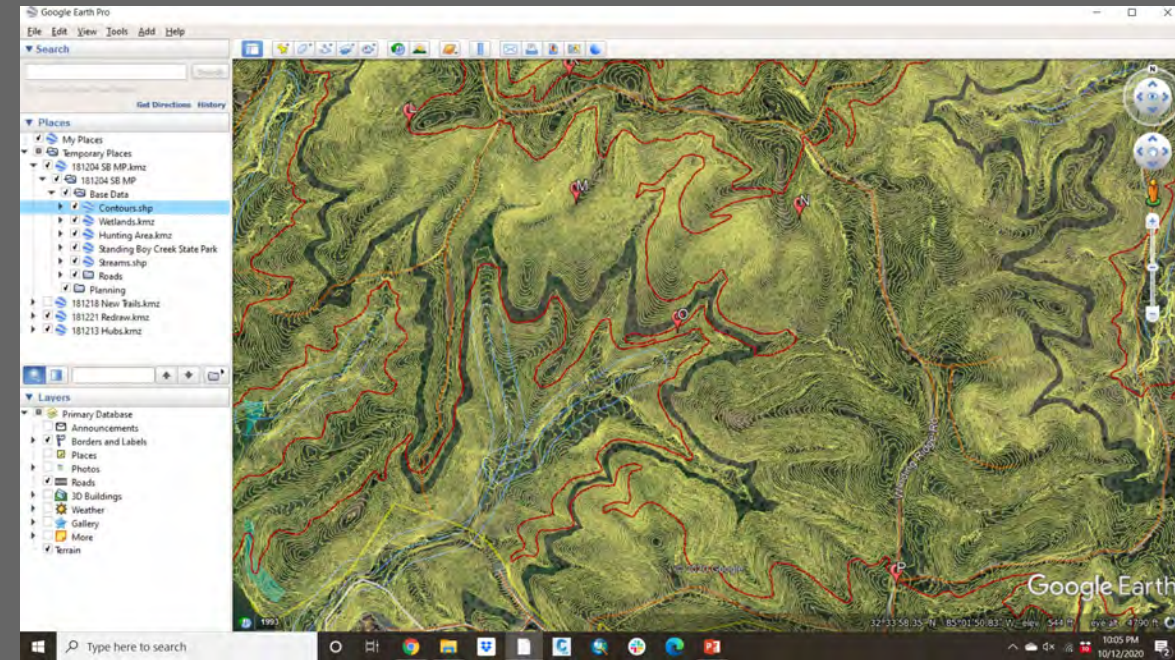
When you draw a line use the distance tool

You aren't shooting for perfection, just trying to sketch a reasonable grade corridor to ground truth

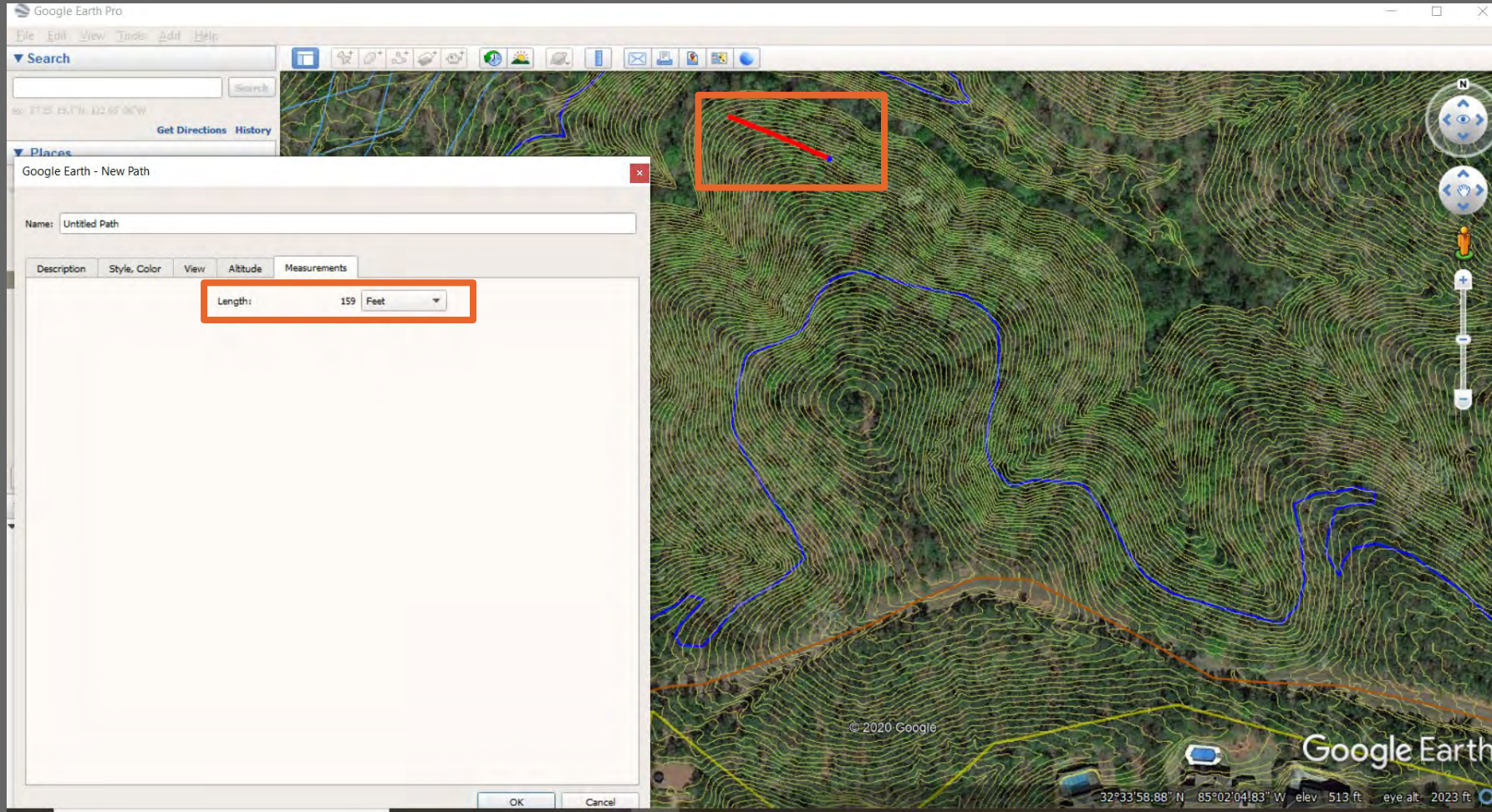
You'll need math...what are the contour intervals? Use the major ones, anything less than 10-feet and you'll go mad. Leave the details for the field ground truthing and flagging.

5% grade means every 10-feet in elevation change needs 200 linear feet of trail corridor

At 5% every 250-feet or so of elevation needs 1-mile of trail, for 10% you'll need 500-feet of elevation for 1-mile



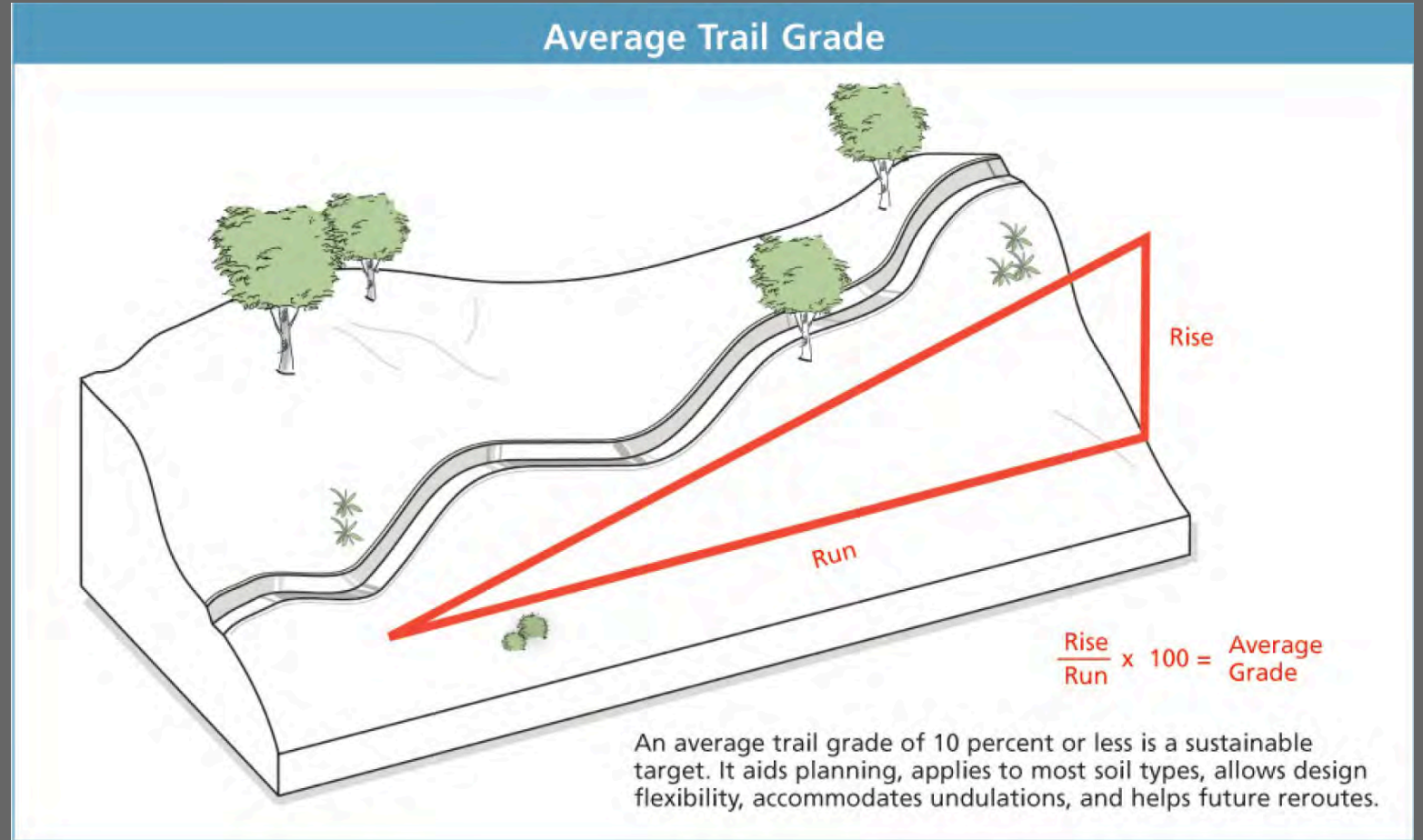
ZONES TO CORRIDOR









AVERAGE TRAIL GRADE/CORRIDOR GRADE

Determines the potential energy of rider and how fast a descent or challenging a climb.

The corridor grade should match the trail style, difficulty, and experience objective.



AVERAGE TRAIL GRADE/CORRIDOR GRADE

| IMBA Trail Difficulty Rating System  | | | | | |
|---|---|--|--|---|---|
| |  EASIEST WHITE CIRCLE |  EASY GREEN CIRCLE |  MORE DIFFICULT BLUE SQUARE |  VERY DIFFICULT BLACK DIAMOND |  EXTREMELY DIFFICULT DBL. BLACK DIAMOND |
| TRAIL WIDTH | 72" (1,800 mm) or more | 36" (900 mm) or more | 24" (600 mm) or more | 12" (300 mm) or more | 6" (150 mm) or more |
| TREAD SURFACE | Hardened or surfaced | Firm and stable | Mostly stable with some variability | Widely variable | Widely variable and unpredictable |
| AVERAGE TRAIL GRADE | Less than 5% | 5% or less | 10% or less | 15% or less | 20% or more |
| MAXIMUM TRAIL GRADE | Max 10% | Max 15% | Max 15% or greater | Max 15% or greater | Max 15% or greater |
| NATURAL OBSTACLES AND TECHNICAL TRAIL FEATURES (TTF) | None | Unavoidable obstacles 2" (50 mm) tall or less Avoidable obstacles may be present Unavoidable bridges 36" (900 mm) or wider | Unavoidable obstacles 8" (200 mm) tall or less Avoidable obstacles may be present Unavoidable bridges 24" (600 mm) or wider TTF's 24" (600 mm) high or less, width of deck is greater than 1/2 the height | Unavoidable obstacles 15" (380 mm) tall or less Avoidable obstacles may be present May include loose rocks Unavoidable bridges 24" (600 mm) or wider TTF's 48" (1,200 mm) high or less, width of deck is less than 1/2 the height Short sections may exceed criteria | Unavoidable obstacles 15" (380 mm) tall or less Avoidable obstacles may be present May include loose rocks Unavoidable bridges 24" (600 mm) or narrower TTF's 48" (1,200 mm) high or greater, width of deck is unpredictable Many sections may exceed criteria |



GROUNDTRUTH

- Remember, this is iterative, and trails require in-depth site knowledge.
- After you have corridors sketched you feel good about, you need to walk those lines and gather more detailed information to refine the lines and complete the documentation required for next steps (permitting, procurement, construction, etc.)
- You may walk a corridor and make changes, record those and refine your lines, then rewalk.
- Minor control points will become key during this iterative groundtruthing phase.
- Don't expect to get it right the first time. Flag 4 miles to get a 1 good mile.
- Best done when ground is visible.



MINOR CONTROL POINTS

Positive Control Points

- Trailheads
- Viewpoints
- Unique vegetation
- Unique rock feature
- Water features
- Good turn locations
- Intersection & hub locations
- Good bridge or crossing locations
- Existing roadbeds
- Gateways
- Open forest (sightlines)

Negative Control Points

- Low-lying wet areas
- Flat areas
- Rare, Threatened or Endangered Species/ Sensitive habitat
- Other trails (or flaglines)
- Cultural resource
- Hazard tree
- Dense vegetation
- Private property
- Existing roadbeds
- Unstable slopes

TERRAIN TRAPS

Terrain traps – landscape features that are difficult or impossible to build through, “cruxes”, the 90/10 rule (90% of trail construction will cost 50% of the total, the remaining 10% will cost the other 50%)

These important landscape features will limit the design either by preventing it or requiring more intense/special construction (higher cost). Terrain traps should be identified on map data and groundtruthed.

Examples

- Rocks
- Steep slopes/cliffs/escarpments
- Terraced terrain
- Streams
- Unstable slopes
- Seeps
- Bedrock close to surface
- Unsuitable soils (clay & too little slope or sand & too much grade)
- Early successional forest / thickets /dense veg



MINIMIZE USER CONFLICTS: DESIGN

- Sightlines – dense vegetation on shared use?
- Choke points – tree gateways, rocks
- Intersections – uphill from all directions
- Speed checks – uphill, tread texture
- Design lets us use passive techniques to influence visitors
- People react better to passive instruction

PASSIVE DESIGN

- What is one of the most common social conflicts on shared use trails?

Speed differential!

Walkers/hikers – average 2-3mph

Runners/Pedaling riders – average 5-10mph

Downhill riders – average 10-30mph

- What is the best way to slow visitors down?

Uphill!

Gravity will naturally slow riders down better than any choke, speed check, or sign.

- Where is the most common social conflict?

Intersections, places people stop (views).

Slowing riders down through uphill and other techniques prior to these spots will help reduce conflicts long-term.

- On trail methods:

Tree gateways – naturally occurring tight trees

Anchor stones – downhill rocks that “push” visitors to the inside edge and keep them on tread, these can be placed to slow visitors down by pinching them between the rock and a tree or backslope

Rumble strip – rock armored texture, best used prior to an intersection

Some of these are implemented in construction, but need to be considered during design.



SUSTAINABLE TRAIL FUNDAMENTALS



AVOID SOIL EROSION CAUSE BY WATER

Trail erosion is caused by a combination of trail users, water, and gravity.

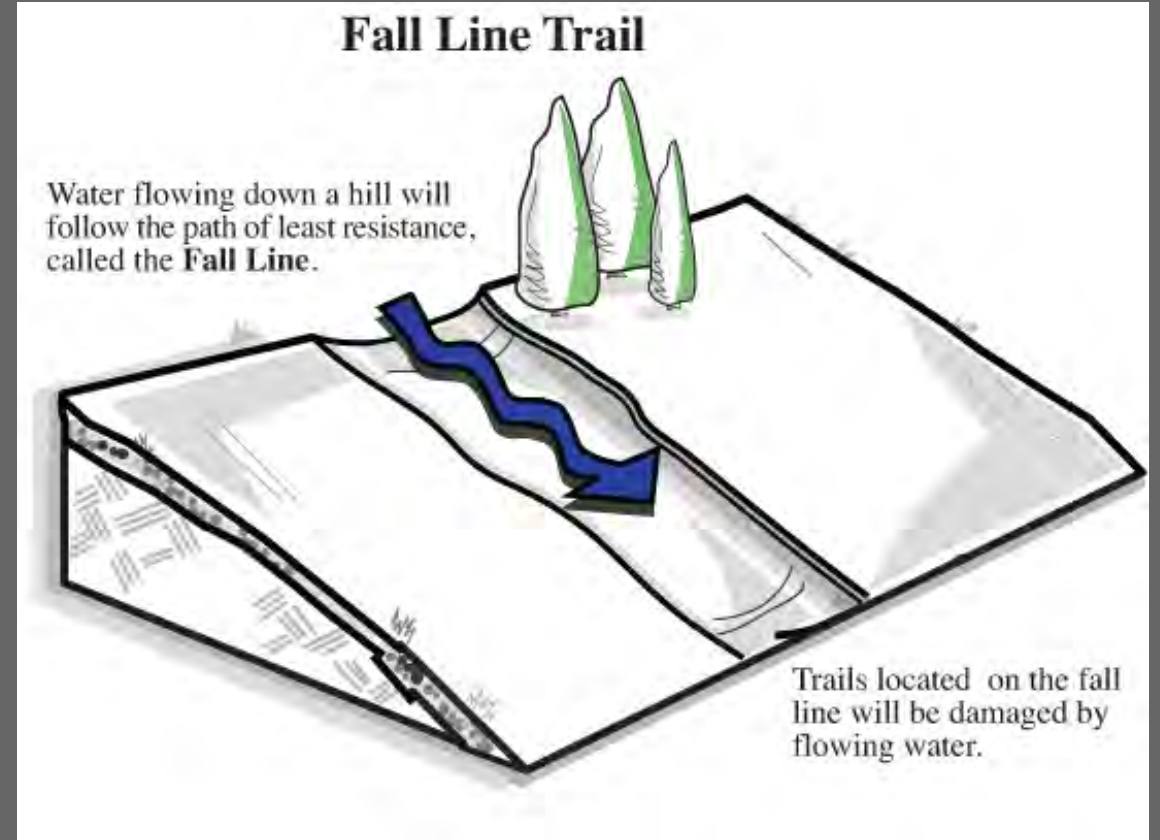
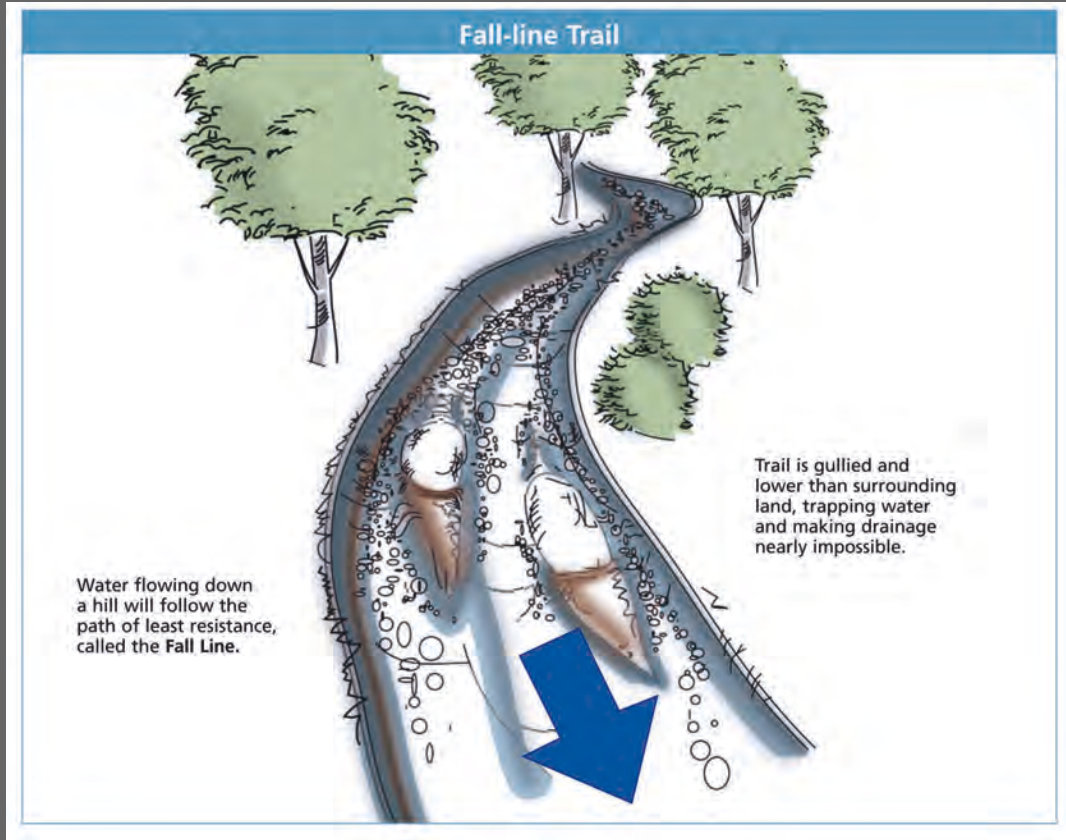


AVOID THE FALL LINE

- *The steepest route of descent down a slope*
- Water will travel down the fall line
- Trails that follow the fall line will focus water



AVOID THE FALL LINE



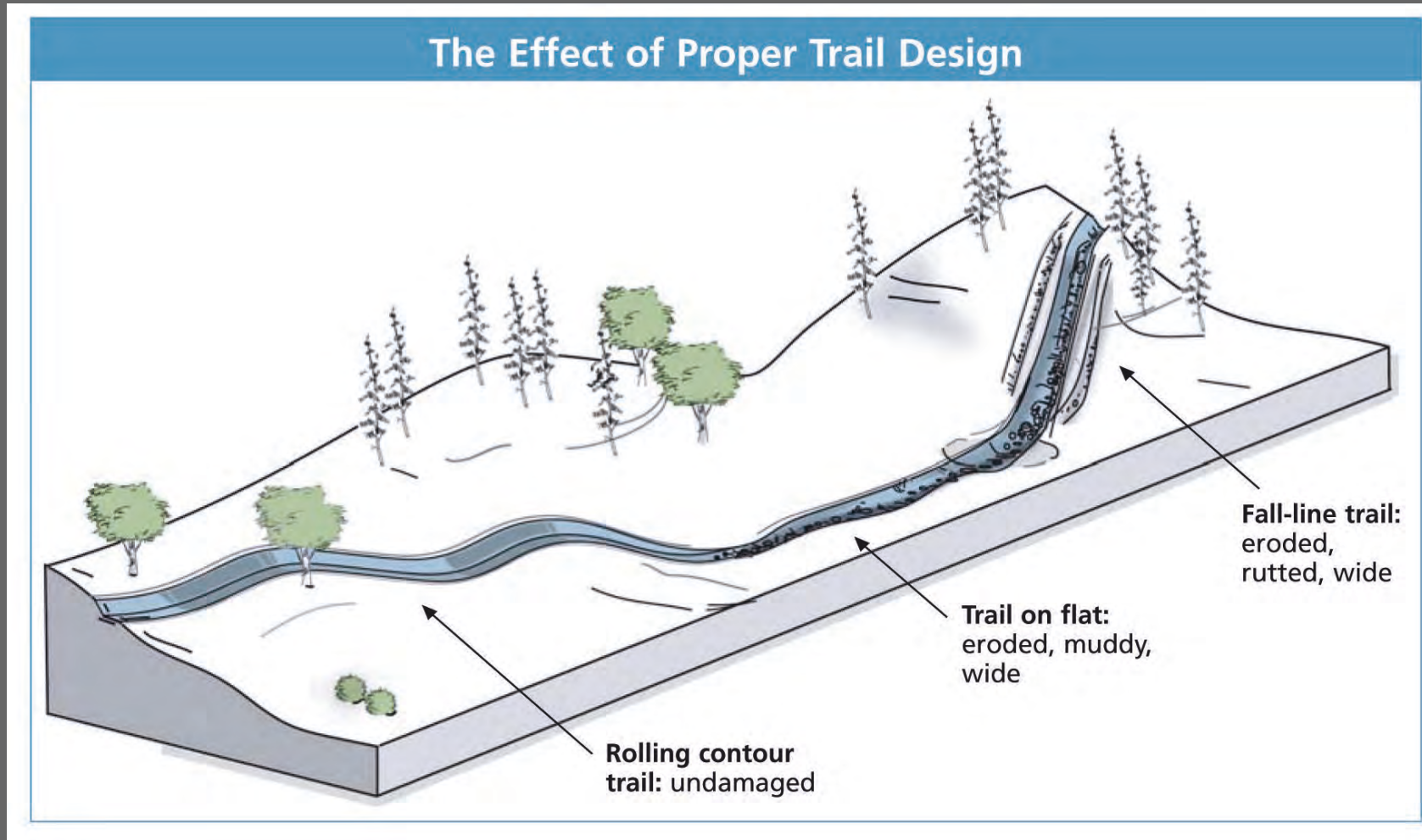
AVOID LOW AND FLAT AREAS



USE THE CONTOUR

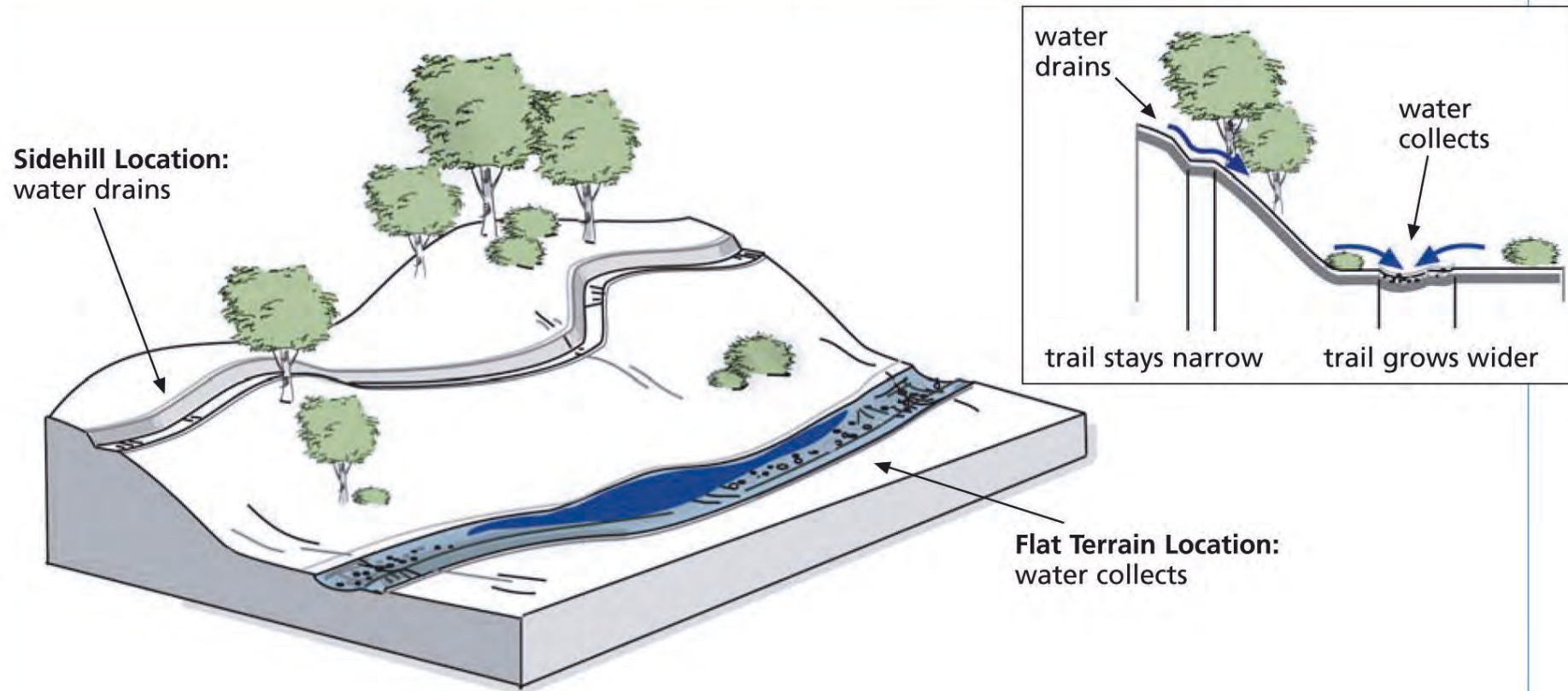


USE THE CONTOUR



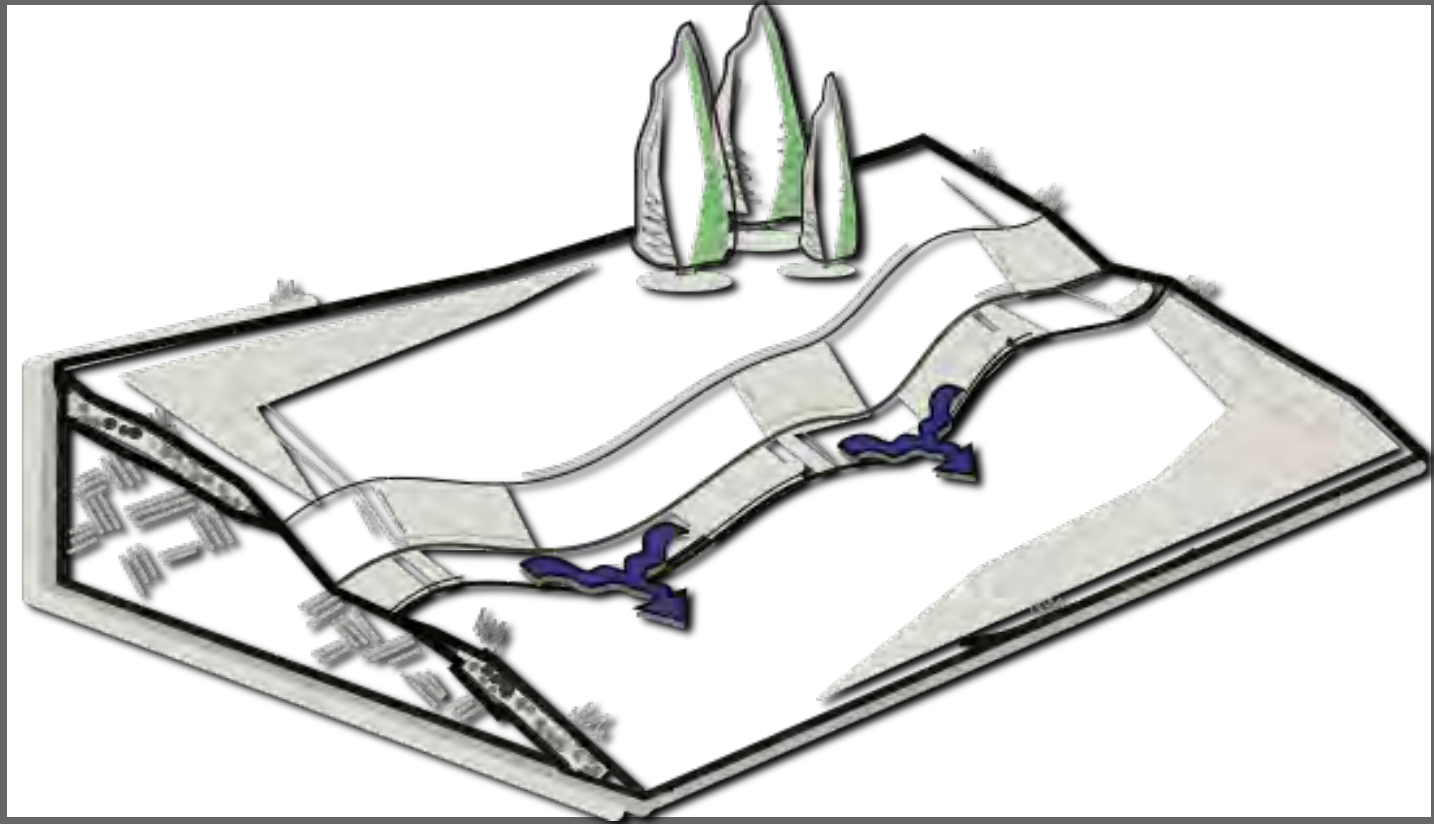
USE THE CONTOUR

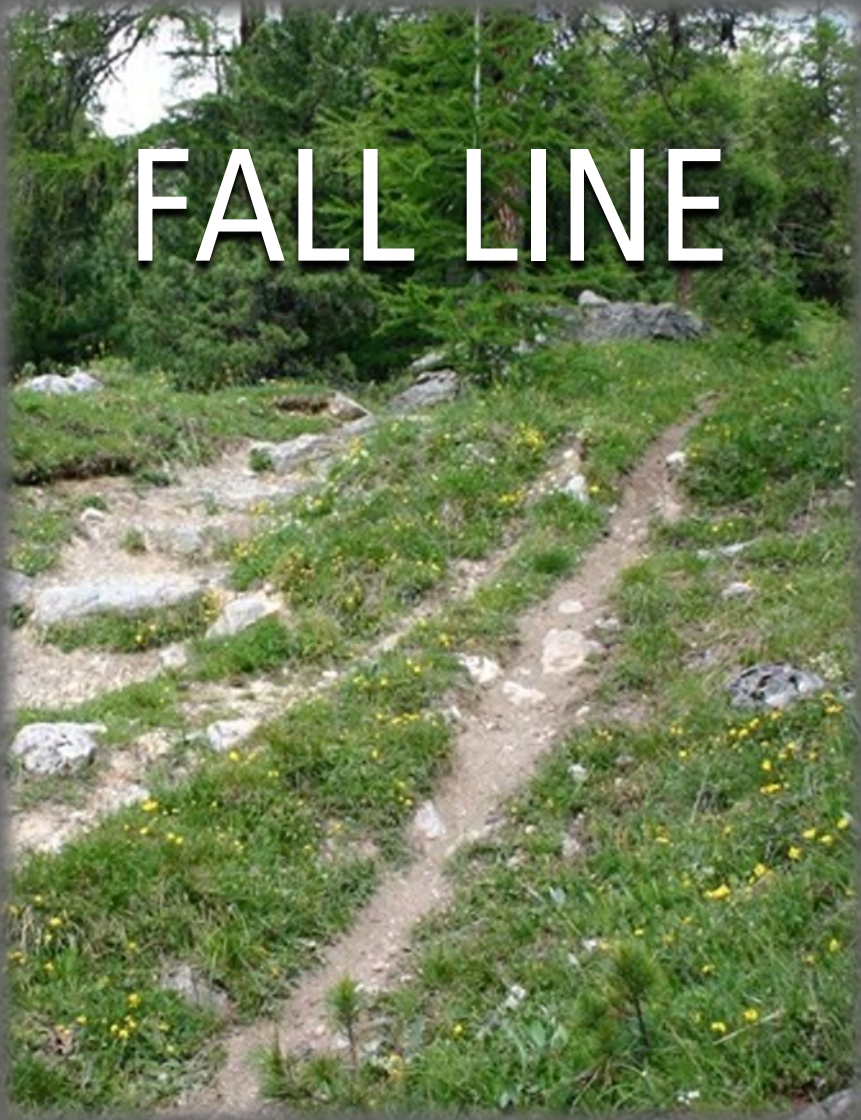
Trail Location: Sidehill Trails Are the Best



USE THE CONTOUR

- Build on the sideslope
- Use sustainable grades
- Incorporate grade reversals
- Outslope trail tread (in drains at a minimum)
- Facilitates sheet flow





FALL LINE



CONTOUR



FALL LINE



CONTOUR