The SET test for Trail Features | Sustainable. Effective. Traversable.

History

The SET test is born out of 25 plus years of trail maintenance experience and a realization that many features built on trails don't last very long, are ineffective, and/or are user impediments.

Firmly rooted in sustainable trail principles, the SET test can help a legacy trail that was not built sustainably to become more manageable.

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The goal of the SET test is to give land managers, trail crews, and trail maintainers a tool to assess existing or planned built trail features.




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Definitions

So what is the SET test?

- It is three questions we can ask of all trail features.
- To pass the SET test, a feature must satisfy all three criteria.

S is for sustainable. The feature must last a long time, must serve its function for a long time, and must require minimal maintenance.

E is for Effective. The feature must accomplish its purpose, and do so for a long time, with minimal maintenance.

T is for Traversable. The feature must be easy enough to traverse that it does not force users off the trail. Preferably they don't even notice it.

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Definitions

Before we start, lets define a few common trail terms.

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Definitions

Legacy trails

Most of the trails in our mid Atlantic region are **Legacy Trails.**

Legacy trails are trails that were built before the concept of **sustainable trail design** was developed. Legacy trails are often old roads or farm tracks, or the shortest distance between two points. No thought was given to water management.

This results in **fall-line trail,** which goes straight up and down the slope. Water runs straight down the trail, erosion turns the trail into a gully.

Often the trail is in an old road bed that is already a gully - there is nowhere to drain water but down the trail.

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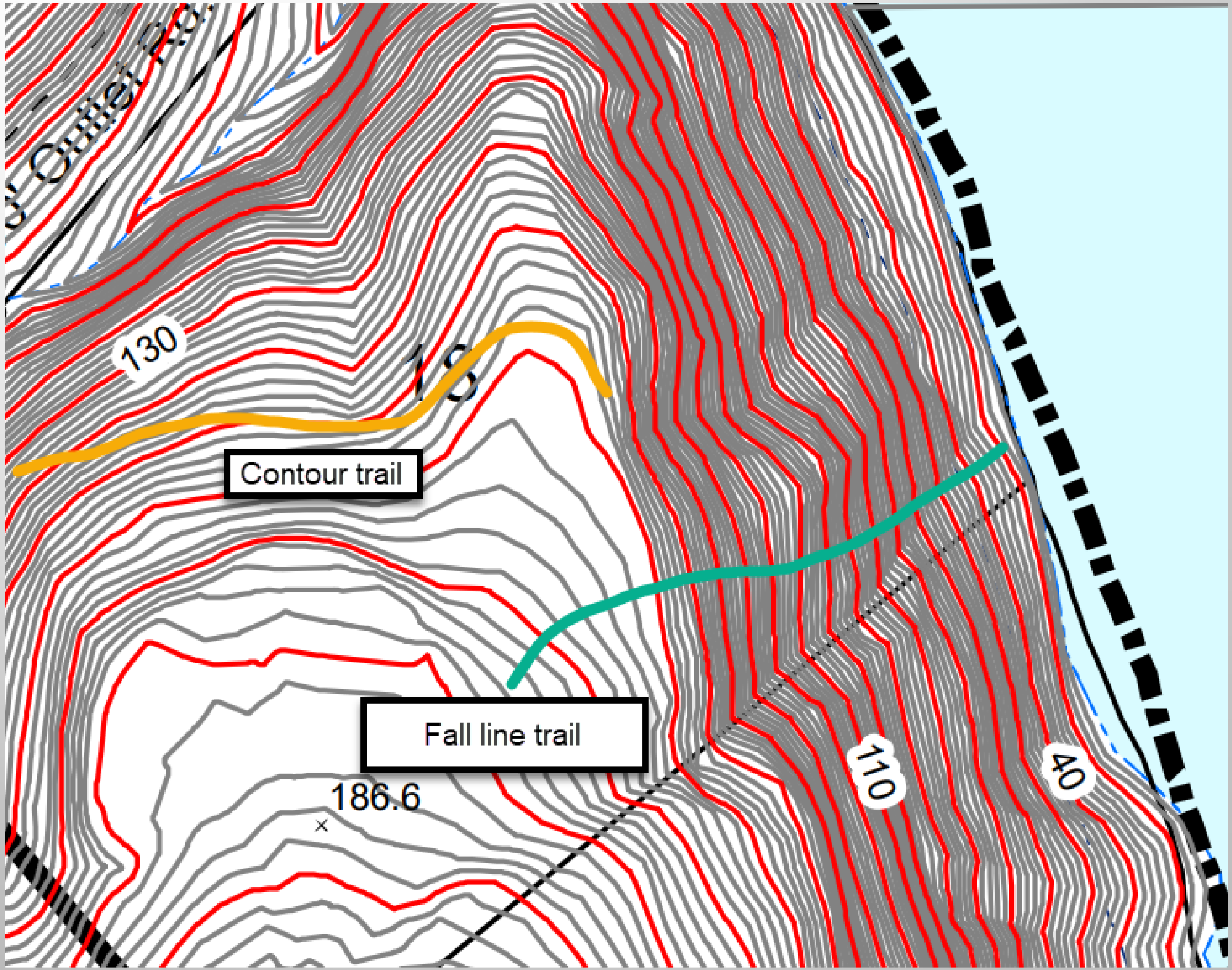
Definitions

Fall line alignment



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Our number one trail issue generally is water.

The SET Test can be applied to basically any built feature, but as water is our main issue, we will start with discussing water.

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Why is water on the trail bad?

1. Soil loss (erosion)

Moving water carries away soil, harming the trail, making it less safe or appealing to walk.

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Why is water on the trail bad?

2. Trail Widening; rough trail

Moving water carries away soil, leaving a rough surface on which people don't want to walk so they move off to the side.

This strips off the organic cover, and allows soil loss to accelerate in the new location, and the trail keeps getting wider.

The bare soil sheds rain water faster, increasing run off and soil loss down slope.

More trampled area increases the environmental impact of the trail.

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Why is water on the trail bad?

2. Trail widening; muddiness

Hikers tend to avoid wet or muddy trail, leading to trail widening or the creation of bypass trails.

More trampled area increases the environmental impact of the trail.

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Why is water on the trail bad?

3. Environmental degradation

The soil removed from the trail usually ends up in the local creek or stream, degrading water quality, harming aquatic vegetation and animals.

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Why is water on the trail bad?

1. Soil Loss
2. Trail widening
3. Environmental degradation

So what do we do about it?

First, lets talk about the basic physics of water on the trail.

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Water dynamics-Principles for trail builders

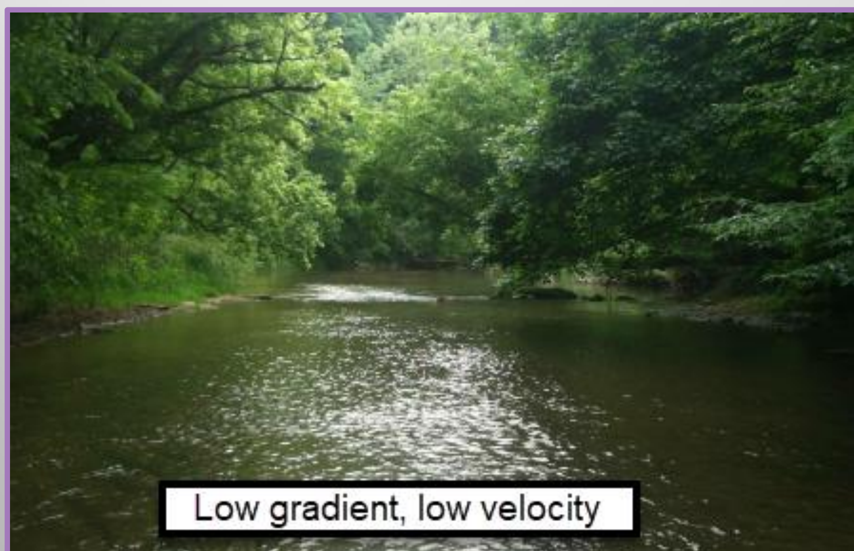
Velocity = volume x gradient

- Velocity = speed of the water = erosive power
- The faster the water moves, the more it can erode the trail

Water dynamics-Principles for trail builders

Velocity = volume x gradient

- Velocity = speed of the water = erosive power.
- The faster the water moves, the more it can erode the trail
- The steeper the gradient (slope) the faster the water moves. Think flat slow creek vs. steep fast mountain creek



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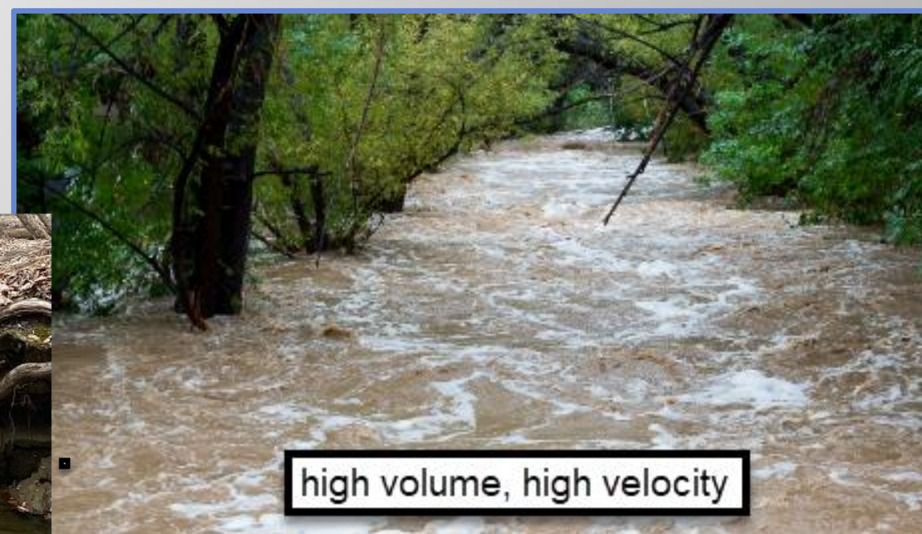
Water dynamics-Principles for trail builders

Velocity = volume x gradient

- Velocity = speed of the water = erosive power.
- The faster the water moves, the more it can erode the trail

- Volume-the more water there is, the faster the water moves. Think creek in drought vs. flood



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Water dynamics-Principles for trail builders

Water moves soil in two ways.

1. The suspension load is small particles suspended in the water. This is what makes flood waters muddy. The water is mixed with fine particles of soil.

2. The traction load is larger particles, pebbles, rocks, even boulders. This is material that rolls and bounces down the trail, pushed by the moving water. The more water, the greater the velocity, the bigger the pieces that the water can move.

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Water dynamics-Principles for trail builders

- ❑ Moving water picks up and transports soil. (Erosion) Think Grand Canyon .

The converse is also true and important to understand for trail drainage.

- ❑ Water that slows down drops its sediment load. (Deposition) Think Nile delta.

Much more about deposition later!

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Water dynamics-Principles for trail builders

So the two factors that control soil loss from water on the trail are:

1. Steepness of the trail, the trail grade
2. Amount of water (volume) on the trail.

Our goal is to reduce the velocity of the water on the trail to the point where it cannot erode soil from the trail.

Since we cannot control the **grade** of the existing trail (unless we relocate the trail) we need to focus on controlling the **volume** of water on the trail.

What's the classic way to remove water from the trail?

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The Water Bar!!!

Remember our goal is to remove water from the trail before it has enough volume to have sufficient velocity to erode the trail.

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Water bars are generally either stone, or wood.

Stone

Wood water bars

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Water bars

Generally the idea is that the water bar is built at a 45 degree angle to the trail, and forces water off on the low side of the trail

Waterbars

Waterbars are commonly used drainage structures. Make sure that waterbars are installed correctly and are in the right locat
Water moving down the trail turns when it contacts the waterbar and, in theory, is directed off the lower edge of the trail (figur
17).

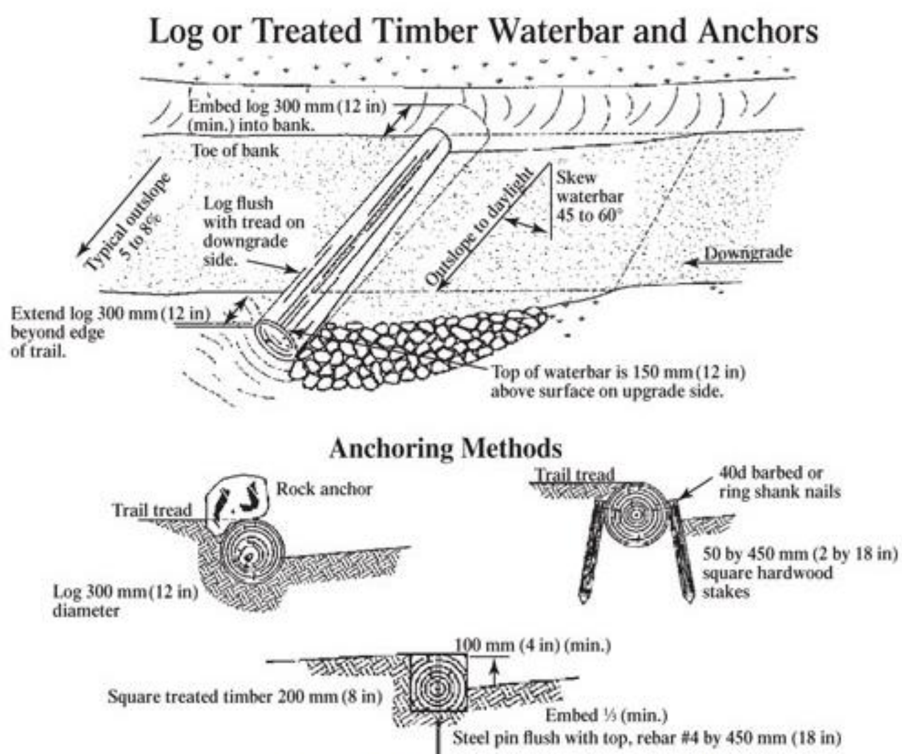

Figure 17—Logs used for waterbars need to be peeled (or treated with preservative), extended at least 300 millimeters (12 inches) into the bank, staked or anchored, and mostly buried.

From the US Forest Service Trail Notebook

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So lets apply the SET test to water bars. But first, lets review the SET test.

S is for Sustainable. The feature must last a long time, must serve its function for a long time, and must require minimal maintenance.

E is for Effective. The feature must accomplish its purpose, and do so for a long time, with minimal maintenance.

T is for Traversable. The feature must be easy enough to hike over that it does not force users off the trail. Preferably they don’t even notice it.

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Why do water bars fail?

Too short, water goes around

Why do water bars fail?

Too porous, water goes through

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Why do water bars fail?

Rots away

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Why do water bars fail?

The number one reason they fail and are high maintenance….
They silt up, and the water goes right over them

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Why do they silt up? It goes back to our water formula.

Fast moving water can carry sediment. As soon as it slows down it drops sediment. Remember the Nile Delta?

Water coming down the trail hits the water bar, slows down, drops its sediment load, and clogs the water bar.

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Fine soil and silt washed down from up trail that has been deposited behind the water bar

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Stones and silt washed down from up trail
that has been deposited behind the water bar

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If a water bar does not have a **drain** to carry the water away from the water bar, the water slows down or stops and drops its sediment load.
The area uphill of the bar silts up, and then the water just goes over it.

This lack of a good drain is what makes most water bars unsustainable and ineffective

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So the classic water bars (of which there are thousands on our trails) generally do not pass all three criteria of the SET test.

So what does?

Dips Are In, Bars Are Out

For existing trails with water problems, we encourage the use of rolling grade dips or knicks instead of waterbars. Here's why. By design, water hits the waterbar and is turned. The water slows down and sediment drops in the drain.

Waterbars commonly fail when sediment fills the drain. Water tops the waterbar and continues down the tread. The waterbar becomes useless. You can build a good rolling grade dip quicker than you can install a waterbar, and a rolling grade dip works better.

USDA United States Department of Agriculture
United States Forest Service
Technology & Development Program

Trail Construction and Maintenance Notebook

Surface Water Control 2007

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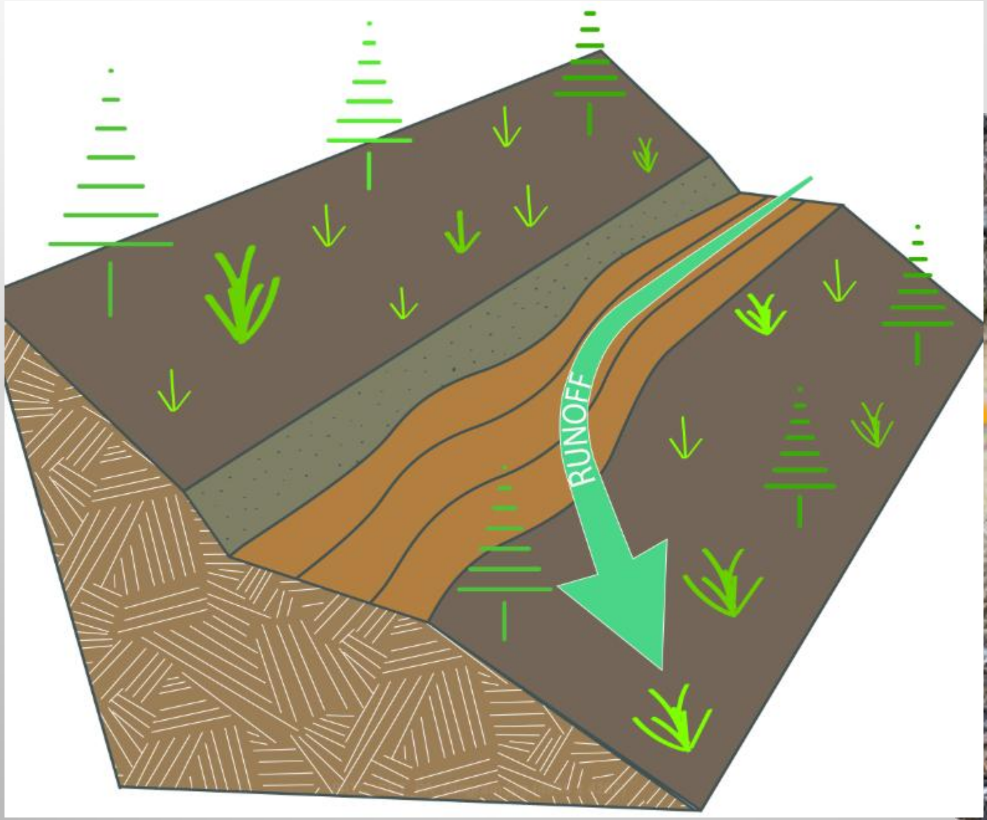
The Rolling Grade Dip

A wide sweeping drain, like the off ramp on a super highway, carries water off the trail. Water does not slow down!



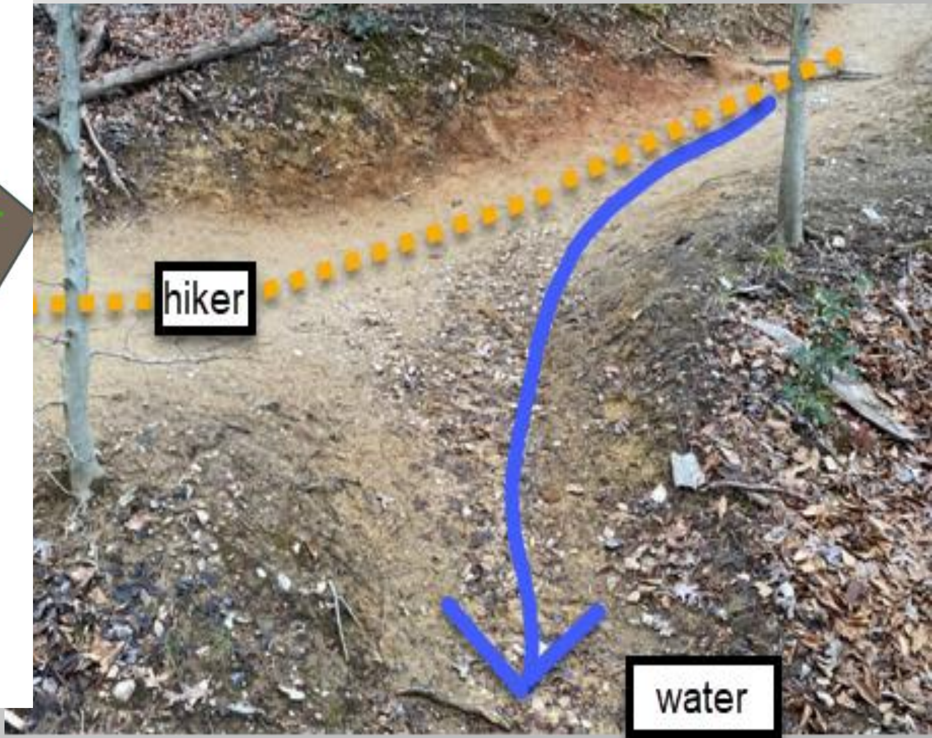


Diagram by
Abigail Ingram

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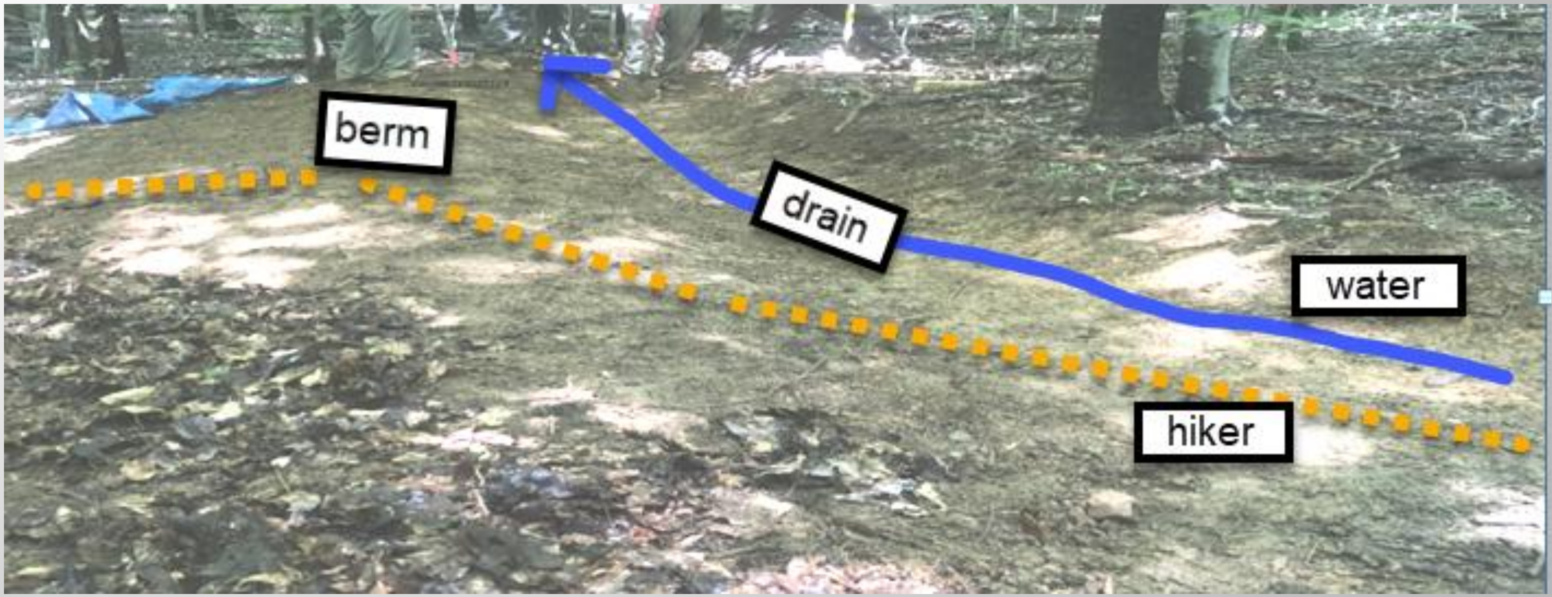
The Rolling Grade Dip

A wide, gentle berm helps guide water into the drain



Sustainable. Gentle sides and large size means the feature will last, and function, a long time.
Effective. The drain gets water off the trail.
Traversable. The gentle sides means the feature is easy to cross.

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Grade Dips

Berm is wide and gentle so it is stable and traversable

Drain is wide and gentle so it is stable and is difficult to block up

Sustainable. Gentle sides and large size means the feature will last, and function, a long time.

Effective. The drain gets water off the trail.

Traversable. The gentle sides means the feature is easy to cross.

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Grade Dips

There must be somewhere downhill for water to drain, and not back onto the trail.

Downhill side of the berm should be ramped gently down to the middle of the trail to help guide hikers where you want them to walk.

The **outslope** of the drain out must be as steep or steeper than the trail coming into the drain.
Prevents water from slowing down and dropping its sediment load.
Water that speeds up in the drain will help it stay self cleaning.

Steeper trail needs longer ramp.

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Grade Dips

Review

Drain

1. Gentle curve off trail so water does not slow down
2. Must be a place for water to go
3. Wide
4. Gentle sides
5. Steeper outslope than the tread grade along the direction of travel

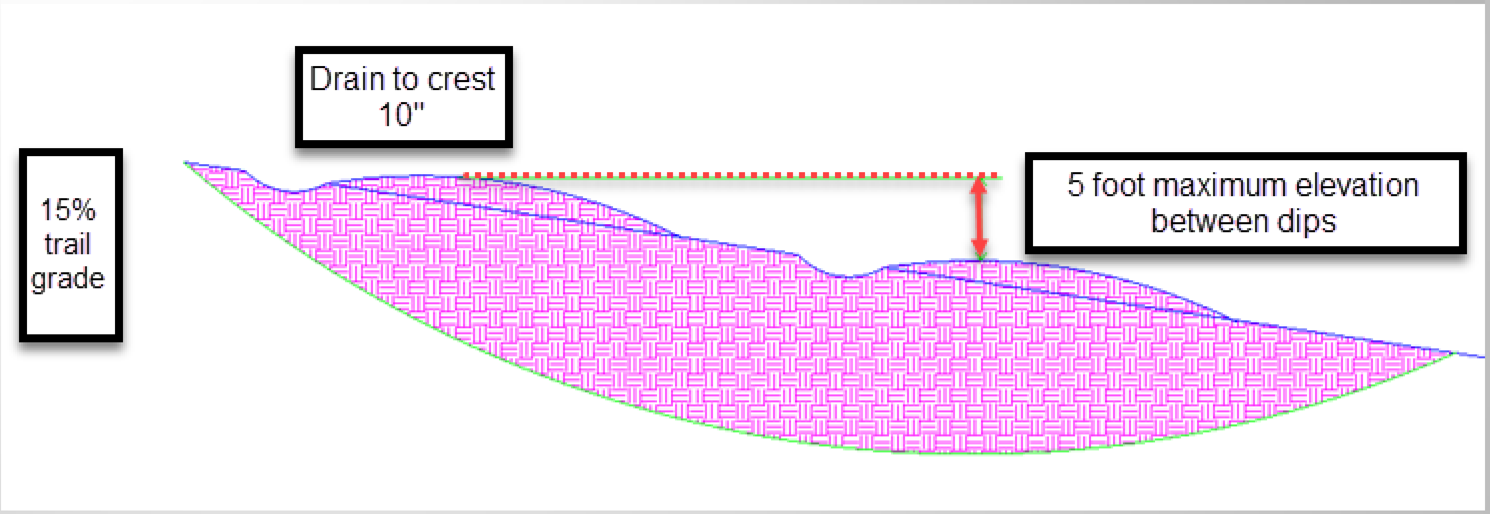
Grade Dips

Review

Berm

1. Wide and gentle
2. Follows sweep of drain
3. Ramp down back side
4. High enough to stop water
5. Overall size/volume sufficient to withstand compaction from use.
6. High road for the hiker.
7. Low road for the water

Grade Dips



Five foot maximum elevation change between dips.

More often (3’ or 4’) if big tread watershed, soft soil, heavy use

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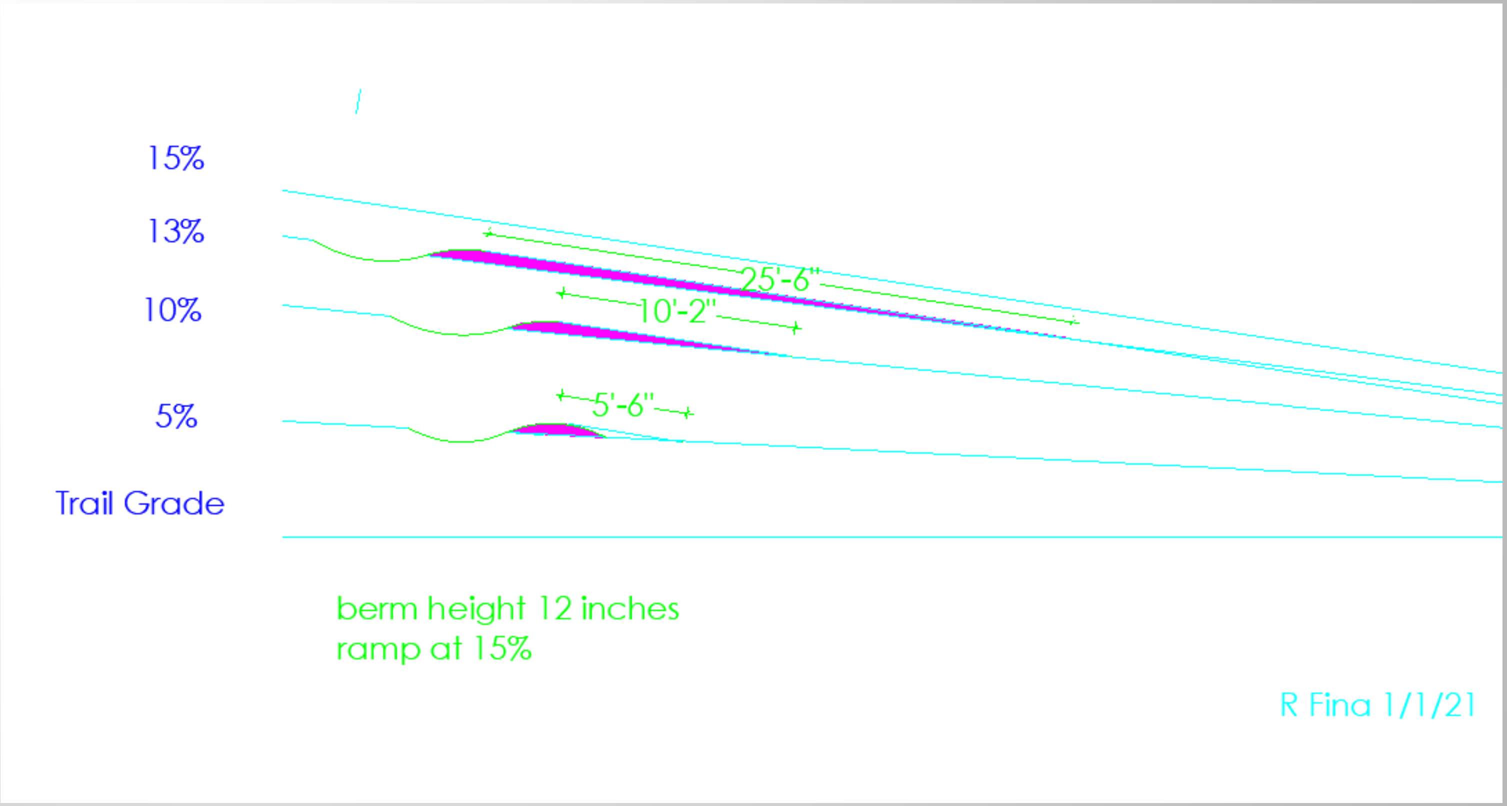

Grade dips work well on trail up to about 15% tread grade, after that the ramp down the back side starts getting too steep.

So what other options do we have?

The SET test: Flush Water Bar. Sustainable. Effective. Traversable.

Flush water bar

Top of water bar stones are flush with the trail and tightly fit together.

Water cannot run through the joints between stones because of solid soil backing.

There is a flat landing to step on rather than having to step over the water bar.

Same principles as a rolling grade dip:

Drain must continue far enough off the trail that water does not flow back onto the trail.

Wide, drain with gentle sides lets leaves blow out, sides will not cave (collapse) inward.

Sustainable. Stone bar and large size means the feature will last, and function, a long time.

Effective. The large drain gets water off the trail.

Traversable. The gentle sides and low bar means the feature is easy to cross.

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The SET test: Landing Water Bar.

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Drain shallow on this end - easy to walk over.

Top of water bar stones are **flush** with the trail and tightly fit together.

Water cannot run through the joints between stones because of **solid soil backing**.

There is **a flat landing** to step on rather than having to step over the water bar.

For grades over 10% add a **landing and step or steps** down back side of landing so landing does not erode. Trail in this photos is about 25% grade.

R. Fina 10.10.20

Sweeping curved drain and water bar routes water off trail without water slowing down and dropping sediment in drain.

Drain deeper this end to accelerate water so sediment does not drop out and block drain. I.e. **Drain has increasing outslope**.

Drain must continue far enough **off the trail that** water does not flow back onto the trail.

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The **landing water bar**.

- **Good angle** to shed water
- **Wide open, big drain.**
- **Stones of the water bar are fully backed** by the landing fill so water cannot flow through.
- Landing for hikers to **step on**, don't have to step over.
- **Low**, easy to step over
- This photo on 25% trail grade

Sustainable. Stone bar sides and large size means the feature will last, and function, a long time.

Effective. The large drain gets water off the trail, hard to block up

Traversable. Low stonework and landing makes it easy to step over.

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Landing water bar

If you don't have enough big flat rocks, bookstack smaller rocks on edge.

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Another landing type water bar.

Angle is not good but water will not flow between rocks.

What sustainability issue does the poor angle cause?

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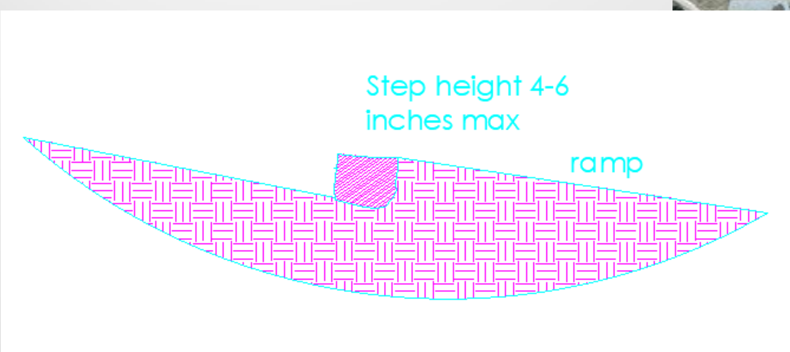

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Any feature will function better with a large, steep drain.

One of the main differences between a standard water bar and a grade dip is the volume of the drain. The tiny volume behind a standard waterbar can silt up and overflow in just one storm.

Location of drain right behind the bar promotes sedimentation.

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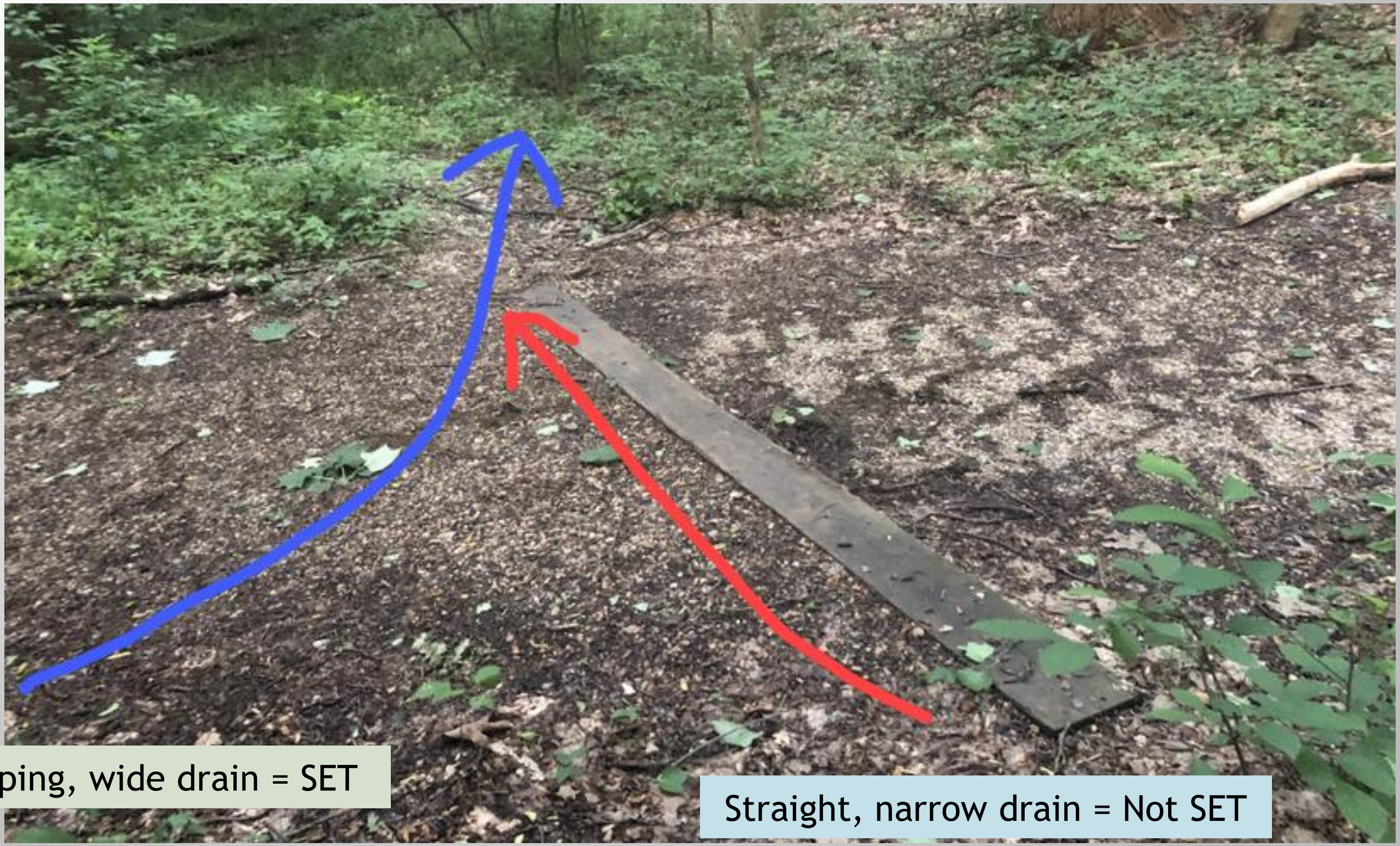
Any feature will function better with a large, steep drain.



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A grade dip, with its large drain and berm, will take a long time to silt up even if it has no maintenance.

Any feature will function better with a large, steep drain.

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Grade dips are not maintenance free. They need to have sticks, branches and rocks removed. Anything that blocks the water flow causes the water to slow down and drop sediment, blocking the drain and starting the cascade of failure.

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Check dams

Check dams are used in gullies where there is no way to remove water from the trail. They are designed to stop the downward erosion of the gully and to trap soil behind them. But they still need to pass the SET test.

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Effective?

Traversable?

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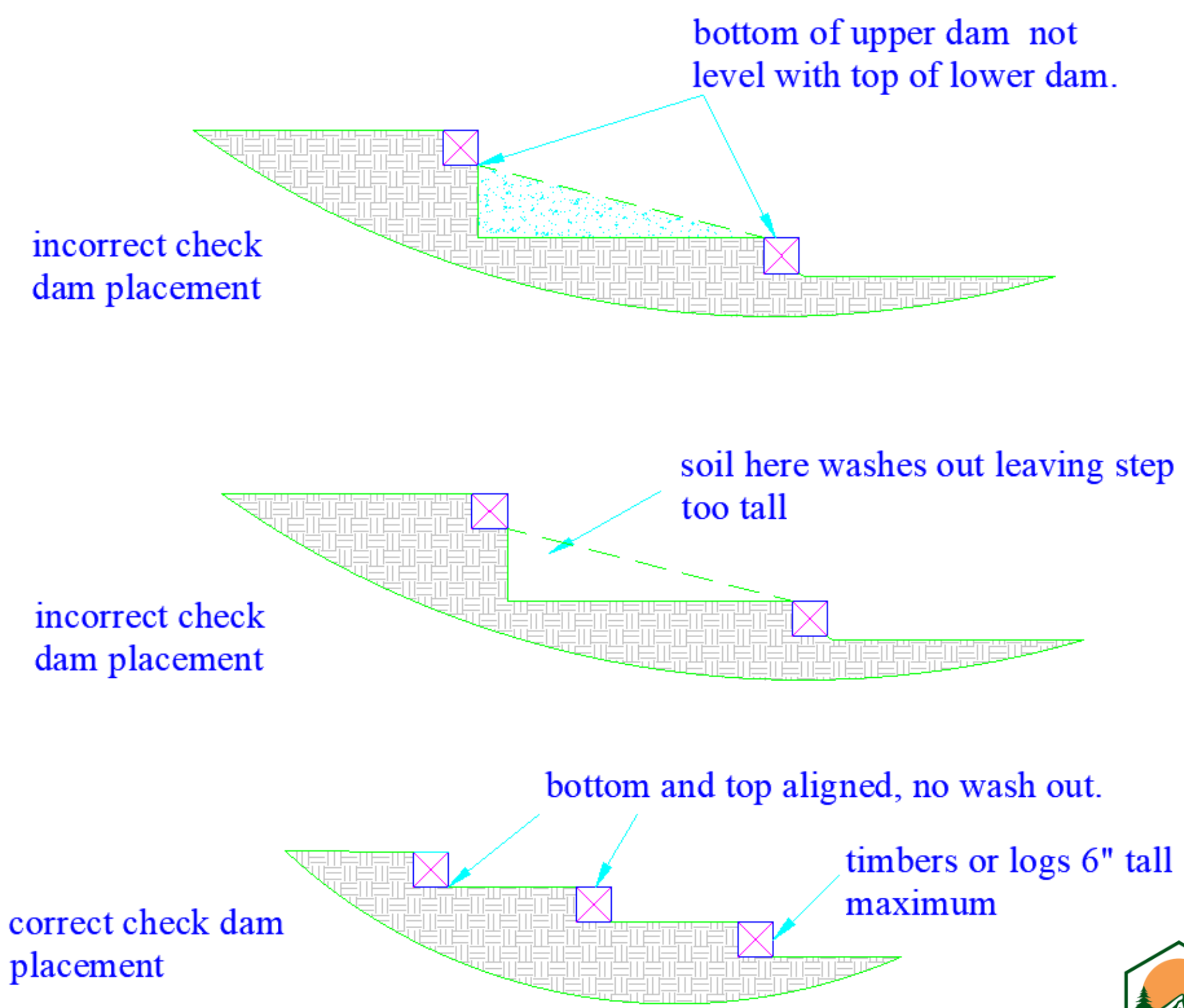
Check Dam Construction



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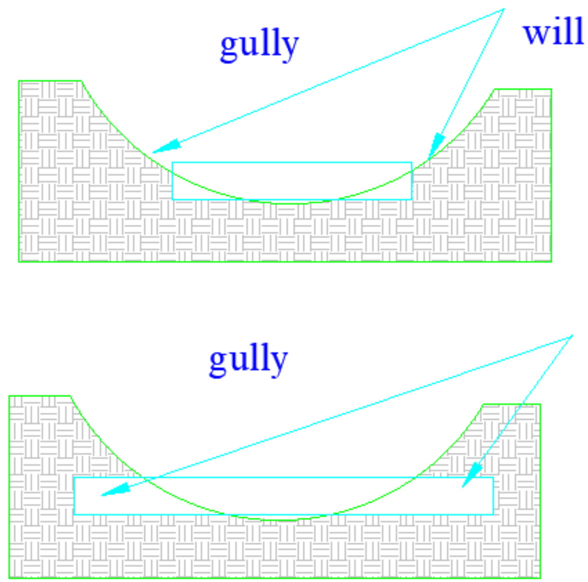
check dams too short. people and water will go around them.

incorrect length



correct length

check dams dug deep into side of gully, water, people cannot go around.

check dams should be level so water flows over them evenly, not channeled to one side or other.

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The SET test works for all types of structures

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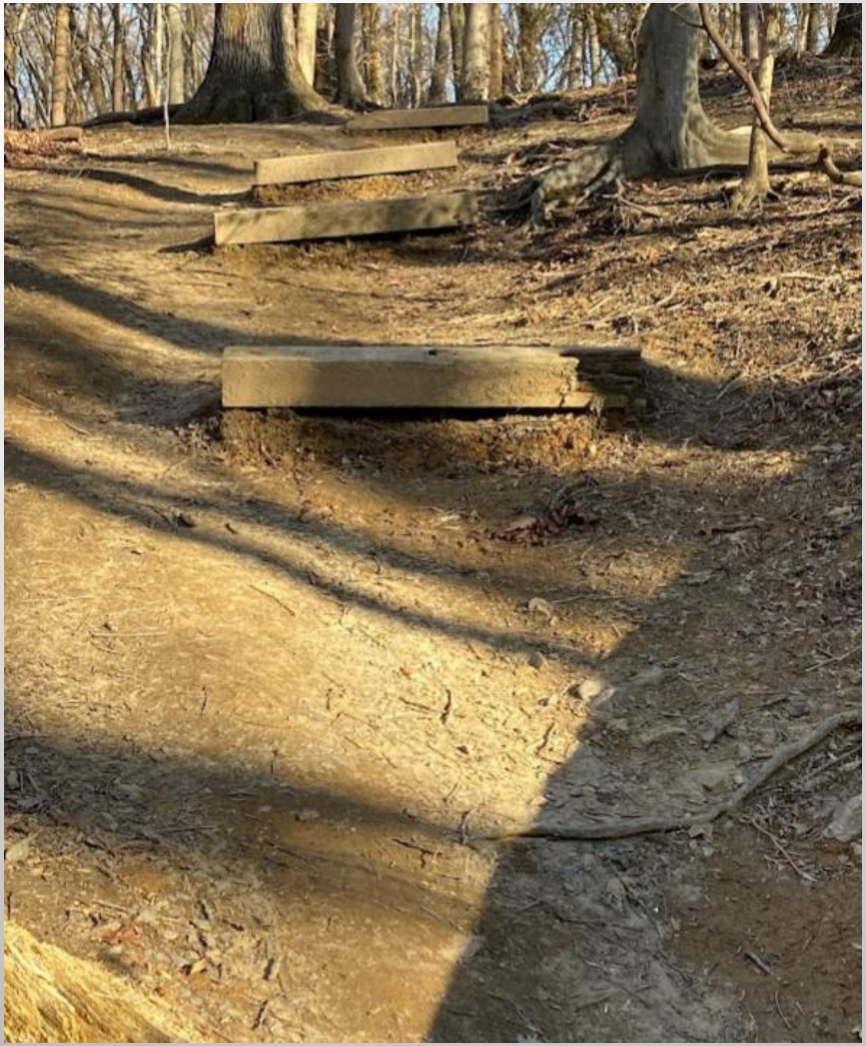

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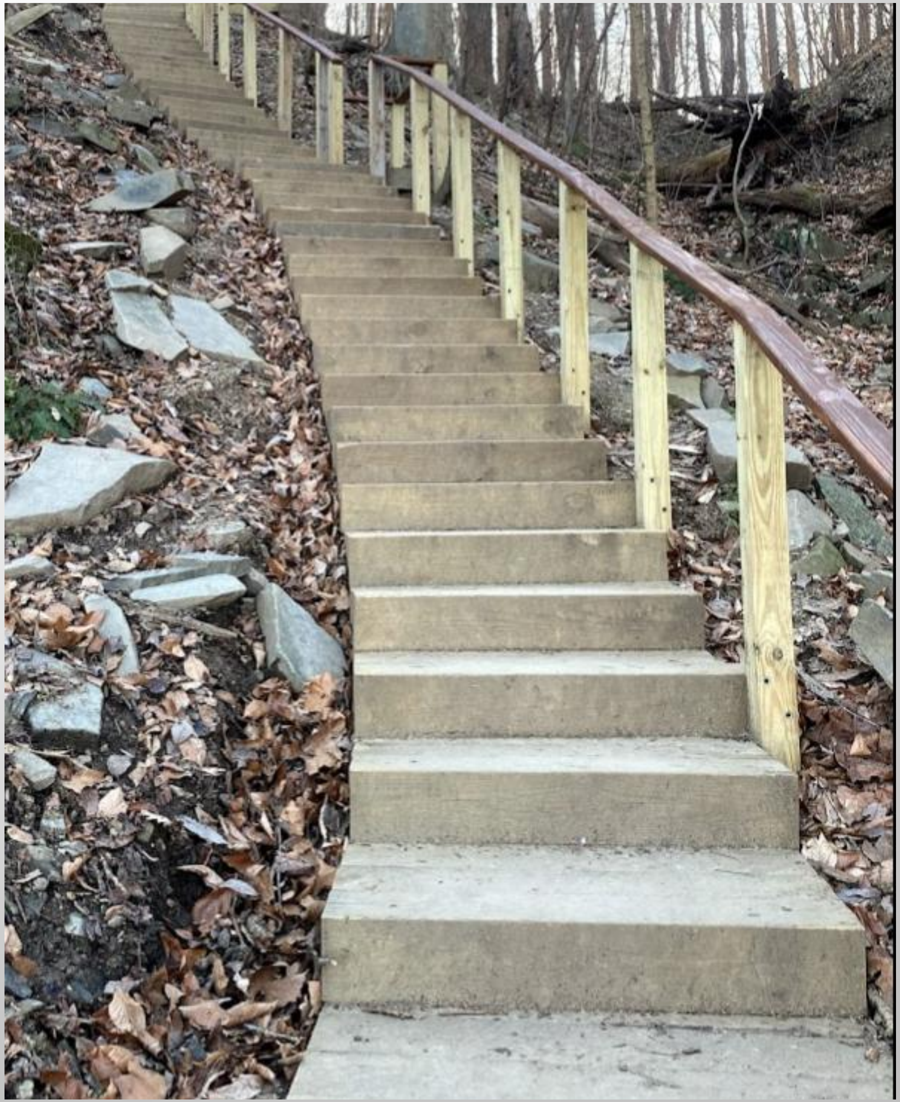

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The goal of the SET test is not to say some features are better than others.

The goal is to have a tool to evaluate each individual feature and apply the three criteria to it.

If it passes, good.

If not, can it be fixed or does it need to be replaced?
If it is a planned feature, the test can be applied to help decide if the design is adequate, or maybe it requires some rethinking.

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Thank you for you attention.

Questions or comments?

Robert Fina
Robert@FinaTrails.com
www.FinaTrails.com
mobile 703-732-8493

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