Outdoor Sports Institute – Online Trail Build School

Building Great Trail Experiences

IMBA
INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION

IN PARTNERSHIP WITH

IMBA TRAIL UNIVERSITY
PART 3 - DESIGN

INTERNATIONAL MOUNTAIN BICYCLING ASSOCIATION


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

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

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REVIEW OF CONSTRUCTION

Parts of a Trail

- Critical points, backslope, and tread

Tools/PPE

- Corridor clearing tools
- Grubbing tools
- Fine grading tools
- Machines
- Personal Protective Equipment

Compliance

- SWPPP
- Environmental/cultural clearances
- Utility locations

Basic Construction

- Full and partial bench
- Inslope vs. outslope tread
- Elevated and at-grade turns
- Fords and bridges
- Rock armoring
- Optional lines and features
- Important shared-use tactics
- Basic trail maintenance

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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."

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

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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

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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 feedbacks 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.

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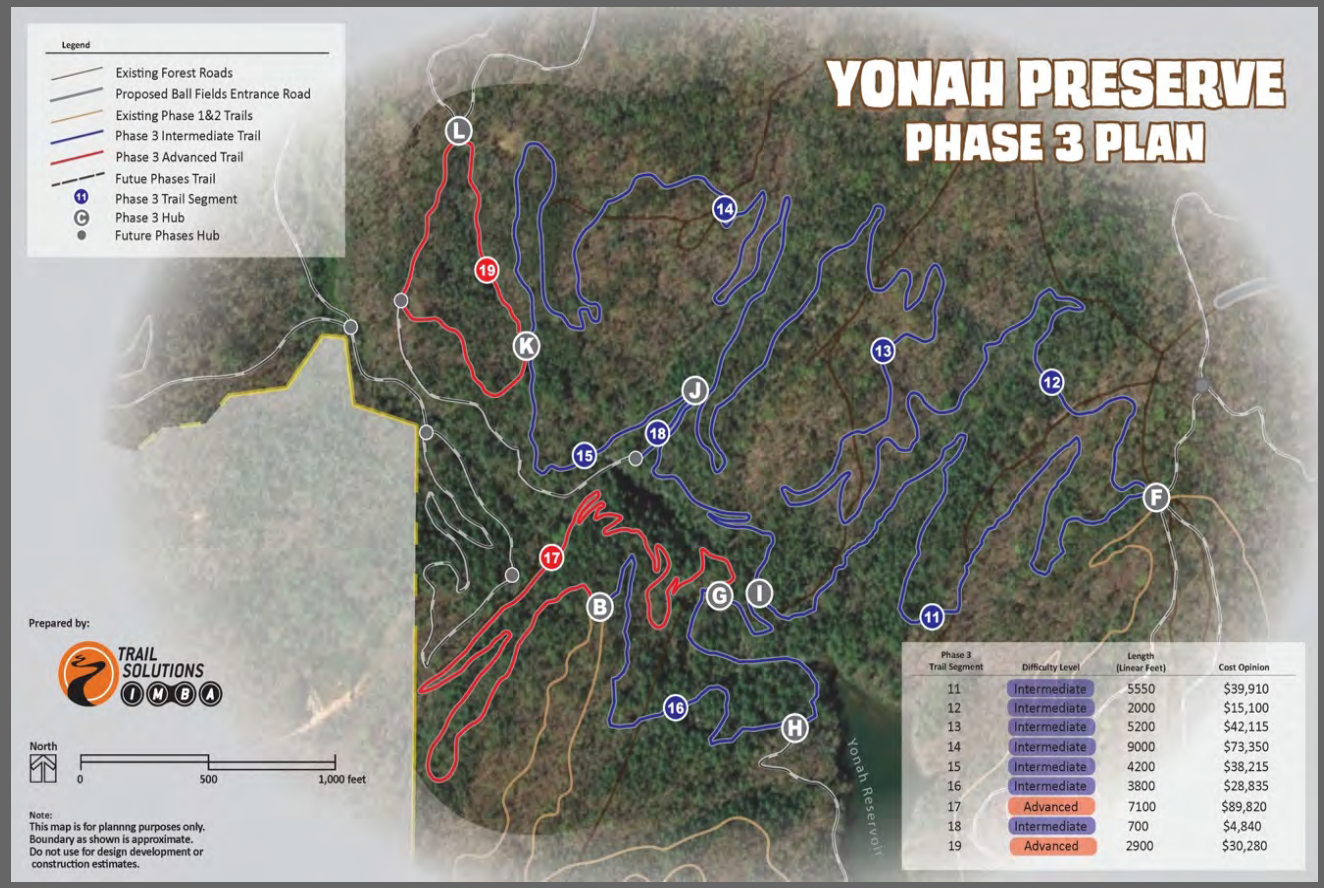
CONSIDERATIONS ON PROJECT PHASING

- 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?



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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

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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.

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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 grisescnes*). 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…

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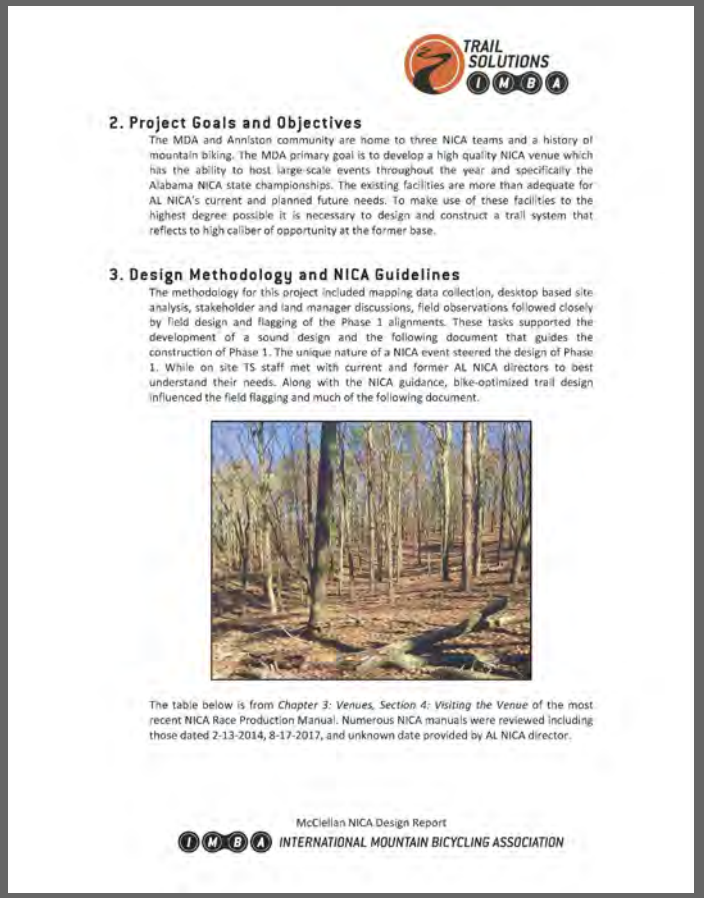
REVIEW THE PLAN TO DETERMINE CORRIDOR NEEDS

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



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2. Project Goals and Objectives

The MDA and Anniston community are home to three NICA teams and a history of mountain biking. The MDA primary goal is to develop a high quality NICA venue which has the ability to host large-scale events throughout the year and specifically the Alabama NICA state championships. The existing facilities are more than adequate for AL NICA's current and planned future needs. To make use of these facilities to the highest degree possible it is necessary to design and construct a trail system that reflects to high caliber of opportunity at the former base.

3. Design Methodology and NICA Guidelines

The methodology for this project included mapping data collection, desktop based site analysis, stakeholder and land manager discussions, field observations followed closely by field design and flagging of the Phase 1 alignments. These tasks supported the development of a sound design and the following document that guides the construction of Phase 1. The unique nature of a NICA event steered the design of Phase 1. While on site TS staff met with current and former AL NICA directors to best understand their needs. Along with the NICA guidance, bike-optimized trail design influenced the field flagging and much of the following document.

The table below is from *Chapter 3: Venues, Section 4: Visiting the Venue* of the most recent NICA Race Production Manual. Numerous NICA manuals were reviewed including those dated 2-13-2014, 8-17-2017, and unknown date provided by AL NICA director.

McClellan NICA Design Report

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ONE PAGE REVIEW OF TRAIL TYPES

Shared-Use

- Traditional
- Bike-optimized

Single-Use

- Bike gravity
- Hiking only
- Equestrian only

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TRAIL TYPE INFORMS CORRIDOR

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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

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Trail Specifications

Duluth Traverse Trail System

Version: 1.2 (130220)

Label	Working title	Difficulty Rating	Symbol[1]	Use	Directional	Feature Frequency[2]	Constructed Tread Width[3, 4]	Ave Trail Grade per 1000'	Max Trail Grade: climbing[5]	Max Trail Grade: descending[6]	Min Turn Radius	Max Turnpad Grade[7]	Max Berm/Turn Camber[8]	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.)	Roughasity (surface texture)[9]	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 the 18"	less then 2"	less then 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 then 48"	less then 8"	less then 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 then 18"	less then 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. Trials 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 the 36"	less then 2"	less then 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 then 60"	less then 2"	less then 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 then 120"	less then 8"	less then 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 the 36"	less then 2"	less then 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%	oo%	48-72"	12'-15'	less then 60"	less then 2"	less then 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%	oo%	48-72"	12'-15'	less then 120"	less then 8"	less then 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 the 36"	less then 18"	less then 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	oo% (mandatory drops	15'	25%	oo%	36"-72"	12'	less then 60"	less then 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	oo% (mandatory drops	15'	25%	oo%	36"-72"	12'	less then 120"	less then 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%		10-12'							Very front-country, likely connected to a recreation park. Typically under a mile.
Spec 14	Accessible trail	Easiest		bike, foot, horse	Two-Way	none																AASTHO 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			
Ascent	1% to 5%	1% to 7%	1% to 10%
Descent	-1% to -7%	-1% to -12%	-1% to -20%
Maximum Segment Grade			
Climbing (segment cannot exceed 50' in length)	+10%	+15%	+25%
Descending (segment cannot exceed 150')	-10%	-20%	-40%
Turn Diameter (min. >90 degrees)	16'	12'	8'
Height of Unavoidable Obstacles (max.)	2"	10"	20"
Tread Cambering (excludes turns, TTFs)			
Outslope (avg.)	0% - 5%	0% - 5%	0% - 10%
Outslope (max.)	5%	10%	20%
Inslope (avg)	0% - 5%	0% - 5%	0% - 10%
Inslope (max)	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			
0% - 5% sideslope	12" - 24"	8" - 24"	6" - 18"
6% - 25% sideslope	16" - 36"	12" - 30"	8" - 24"
26% - 50% sideslope	24" - 42"	16" - 36"	12" - 30"
51% - 75% sideslope	Not recommended	30" - 48"	18" - 42"
75+% sideslope	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		
Pedestrians	Enjoying nature, solitude, aerobic fitness, relaxation, connectivity	N/A
Mountain Bikers	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		
Intersections	Trails should slow visitors speeds prior to the intersection.	Trails must slow visitors speeds prior to the intersection.
Turns	Turns should be platform in nature with slight inslopes, turns should be adqueate radii to ensure good sightlines.	Turns should be downhill bike optimized, including wider radii and more elevation drop. Berms may be required.
Sightlines	Sightlines should be adequate for quickly moving visitors in both directions.	Sightlines must be adequate for quickly moving visitors in both directions.
Trail Meander	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 experiencal goals.
Corridor width and height	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.
Trail corrals and gateways	Trails should be tight in nature, relfecting skill level guidelines. The use of native material and features to corral and slow riders is encourgaed.	Trails may be wider or narrower than skill level guidelines to accommodate desired experiences.

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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 1000'	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 advacing 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 determinded 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 tigher 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

1. Feature Frequency is averaged over long distances. Per 100': "low" = 2-3 features, "med" = 3-5 features, "high" = 5-10 features.
2. Constructed tread width may narrow over short distances to 50% of spec. Examples include rock or tree gateways.
3. 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.).
4. Max grades climbing and descending refer to extremely short segments, 10 feet or less.
5. Turnpad grade measures the rise/fall across the turning surface at the base of any inslope.
6. Max camber is measured at the top of the inslope. Turns can not be outsloped.
7. Corridor height should be reduced in thick laurel or rhododendron where appropriate to provide a more natural "tunnel experience".
8. Rugosity attempts to capture average tread coarseness. Tread area with obstacles: "low" = less then 5%, "med" = less then 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

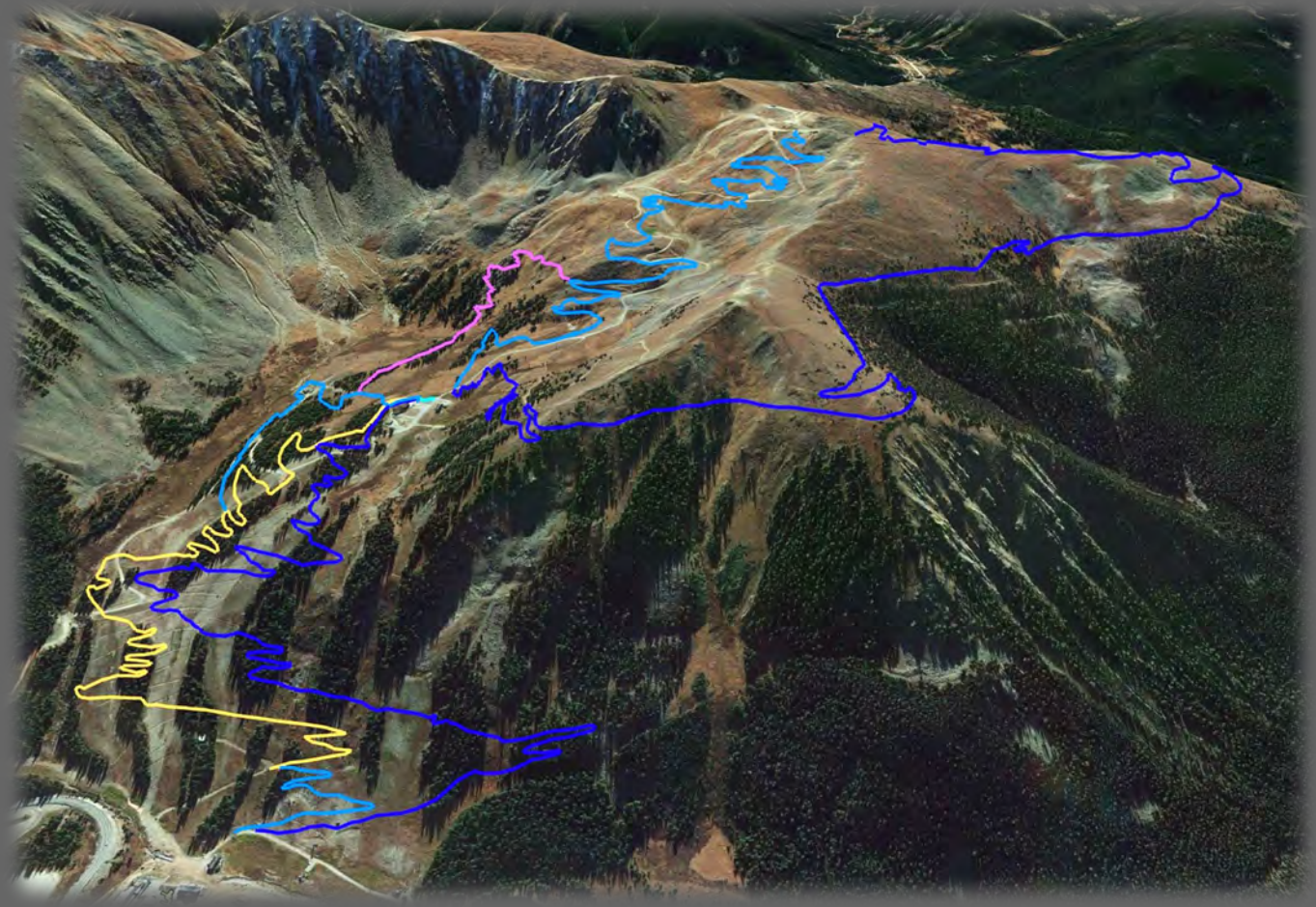
Google Earth

GIS

Avenza Maps

Analog

Sketching on maps



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ZONES TO CORRIDOR

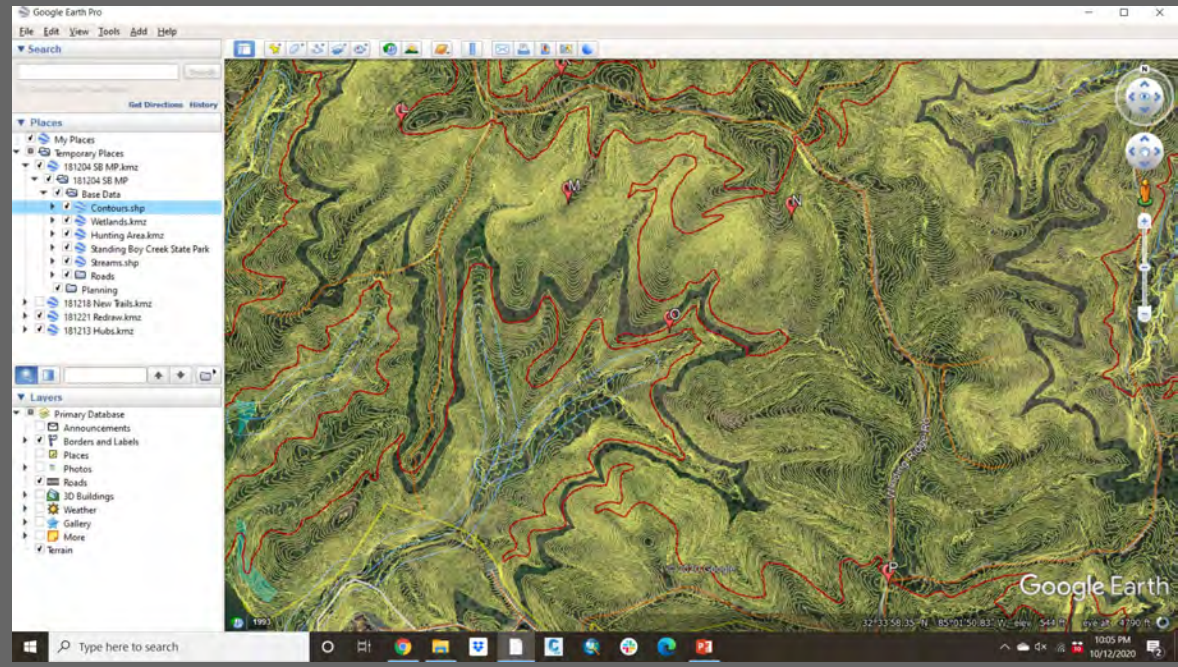
Google Earth

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

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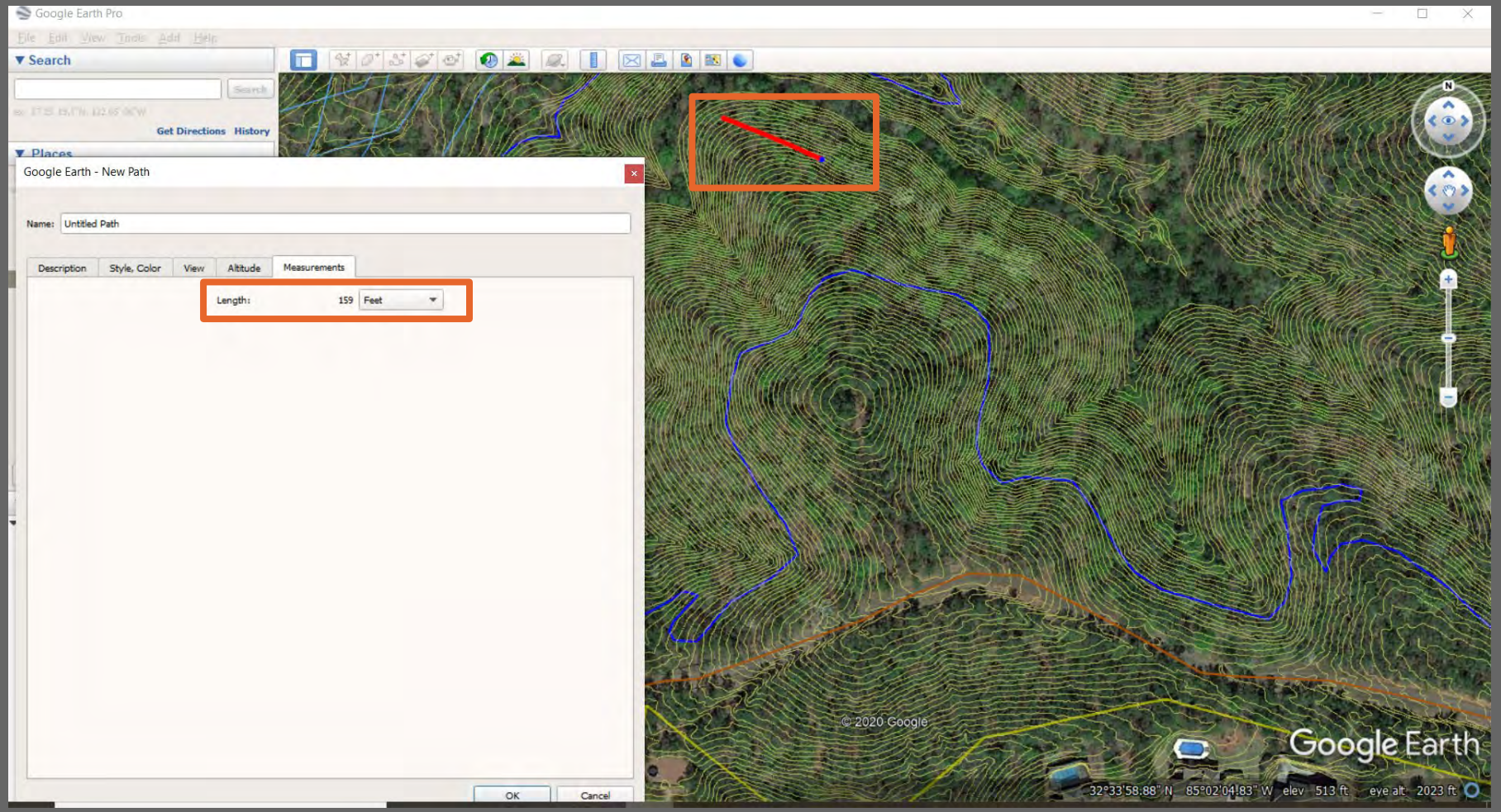
ZONES TO CORRIDOR



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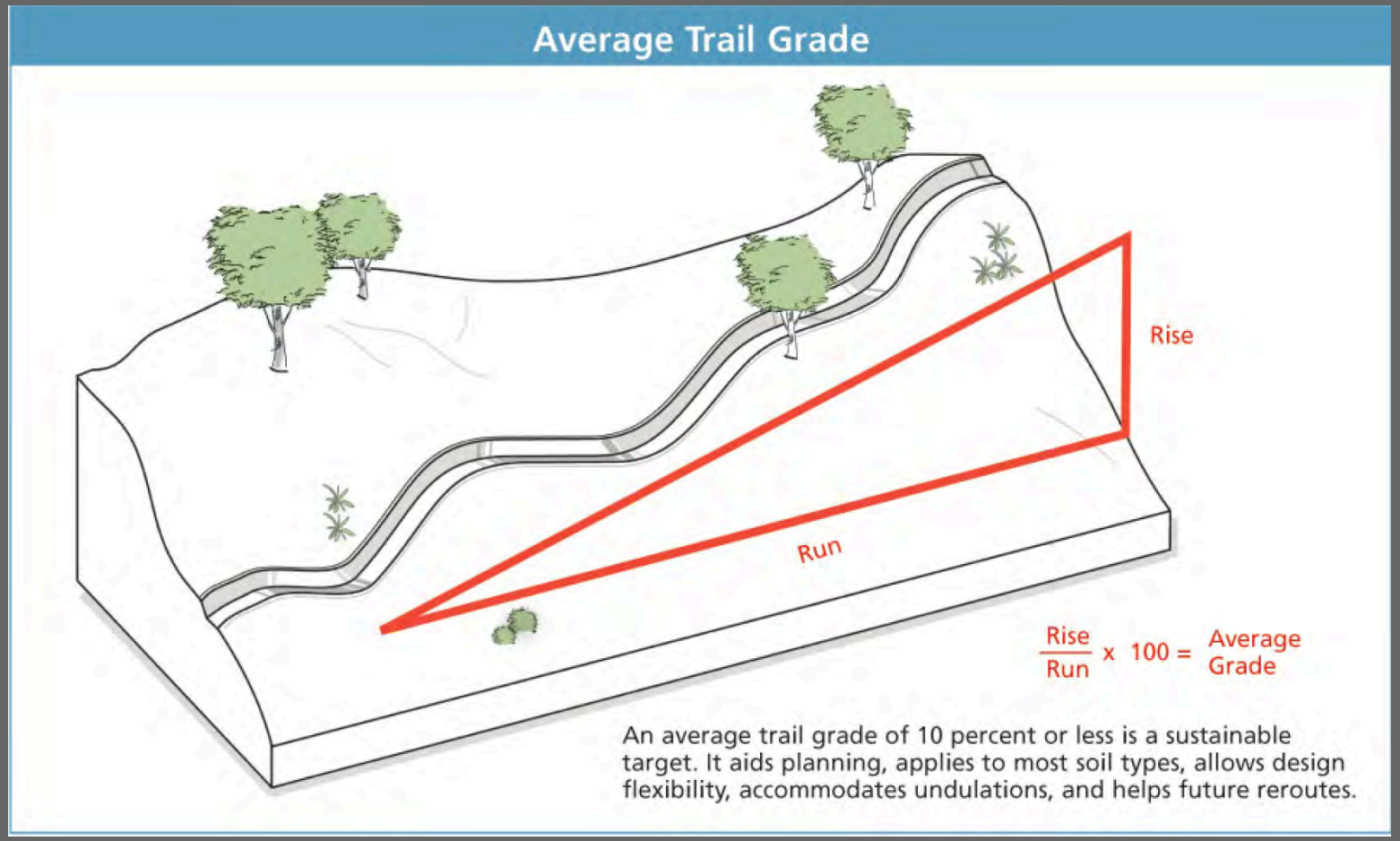
AVERAGE TRAIL GRADE/CORRIDOR GRADE

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.



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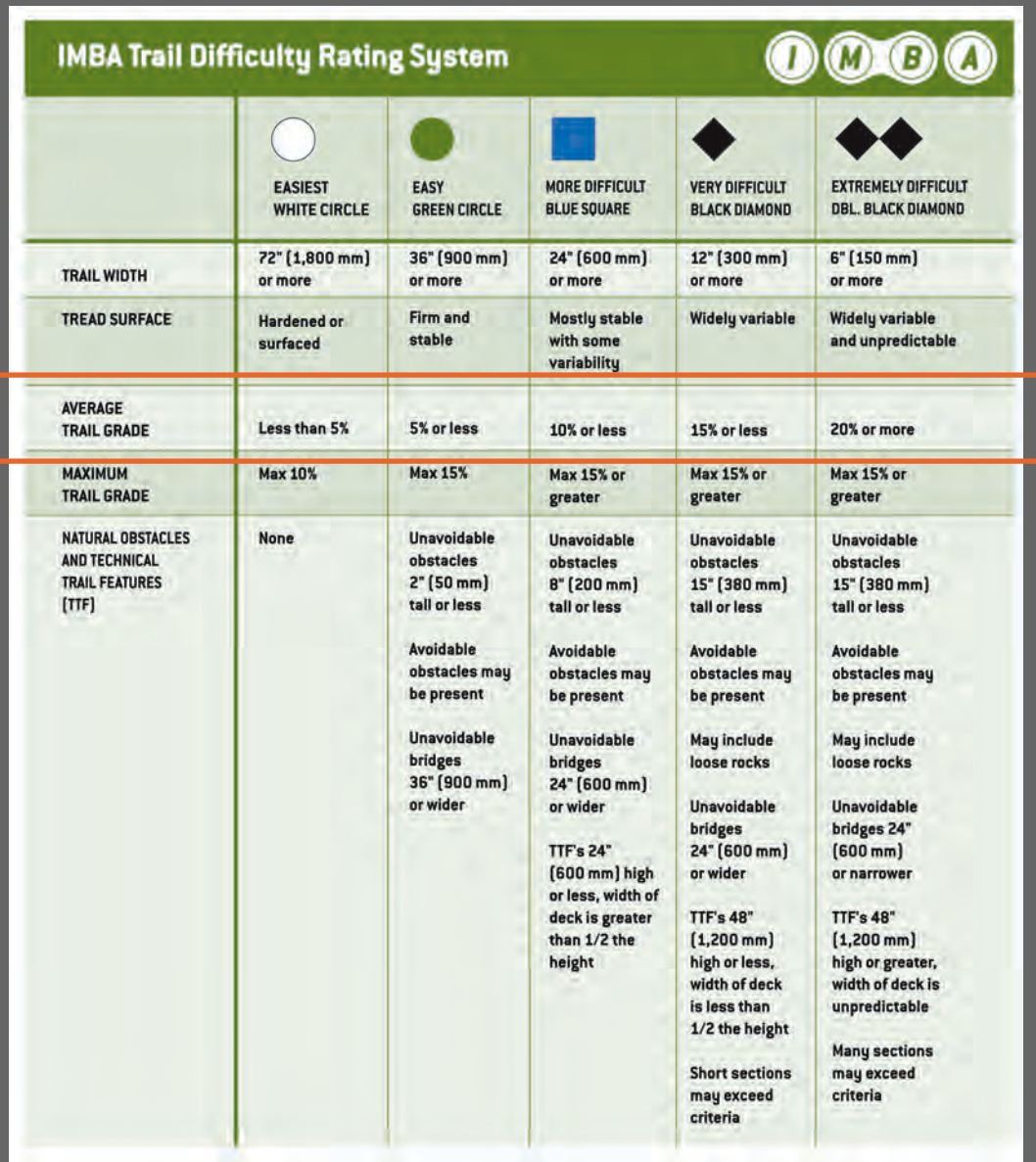
AVERAGE TRAIL GRADE/CORRIDOR GRADE



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

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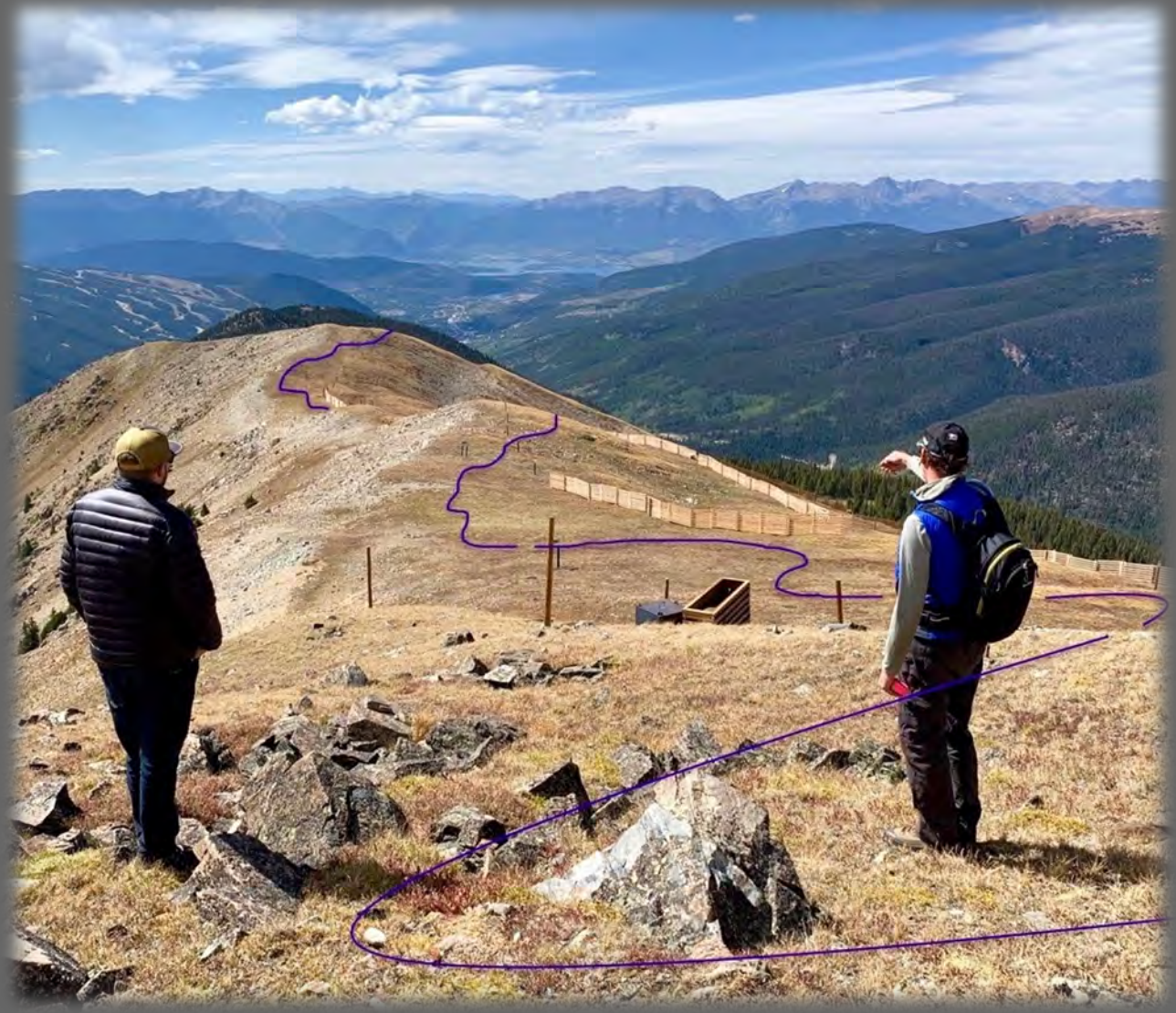
GROUNDTRUTH

- 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.



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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

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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.

<u>Examples</u>

- 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

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MINIMIZE USER CONFLICTS: DESIGN

- Sightlines – dense vegetation on shared use?
- Choke points – tree gateways, rocks
- Intersections – uphill from all directions
- Speed checks – uphills, tread texture

- Design lets us use passive techniques to influence visitors
- People react better to passive instruction

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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 uphills 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.

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SUSTAINABLE TRAIL FUNDAMENTALS

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AVOID SOIL EROSION CAUE BY WATER

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

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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**

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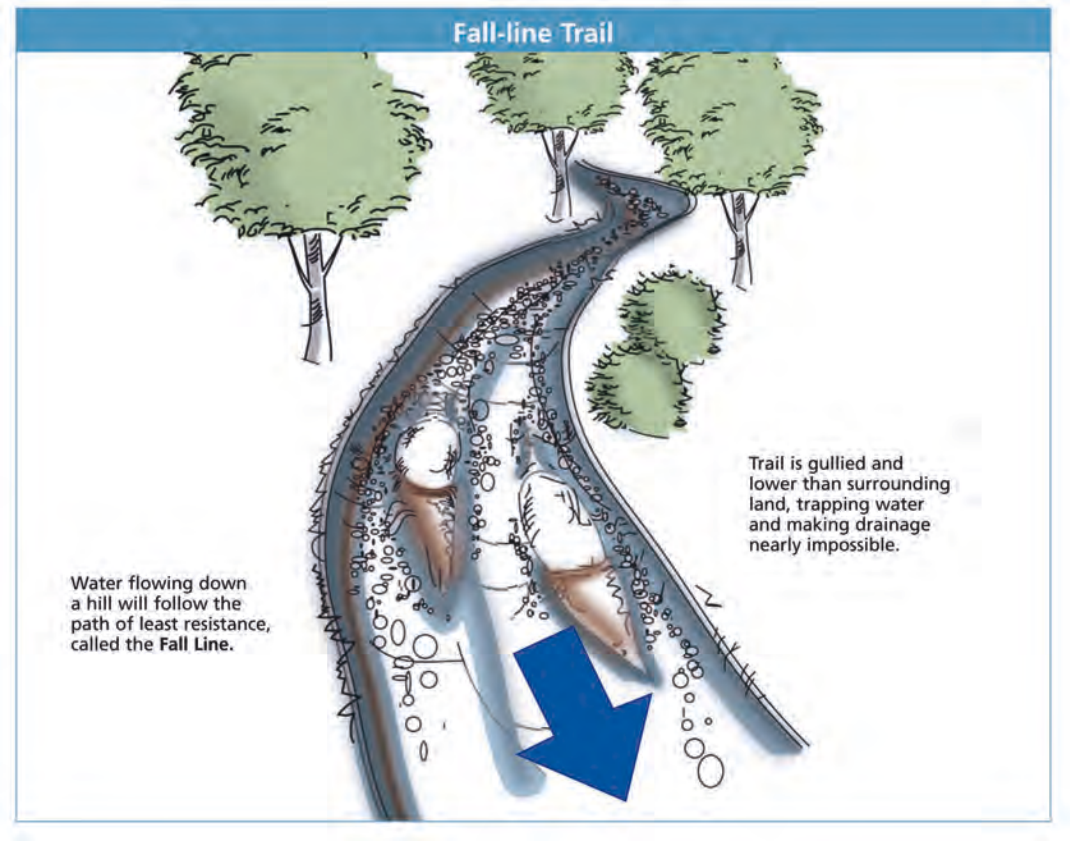
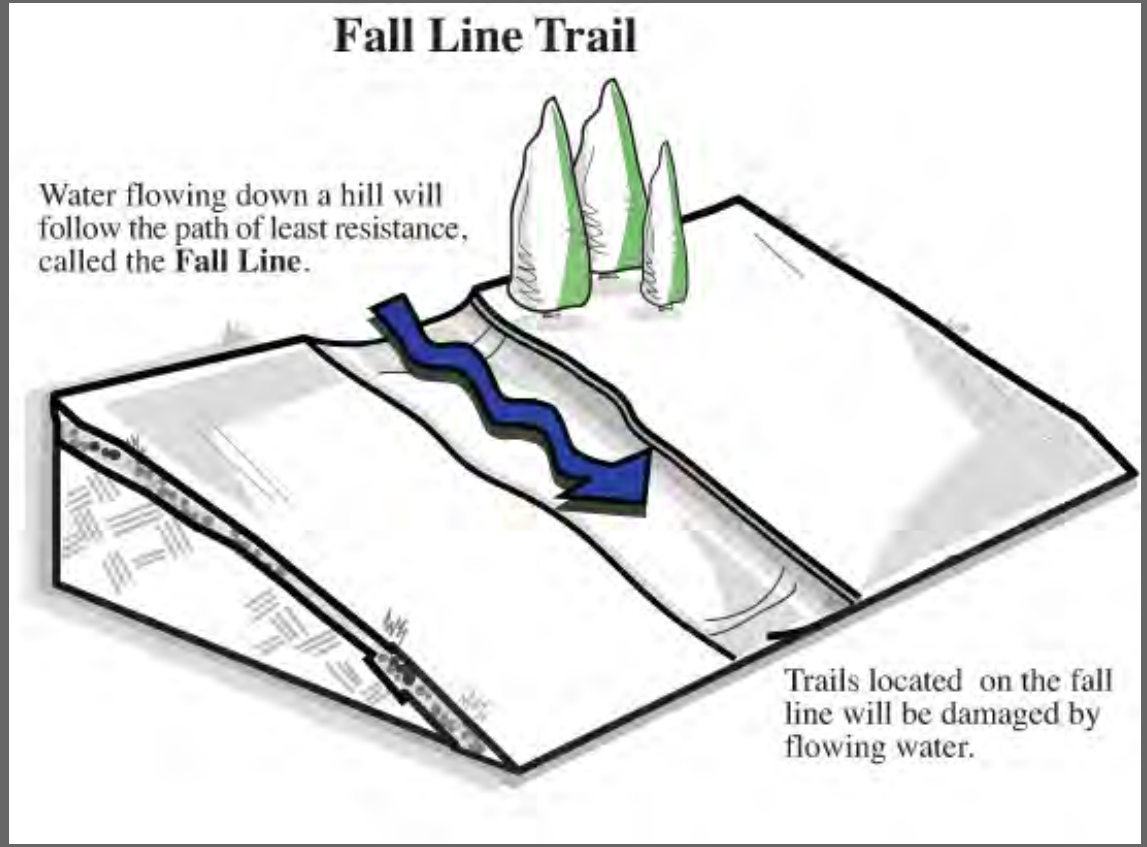
AVOID THE FALL LINE





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AVOID LOW AND FLAT AREAS

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USE THE CONTOUR

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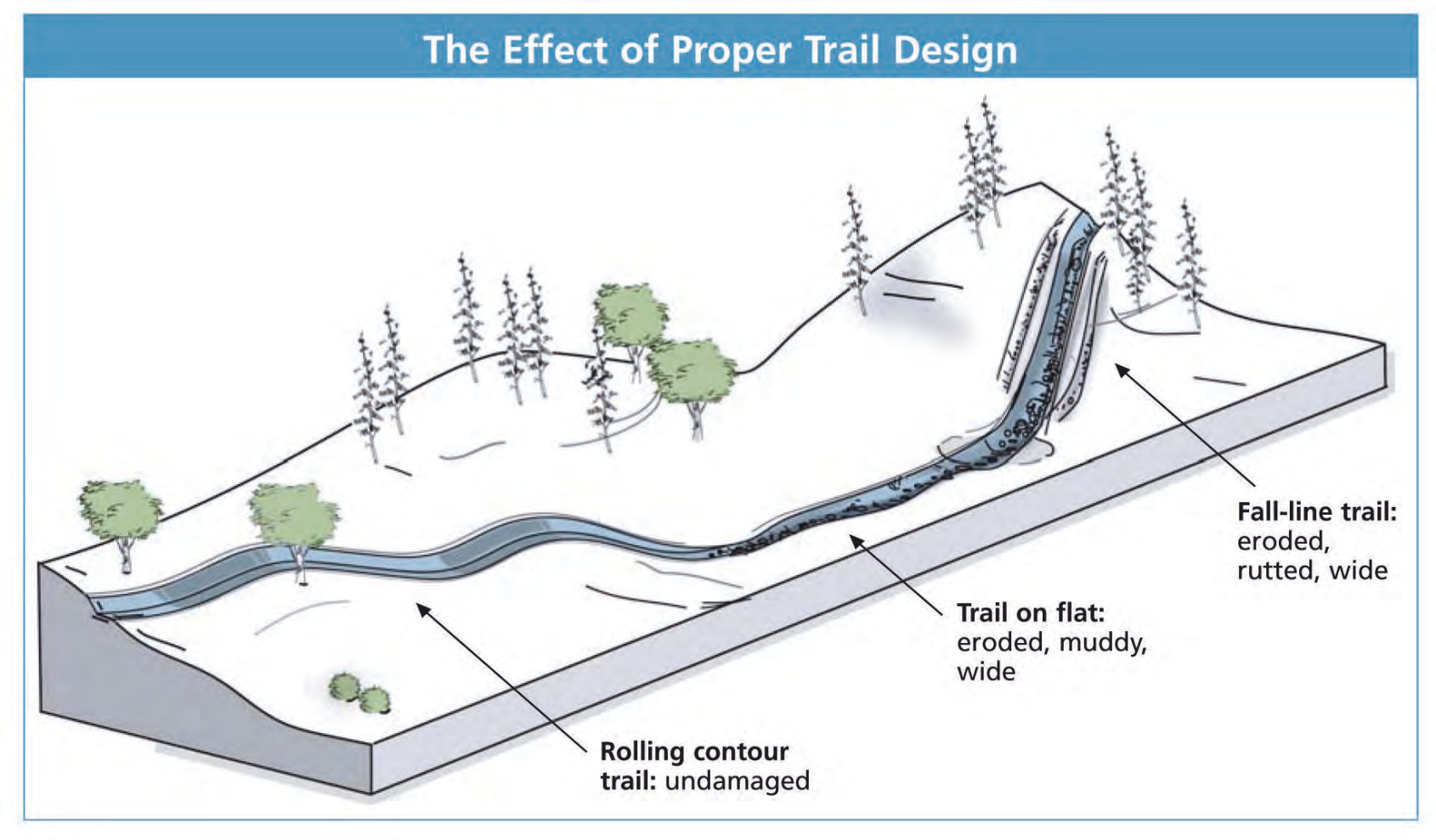
USE THE CONTOUR



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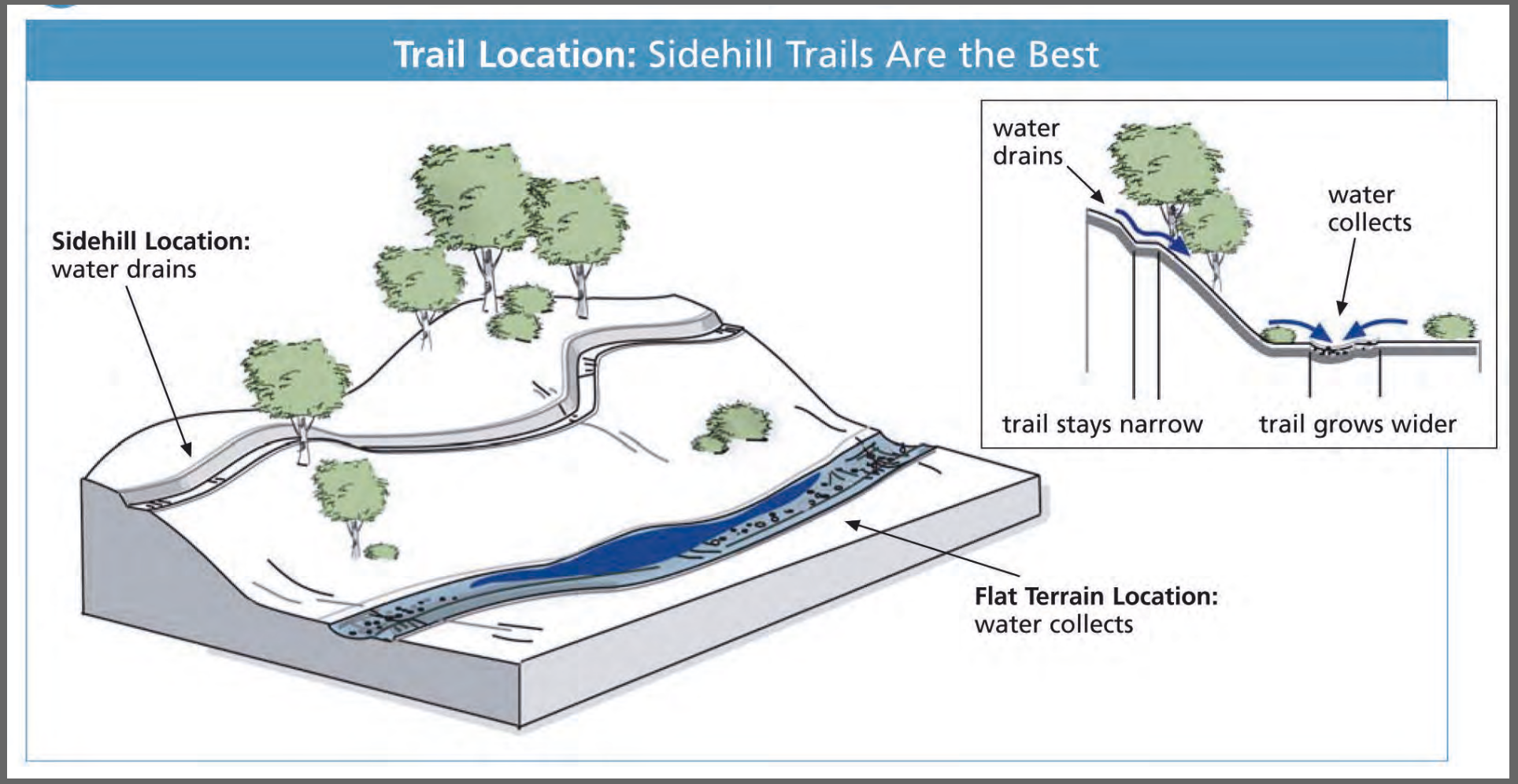
USE THE CONTOUR



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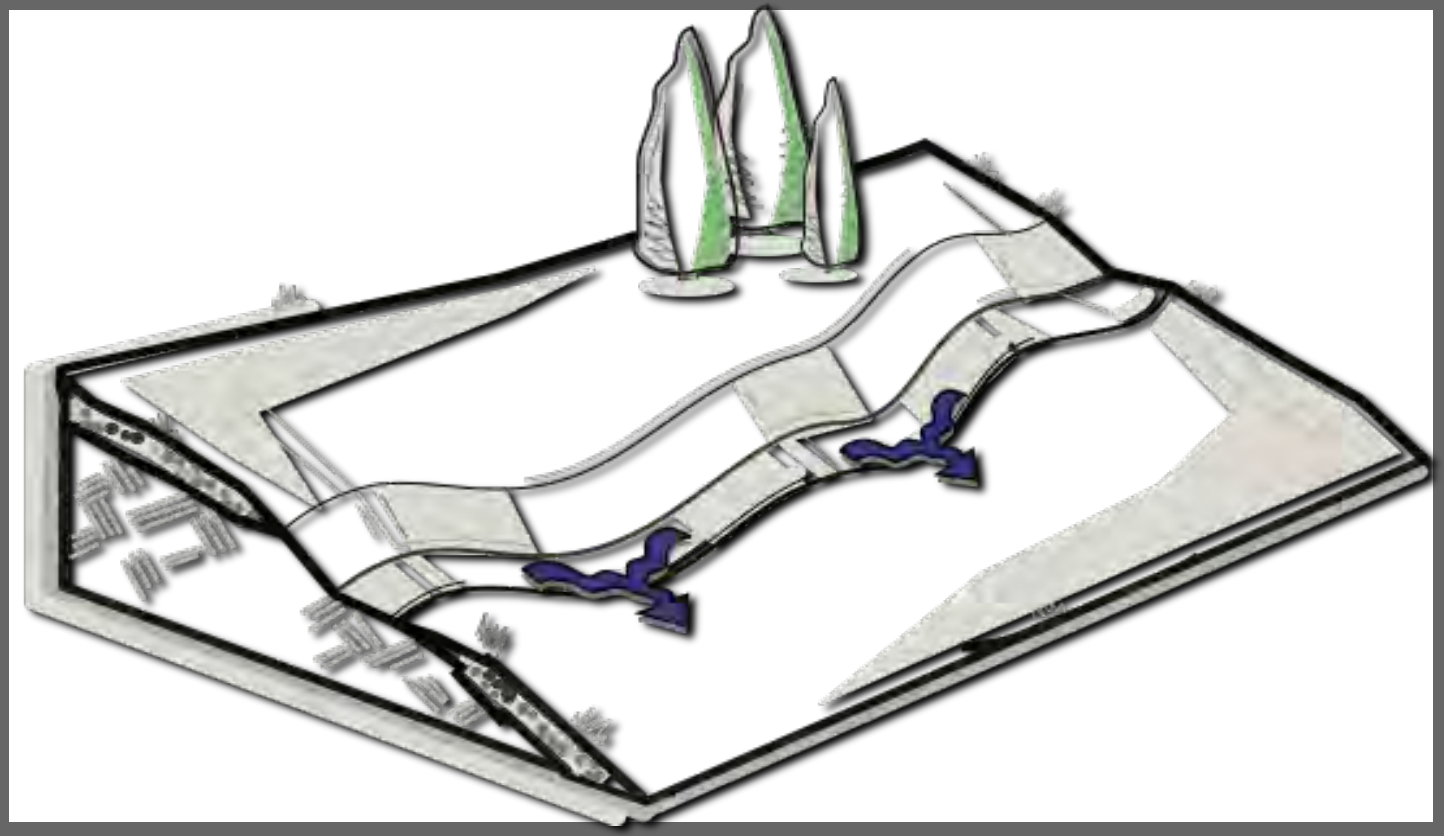
USE THE CONTOUR

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



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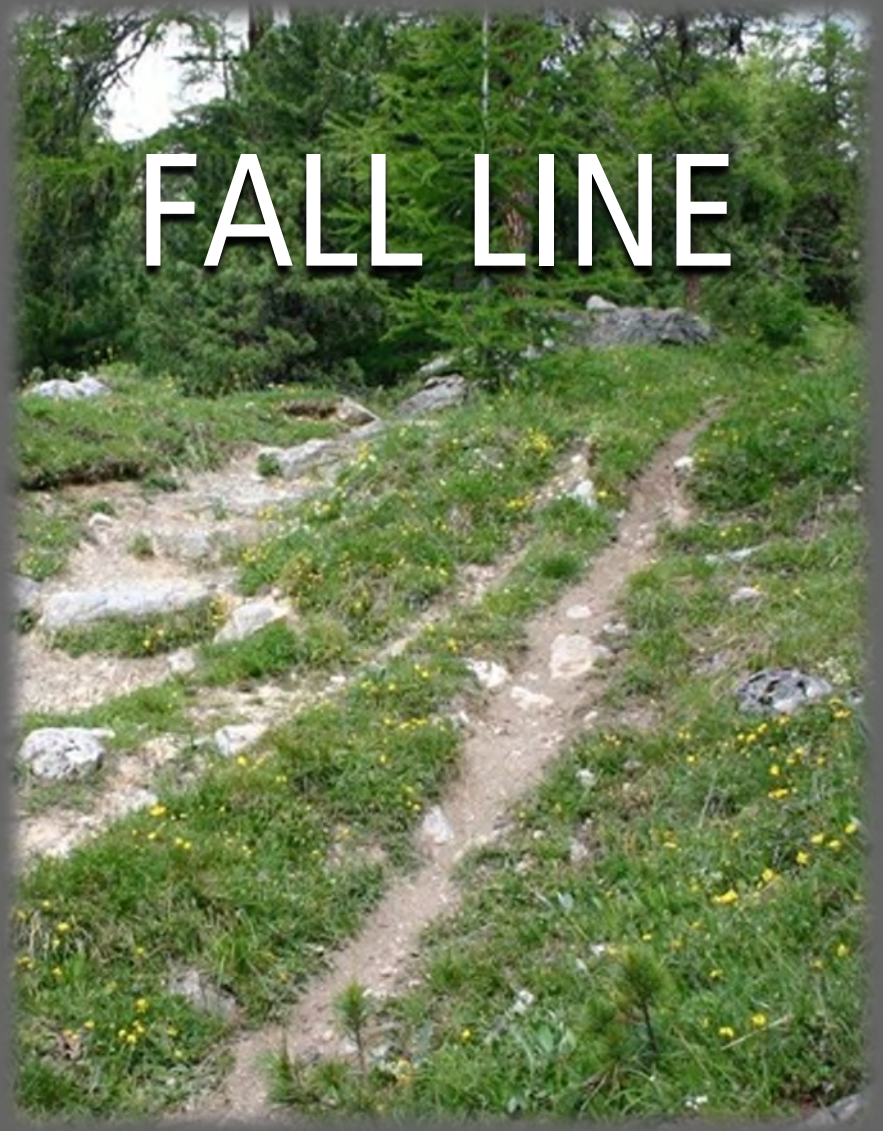

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FALL LINE

CONTOUR

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