SUSTAINABLE TRAIL FUNDAMENTALS

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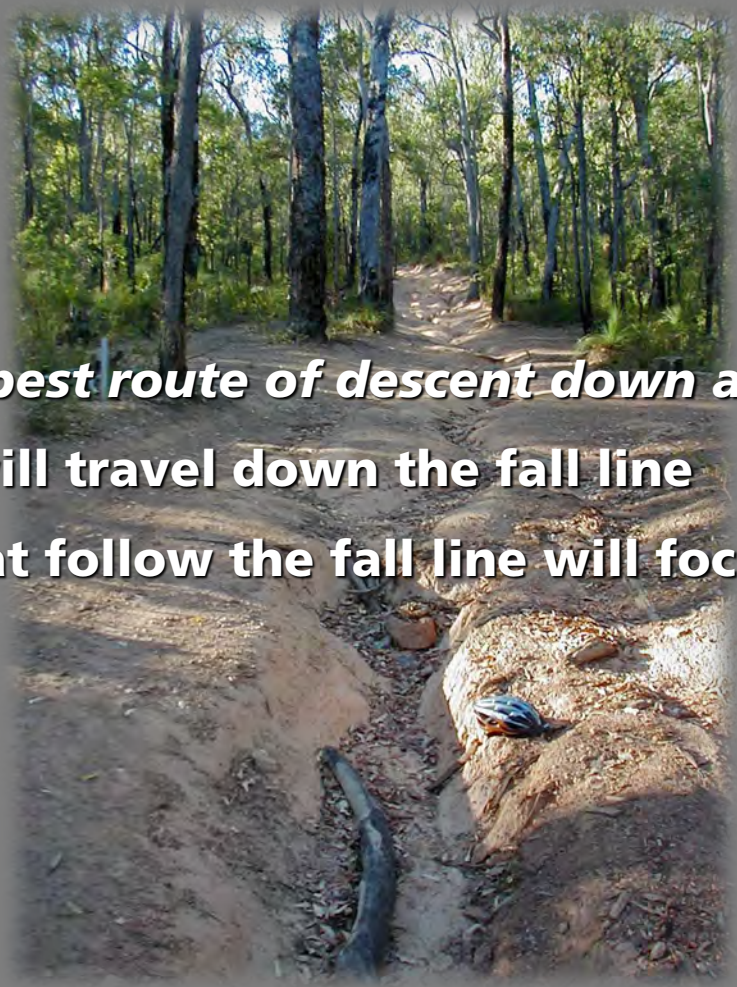
AVOID SOIL EROSION CAUSED BY WATER

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**

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AVOID LOW AND FLAT AREAS

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USE THE CONTOUR

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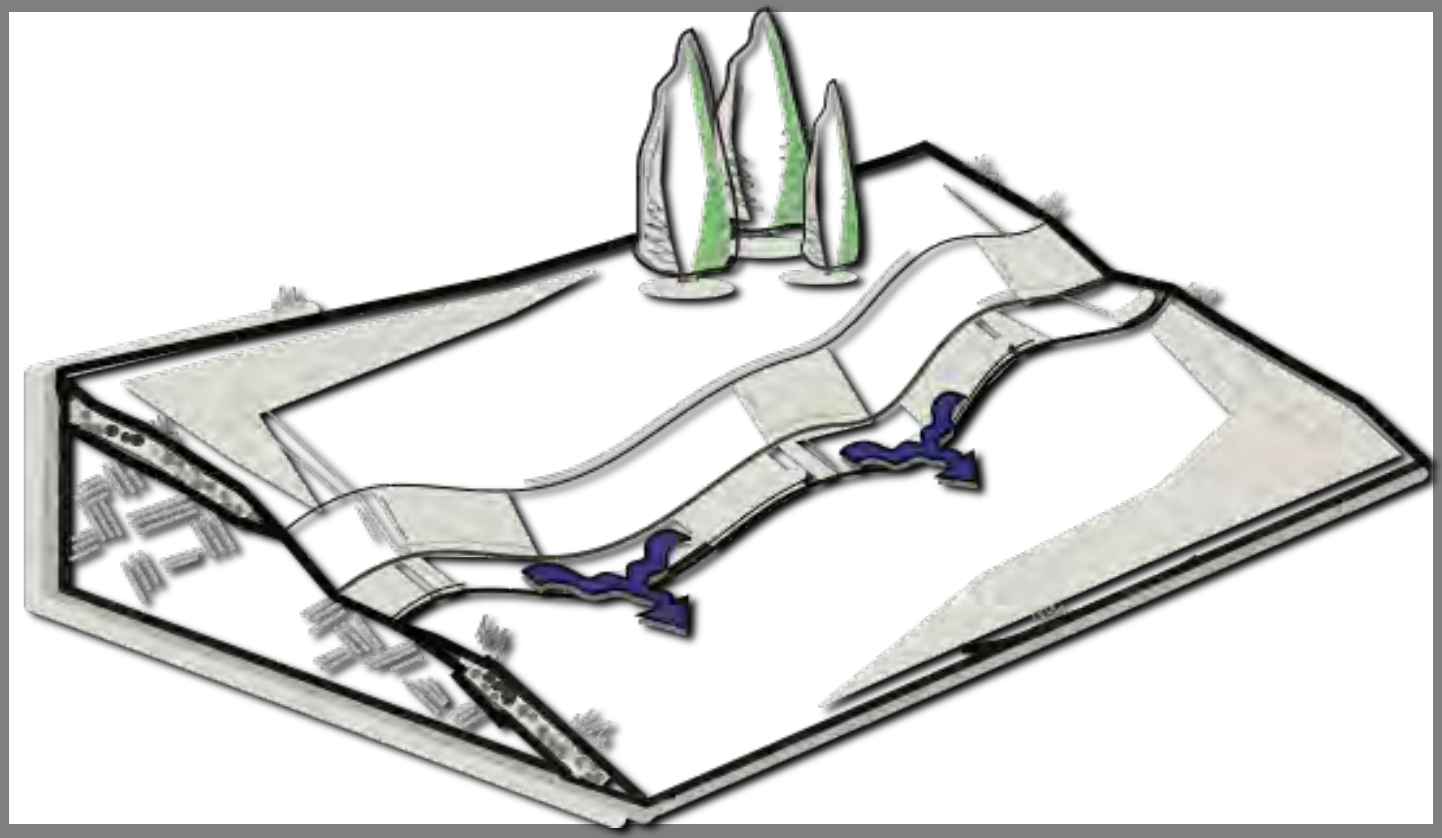
USE THE CONTOUR

- Built on the sideslope
- Sustainable grades
- Incorporates grade reversals
- Outsloped trail tread
- Facilitates sheet flow



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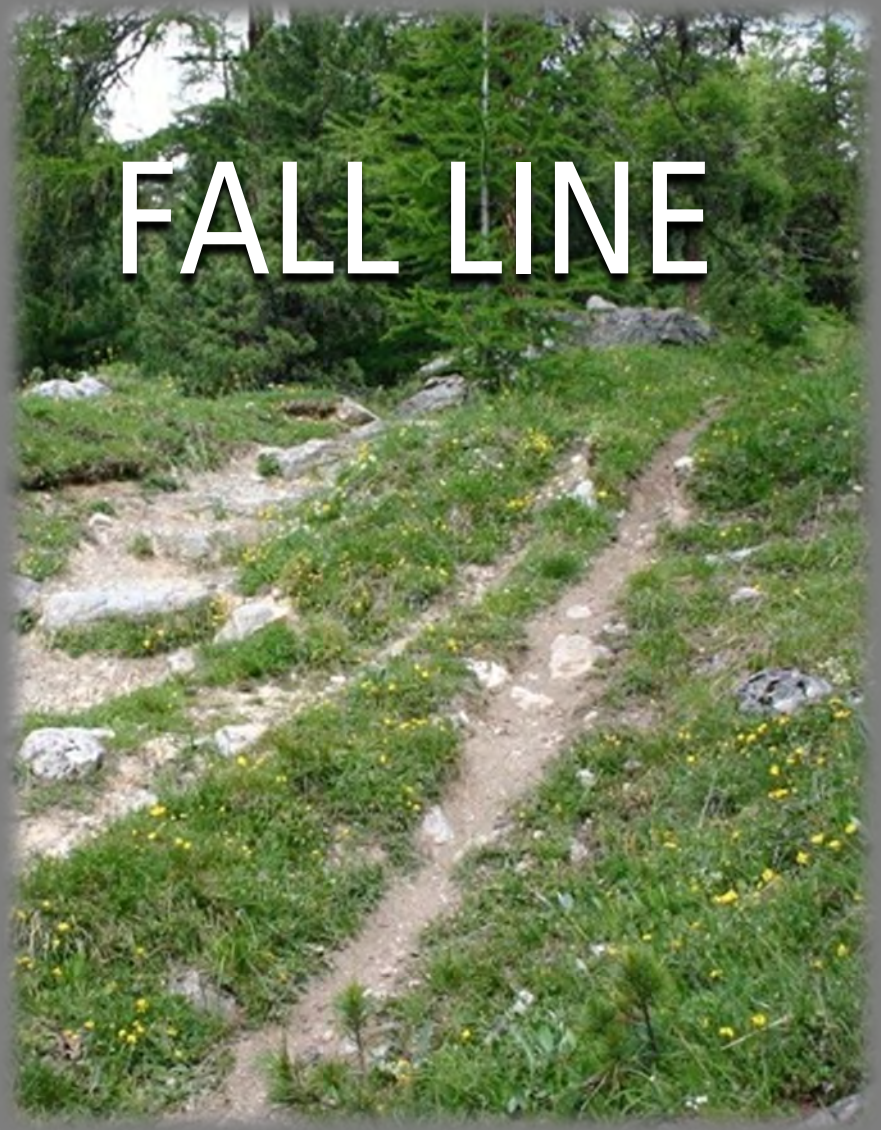

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FALL LINE

CONTOUR

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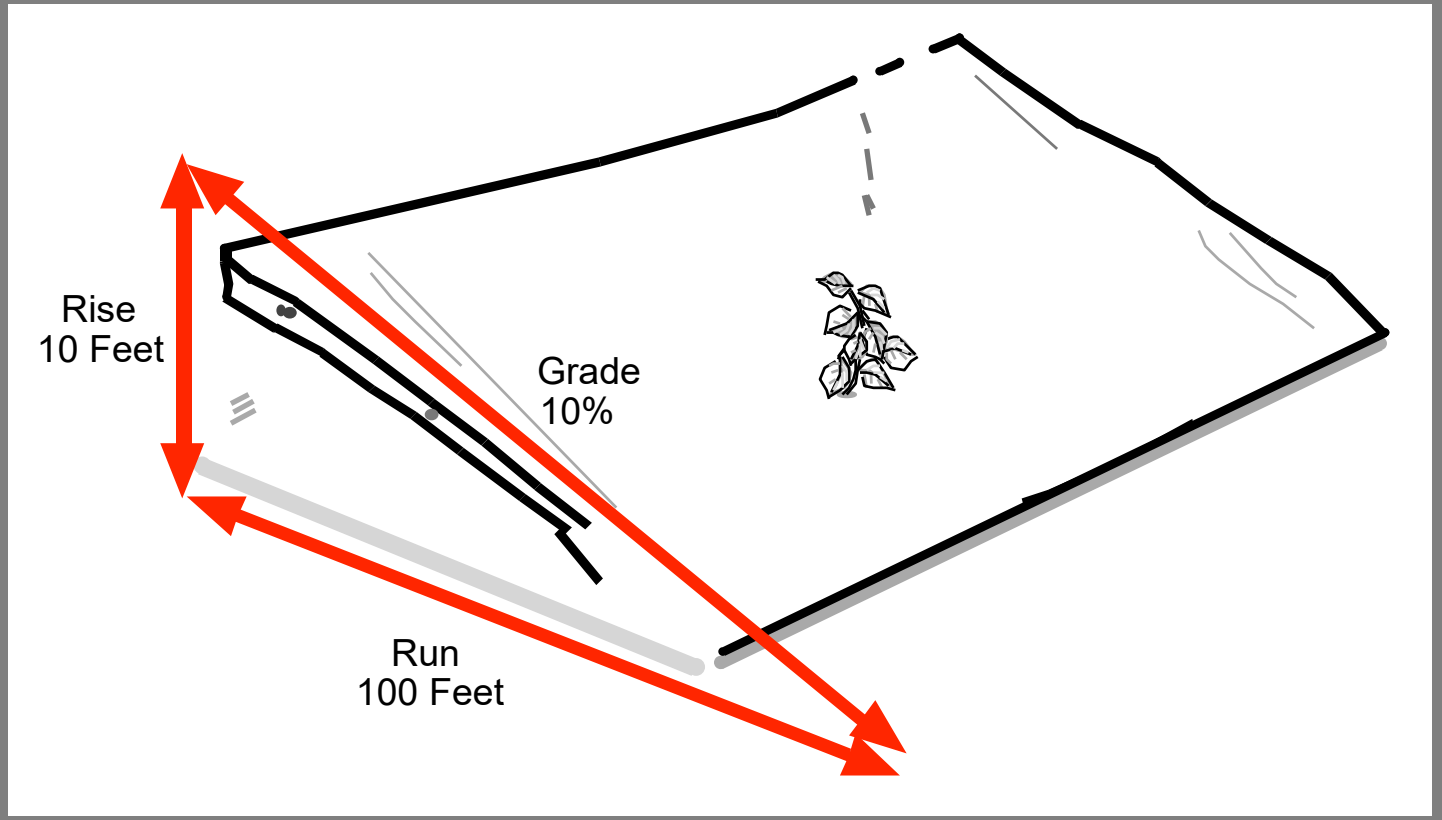
WHAT IS GRADE?

Trails have “grade” - the percent change in elevation (rise) over run (distance along trail alignment)

Hills have “slope”



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HALF RULE

The grade of trail must be less than ½ the slope of the land it's crossing to allow for effective drainage

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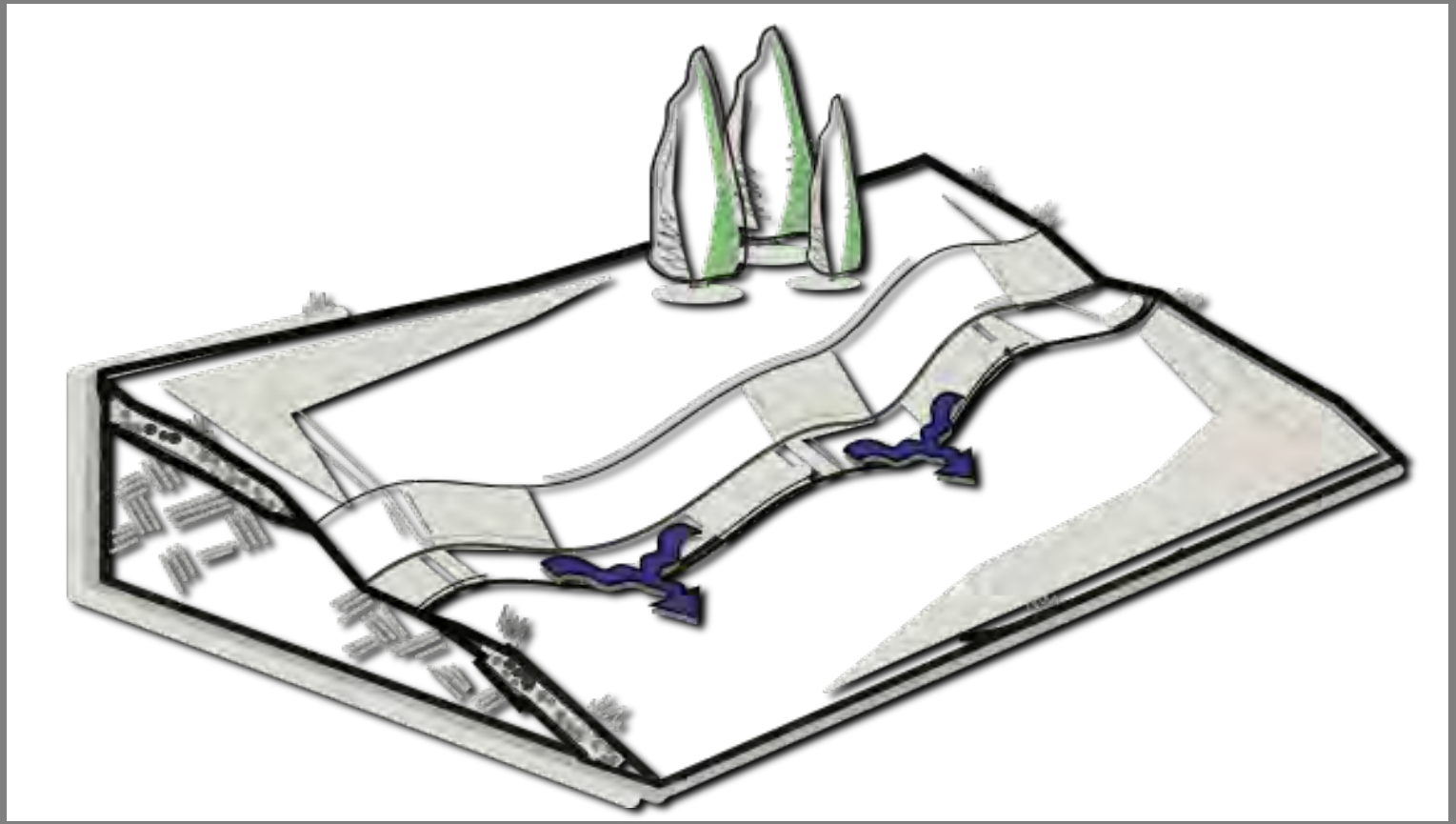
INCORPORATE GRADE REVERSALS

Following the ½ rule allows for effective grade reversals during construction and during maintenance



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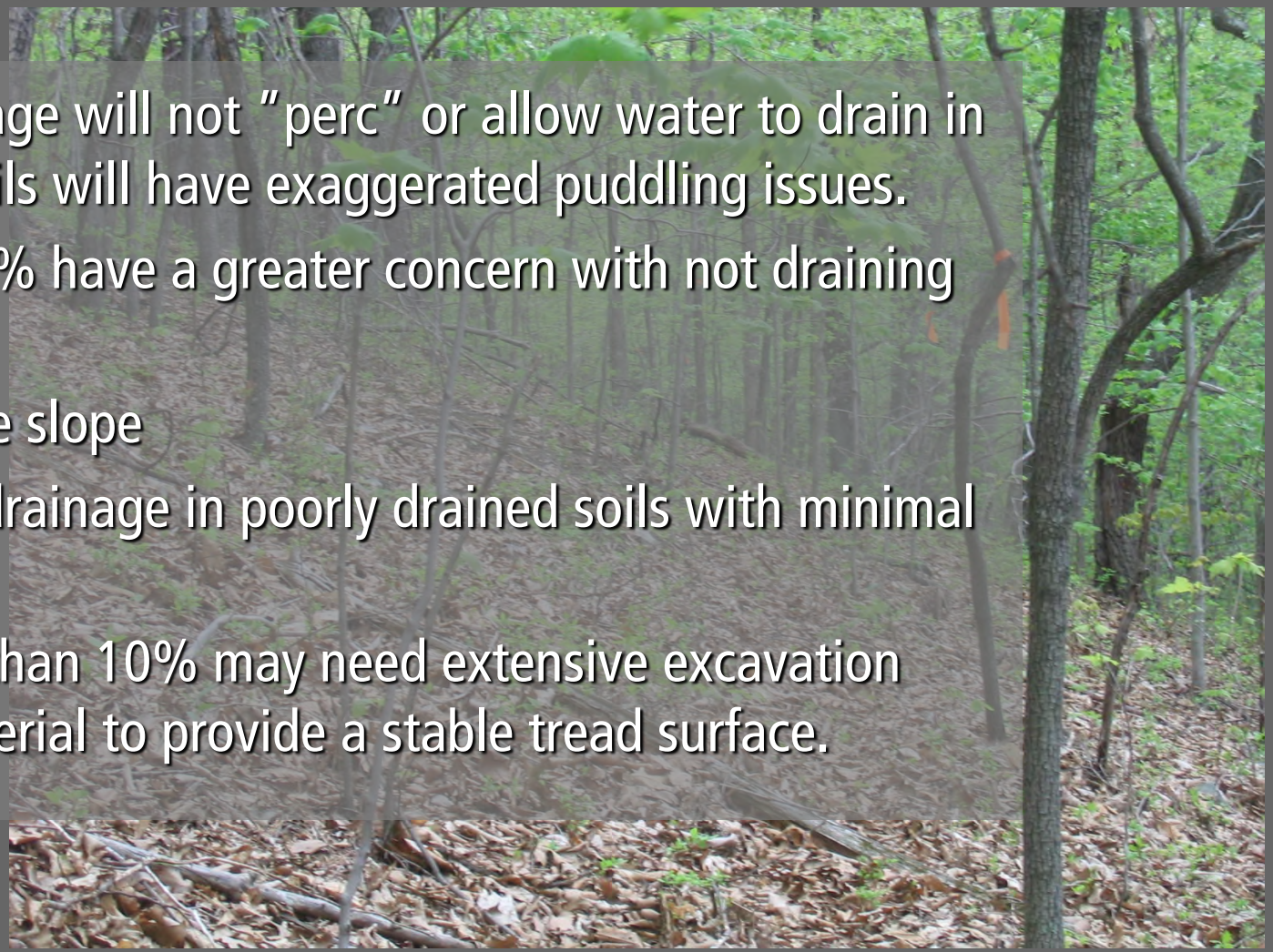
SUFFICIENT SIDESLOPE IN CLAY SOILS



Soils that have a high clay percentage will not "perc" or allow water to drain in the soil once compacted. These soils will have exaggerated puddling issues.

Clay soils on slopes of less than 10% have a greater concern with not draining than with erosion.

The golden window: 20%-40% side slope

Allows for compaction and future drainage in poorly drained soils with minimal excavation.

Trails on clay soils and slopes less than 10% may need extensive excavation "super elevation" or imported material to provide a stable tread surface.

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MEASURE SIDESLOPE

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MAXIMUM SUSTAINABLE GRADE

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MAXIMUM SUSTAINABLE GRADE

Setting Maximum Sustainable Trail Grades

The variables to be considered when setting the target maximum trail grade include:

Trail Alignment: the trail should be aligned generally perpendicular to the fall line, even on gentle hillsides.

Half Rule: A trail's grade should never exceed half the grade of the sideslope.

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.

Annual Rainfall: 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 that are especially susceptible to user-caused soil displacement.

Vegetation: Vegetative cover can have a significant impact on trail sustainability. Vegetation and organic matter helps to break up and absorb the flow of water and tree canopies help protect the tread from direct impacts of rainfall.

Grade Reversals: Frequent grade reversals will allow for slightly steeper trail grades.

Type 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 percent for short distances, depending on soil and rainfall. Trails open to visitors with higher impact, such as horses or motorized users, should have more gentle maximum grades.

Number of Users: Trails with high anticipated use may need to be designed with lower maximum trail grades.

Difficulty Level: Trails with a higher level of technical challenge may incorporate steeper grades, but construction techniques such as frequent grade reversals and armoring may be necessary to ensure sustainability.

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EXCEPTIONS

Natural Rock

Built Structures

Armored Sections

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https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Knowing the soil type and percolation rate are most important in low slope areas and post glaciated areas.

Erodibility is a function of slope – ignore the USDA rating as it applies to barren hillsides, not graded trails.

Search

Map Unit Legend

Rockingham County, Virginia (VA165)

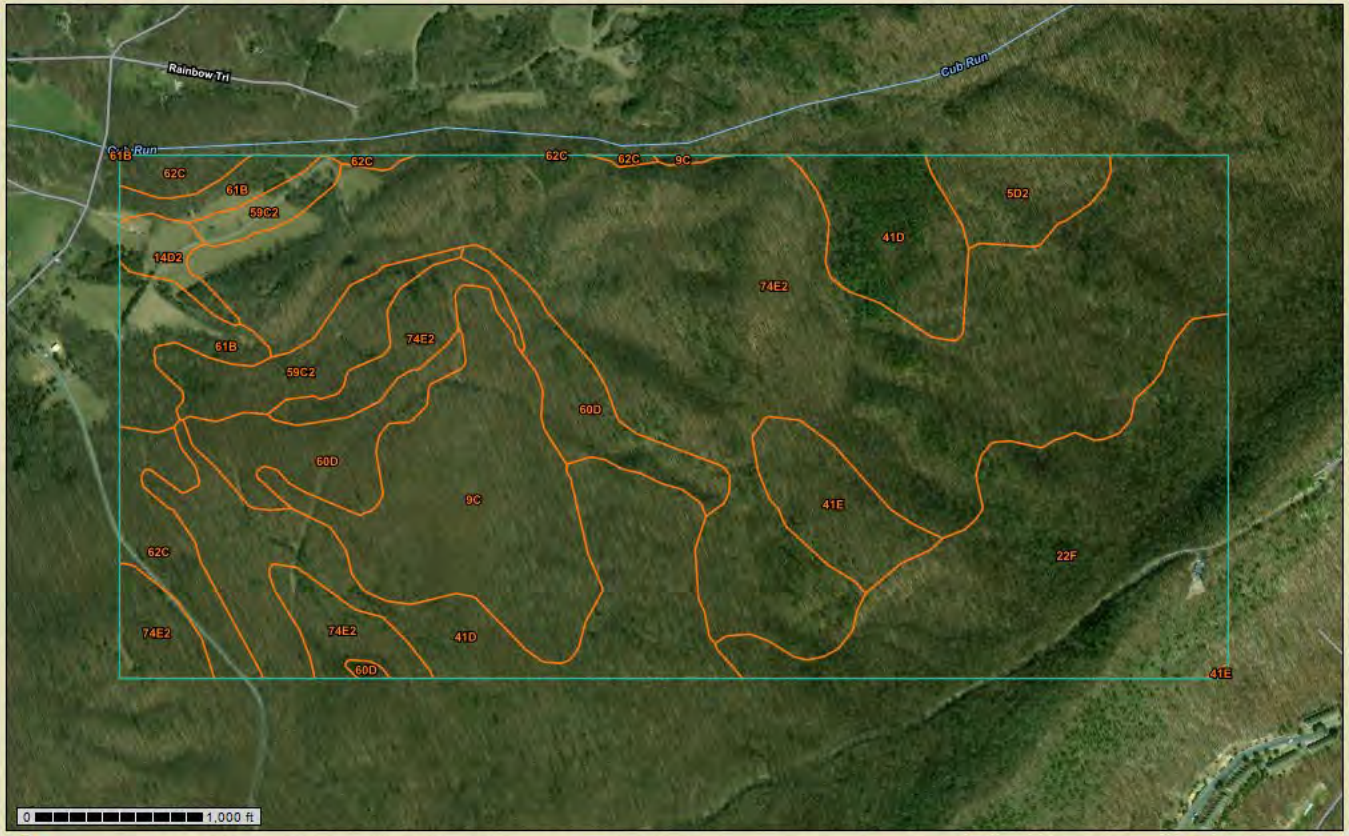
Rockingham County, Virginia (VA165)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5D2	Berks-Weikert channery silt loams, 15 to 25 percent slopes, eroded	10.3	2.1%
9C	Buchanan fine sandy loam, 7 to 15 percent slopes, very stony	44.9	9.4%
14D2	Chilhowie silty clay, 15 to 25 percent slopes, eroded	4.4	0.9%
22F	Drall sandy loam, 40 to 70 percent slopes, extremely stony	72.0	15.1%
41D	Laidig fine sandy loam, 15 to 25 percent slopes, very stony	62.0	13.0%
41E	Laidig fine sandy loam, 25 to 45 percent slopes, very stony	13.0	2.7%
59C2	Sequoia-Berks silt loams, 7 to 15 percent slopes, eroded	17.1	3.6%

Legend

Soil Map

Scale (not to scale)



Warning: Soil Map may not be valid at this scale.

You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mapping of soils is done at a particular scale. The soil surveys that comprise your AOI were mapped at 1:20,000. The design of map units and the level of detail shown in the resulting soil map are dependent on that map scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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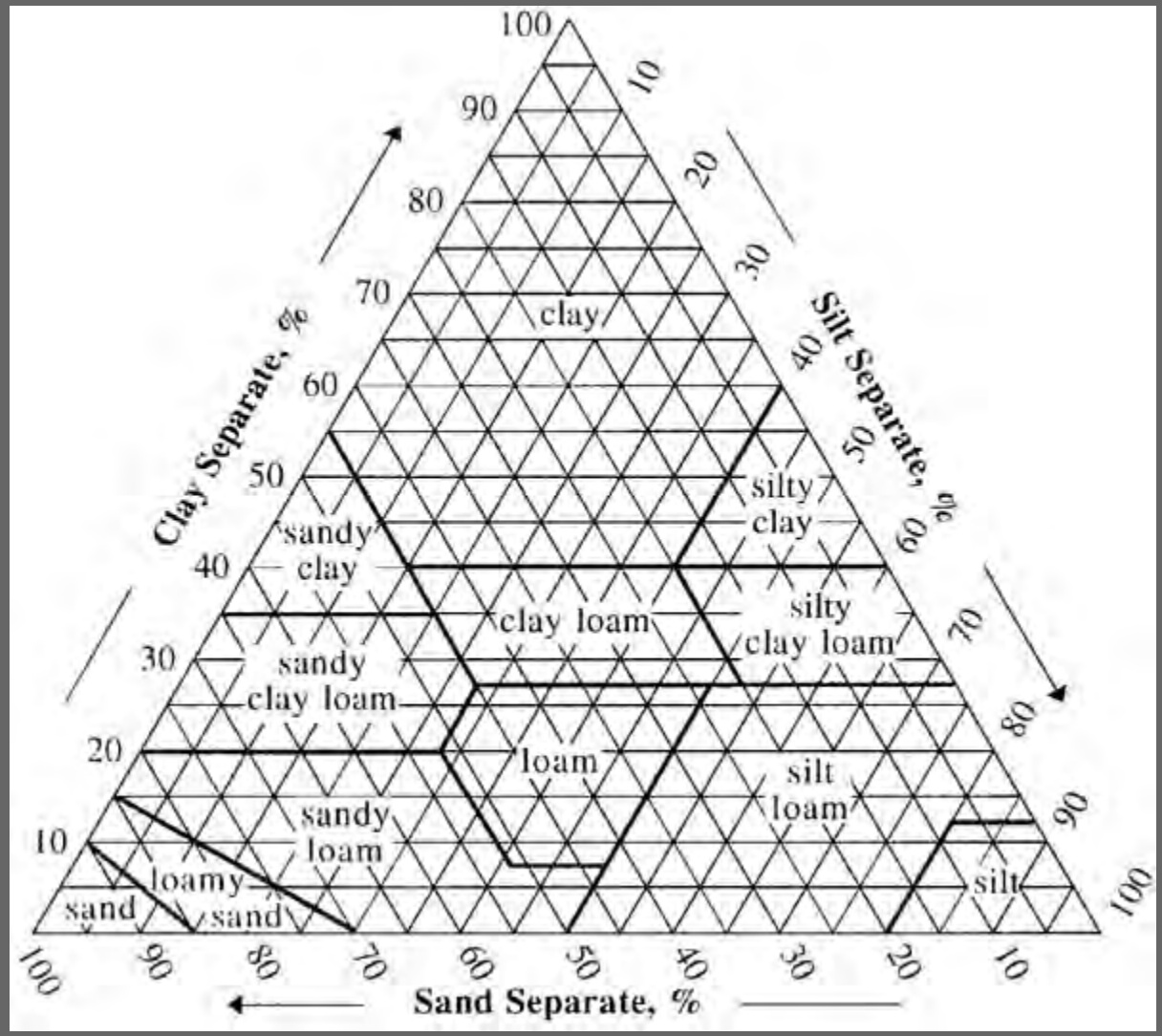
SOILS

If you can make a ball it will hold together with sustainable grades.

If you can make a ribbon it will not drain well, but hold steeper grades.

The more sand and less clay the better it will drain and resist puddling, but also erode easier.



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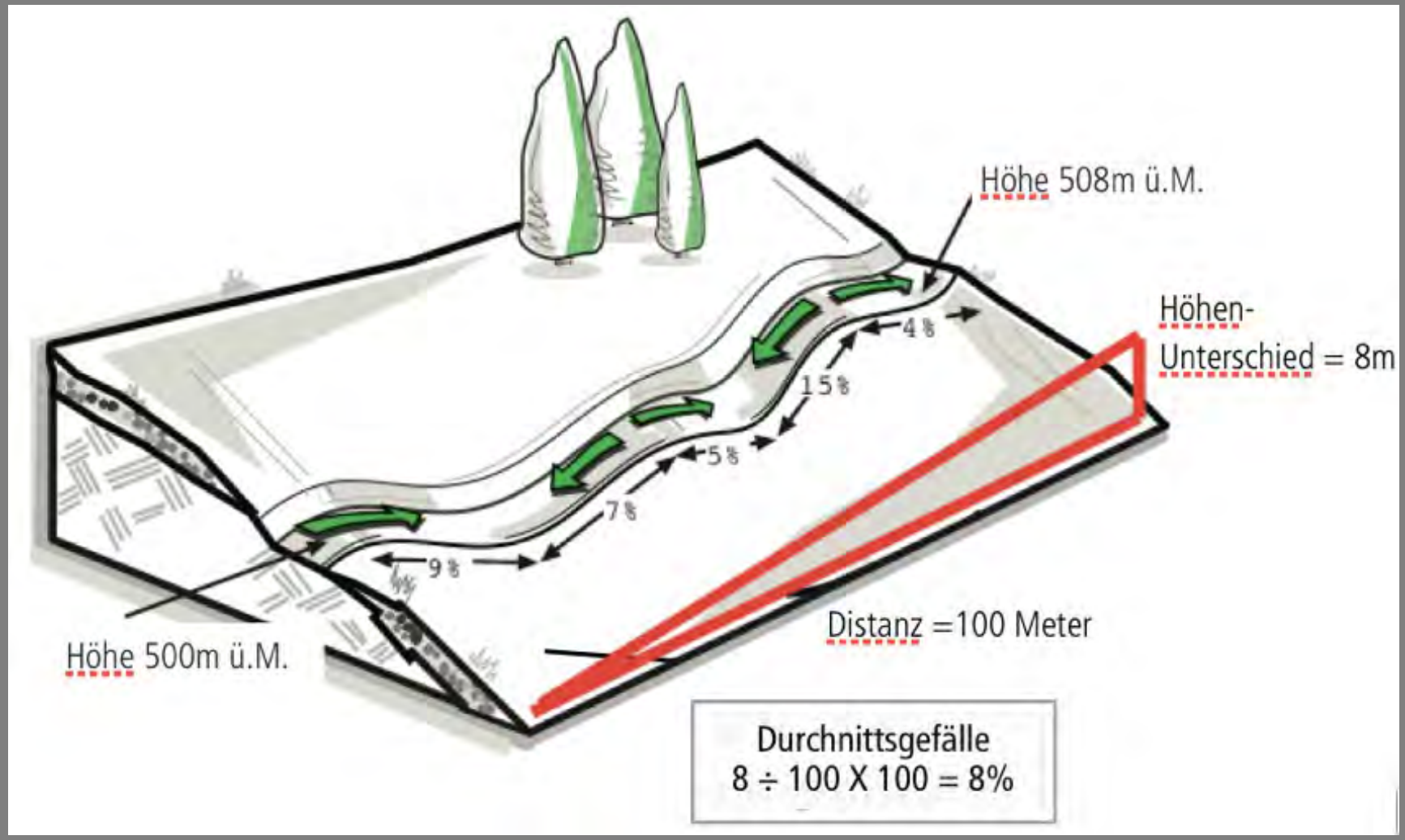
10% AVERAGE



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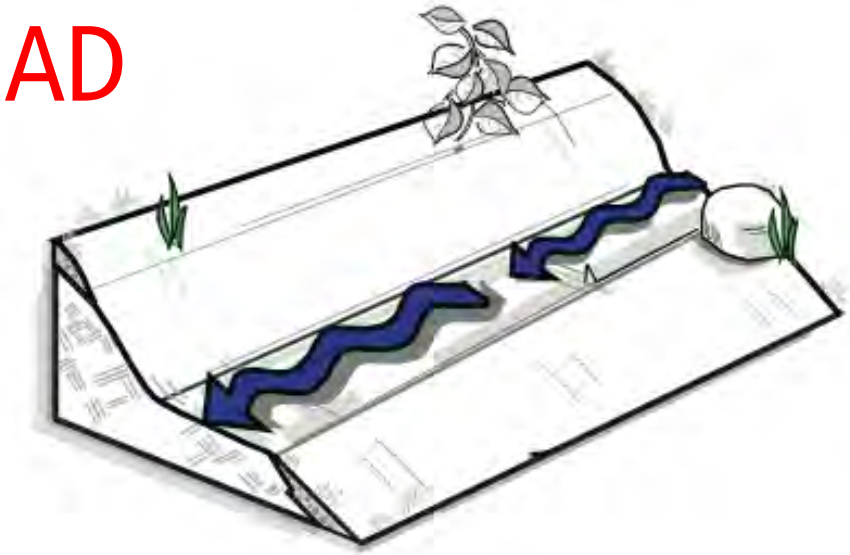
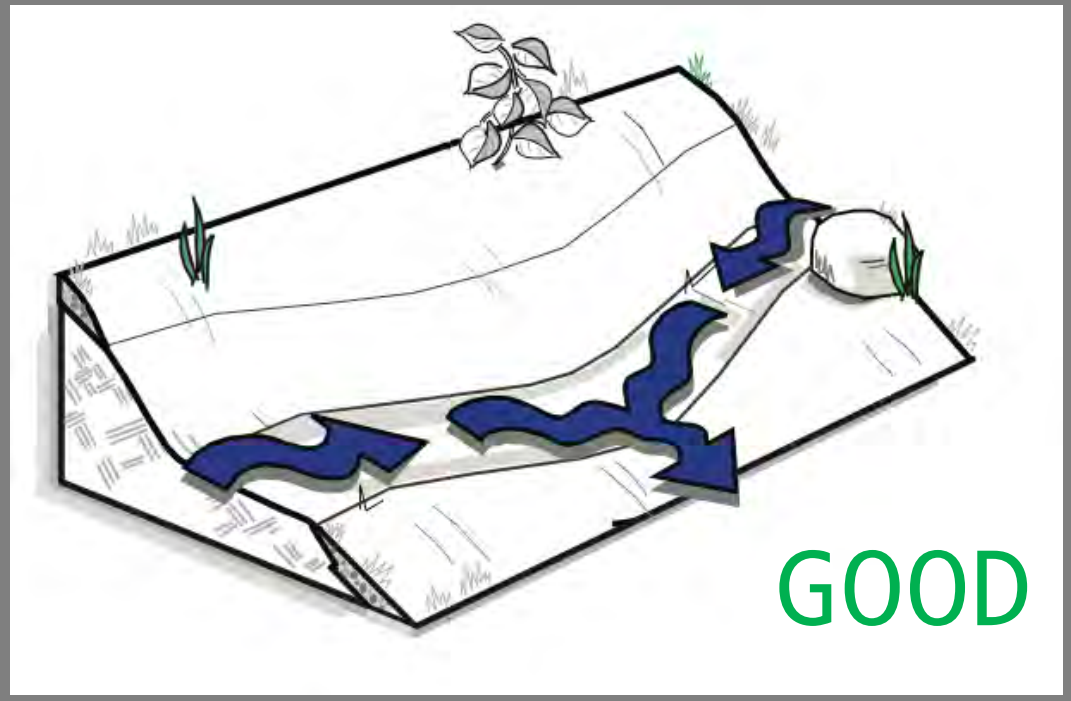
GRADE REVERSALS

BAD





GOOD

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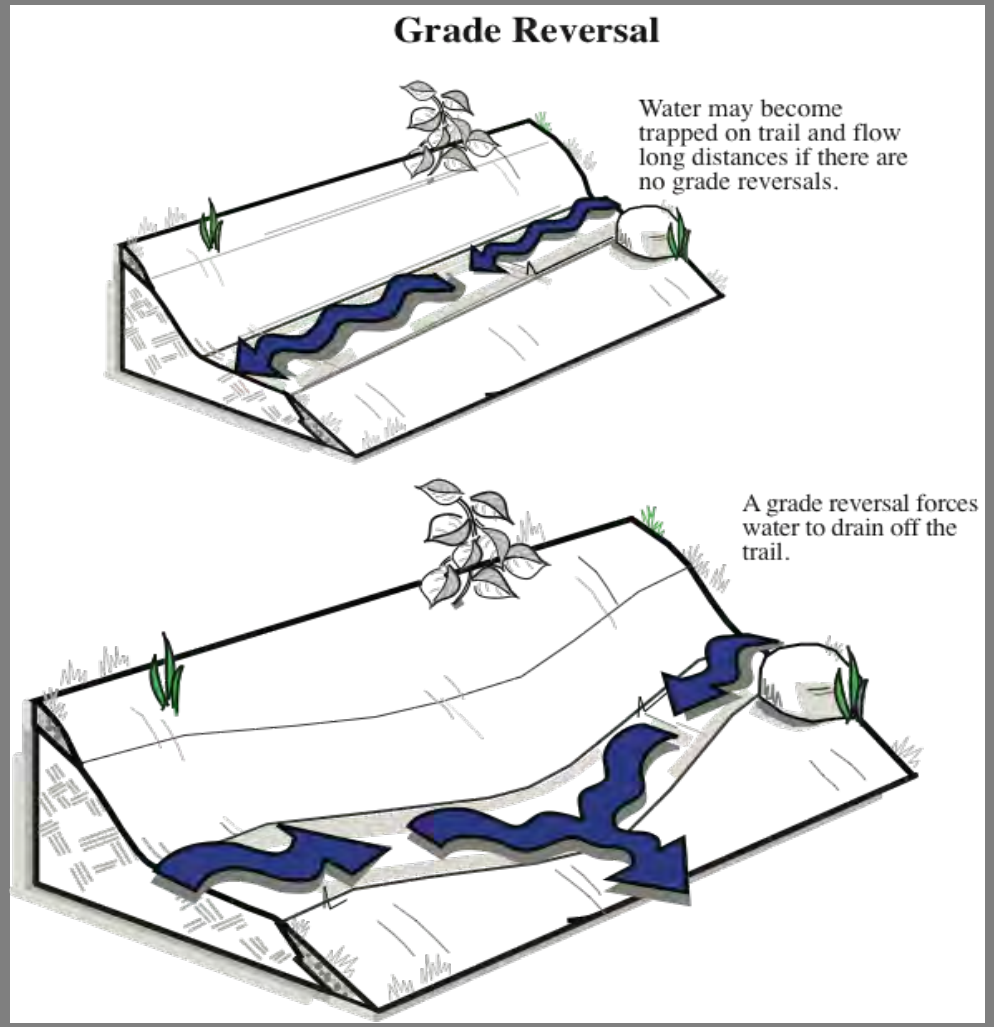
GRADE REVERSALS

GRADE REVERSALS



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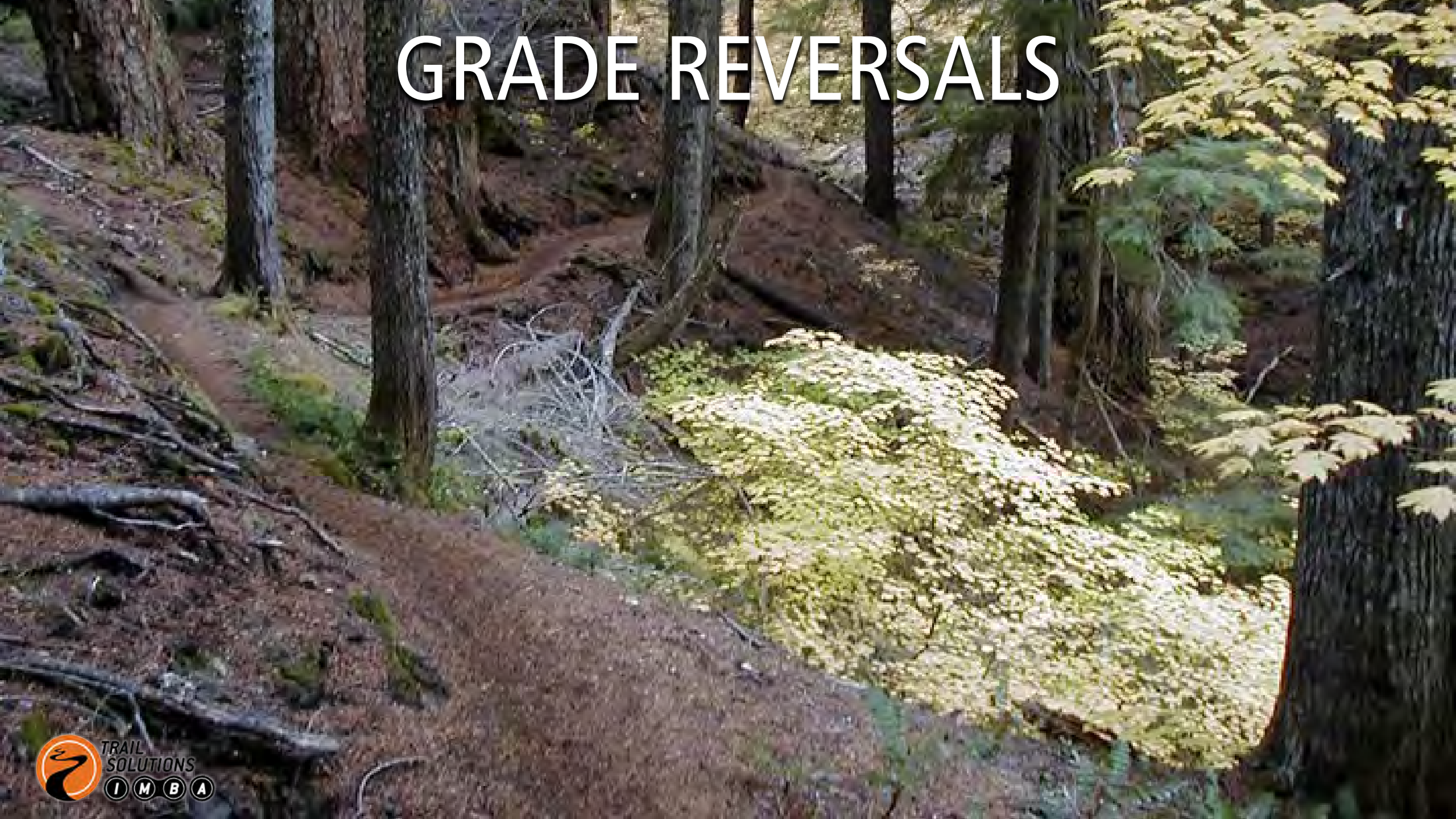
GRADE REVERSALS



GRADE REVERSALS

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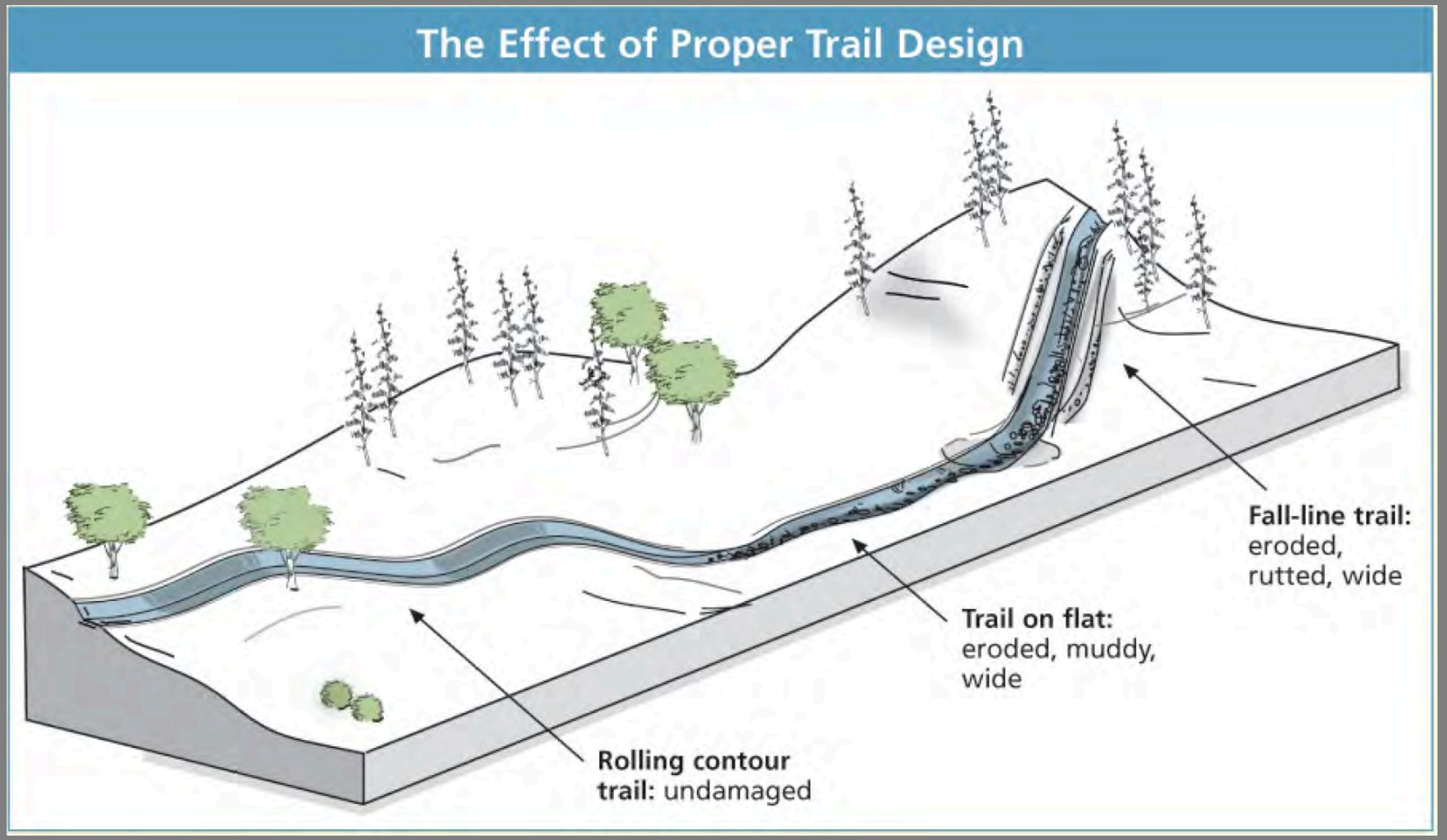
The Effect of Proper Trail Design



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USING A CLINOMETER

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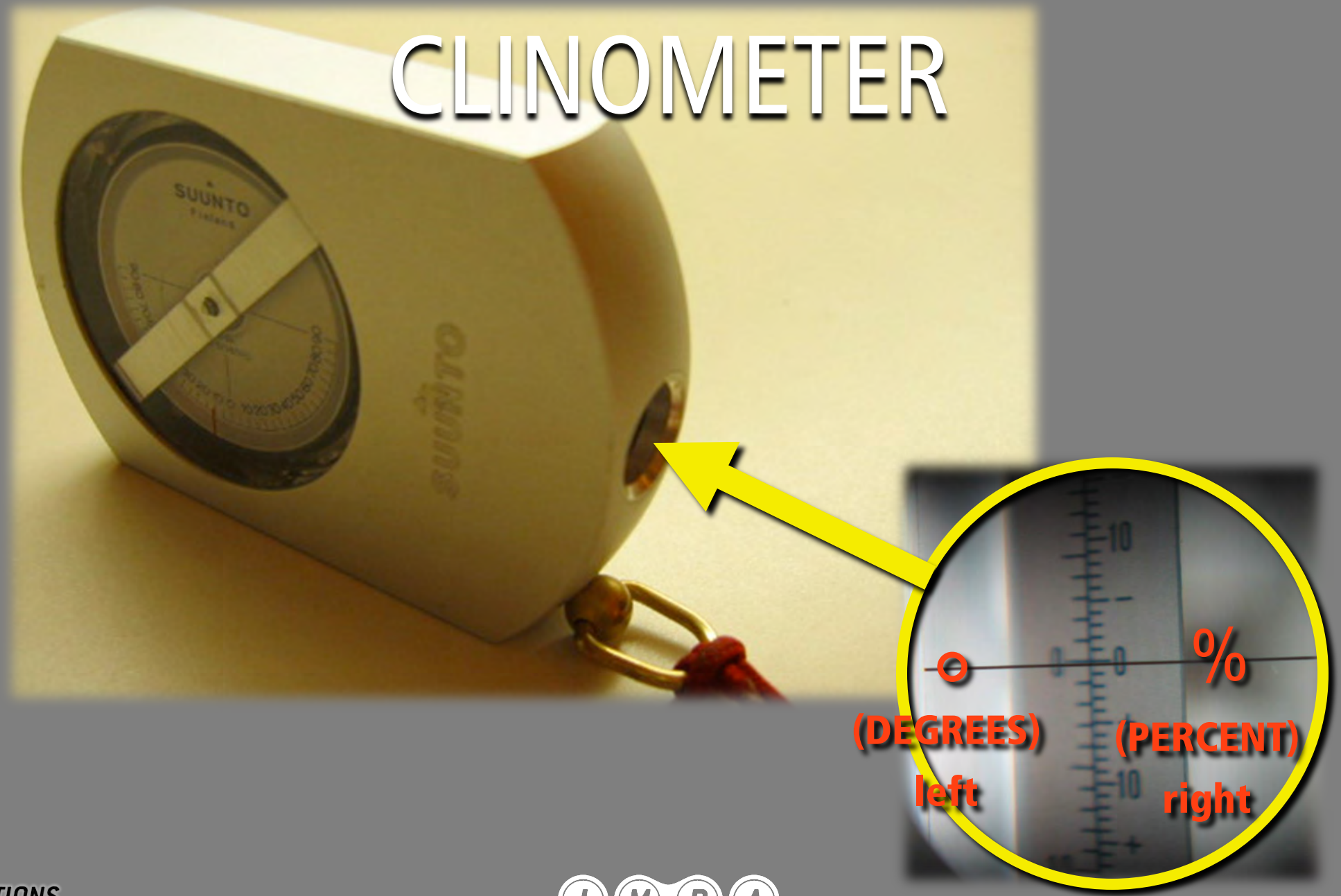
CLINOMETER



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CLINOMETER BASICS

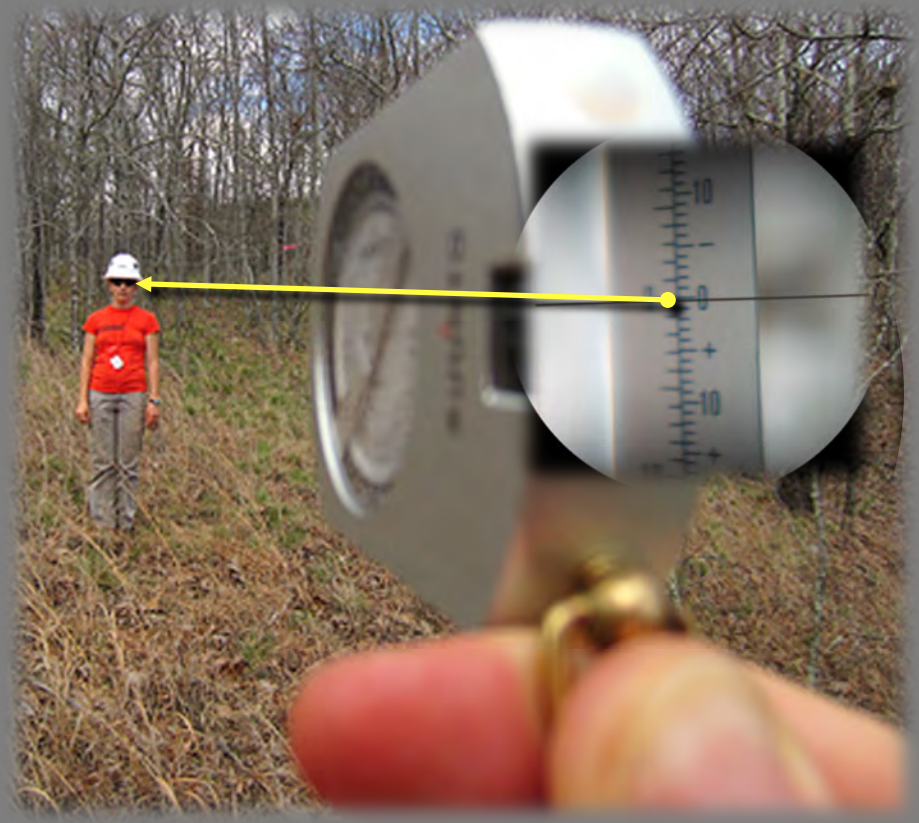
1. Work with a partner

2. Hold the clinometer up to your eye

3. Keep BOTH eyes open

4. “Zero out” with partner on LEVEL ground to determine site point

5. On the trail, align the horizontal line with partner’s zero point and read percentage grade



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WORK WITH PARTNER

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HOLD CLINO TO EYE; KEEP BOTH OPEN

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ZERO OUT ON LEVEL GROUND

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ON TRAIL, READ GRADE

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TRAIL FLOW

- Determine the flow and feature frequency for the corridor
- Flow is hard to define, go ride a bike! Good flow is the sweet spot between anxiety and boredom.
- Understanding the flow of a trail can help reduce erosion and user conflict.
- Bad flow is a common cause of trail damage
- Use the natural terrain to create organic flow instead of forcing the flow.
- Match type of flow with vegetation and terrain
- The flow of a trail is not unlike the flow of a road. If you're driving along on a highway, engineers have designed it in a way that you will ideally be able to maintain a certain speed, never having to slam on your brakes to make a corner. The difference is that roads have speed limits and signs to warn for sharp corners. On trails this should all be done through design.
- Think of design speeds, is this trail supposed to be fast with air? Slow with challenge?

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TRAIL FLOW

Consistent Flow

All trails have a rhythm or tempo determined by the landscape and the sequence of turns, ups and downs, and trailside objects. Smooth and consistent flow can reduce user-caused soil movement by minimizing locations where visitors are forced to exert more ground force or sideways motion to stay on track. The goal is to strategically manage the trail user's speed and momentum through trail design, thus preventing soil displacement. It's key is to avoid abrupt transitions that are likely to make cyclists brake hard or skid, resulting in braking bumps, trail widening, and, in extreme cases, users going off trail. You want users to pack the soil into the ground, not move it off the trail.

Much a song a change in the rhythm and tempo mid trail can be desirable.

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TRAIL FLOW

Open and Flowing:

- Long Sweeping Corners
- Good Sightlines
- Relatively Higher Speeds

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TRAIL FLOW

Tight and Technical:

- Twisting, Tight Turns
- Emphasis on Balance
- Relatively Slow Speeds

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TOOLS FOR DESIGN

GIS & Google Earth

Avenza or other mobile mapping map tools

GPS enabled device that can view geo referenced maps and images (phone, tablet, or GIS specific device)

Clinometer

Flagging tape

Permanent marker

Plastic markers for signs

Waterproof note taking tool (tablet of rite in rain and pencil

Soil Probe & soil sample bags

Food, water, first aid kit, and appropriate attire.

Cell phone or SPOT style device for emergency

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FLAGGING CONVENTIONS

Flagging Tape

Solid colors are best. Use two combined colors before patterns. Blue is most visible. Check what colors are already in use or allowed by land owner

Flagging Symbology

1 flag = trail corridor, 2 flags = 90+ degree turn or significant change in condition such as road to new trail or open to dense veg, 3 flags = end of flagline (don't bother looking for another flag). Knot side indicates trail side.

Styles

Build line - downhill/anchor - mark grade reversal anchors on down hill edge of trail

Corridor - Center of corridor may allow builders choice in wider corridor

Intersection Marking

Plastic placards with segment numbers, intersection schematic, and hub ID#

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TRAIL CORRIDOR MARKING

- Always flag and mark assuming it will not be you that has to follow the flagline.
- The easier it is to follow and interpret the more likely it will get approved and that you'll get a better price quoted. The more likely the trail you intended to be built, is actually built.
- If those who follow your flags can't find them they 'll assume the rest of your project management is of the same quality.
- A good trail hinges on good design. Do not shortcut this part of the process.

"Any other feature of construction may be improved from month to month or from year to year, but if the grade is not properly established the trail must in time be abandoned. Thus not only may time and money be wasted, but the trail while in use will be unsatisfactory" – USDA Forest Service, *Trail Construction on National Forests*, 1915

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TRAIL CORRIDOR MARKING TIPS

- Start from major control points; trailhead, access, point, hub, intersection, scenic view, water crossing, crux point between cliffs, etc.
- Flagging with a partner allows easier clinometer use and two sets of eyes and minds. If there is a team flagging, everyone has to be on the same page as far as standards and plan.
- Have a design plan. What needs to be flagged first? Is there a phasing plan? What areas are harder to flag (remote, challenging terrain, difficult trail type, etc.)? What is the easiest to flag? Knowing your way around the site is key.
- As is the case with all planning/design; flagging is iterative. In general expect to walk 2-4 miles for every 1 flagged miles. Sometimes its useful to flag part of a segment from one major/minor control point, then skip ahead to the next major/minor control point and flag back. This ensures the control points are used and while it involves more hiking, is an efficient approach to dialing in a good corridor.
- Remember your corridor guidelines, is this an intermediate flow trail? A beginner gateway trail? An advanced technical rocky shared-use singletrack? What are your acceptable corridor grades? How wide is the specialist reviewed corridor?
- Think sightlines on shared-use trails! Is the alignment rounding a natural terrain feature like a ridge where sightlines are shorter? Go uphill in both directions if possible. Are you in tight, dense vegetation? Meander and make the trail go up and down more to slow visitors speeds naturally.
- Identify your minor control points through fieldwork (this may be more planning type visits, a pre-design visit, desktop assisted, etc.) Turns are often very important minor control points. Finding good turn locations and working iteratively back to your previous flagline will ensure you use the right turn location.
- Turns are an easy way to gain separation from other trails or negative control points. A quick chicane (2 turns, serpentine S-curve) can buy elevation or separation easily. But turns must be appropriate for that trail experience and terrain location.
- Water crossing locations are likely a major or minor control point, you may want to start flagging from these points back to a previously flagged section of the trail, again in an iterative approach to dial in a corridor that matches the planned trail objectives with the terrain and the identified control points.
- Don't be afraid to change flaglines during design!

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TRAIL INVENTORY TIPS

- When do you identify features, units, etc.? If there is a team of designers, you may have one member following flagging crews to collect important data. If you are with a partner or alone, you may walk that line after its flagged. Collecting data (including GPS tracks) during the initial flagging can be difficult due to the iterative approach suggested. It can be useful to track during the first design, but a follow up clean walk of the flagline will allow one to have fresh eyes for more detailed information collection.
- How much information/data do you need? As much as you need for compliance and a successful build! In general its good to know what will make a segment difficult or unique to build. Are the turns on steep slopes that require retaining walls? Is there a low lying area with planned causeway that needs imported material? Will this lower segment on open gentle slopes planned as a flow trail require a different machine than the narrow, rocky segment above? Bridge? Rock armor? Rocky section?
- Pictures! Generally most phones can take GPS tagged photos, using an app like Avenza Maps you can embed these pictures in KMZ data points. This can be very useful when you want to go back later and remind yourself of something, such as why you called for rock armor in this one area, etc.
- Collecting units for competitively bid projects can be difficult (and is often part of the larger bid package development) – you may want professional assistance.

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COST ESTIMATING: TRAIL & FEATURE INVENTORY

YONAH PRESERVE TRAIL CONSTRUCTION PROJECT

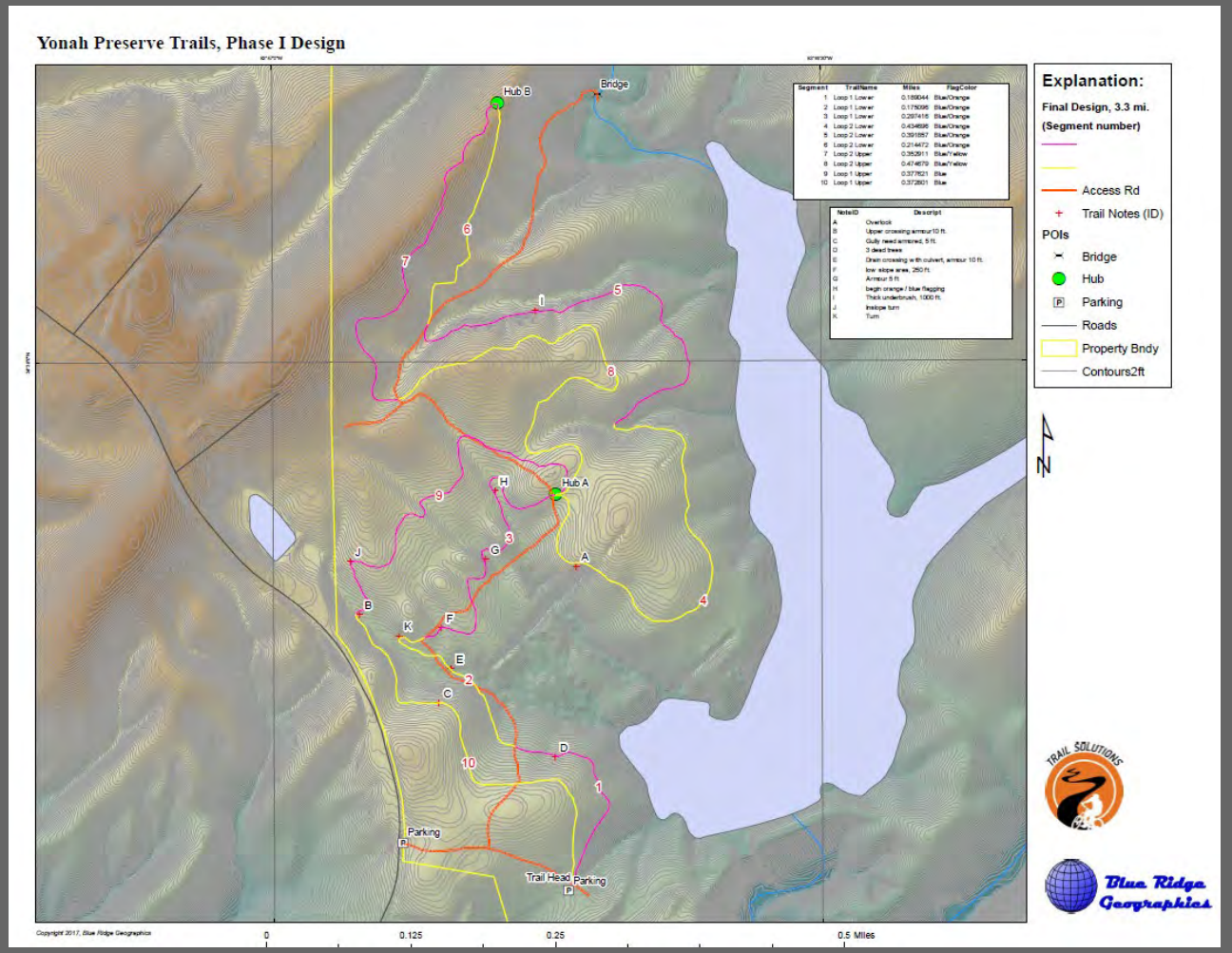
11.2 Bid Worksheet B

YONAH PRESERVE TRAIL CONSTRUCTION PROJECT WORKSHEET B

Item	Unit measure	Estimated Quantity	Price	Total
Mobilization	Lump Sum	1		
Tread Grading (type I)	Linear foot	16424		
Rock Armor	Square Foot	750		
Insloped Turn	Each	2		
Rock Retaining Wall	Square Foot	250		
Rock Rip-rap	Square Foot	200		
Wattle	Linear foot	200		
Tread Grading (type II)	Linear foot	1000		
			Total	

Construction of typical trail features that are approximately 12" or less in height are included in the base trail cost and will not be bid as separate feature units (ex. rollers, grade reversals <12").

Contractors cannot invoice for both trail construction and constructed features of a given linear foot of trail. Features not only include the trail itself, but also any elements used to create the feature, including the required drainage elements before and after. For example, a turn is billed as a "whole" unit. The unit starts at the initiation of the uphill and completion of the downhill drainage structures. Contractor cannot invoice for both trail construction and armoring, bridging, or boardwalks of a given linear foot of trail.



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COST ESTIMATING: UNIT STYLE

Determine what units to use to estimate cost and/or bid project

Types of trail – May differentiated by style, difficulty, terrain, and location

Expensive Features such as rock armor, turns, walls, signs, bridges, boardwalks.

Imported materials – rock, gravel, soil, wattle, jute mat, logs

List by measurable units - Linear Foot, Square Foot, Face Foot, Cubic yard

1a	*Bethel Entrance*				COMPLETE
	Trail Tread I	357	$ 6.50	$	2,320.50
	Rock Armor	38	$ 20.00	$	760.00
	Rock Foundation		$ 12.50		
	Soil Stabilization	900	$ 0.20	$	180.00
				$	**3,260.50**
1b	*Bethel Overlook*				COMPLETE
	Trail Tread I	1690	$ 7.50	$	12,675.00
	Turn II	3	$ 2,500.00	$	7,500.00
	Rock Armor	205	$ 20.00	$	4,100.00
	Rock Wall	65	$ 30.00	$	1,950.00
	Rock Foundation	450	$ 12.50	$	5,625.00
	Soil Stabilization	3250	$ 0.20	$	650.00
				$	**32,500.00**
16b	*GTFOH*				COMPLETE
	Trail Tread II	750	$ 6.50	$	4,875.00
	Turn Type II	3	$ 2,500.00	$	7,500.00
	Rock Foundation	450	$ 12.50	$	5,625.00
	Soil Stabilization	2400	$ 0.20	$	480.00
				$	**18,480.00**
17a	*Boundary*				COMPLETE
	Trail Tread I	800	$ 6.50	$	5,200.00
	Soil Stabilization	2500	$ 0.20	$	500.00
				$	**5,700.00**
15a1	*Take Me Home*				COMPLETE
	Trail Tread I	650	$ 6.50	$	4,225.00
	Rock Armor	60	$ 20.00	$	1,200.00
	Soil Stabilization	800	$ 0.20	$	160.00

Project	Work	Unit measure	Price	Estimated Quanity	Estimated Total
A	**Keyawee Trail -**				
	Trail Construction	Linear foot	$6	1600	$9,600
	Trail Reroute	Linear foot	$6	200	$1,200
	Rock Armor	Square Foot	$75	250	$18,750
	Insloped Turn	Each	$200	2	$400
	Rock Retaining Wall	Square Foot	$150	250	$37,500
	Rock Rip-rap	Square Foot	$50	200	$10,000
	Straw Wattle	Linear foot	$50	250	$12,500
	Trail Closure	Linear foot	$2	300	$600
					$90,550

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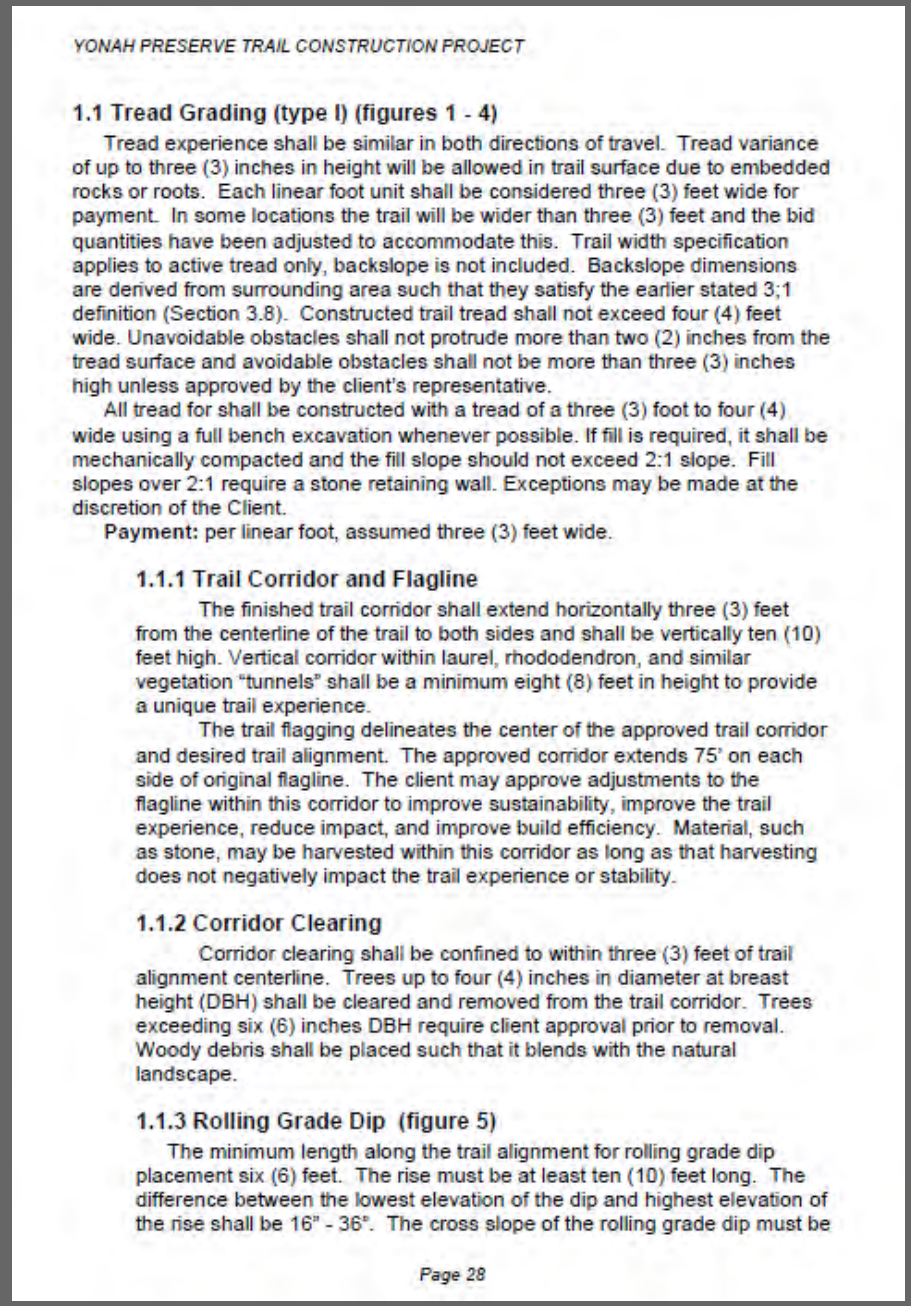
LEVEL OF DETAIL

When competitively bidding a build provide enough detail to ensure bidders are bidding on the same items.

Measurable specifications are necessary to ensure bids can be prepared and that contractor can be held to their bid.

This is extremely important when bidding out work using taxpayer funds.



1.1 Tread Grading (type I) (figures 1 - 4)

Tread experience shall be similar in both directions of travel. Tread variance of up to three (3) inches in height will be allowed in trail surface due to embedded rocks or roots. Each linear foot unit shall be considered three (3) feet wide for payment. In some locations the trail will be wider than three (3) feet and the bid quantities have been adjusted to accommodate this. Trail width specification applies to active tread only, backslope is not included. Backslope dimensions are derived from surrounding area such that they satisfy the earlier stated 3;1 definition (Section 3.8). Constructed trail tread shall not exceed four (4) feet wide. Unavoidable obstacles shall not protrude more than two (2) inches from the tread surface and avoidable obstacles shall not be more than three (3) inches high unless approved by the client's representative.

All tread for shall be constructed with a tread of a three (3) foot to four (4) wide using a full bench excavation whenever possible. If fill is required, it shall be mechanically compacted and the fill slope should not exceed 2:1 slope. Fill slopes over 2:1 require a stone retaining wall. Exceptions may be made at the discretion of the Client.

Payment: per linear foot, assumed three (3) feet wide.

1.1.1 Trail Corridor and Flagline

The finished trail corridor shall extend horizontally three (3) feet from the centerline of the trail to both sides and shall be vertically ten (10) feet high. Vertical corridor within laurel, rhododendron, and similar vegetation "tunnels" shall be a minimum eight (8) feet in height to provide a unique trail experience.

The trail flagging delineates the center of the approved trail corridor and desired trail alignment. The approved corridor extends 75' on each side of original flagline. The client may approve adjustments to the flagline within this corridor to improve sustainability, improve the trail experience, reduce impact, and improve build efficiency. Material, such as stone, may be harvested within this corridor as long as that harvesting does not negatively impact the trail experience or stability.

1.1.2 Corridor Clearing

Corridor clearing shall be confined to within three (3) feet of trail alignment centerline. Trees up to four (4) inches in diameter at breast height (DBH) shall be cleared and removed from the trail corridor. Trees exceeding six (6) inches DBH require client approval prior to removal. Woody debris shall be placed such that it blends with the natural landscape.

1.1.3 Rolling Grade Dip (figure 5)

The minimum length along the trail alignment for rolling grade dip placement six (6) feet. The rise must be at least ten (10) feet long. The difference between the lowest elevation of the dip and highest elevation of the rise shall be 16" - 36". The cross slope of the rolling grade dip must be

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RISK MANAGEMENT

Never say safe - the outdoors is risky!

Risk management is a critical element to mitigate financial liability and personal injury.

Appropriate risk management techniques should be included in design and construction planning documents.

Allow public to make informed decisions about potentially dangerous activities.

Inform, offer progression, & facilitate wayfinding.

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RISK MANAGEMENT

Operations and Maintenance (O&M)

"If you don't have an O&M plan you're running blind and planning for crisis response solutions."

- An O&M plan can be a useful management tool and liability reduction tool.
- Draft near the end of the design phase to facilitate creating operation budgets and determine inform the owners risk management.

INSPECTION AND MAINTENANCE GUIDELINES

BIG MARSH BIKE PARK

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SILO CENTER BIKE PARK
OPERATIONS AND MAINTENANCE PLAN

JUNE 2017

PREPARED FOR: 21st Century Parks

PREPARED BY: The International Mountain Bicycling Association
Trail Solutions Program

THE PARK LANDS of Floyds Fork

TRAIL SOLUTIONS IMBA

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RISK MANAGEMENT

Developing a signage plan is part of the design process.

Signage should:

- Inform of risks and responsibilities (hold harmless language)
- Present expected behavior
- Give guidance on difficulty
- Allow for successful navigation and wayfinding
- Be reviewed by a Personal Injury attorney in your state and the land owner.

Caution : The local laws and case history determine the optimal hold harmless language for your location

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ADVANCED DESIGN TOPICS

- Road to Trail & Road to Flow
- Water Crossing and Wet Areas
- Competitive Venues
- If you have questions about these topics please ask in Slack or during the webinar.

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Thank You!
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“The mountains call and I must go.”
-John Muir