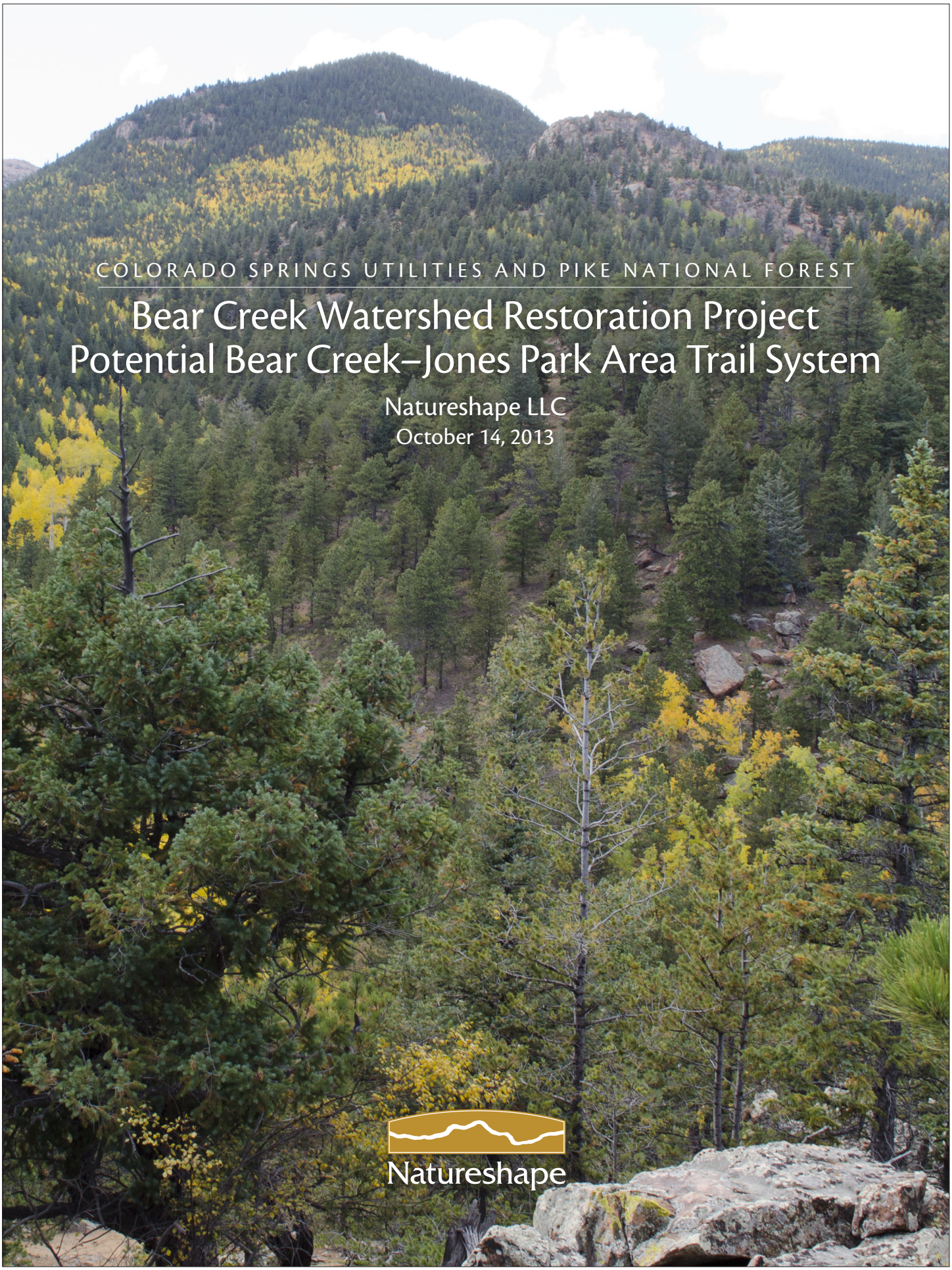

COLORADO SPRINGS UTILITIES AND PIKE NATIONAL FOREST

Bear Creek Watershed Restoration Project
Potential Bear Creek–Jones Park Area Trail System

Natureshape LLC

October 14, 2013

Natureshape

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Potential Bear Creek–Jones Park Area Trail System

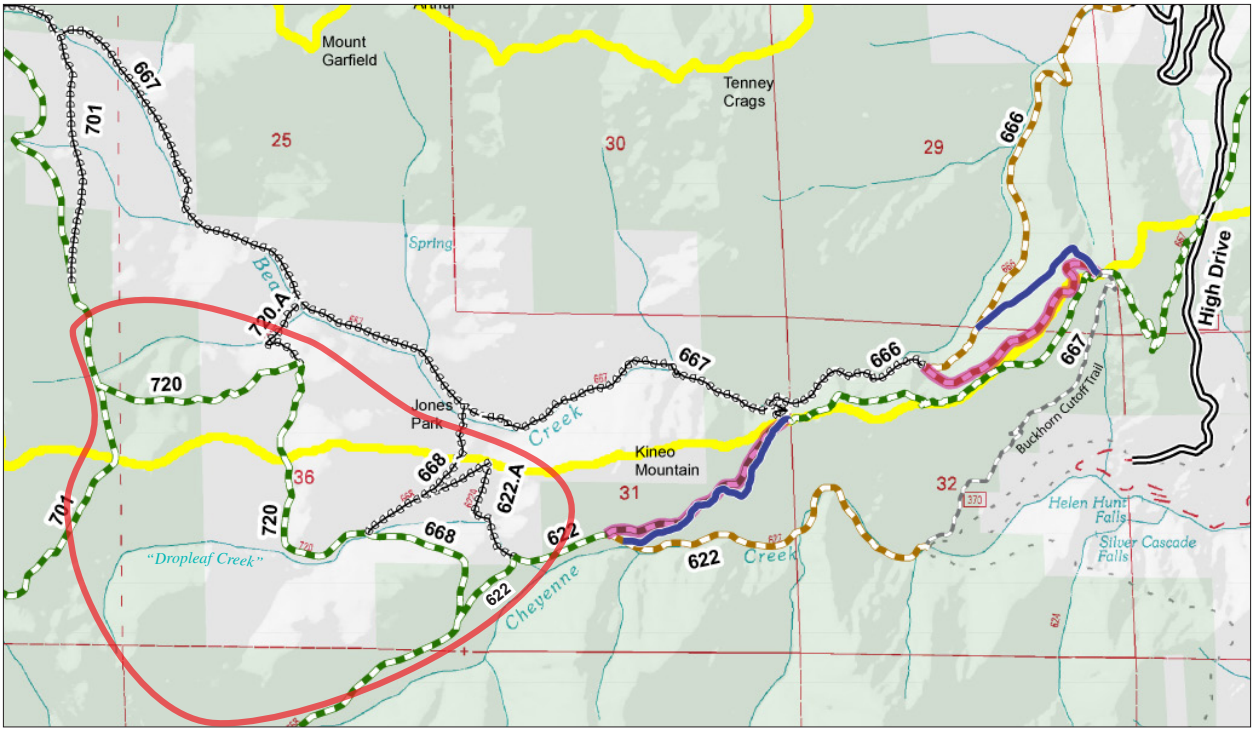
Troy Scott Parker, Natureshape LLC

October 14, 2013

Purpose

Trail closures and trail system revisions initiated by Pike National Forest's Bear Creek Watershed Restoration Project will change patterns and amount of trail use on remaining trails on land owned by Colorado Springs Utilities (CSU) within and adjacent to the Project area. Trail-related questions include:

1. Based on their relationship to topography and patterns of soil movement on trails caused by user impacts and erosion, how sustainable are the remaining trails (Trails 622.A, 720, and the northern end of 668 on CSU lands)?
2. Through cooperation with USFS and in accordance with land-management objectives of CSU and USFS, could a sustainable and enjoyable multi-use (pedestrian, mountain bike, equestrian, motorcycle) trail/system be formed to connect Trails 622 and 668 with Trail 701 (an elevation gain of about 1,250 vertical feet) while respecting the Bear Creek watershed closure? If so, what would this trail/system look like?
3. Can the final trail/system be located off of CSU lands as much as feasible, or at least be concentrated near the southern edge of CSU lands (shown in white in the map below)?



Primary study area in this report

Physical Forces on Natural Surface Trails

Much of the sustainability of a natural surface trail comes from its ability—or lack of ability—to maintain a usable shape over decades, even centuries (how old is the Bear Creek Trail?).

Regardless of whether or not a trail is designed and constructed, three unavoidable physical forces strongly shape and reshape a natural surface trail over time:

1. **Compaction**—downward (vertical) force imparted through feet, hooves, and wheels on soil particles and the trail tread (trail surface). Compaction presses soil particles into closer contact and enables any natural cementing agents in the soil (typically clays and some silts) to form tighter bonds between particles. Compaction tends to deepen tread relative to untraveled areas but also makes it harder and firmer. Decomposed granite (DG) soils throughout the study region have varying amounts of natural clays as binders, but the more gravelly the soil, the less clay and silt it has and the less it can be hardened by compaction.
2. **Displacement**—sideways (horizontal) force imparted by friction and acceleration forces imparted by feet, hooves, and wheels scraping, kicking, grinding, and flinging soil particles in the trail surface. Displacement by trail users is usually inadvertent and unavoidable.

   Some soil particles dislodged by users are kicked entirely out of the tread, causing the tread to lose material and sink. Others stay within the tread as loose gravel and dust that can be further kicked around or transported by erosion.

   Displacement also includes mass wasting (landslides) driven by gravitational acceleration, including the tendency for the outside edge of trails to fall off on steep, loose DG slopes.
3. **Erosion**—transport of material by a fluid, usually water but also wind in windy areas.

In the Pikes Peak region (and many others), compaction and displacement cause trail tread to sink over time (months, years, decades), creating a sunken tread that can channel water. The trail then catches and

Compaction, displacement, and erosion on Trail 720.

conveys any water that falls directly on it (rain) as well as runoff from the trail or slopes above. The more force the water has through volume and speed (trail grade), the more erosion it can cause. Compaction and clay binding helps reduce erosion but does not prevent particles loosened by displacement from eroding, and water with enough speed and volume can erode even hardened tread.

Furthermore, some trail uses cause more displacement than others. Off-highway motorcycles (OHMs) cause a relatively high amount of displacement due to their quick acceleration, knobby tread-grabbing tires, and heavier weight of bike plus rider. In DG soil, displacement loosens and flings particles in all directions including out of the tread, deepens treads into ruts (incised tread), and creates banked curves through use. Mountain bikes exert the same forces but with much less intensity, causing treads in cross-section to become shallow, wide pans rather than deeper ruts. Hikers tend to cause more compaction than displacement due to slower speeds and more vertical impact. Horses cause intense compaction with the weight of horse and rider pressed into part of one horseshoe at a time, but also cause relatively high displacement because they flip their hooves and fling soil a short distance.

On level tread in DG soil, all users exert more compaction than displacement force, yet OHMs will still cause rutting faster than other users. As tread grade increases, however, gravity causes more sliding force that increases displacement and reduces compaction, especially when traveling down grade. If you feel that you're sliding when you're going downhill or uphill, you are intensely displacing the tread, loosening particles for erosion that will be more intense because of the steeper grade. Hence the steeper the grade, the faster a trail incises from displacement and erosion—especially with OHMs and horses—and the less compaction there is to reduce displacement and erosion.

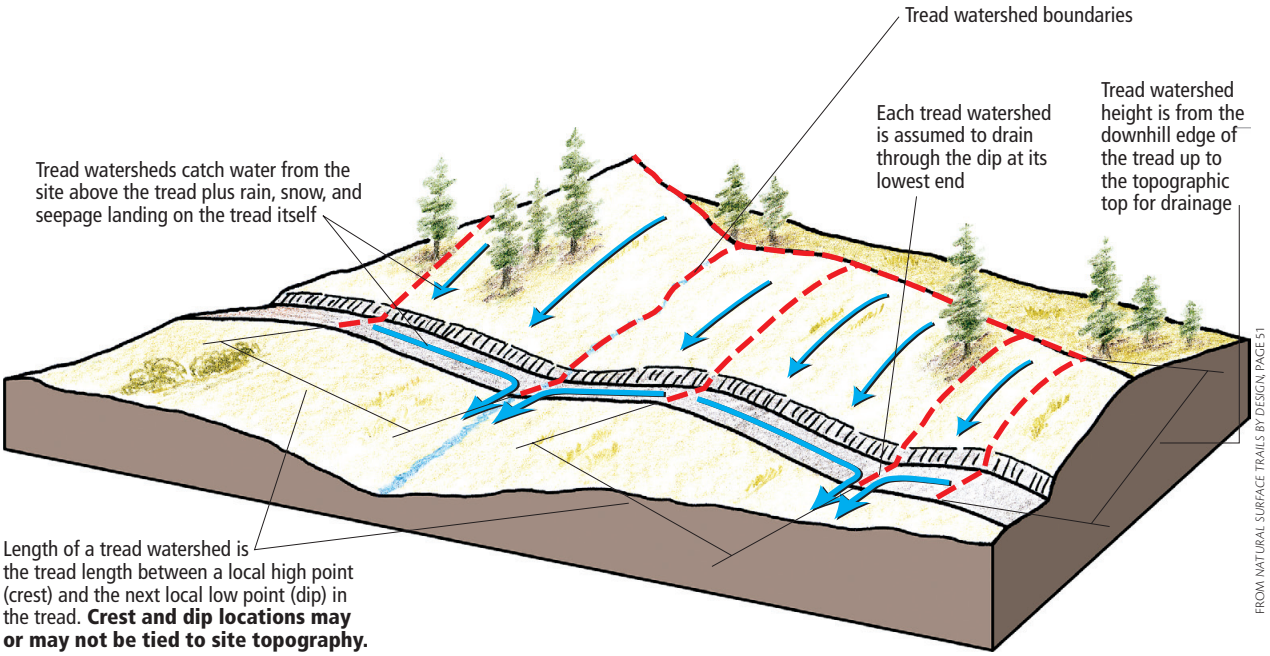
For more about compaction, displacement, and erosion, see *Natural Surface Trails By Design.*

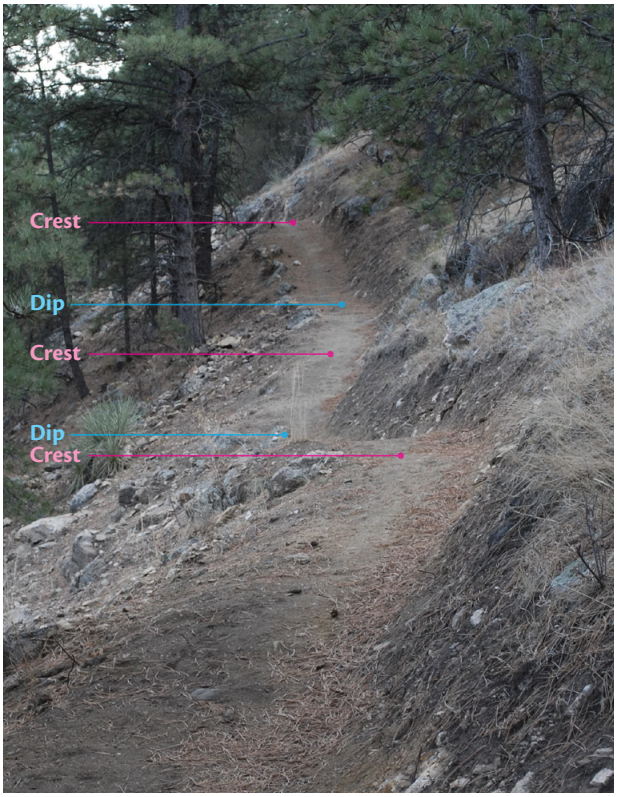
In this level section of (motorized) Trail 668 along the pipeline, tread is incised from compaction and OHM displacement alone.

In this near-level section of Trail 662 near its junction with 622.A, non-motorized tread is not incised. (Both photos are from the same day).

What Do Sustainable Trails Look Like in this Context?

Physical sustainability results from shaping a trail such that compaction, displacement, and erosion interact in ways that can maintain a usable shape over time with minimal maintenance (reshaping). The most effective trail shape for high-displacement uses in DG soil is tread formed as a series of small crests and dips. Each piece of tread between a crest and an adjacent dip, plus the slope above it that can drain onto it, is called a tread watershed (see *Natural Surface Trails By Design*, page 51):





The combination of grades, slopes, tread grade between crest and dip, rain and runoff potential, compaction and displacement forces, and other factors needs to be such that the amount and force of water flowing down an incised tread will cause only limited erosion before falling off the trail in a dip.

Ideally, dips and crests are formed purely by the alignment of the trail with no construction or maintenance at all. Waterbars, drainage dips, and other constructed water diversions are less desirable, constructed, expensive, and maintenance-intensive ways of retrofitting crests and dips to trails.

Trails shown on pages 4-8 of this report are the Fourmile Link and Benjamin Loop Trails (for hiking, horse, mountain bike use) at Betasso Preserve, Boulder County (Colorado) Parks and Open Space Department in 2009-2012. The Preserve also has DG soil, albeit with a bit more clay and smaller granite particles than soils in the Pikes Peak area. Trails were designed by skilled county staff and built with trail-scaled equipment (see page 34) and hand tools by staff and volunteers.

Dips are crests are formed by weaving up and down the slope while traversing it, either going around existing anchors such as trees and rocks…

…or simply weaving up and down without going around anything specific. The rocks on the outside edge here were placed to prevent tread widening by horses and mountain bikes. This trail is dropping; note its downward path in the background.

For sustainability and drainage, each crossing of a natural drainage must be a dip in the tread. The dip causes water to flow across the tread on its original course rather than be intercepted and rechanneled by the tread. A number of heavy erosion areas on Trails 720, upper 668, and upper 622 are caused by intercepting natural drainages.

The more three-dimensionally the trail bobs and weaves up, down, left, and right, the more interesting and fun it is. Hence forming small tread watersheds makes trails more sustainable and enjoyable at the same time.

Trails can and do climb while continually cresting and dipping.

Exaggerating the ups and downs makes the trail more fun and flowy for motorcyclists and mountain bikers.

As the average trail grade increases, it becomes increasingly difficult to form dips deep and long enough to drain sustainably without maintenance. This small dip in a steep section requires some maintenance to keep its crest from being knocked off through use.

Some of the loveliest trails result from cresting and dipping through natural anchors (trees, shrubs, rocks) and weaving through site constraints. Trails should look at such situations as opportunities rather than obstacles—just like users do.

What Do Existing Trails in the Study Area Look Like?

Motorized trails, with the exception of the level sections of Trail 668 along the level pipeline route, are generally unsustainable because they lack the small-scale, frequent crest and dip pattern. Instead, tread watersheds are long and large, dips are infrequent and unsustainably small, and incised trails channel large volumes of water at high speed. Recent flooding rains in September 2013 worsened extensive pre-existing erosion but the seeds for that erosion were planted when the trails were first formed years ago.

Where treads are not rocky or eroded, they are generally narrow at 18-24 inches wide. This is all a motorcyclist or mountain biker needs. Clearance is also often very narrow, making the trails seem more wild. As shown on the preceding pages, new trails can also be formed with narrow treads and tight clearance.

Motorized trail segments on steeper grades with few crests or dips suffer tread widening and heavy to extreme erosion. This photo of lower Trail 720 is typical of motorized trails on the ridge between the Bear Creek and North Cheyenne Creek watersheds.

Trail 720: Sediment from the photo on the preceding pages washes directly into a small creek.

A lone log waterbar on upper Trail 720 has a doomed, high-maintenance geometry on this near-fall-line-alignment trail. This waterbar is currently nonfunctional as water overtops it and continues down the trail. Motorcyclists and mountain bikers dislike waterbars because the angle can divert their tires.

Long stretches of trails, here upper 720, have no dips or crests in their alignment. The rectangular rock in the center is a remnant of a nonfunctional stone waterbar, a vain attempt to retrofit crests and dips to a trail aligned without any.

Trail 720 at one point is not only on the fall line but also follows a natural drainage straight up the slope. Naturally, it erodes, but some of the damage is covered by sediment washed down from the trail above ("upstream").

Trail 720, about 0.3 miles below its junction with Trail 701, has long, incised, eroded sections with no functional drainage. Here the tread is washing down to a rocky base, causing users to widen the trail to get around rock obstacles and increasing the amount of bare soil subject to displacement and erosion.

One of several very deep erosion ruts on Trail 720. All of these ruts result from long stretches of tread which capture and channel both rain and site runoff for long distances on steeper grades.

Trail 720: Motorized tread remains narrow without erosion where tread is close to level (0% grade). Steeper motorized grades heavily erode where tread watersheds are large.

Trail 720: Motorized tread is incised but remains narrow where smooth and grades are gentle. This is a long tread watershed but at a gentle tread grade that slows erosion.

Trail 720: Motorized tread remains narrow without erosion where tread is close to level (0% grade). Note the tight clearance with adjacent trees.

Trail 720: Narrow clearance between spruce trees on both sides of trail. Riders can deal with tight clearance in limited spots; occasional tightness makes the trail feel more primitive.

Trail 622.A along the east side of Dropleaf Creek was designed and built relatively recently as a non-motorized trail with a generally sustainable alignment of crests and dips. Note the similarities to the shapes of sustainable trails shown on pages 4-8. Some small reroutes to add more crests and dips would be needed to increase sustainability for motorized use.

Trail 622.A along the east side of Dropleaf Creek follows the creek through a pleasant small canyon as a well-formed non-motorized tread that can be modified to motorized.

Trail 622.A along the east side of Dropleaf Creek has a few steep sections with risers (steps) that would need to be rerouted to be suitable for motorized use.

Trail 622.A along the east side of Dropleaf Creek is close to the creek in a few spots but further away in most. Being along the creek is a pleasant, prized trail experience for users (although possibly at the cost of wildlife).

At an average grade of 11% to 15% along its length, this trail would need additional crests and dips to be sustainable under motorized use. For instance, the segment visible in the background—which is sustainable for non-motorized use—would displace, erode, and incise under motorized use. Yet because 622.A is in excellent condition, crests and dips can be easily added as large drainage dips or tiny reroutes with little impact.

Trail 622.A along the east side of Dropleaf Creek has a sustainable, pleasant relationship to its canyon. Some modifications would be needed to use the trail for OHMs such as removing the two rocks in the center of the tread here. Note the beautifully anchored natural crest formed by aligning the trail over this rock outcrop instead of staying on a more level grade line nearer the creek.

The old alignment of 622.A on the west side of the creek is faintly visible in the upper left background. The east side alignment is more pleasant, open, sustainable, less eroded, and generally farther from and higher above the creek than the old west alignment. Dropleaf Creek is along the spruces and aspen between the two alignments.

ABOVE AND BELOW Two possible worlds of trails. Both trails are on the same slope, the northern slope above Dropleaf Creek. The trail above is the newer 622.A aligned with enough crests and dips to be sustainable for non-motorized use, and nicely compacted by (mostly) hikers and a few mountain bikers. Below is the motorized "social" trail along the creek between 622.A and 668. It is deeply eroded because motorized trails need even more frequent and larger crests and dips to be sustainable with high-displacement trail use, yet it has very few crests and dips.

ALL PHOTOS ON THIS PAGE Trail 667 (motorized) is outside of the study area but part of the reroute for all users out of Bear Creek/Trail 666. This segment of Trail 667 climbs at a 13% average grade. Originally outsloped (tread surface pitched to the outside for drainage like the top photo on the previous page) but now incised from compaction (a bit), displacement (a lot), and subsequent erosion (a lot), it now relies on small openings in its outside berm—microdips—to drain water on the trail at intervals. This trail has sufficient dips to reduce erosion enough for the tread to become relatively firm by compaction, thereby helping the tread to resist erosion.

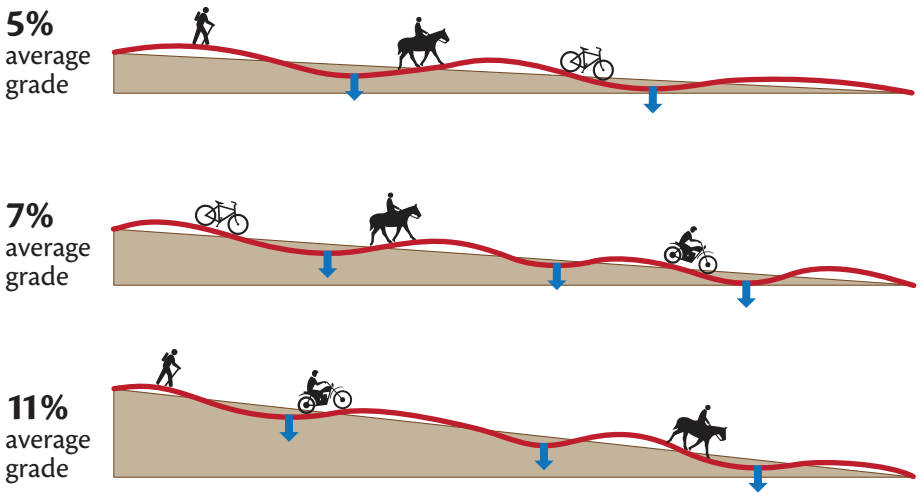
An obvious problem, however, is that microdips are so small that they are fragile. Small dips can easily fill in by displacement and erosion, and small crests can be knocked off by displacement through normal trail use—especially high-displacement motorized use. Hence this drainage method requires more maintenance than aligning a trail with larger crests and dips in the first place.

The high end of Trail 622, between its junctions with 622.A and 668, has an average grade of 30%, meaning some sections are even steeper than 30%. The segment shown here is approximately 37%—absurdly steep for a tread in DG without erosion control structures.

The high end of Trail 622, between its junctions with 622.A and 668, is so steep that it can only drain occasionally through microdips. It intercepts most of the natural drainages it crosses, further eroding the trail. This trail suffered major erosion during the September 2013 flooding rains yet it is not as eroded as motorized trails that are less steep. (A trail as steep as this would be quickly destroyed by any motorized use.) That this trail withstands erosion as well as it does is due to how well pedestrian traffic has compacted the tread and by the light amount of trail use it receives.

About Trail Grades and Sustainability

The **average grade** of a trail is often different from the **tread grade** at any given point. In trails with significant crests and dips, tread grades may be twice or three times the average grade at any given point. In the following diagram, the trail grade is shown by the tan wedge while the tread grade (the trail surface in profile) is shown as a red line. Blue arrows mark the bottoms of the dips where water is forced off of the trail.



While the pattern of sustainable crests and dips can exist at steeper average grades, tread grades also become steeper at up to twice or three times the average grade. Steeper average and tread grades can lead to greater local erosion, greater displacement (especially when traveling downhill with gravitational acceleration), faster downhill trail travel, decreased safety, and a more difficult trail in both directions. The diagram is drawn with all of the users heading downhill because downhill is the more problematic direction.

Note that the height of crests, the depth of dips, and the spacing between crests and dips are all variable. There are no preset rules but there are values that make the most sense within a given context. Often the values need to be worked out in reaction to the exact site including each tree and rock.

The best results occur when trails traverse slopes (as opposed to climbing straight or nearly straight up the hill) at average grades of 4% to 7%. In this range, trails can be easily sustainable and quite enjoyable with (optionally) locally steep grades between crests and dips. Muscle-powered uphill travel is not much more difficult than downhill travel; mountain bikers love this range. Motorcyclists don't find the thrills offered by steeper grades but careful trail design can form a flowy rhythm that's fun for motorcyclists and mountain bikers alike while creating a more curving, three-dimensional, trail-like experience for hikers as opposed to a roadlike constant grade. Lower grades also cause trails to be longer in length which is generally desirable for recreational trails.

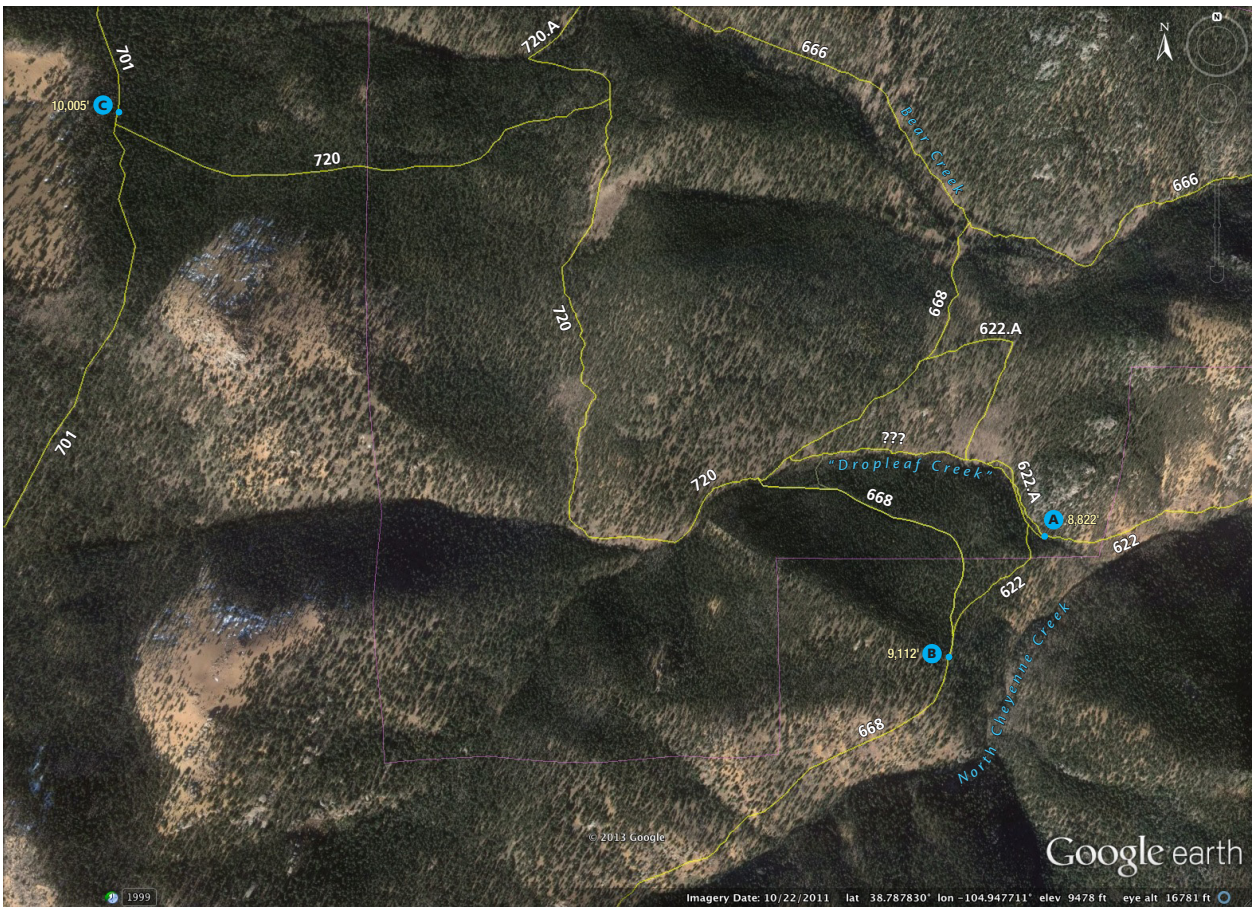
Trail System Options on CSU Land

Three trail system options have been identified as feasible and worth considering. In all options, new, sustainable, shared use trails (hiking, equestrian, mountain biking, motorcycling) usually have **average grades of 5% to 7%** (see page 18). A few average grades are up to 10%—for as short of a distance as feasible—in order to avoid adding one or more pairs of switchbacks.

Topographic constraints combined with the stated intent for trails to be as far south and west as feasible relative to CSU lands creates three control points (points through which the trails must pass). From the lowest to the highest elevation, the control points are labeled **A** (elev. 8,822'), **B** (elev. 9,112'), and **C** (elev. 10,005'), in the following maps. The total elevation gain from **A** to **C** is approximately **1,183** feet. Note that the location of **C** is approximate since the exact location of Trail 701 in that area is not shown on these maps.

The following maps show overviews of existing and proposed trail systems as rendered by Google Earth. Each map is seen from the same point looking straight down from an eye altitude of 16,781 feet. Perspective views of the different options and detailed discussion of options follows.

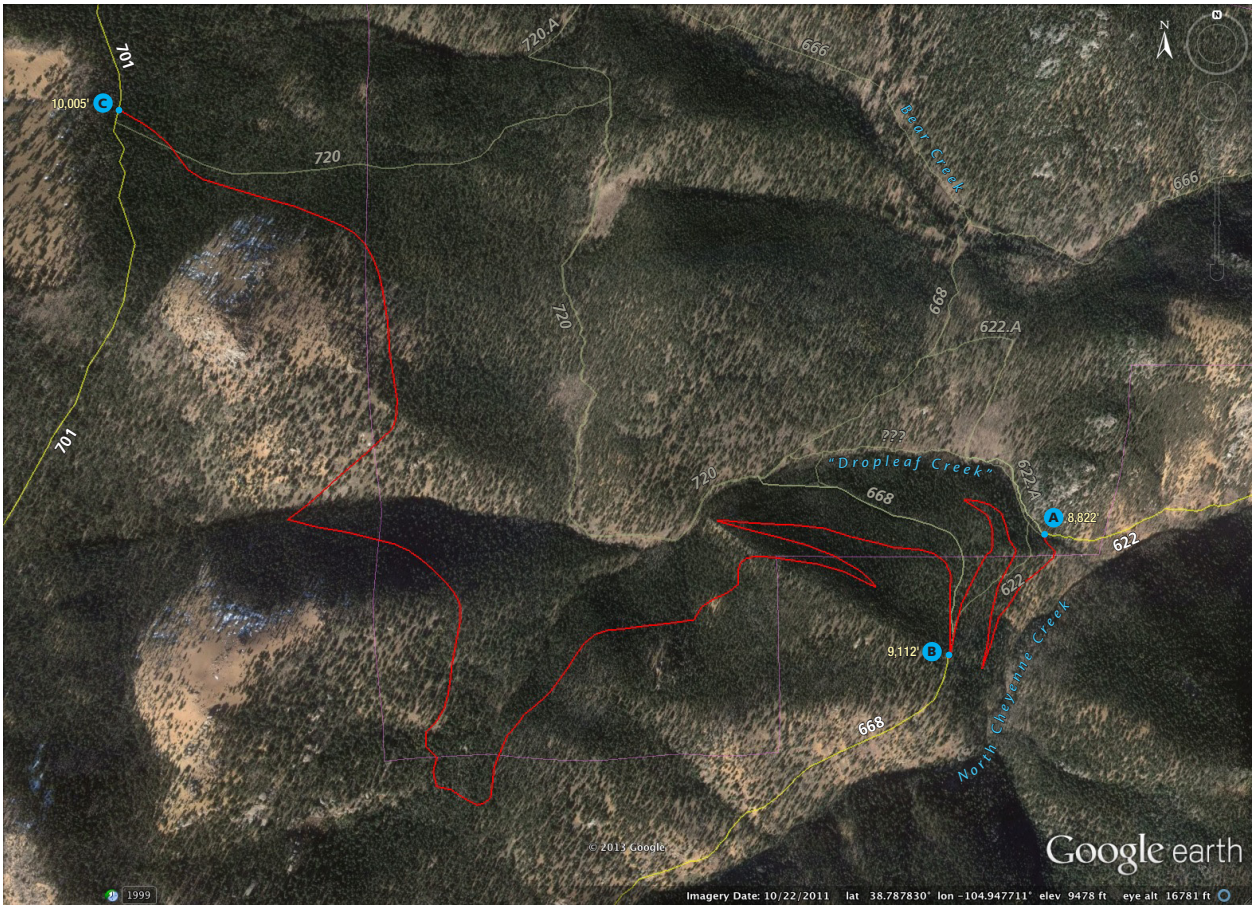
CURRENT TRAIL SYSTEM



CSU property boundary (approximate location)

Existing trails

OPTION 1



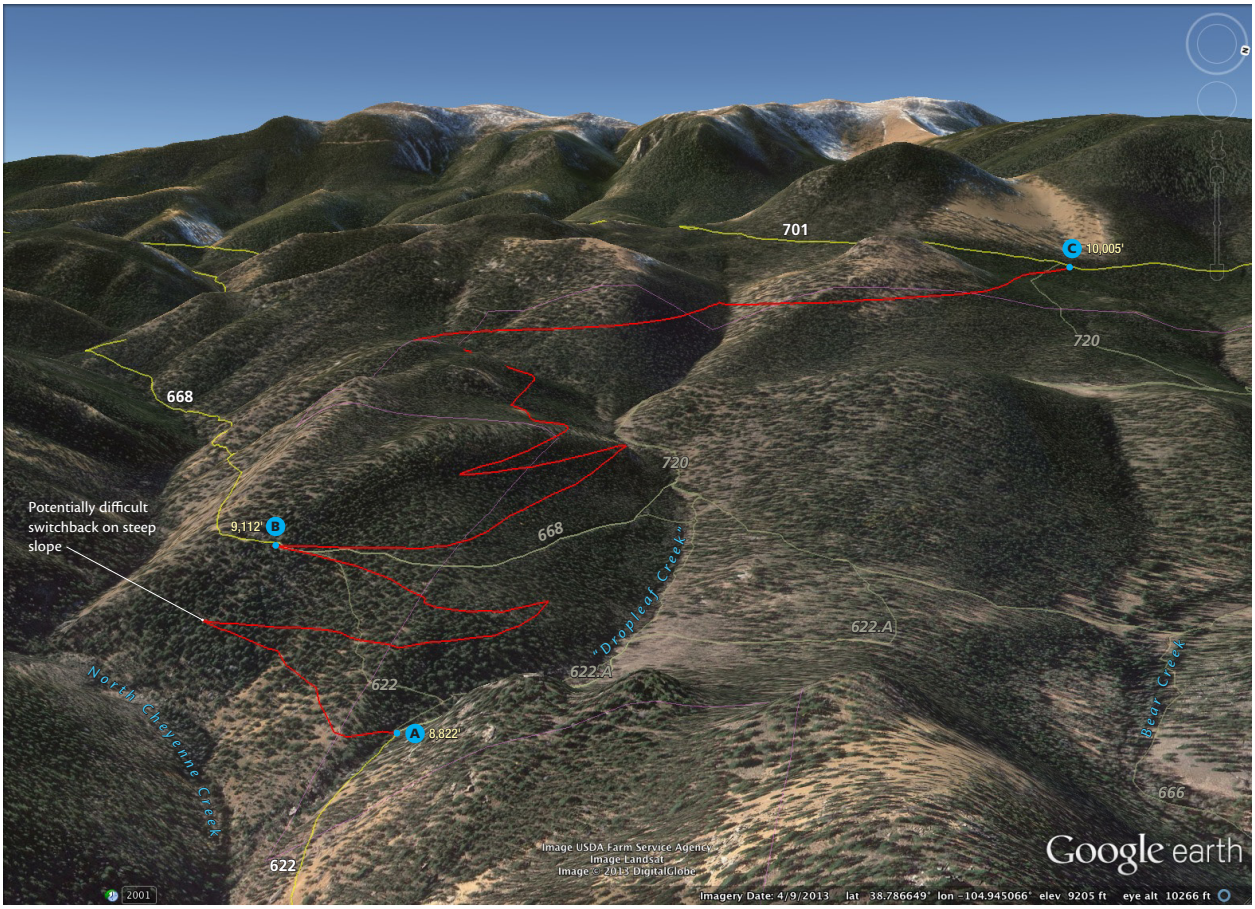
Total new constructed trail mileage	3.41
Existing trail mileage to be used and/or modified	0.0
Total mileage	3.41
Average grade of entire trail (rise ÷ run)	6.57%

CSU property boundary (approx. location)
Existing trail to use in new system
New trail
Decommissioned trail

Due to topographic constraints, all three options use the exact same corridor from **B** to **C**. This segment is 2.65 miles in length, runs at 7% except for a few areas of 9-10%, and forms approximately 75% of the total length between **A** and **C**. The location of Trail 701 is approximate as shown and so the junction and elevation of the new trail and 701 are also approximate.

Option 1 between points **A** and **B** climbs new switchbacks on the north bank of North Cheyenne Creek. From the bottom, beginning where Trail 622 currently crosses Dropleaf Creek, 0.76 mile of new switchbacks climb at 7% across the slope that old Trail 622 climbs. This necessitates decommissioning Trail 622 between **A** and **B**. All other trails in the study area besides 622, 701, and 668 southwest of point **B** also decommissioned.

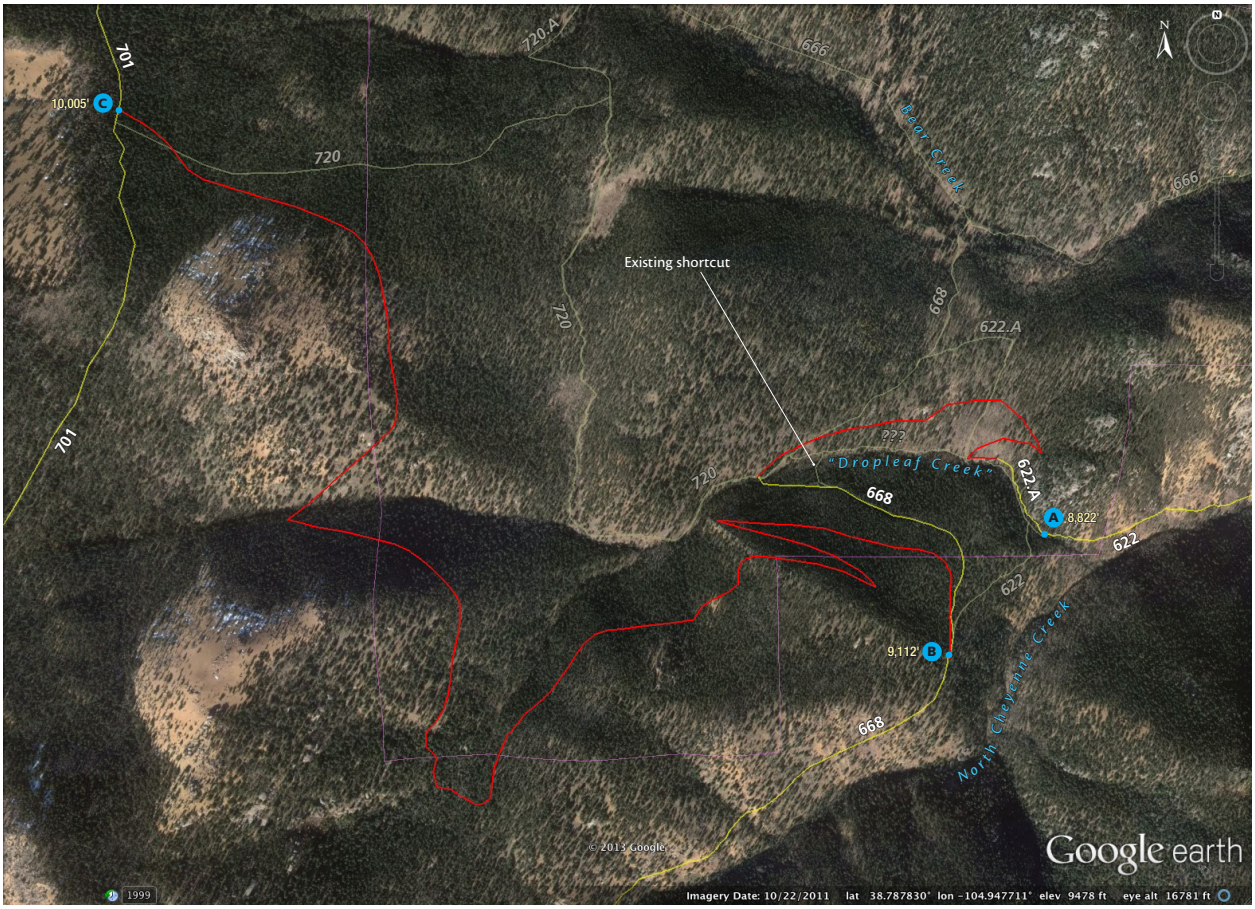
OPTION 1 DISCUSSION



Option 1 switchbacks, bottom left, climb at 7% from **A** to **B** as seen from the east. Trail 668 north of **B** is decommissioned.

Pros of Option 1	**Cons of Option 1**
• Southernmost alignment; locates more trail mileage on USFS land than other options and closes all trails along and north of Dropleaf Creek. • Uses excellent crossing that 622 currently uses to cross Dropleaf Creek, so no additional impacts in the creek crossing. • The switchback below **B** is on a gentler slope with no issues.	• The lowest switchback above **A** is on a steep slope and therefore expensive to build. Safety: The slope is possibly steep enough that material dislodged from the upper leg could roll down to the lower leg. • The slope between **A** and **B** is very much like the rest of the trail higher up. Hence users would not experience the lovely canyon along 622.A and the creek and aspen meadows above it as they would with the other options. • Trail 622 between **A** and **B** would need to be closed, but users will be tempted to keep using it because it's such an obvious shortcut.

OPTION 2



Total new constructed trail mileage	3.26
Existing trail mileage to be used and/or modified	0.58
Total mileage	3.84
Average grade of entire trail (rise ÷ run)	5.83%

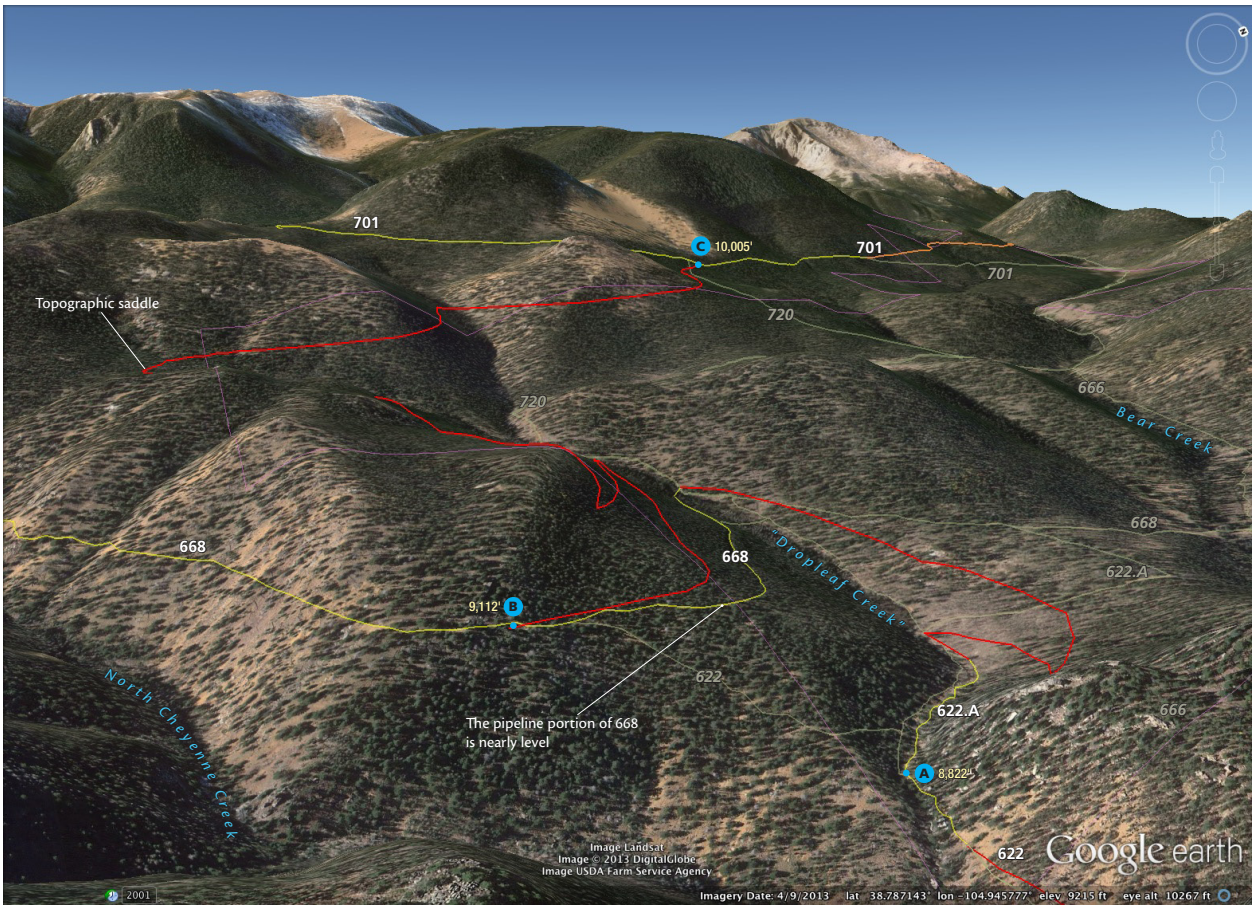
- CSU property boundary (approx. location)
- Existing trail to use in new system
- New trail
- Decommissioned trail
- New trail outside of the study area

In Option 2, starting from point **A**, the trail re-uses the newer, more sustainably designed east-side tread of 622.A through a small but pleasant rocky canyon alongside Dropleaf Creek. After 0.13 miles, the trail emerges from the narrow canyon and switchbacks uphill onto a new, gentler 7% grade away from the creek. The 0.61 mile reroute enables the trail to escape from "chasing the creek" at 11.6% next to the creek along alignments that need to be rerouted to improve drainage or reduce local tread grades, are seriously eroded, or both. The reroute has a second switchback anchored against the rocky cliff of the canyon before sustainably traversing the upper edge of the largest aspen grove on the property. By now, the trail is far above Dropleaf Creek.

The reroute continues to climb at 7% until it reaches where Trail 668 crosses Dropleaf Creek. At this point, the trail then reuses the existing Trail 668 along the pipeline route, which is nearly level, for 0.45 mile until it reaches point **B**. The trail then continues up the new **B-C** segment to Trail 701.

Note that users are already shortcutting Trail 668 where it crosses Dropleaf Creek (see the "Existing shortcut" note in the map above). This shortcut is currently recorded as being the actual trail (named "Pipeline") in Google maps.

OPTION 2 DISCUSSION



Starting from the bottom, option 2 has two lower switchbacks on gentle slopes. It crosses Dropleaf Creek at the existing and sustainable 668 crossing and continues up the existing, nearly level "pipeline" section of 668 to point **B**.

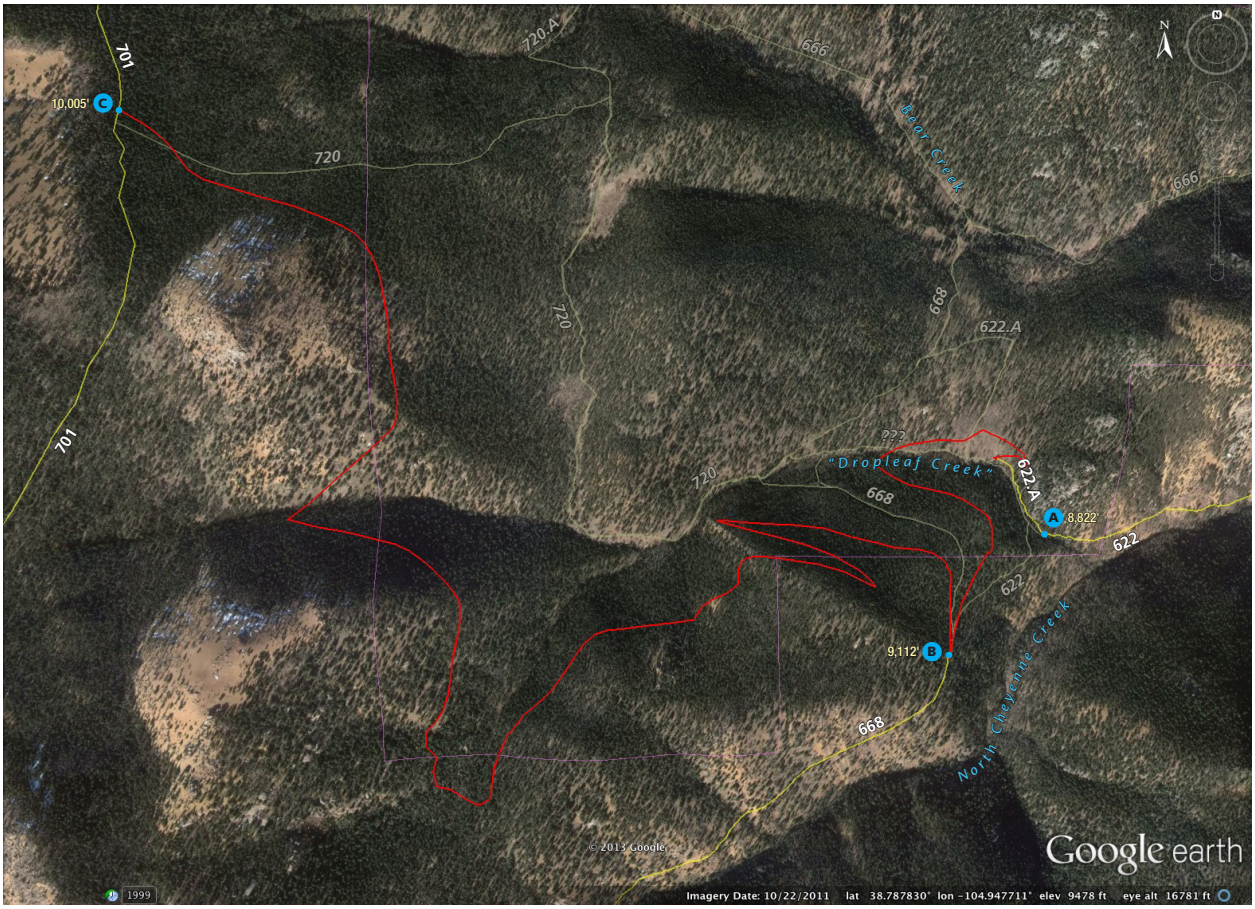
Pros of Option 2

- The most scenic part of Trail 622.A is reused, and trails pass through or near the typical yet very pleasant high-country creek, meadow, aspen, and ponderosa ecosystem along Dropleaf Creek.
- Existing trails along Dropleaf Creek are closed and can be backfilled and restored with material excavated from the new, higher trail above. The newer trails are more sustainable with 7% average grades well away from the creek instead of the 11.6% average of existing trails close to the creek.
- The switchback below **B** is on a gentler slope with no issues.

Cons of Option 2

- The reused "pipeline" section of 668 actually does have an old water diversion pipeline which is occasionally exposed. The trail grade is minimal at 1-2%, which causes more of the climbing to be done on the valley wall south of Dropleaf Creek. The high points of that segment are not far below the watershed divide between Dropleaf Creek and Bear Creek.
- The nearly level pipeline portion of 668 causes two shortcutting problems: 1) users are already shortcutting 668 where it crosses Dropleaf Creek, and 2) users have similar incentive to shortcut the switchback/junction at **B** to reach the new trail leg above it.
- Trail 668 along the pipeline is an old utility road. While it has the patina of time and a weaving, bobbing, highly sustainable tread, it's still fundamentally straight, level, and road-like compared to a more trail-like trail.
- Partly because of the level grade on Trail 668 and the extra 2000 feet of trail that levelness creates versus Option 3, users will still be tempted to use Trail 622 between **A** and **B**. Ideally, however, Trail 622 between **A** and **B** would be closed to minimize maintenance and maximize safety and sustainability.

OPTION 3



Total new constructed trail mileage	3.34
Existing trail mileage to be used and/or modified	0.13
Total mileage	3.47
Average grade of entire trail (rise ÷ run)	6.46%

- CSU property boundary (approx. location)
- Existing trail to use in new system
- New trail
- Decommissioned trail
- New trail outside of the study area

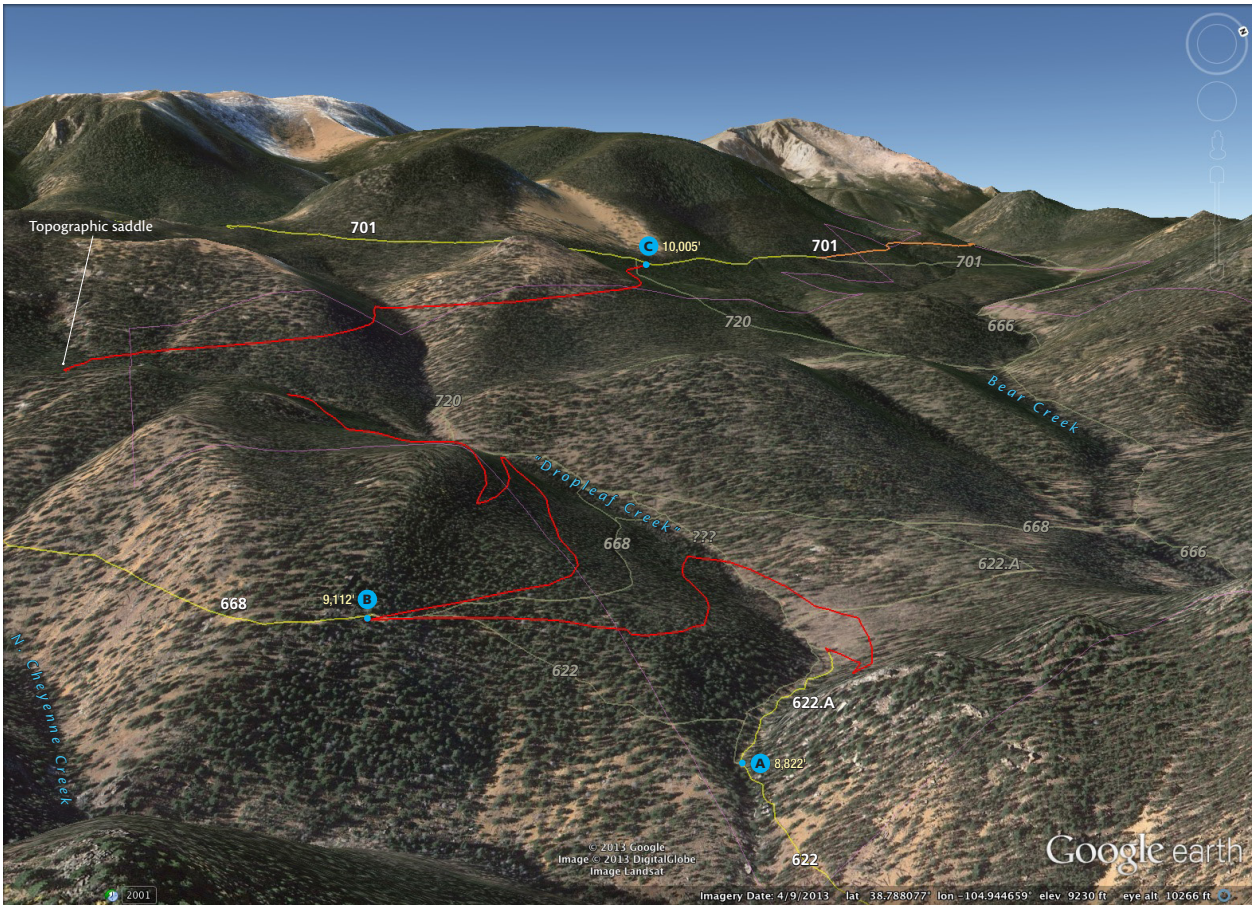
Option 3 is a shorter version of Option 2 with more consistent grades, a more trail-like feel, and more distance from Bear Creek. Instead of reusing the near-level pipeline portion of 668 in Option 2, Option 3 cuts a shorter new trail at a 5% to 7% average grade between Dropleaf Creek and **B**. This shortens the overall trail by 0.37 mile (1,954 feet) and puts more distance between the switchback legs on both sides of **B**, hence reducing incentive to shortcut the switchback. (For a tired user or one in a hurry to cut off 1,954 feet by shortcutting is a significant incentive to cut a switchback.)

Along Dropleaf Creek, the trail is about 1,000 feet shorter than in Option 2, and the trail is lower on the valley wall and therefore farther from Bear Creek. The Option 3 trail spends more time in the aspen grove and meadows than the Option 2 trail, enabling users to enjoy this lovely experience that they can't get anywhere else on the proposed trail.

The trail will have a new crossing of Dropleaf Creek but, like the other crossings, it wouldn't need a bridge. Finding a natural crossing point or rearranging a few stones would produce a sustainable and naturalistic crossing of this tiny creek.

Trail 668 north of **B** would be decommissioned; the pipeline along it is long abandoned and non-functional. Trail 622 between **A** and **B** would ideally be decommissioned but there will still be some incentive (although less than Option 2) for users to continue to use it as a shortcut.

OPTION 3 DISCUSSION



New trails with average grades of 5% to 7% steadily climb gentle to moderate slopes on both sides of Dropleaf Creek valley up to **B**. While it is possible to follow Dropleaf Creek at 11.6% and eliminate the two switchbacks closest to **A**, users generally tolerate short stacked switchbacks—especially when the switchbacks are well anchored by landscape features as they can be here—and the higher, longer trail can run more enjoyably and sustainably at 6% well away from the creek.

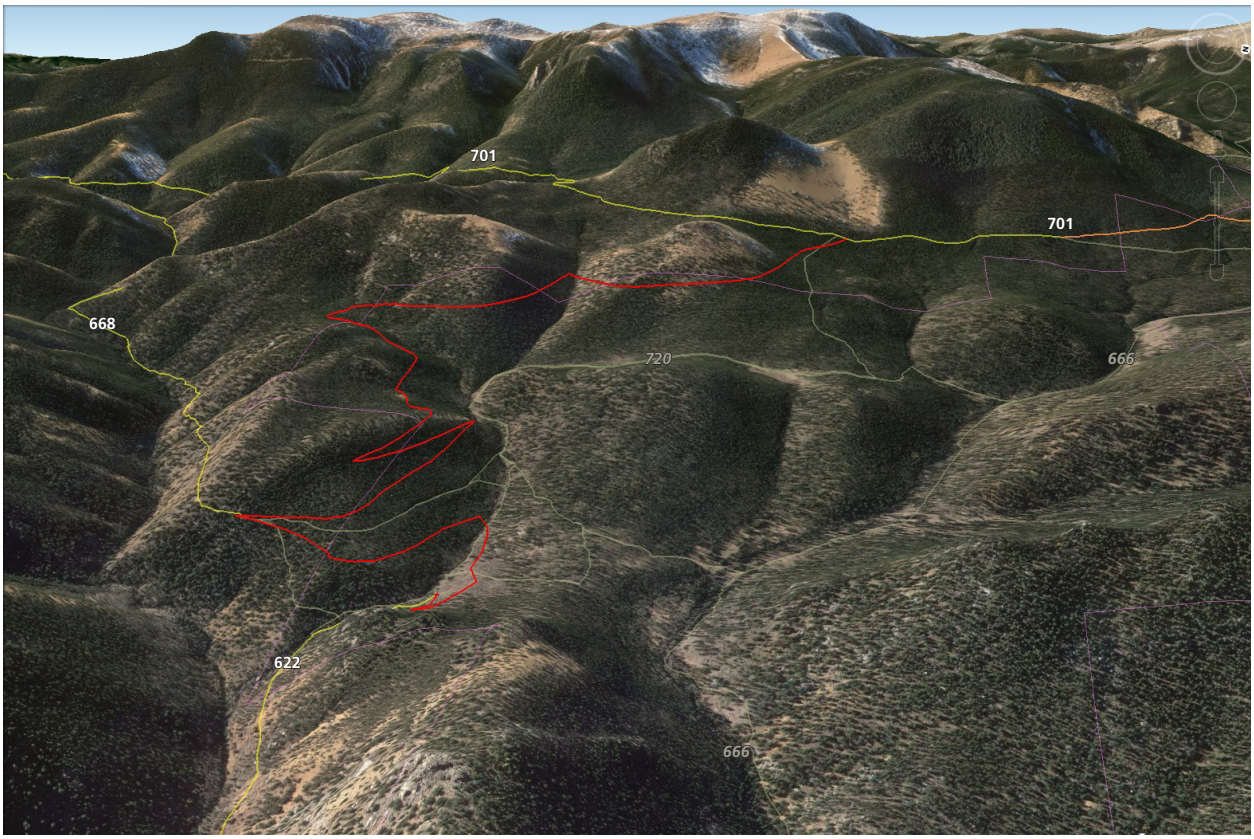
Pros of Option 3

- As with Option 2, the most scenic part of Trail 622.A is reused, and trails pass through or near the typical yet very pleasant high-country creek, meadow, aspen, and ponderosa ecosystem along Dropleaf Creek. Unlike Option 2, the trail stays closer to Dropleaf Creek (and farther from Bear Creek) and spends less time in the valley. Option 3 runs at 6% through the valley whereas Option 2 runs at 7%.
- A new sustainable crest-and-dip trail below 668 will be a more trail-like experience than the old, straight, level utility road that is 668.
- Existing trails along Dropleaf Creek are closed and can be backfilled and restored with material excavated from the new, higher trails above. The newer trails are more sustainable with 5% to 6% average grades well away from the creek instead of the 11.6% average of existing trails close to the creek. Material excavated from the lower end of new trail south of Dropleaf Creek can also optionally be used to backfill decommissioned trails along Dropleaf Creek.
- It is easier to close Trail 622 between **A** and **B** because the new alternative is more efficient than in Option 2.
- Material excavated from the lower end of the new trail above **B** can optionally be used to backfill and restore two trails: Trail 622 below **B** and Trail 668 north of **B**.

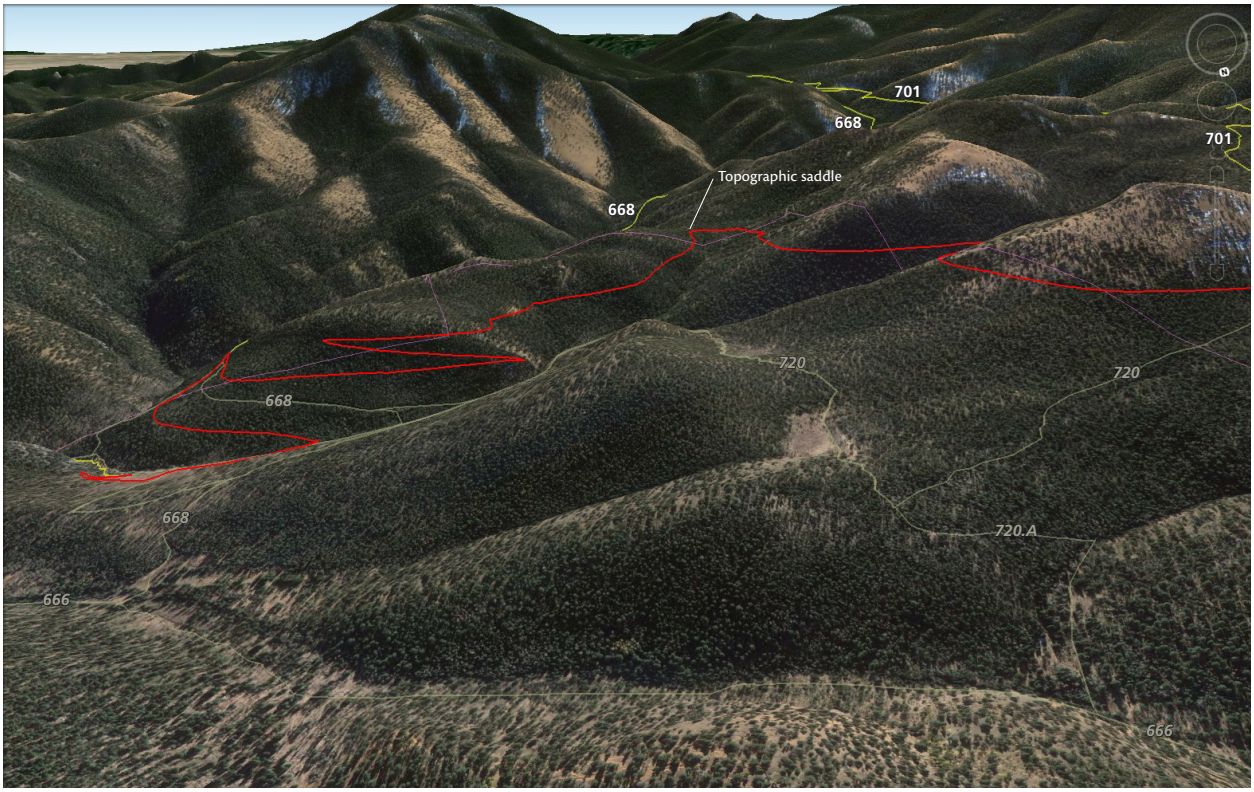
Cons of Option 3

- Some users, particularly hikers, may cut the switchbacks above **A**. Even if they do, however, damage is minimal because slopes are gentle. As with all switchbacks, trail designers use psychology to encourage users to stay on the trail.

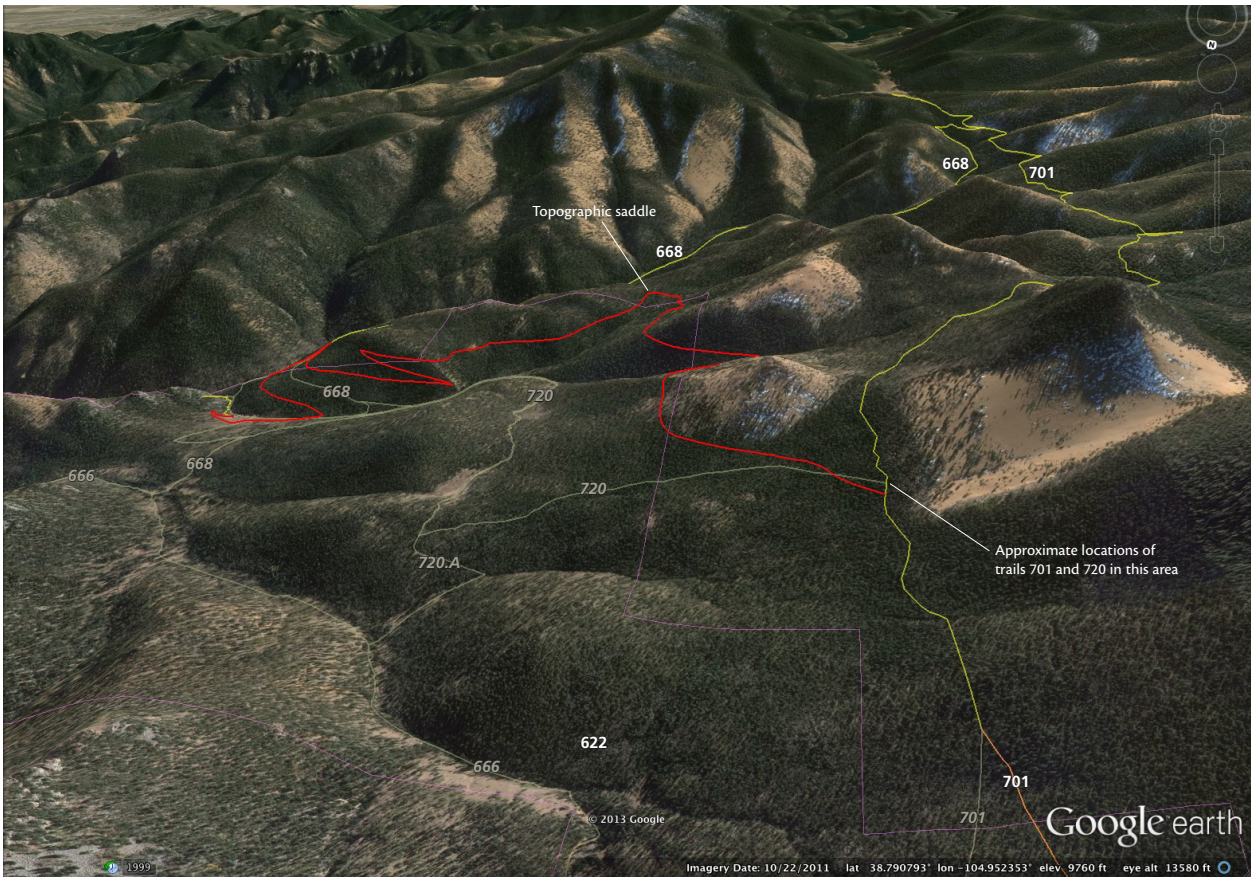
OPTION 3—ADDITIONAL GOOGLE EARTH VIEWS

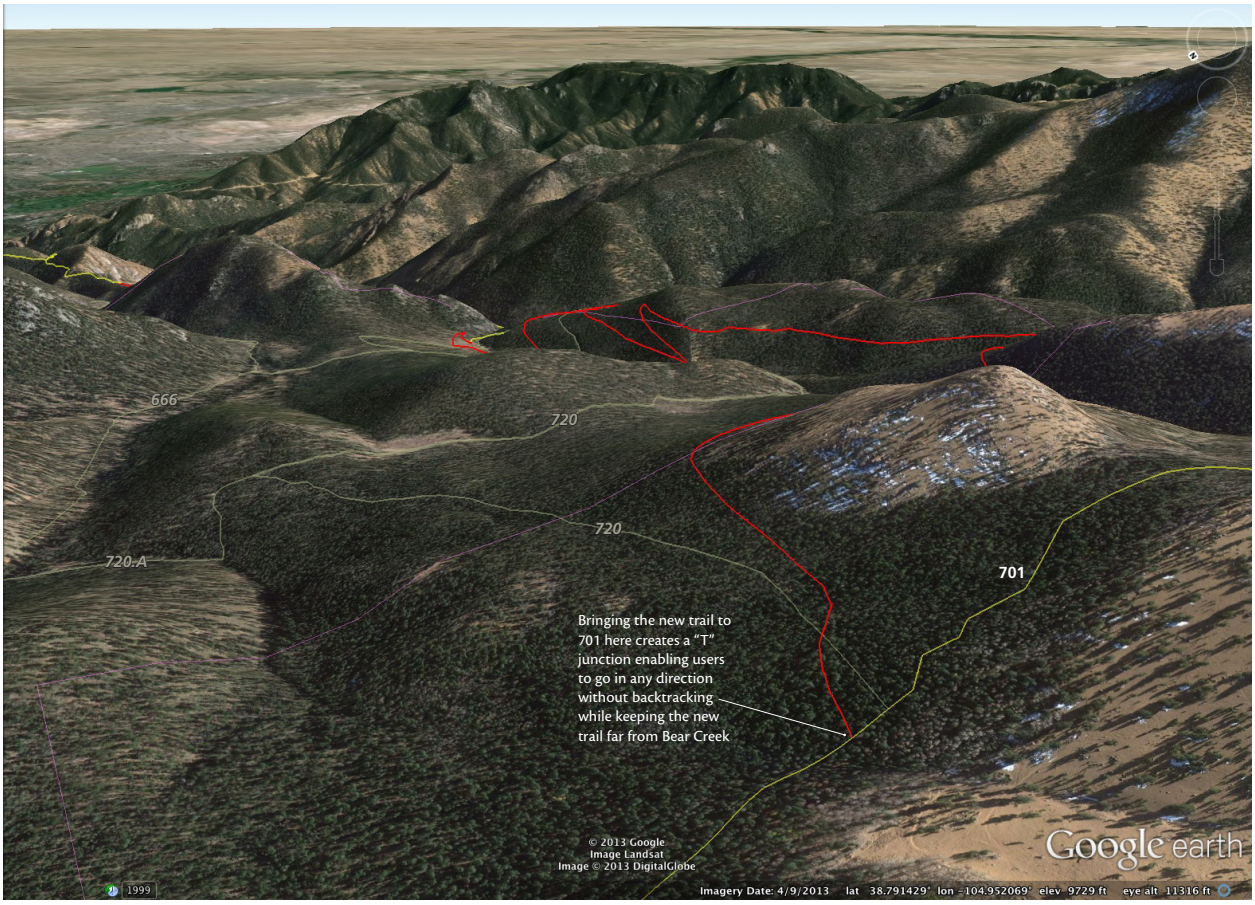


Wider view of the North Cheyenne Creek and Bear Creek watersheds with trails 622, 668, and 701. Proposed Option 3 forms a logical link between all three trails while straddling the CSU-USFS boundary.



Looking south from the Bear Creek watershed shows how steadily the Option 3 trail climbs. The new trail is careful to use the ridge east of the topographic saddle to remain out of sight and out of mind of Trail 668 on the other side of the ridge.


668
701
Topographic saddle
668
668
720
668
666
720
720.A
Approximate locations of
trails 701 and 720 in this area
622
666
701
701
© 2013 Google
Google earth
1999
Imagery Date: 10/22/2011 lat 38.790793° lon -104.952353° elev 9760 ft eye alt 13580 ft


666
720
720
720.A
701
Bringing the new trail to
701 here creates a "T"
junction enabling users
to go in any direction
without backtracking
while keeping the new
trail far from Bear Creek
© 2013 Google
Image Landsat
Image © 2013 DigitalGlobe
Google earth
1999
Imagery Date: 4/9/2013 lat 38.791429° lon -104.952069° elev 9729 ft eye alt 11316 ft

The Dike above Point B

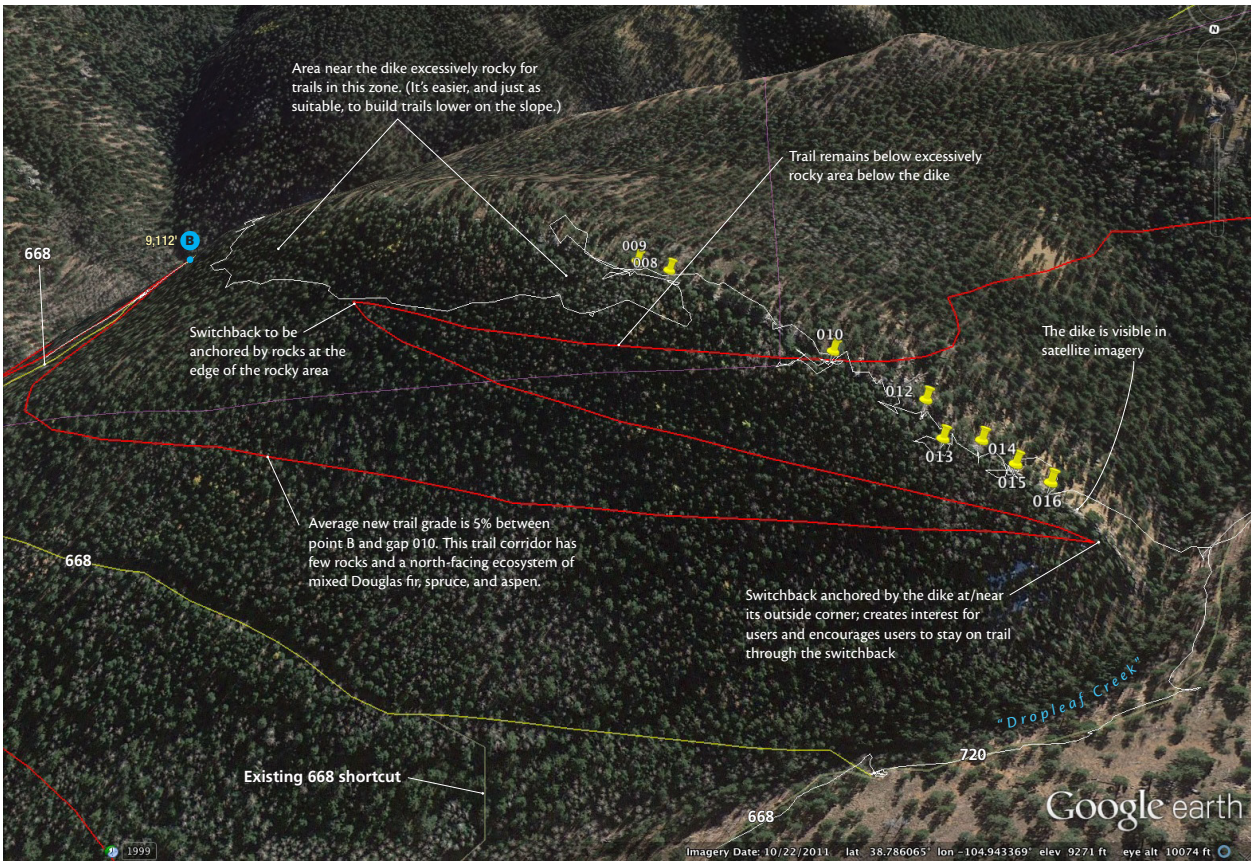
One particular geographic/geologic feature greatly shaped the trail above and around point **B**. Point B is just a few feet north of a continuous, exposed rock dike that forms the backbone of the ridge shown below. Most of the time, this so-called dike presents as a small cliff or a free-standing wall 8 feet thick all along the entire ridge. Trail 668 was blasted through this dike and point **B** is just north of the dike and the rocky area to its immediate north.

A typical view of the dike as a low cliff at the top of the ridge.

The dike was examined in the field (shown by thin, white, wiggly line below) to locate points where the trail could cross it. Exactly eight potential crossing points were found in the area where the trail between **B** and **C** might go. The points are shown as numbered, yellow thumbtacks in the Google Earth image below.

Ultimately, the gap labeled as GPS waypoint 010 was selected for the trail route since it was the closest gap to where the trail needs to be to achieve the climb up to **C**. Although I would have liked to have used gaps labeled 009 or 008 on the map, these are in an extremely rocky area through which trail construction would be excessively difficult. Hence the lower, far less rocky gap 010 was chosen and the trail above it heading toward **C** needs to climb at grades closer to 9-10% at times to make up for crossing the ridge at the lower 010 point. The chosen 010 gap can be used without blasting and only routine stonework.

The dike also nicely anchors the switchback below the lowest gap labeled 016.



Choosing Between the Three Options

There is very little difference in lengths and overall grades, largely because the upper 75% of the trail is identical in all three options:

Trail aspect	Option 1	Option 2	Option 3
Total new constructed trail mileage	3.41	3.26	3.34
Existing trail mileage to be used and/or modified	0.0	0.58	0.13
Total mileage	3.41	3.84	3.47
Average grade of entire trail (rise ÷ run)	6.57%	5.83%	6.46%

However, there are major differences in how the different options look, feel, and are built between points **A** and **B**.

Option 1

Option 1 is probably the most expensive option because it is all new construction on steeper slopes than the other options. It also poses the greatest potential risk to users. Its lower switchback, located almost directly below point **B**, stacks its legs one above the other on a slope which may be steep enough for anything dislodged from the upper leg to roll down to the lower leg.

The intersection of trails 668 (left) and 622 (right), with point **B** behind the camera. The proposed lower switchback in Option 1 is almost directly below this intersection where the slope is about the same steepness or possibly a bit steeper. On slopes this steep, especially if the DG soil is so unstable that it becomes a scree slope, anything that falls off of a trail above (rocks, users, etc.) could possibly roll down to a trail below. Switchbacks are also more difficult to build and maintain on steep slopes.

All other switchbacks in Option 1, as well as all switchbacks in Options 2 and 3, are intentionally located on gentler slopes which do not pose a roll-down risk between their legs. Hence only Option 1 has this problem.

Option 1 also provides the most homogenous (unvarying) trail experience for users. From Point **A** to **B**, it switchbacks through the trees back and forth across the same slope at 7%. If this option were chosen, the

entire trail would be through the trees with no experience of Dropleaf Creek and the lovely meadows and aspen groves along it offered by the other options.

Lastly, the location of Option 1 makes it impractical to backfill any decommissioned trails except Trail 622 between **A** and **B** and some lower sections of 622.A. Hence the scars of trails 668, 720, 622.A, and the unnamed ??? trail along Dropleaf Creek would all need to be stabilized and reclaimed as a separate operation without a ready source of fill material.

Option 2

Option 2 provides users with the high country canyon, creek, meadow, and aspen grove experience along Dropleaf Creek while staying further from the creek than the existing trails. Starting from the bottom, however, the trail must spend more time in the Dropleaf valley in order to climb (at 7%) up to what is functionally a switchback onto the nearly level existing Trail 668. Then, when users have made it to point **B** on a level trail without climbing, the new trail switchbacks up again.

Trail 668, aka "Pipeline," follows an old ceramic pipeline with mortared joints. The now-unused pipe, which is occasionally exposed, appears to be a water diversion from North Cheyenne Creek into Dropleaf Creek. While one could argue that the pipe is a historic feature, it also detracts from the wilderness feel of the area and is somewhat of an obstacle to trail users and to trail construction and maintenance. This photo is at the intersection of 668 and 622 and would be part of Option 2.

The level, roadlike stretch of 668 in Option 2 is essentially a level leg between two switchbacks, a configuration that invites shortcutting on both ends. Users are already shortcutting the lower end near Dropleaf Creek. In addition, the level leg makes it more difficult to close Trail 662 between **A** and **B** because it would still be a tempting shortcut. Hence there is a significantly high psychological, management, and maintenance price to reusing this segment of Trail 668 in Option 2.

In order to climb up to 668, Option 2 climbs relatively high up the north wall of the Dropleaf valley. This takes much of the trail in the valley up into the ponderosas and out of the meadows and aspen that make the valley such a pleasant user experience along the whole trail. Hence we lose part of the best experience of the valley and get closer to Bear Creek than we might otherwise.

Option 3

Option 3 is designed to be a better balance of staying away from Bear Creek and avoiding the heart of CSU's property while providing a varied, enjoyable, and sustainable trail experience. Instead of reusing the level leg of 668, a new trail is constructed below it at a 5% to 7% grade. This new switchback leg reaches Dropleaf Creek roughly 1,000 feet downstream of 668, thereby leaving that much more of Dropleaf Creek without an adjacent trail and shortening the overall trail by nearly 2,000 feet.

New trail on the north side of Dropleaf Creek (at a more easily sustainable 6% instead of the 7% of Option 2) doesn't need to climb as high and hence stays lower on the valley wall and more inside the meadow and aspen zone that makes the valley so pleasant. At the same time, the new trail is still relatively far from the creek.

Constructing 0.45 miles more new trail than Option 2 also creates an additional supply of potential backfill material with which to restore decommissioned trails in the Dropleaf valley (668, 720, 622.A, and the unnamed ??? trail along the creek). While full slope restoration doesn't have to occur, if all excavated material from new trail construction between **A** and **B** were used to backfill and restore the original slopes along all decommissioned trails in the Dropleaf Valley (including the redundant parallel western tread

of 622.A), there would be more material to do so. If it were also decided to close 622 between **A** and **B**, material from new trail construction above **B** could be brought down as backfill. The same is true for optionally backfilling 668 north of **B** for enough distance that it would no longer be visible or inviting to users.

Hence Option 3 offers the best opportunity for users to enjoy part of the richness of Dropleaf Creek without spending too much time in its valley (which preserves more of the creek upstream for wildlife), reduces shortcut temptations associated with reusing 668, replaces the straighter roadlike alignment of 668 with a more trail-like dip and crest alignment, and provides more material for more or fuller restoration of decommissioned trails in the area.

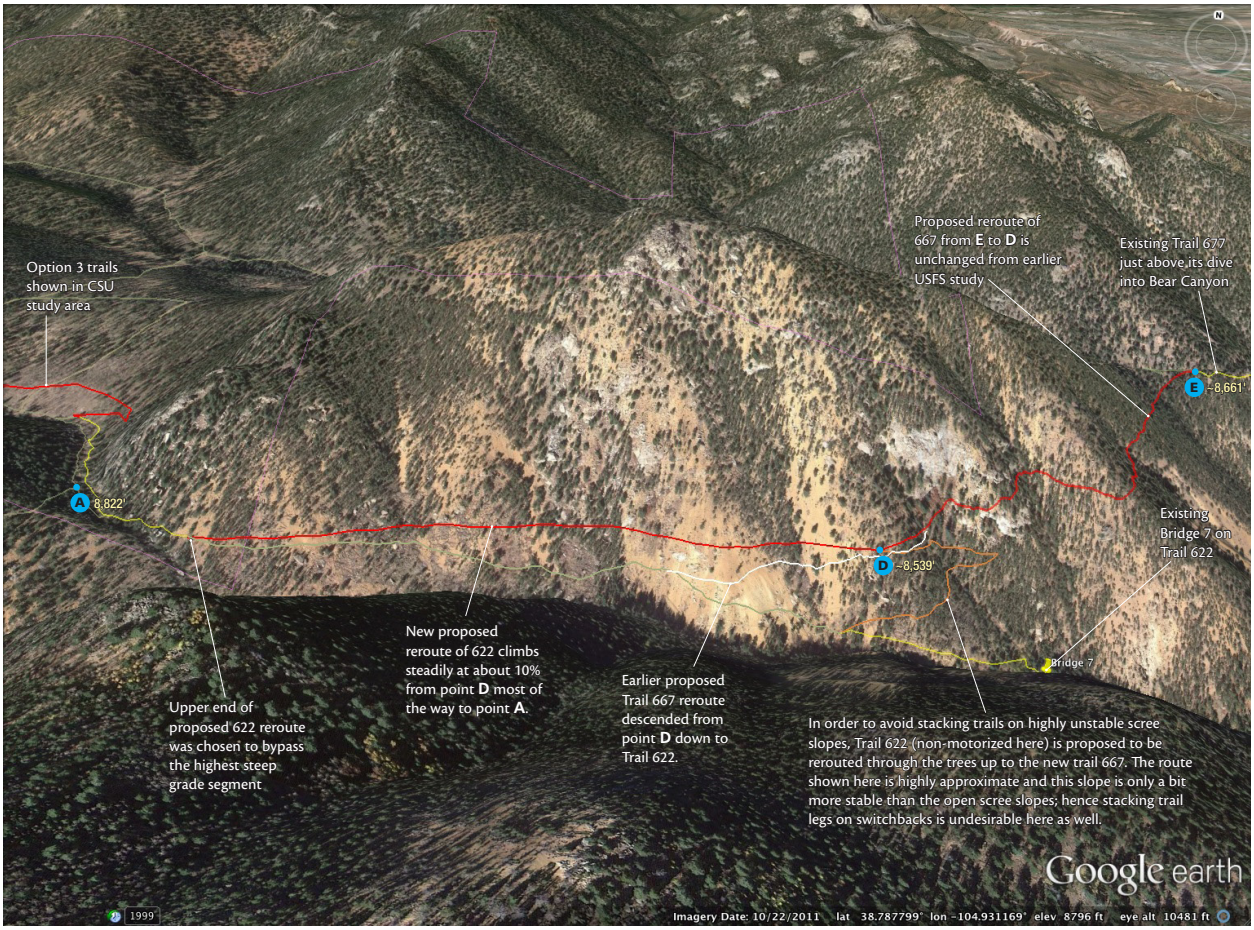
New trail in the Dropleaf Valley can be more like this existing part of 622.A, and the erosion scars of decommissioned trails in the area can be backfilled such that the original slope is more or less restored and native vegetation will naturalize the filled areas. Note how both the backslope (the cut in the hillside above the tread) and the fillslope (the area immediately below the tread where excavated material was deposited) have naturally revegetated. (Typically, fillslopes revegetate faster and more completely than backslopes.)

To maximize the amount of material available for backfilling old trails, new trail can optionally be built as "full bench" in which the entire tread is cut into the hillside (with no fill below) and with all excavated material hauled away to backfill old closed trails. Full bench construction provides a tread which is immediately stable across its entire width, which is advantageous, but the backslope, which can be large on steep slopes, typically revegetates slowly because it is undisturbed (compacted) subsoil.

Note that this photo is a non-motorized trail on which user-imparted compaction can form and sustain a relatively level tread. When trails with this same context are used by motorcycles, they will develop a center depression or rut from displacement followed by erosion. Again, the concept of a trail as a series of crests and dips is intended to guarantee that the trail can drain through its dips. This trail has a dip, which is also a crossing of a natural drainage channel, in the background.

The Larger Project: Proposed Changes to Trails 622 and 667

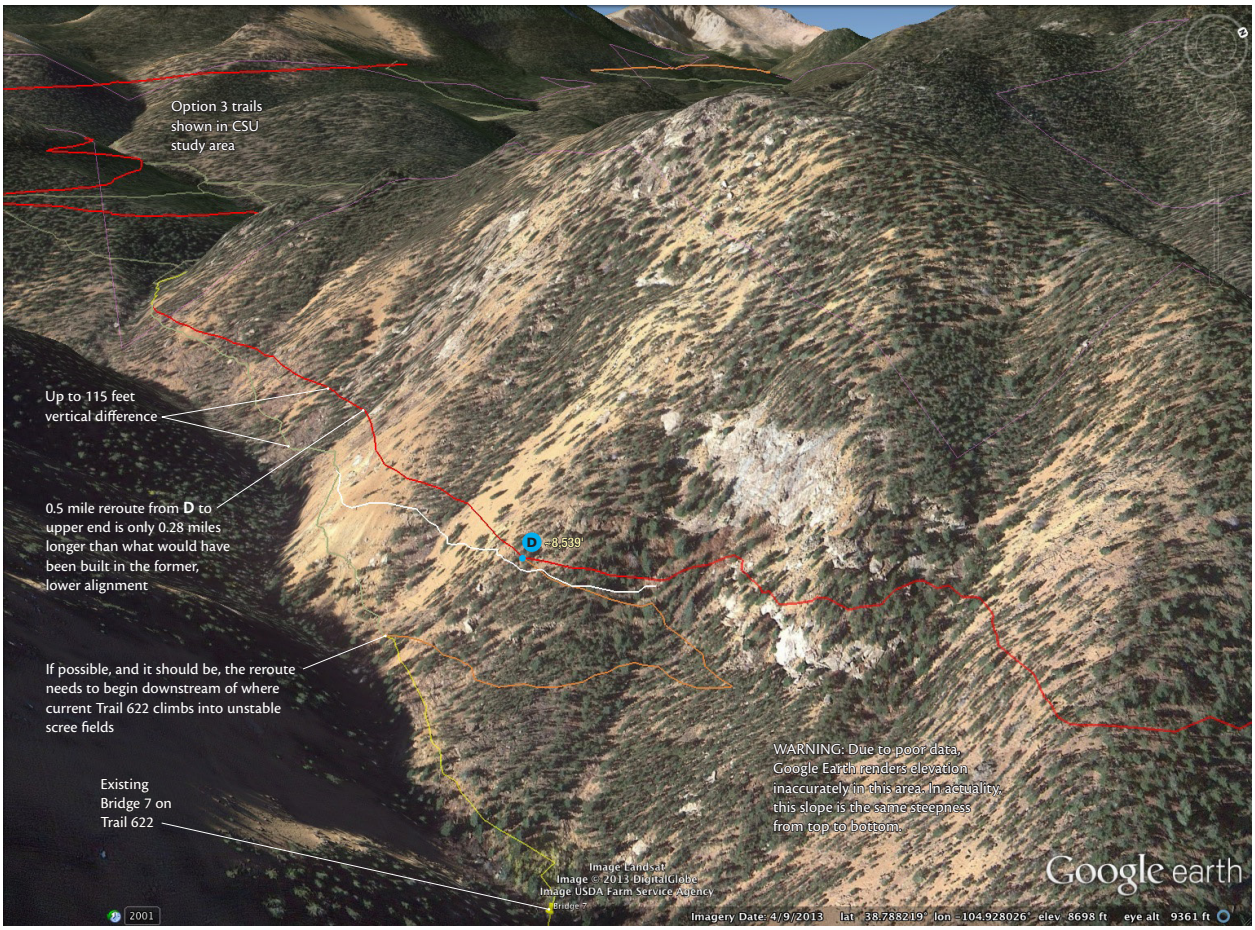
Close examination of trails in the CSU study area also led to proposed changes to earlier plans to reroute Trail 667 out of Bear Canyon and onto Trail 662. The following map shows these proposed changes as relatively rough concepts.



The long 10% climbing reroute of Trail 622 (shown in red) is a grade line that has not been hiked on the ground. It has, however, been seen from Trail 662 with an eye while looking for feasibility of such a route, and it seems possible without major obstacles. For sustainability, the actual trail would have the same crest and dip pattern as new proposed trails in the CSU study area.

The other reroute of the non-motorized segment of 622 below **D**, shown in orange, may be more problematic. Google Earth uses poor-quality elevation data in this area and the slopes here are not always how Google Earth renders them. In actuality, this slope is fairly steep and loose, and there is the same problem that anything that falls from a higher trail may roll all the way down to a lower trail segment. However, the slope is less steep and more stable than the open scree slopes and hence a sustainable and sufficiently safe non-motorized trail could be formed here. Cliffs and rock outcrops in the area make it necessary to do all design in the field, and the actual trail could have a very different alignment than shown here.

Because the rerouted Trail 622 between **D** and **A** will handle the traffic that was formerly handled by three separate trails (666, 667, and 622), it needs to be wider than the 24-32 inches that the existing Trail 622 typically is. Planning and building a new trail makes it easier to obtain a wider width as well as form wider "turnouts" wherever possible to make it easier for users to pass each other. The more consistent and overall gentler grade also improves safety by reducing the tendency of loose granite particles to behave like



marbles underfoot on steep grades. These are some of the reasons for rerouting 622 almost all the way up to **A**.

The 622 reroute from **D** to its upper end near **A** measures 0.50 mile. The former 667 reroute shown in white on the map measures 0.22, so only 0.28 miles (1,478 feet) of additional trail needs to be constructed to form the motorized portion of the 622 reroute. In addition, by avoiding excessive grades the new motorized portion of 622 is as much as 115 vertical feet above the existing 622. For muscle-powered trail users, the reroute removes that much more up and down.

The existing tread of 622 below the reroutes can be easily backfilled in the scree slopes by pulling more scree down into the trail. In areas with vegetation on the slopes, the tread can simply be scarified (loosened by tools so that plants can more readily grow in it) and left to revegetate on its own, or fill can be hauled in from a nearby scree slope. Given the steep slope, it is probably impractical to haul more excavated material than absolutely necessary from the upper reroute down to the lower trail.

A Note about Trail Construction

Using trail-scaled mechanized equipment or hand work, it is possible to build trail with very tight clearance. This enables us to work around trees and rocks without damaging them. Photos on this page are all newly constructed trail built by a combination of machine and hand work.

Rock outcrop sliced through while preserving the adjacent tree.

Trees are kept to anchor the curve and the outside edge of the tread.

The trail is just barely wider than a power wheelbarrow used in construction.

A bike-friendly switchback with its lower leg built up on a high stone retaining wall. There are a number of ways to build switchbacks; this is just one way.

A mini excavator is the machine of choice for narrow trails in steep country. Like the power wheelbarrow, it runs on rubber tracks that cause less damage and provide a better grip on the terrain.

Trails are flagged quite precisely in the field in order to ensure that the crest and dip pattern is correctly implemented.

View of the entire Bear Creek Watershed Restoration Project area (looking east to west)

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