

## CHAPTER 10-- CHANGES MADE TO TRAIL AND SNOWMAKING LAYOUT

This chapter describes changes made to the ski area design, in order to avoid landslides or minimize the impact of development on landslides. In the Progress Report on Geology and Slope Stability (GEO-HAZ, March 2007), we concluded that the proposed “Snodgrass Lite” design conformed with the 3 mountain-wide mitigation measures recommended by USFS (2006, p. 41). That is, no “structures, roads, buried utilities, and lift terminals [will be sited] on active (Class 1) landslides.”

In addition, the latest version of the Snodgrass Lite design considers additional hazard avoidance that go three levels beyond the mountain-wide mitigation measures (termed “Level 1” in Table 7-1). Those additional levels are necessitated by, and defined by, two uncertainties inherent in assessing the geologic hazards on Snodgrass Mountain: (1) uncertainty in what constitutes a historic landslide (Levels 3 and 4), and (2) uncertainty as to the quantitative effects of snowmaking and trail clearing on landslide Factors of Safety (Levels 2 and 4).

Table 7-1. Conceptual levels of avoiding landslides at Snodgrass, and how CBMR is responding to specific instances in the revised Snodgrass Lite design.

Avoidance Level	Landslides to Avoid	Items Proscribed	Location in original Snodgrass Lite design; and conflict	Response by CBMR, in revised Snodgrass Lite design
1 <sup>1</sup>	<b>Active (Qlsh)</b>	<b>Structures, roads, buried utilities, lift terminals<sup>1</sup></b>	<b>NONE</b>	<b><u>None needed</u></b>
2 <sup>2</sup>	Active (Qlsh)	Snowmaking, trail clearing, lift towers <sup>2</sup>	GHU 10A; Trail 31 (snowmake) intersects Qlsh polygon 46	Trail 31 will be shifted north to avoid poly 46
3 <sup>2</sup>	Active <u>and</u> Young (Qlsh, Qlsy, red scarps)	Structures, roads, buried utilities, lift terminals	GHU 3; buried snowmaking line at Ken’s Crux crosses toe of polygon 22	Line to be shifted as far west as possible on slide toe; slide mitigation planned for polygon 22
4 <sup>2</sup>	Active <u>and</u> Young (Qlsh, Qlsy, red scarps)	Snowmaking, trail clearing, lift towers	7 conflicts total, in GHUs 1, 3, 6, and 12	5 will be obviated by shifting trails; 2 will be mitigated in-place

<sup>1</sup> Mountain-wide mitigation required by USFS (2006, p.41)

<sup>2</sup> Higher levels of protection proposed by CBMR

Table 7-1 shows all 4 levels of landslide avoidance at Snodgrass, and how CBMR is approaching each level. Level 1 includes the mountain-wide mitigation measures recommended by USFS (2006, p. 41). These measures recommend that no structures, roads, buried utilities, or lift terminals be placed on active (historic) landslides. The original Snodgrass Lite proposal already conformed to

this Level, because no such actions were planned on active landslides (i.e., no conflicts with the USFS policy).

Table 7-1 shows 3 additional levels of avoidance, in order of increasing margin of safety and conservatism, which have been considered by CBMR and included by IAD into the current ski area design. Level 2 expands the list of prohibited actions on active landslides from 4 to 7, to include snowmaking, trail clearing, and lift towers. At this increased level of safety, the original Snodgrass Lite proposal has 3 conflicts with geologic constraints (all at the same location on the West Face), where proposed Trail 31 (with snowmaking, and a lift line) crossed over an active landslide (Qlsh and Qlsy, polygons 45-46, GHU 10A). Therefore, in the revised Snodgrass Lite design (trails, 30-NOV-2007; snowmaking, 25-OCT-2007), this trail and lift were shifted northward onto a stable bedrock ridge, such that neither the trail nor lift intersects either polygon 46 (active) or 45 (young) (Fig. 10-1). This shift eliminates all conflicts at Level 2.

Avoidance Level 3 would expand the 4 prohibited actions of Level 1, to cover young landslides (Qlsy, and “prominent scarps” mapped by RCE, 1995) as well as active landslides (Qlsh). At this level, there is only one conflict, where a snowmaking pipeline must cross the toe of landslide polygon 22 (Qlsy) at Ken’s Crux for a distance of 150-200 ft. Due to the necessity for a pipeline to ascend through Ken’s Crux, this conflict is not avoidable. Therefore, we plan to follow the mitigation measures recommended by USFS (2006) for increasing the stability of polygon 22 (see Chapter 9).

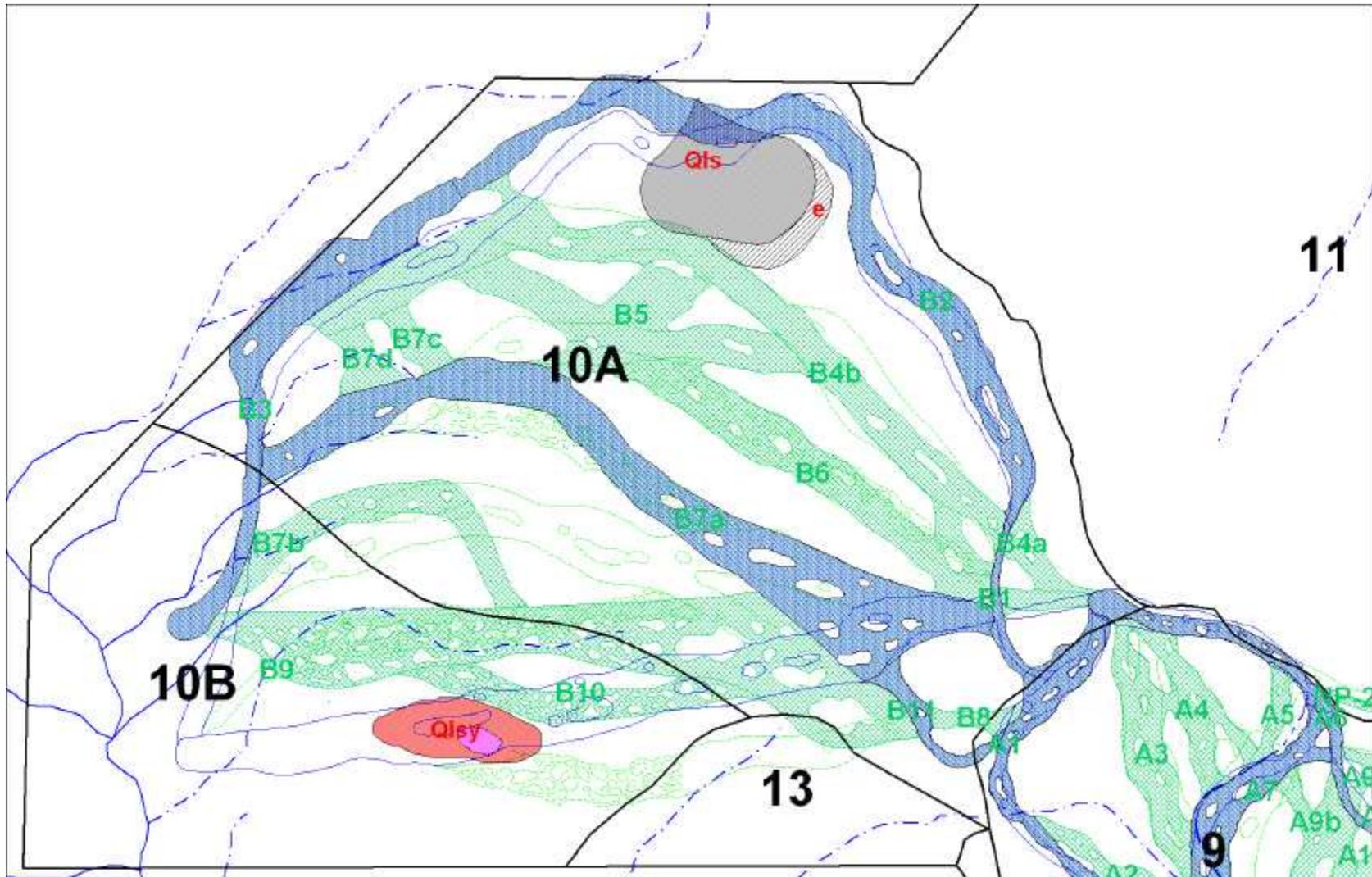


Fig. 10-1. Realignment of trails and snowmaking in GHUs 10A and 10B, which are tributary to Washington Gulch (blue drainage lines at left). Green colors and labels indicate trails; dashed outline, design of 25-OCT-2006; crosshatch pattern, design of 30-NOV-2007. Blue colors indicate snowmaking; blue outline, design of 21-JUN-2007 (basis of our hydrology studies); crosshatch pattern, design of 25-OCT-2007. Landslides are labeled in red according to age class. ACTIONS: Trail B10 was shifted north, and snowmaking was shifted to Trail B7a, to avoid impacting landslide Q1sy. Trail B2 was shifted north to diminish snowmaking on the toe of Q1s.

Avoidance Level 4 is the most extreme, and far exceeds the avoidance recommendations in USFS (2006). It would prohibit all 7 actions listed above, on both historic and young landslides. At this level, we encounter 7 instances where proposed trails cross young landslides (Qlsy). Below, we describe these instances in order of GHU number, and how the ski area design was altered at each site to mitigate the effects of development actions.

**GHU 1A—Conflict #1;** The original alignment of Trail D4 (with snowmaking) intersected 2 “prominent scarps” mapped by RCE (1995) in polygons 2 (Qlsi) and 10 (Qlsiy), which presumably mark younger slump reactivations in those polygons (Fig. 10-2). To eliminate this conflict, Trail D4 was shifted south in its upper part to avoid the scarps (red hachured lines in Fig. 10-2) and to remain mainly on the ridge-like landform of more stable landslide polygon 2. In its lower part Trail D4 was shifted north, to avoid Conflict #2 (next section).

**GHU 1B—Conflict #2;** The original alignment of Trail A11d (with snowmaking) ran southward from Ken’s Crux, down the eastern part of landslide polygon 1, the young earthflow (Qefy). This alignment created a significant conflict with landslides, even at Level 4, because even though the young earthflow is not currently moving, it has a low calculated Factor of Safety related to artesian aquifers at its base (PZ-6A). To diminish this conflict, snowmaking was removed from all of Trail A11d except for the upper 340 ft of polygon 1 (Fig. 10-2), which is the most stable part (Qefi; see Chapter 8 for cross-section). This action removed 900 ft of snowmaking from Trail A11d on polygon 1. The Trail will still exist, but it involves no snowmaking and little trail clearing, because that part of polygon 1 is mainly unforested. An additional 340 ft of snowmaking was removed from polygon 1 by the northward shift of Trail D4. Together, these two actions decreased the amount of snowmaking proposed on polygon 1 from 4.0 acres to 1.7 acres, a decrease of 58%.

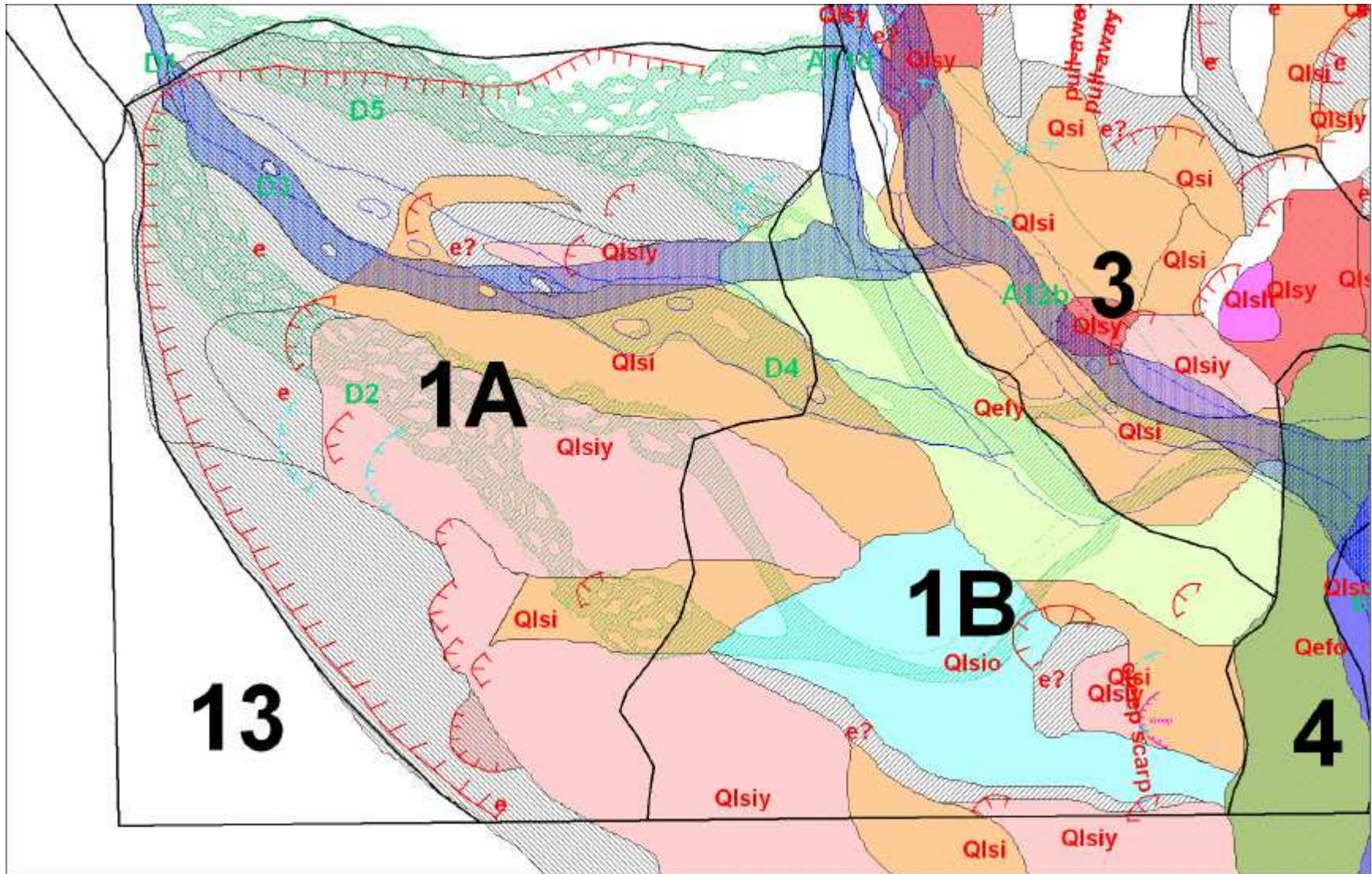


Fig. 10-2. Realignment of trails and snowmaking in GHUs 1A and 1B. Green colors and labels indicate trails; dashed outline, design of 25-OCT-2006; diagonal pattern, design of 30-NOV-2007. Blue colors indicate snowmaking; blue outline, design of 21-JUN-2007 (basis of our hydrology studies); crosshatch pattern, design of 25-OCT-2007. Landslides are labeled in red according to age class. NOTE: this map does not show the shift of Trail A12b snowmaking westward off of Qlsiy (polygon 21) on the steep slope band.

**GHU 3**—Trail A12 (with snowmaking) runs down the center of GHU 3, the Middle Slide complex. Although most of the center of the Middle Slide complex is Qlsi, there are 2 Qlsy polygons crossed by Trail A12, described next.

**Conflict #3**; At the head of GHU 3 (just below Ken's Crux), Trail A12 crosses the toe of polygon 22 (the Ken's Crux slump). The trail with its snowmaking will be shifted to the western edge of the quadrangle (not shown on Fig. 10-3). This landslide was discussed previously in Level 3, and was analyzed for stability in Chapter 8. The post-development Factor of Safety was predicted to be 1.71. Therefore, no mitigation is proposed at this time.

**Conflict #4**; Farther to the SE of polygon 22, proposed Trail A12 crosses the western edge of polygons 23 (Qlsy) and 21 (Qlsiy) (Fig. 10-3). Polygon 23 will be regraded so it is no longer a closed depression, and this will decrease infiltration to the head of polygon 21. To avoid polygon 21 (which has a post-development Factor of Safety of 1.05), the trail has been shifted west in the final design. [NOTE: The blue crosshatch pattern in Fig. 10-3 shows an older location for snowmaking; it will be moved westward as shown by the blue arrowed lines, to avoid polygon 21].

The Main Lift that ascends from the Slump Block to the summit of Snodgrass crosses the long axis of GHU 3, and crosses over young landslide polygons 22 (170 ft distance) and 44 (200 ft distance). Because these distances are <400 ft, it should be possible place lift towers as to avoid these 2 stretches (so, no anticipated conflict).



GHU 6—Conflict #5; Above Ken's Crux, Trail A11c (no snowmaking) splits apart from Trail 12, and was proposed to cross the western edge of polygon 44 (Qlsy). Therefore, Trail A11c will be shifted west to avoid this.

Conflict #6; Trail A15 (no snowmaking) covers the eastern edge of polygon 43 (Qlsy) for a distance of 340 ft, and the center of polygon 42 (Qlsy) for an additional 800 ft. However, this is not as bad as it looks. First, Trail A15 will not have snowmaking. Second, the 340 ft of Trail 12A on polygon 43 can be shifted east only 50 ft to avoid the polygon. Third, on polygon 42, the trail cannot be shifted, so aggressive surface-water mitigation will be performed in the Chicken Bone meadow above, moving runoff to the east.

GHU 12—Conflict #7; Trail 13 (snowmaking on southern half) was proposed to cross an old (RCE) scarp and polygon 48 (Qlsiy). Although these two landslide features are, strictly speaking, too old to be considered in Level 4, it was relatively easy to shift the snowmaking to the northern half of Trail 13. This action moves all the snowmaking onto stable bedrock terrain.

In summary, 7 conflicts exist at Level 4 between proposed actions and young landslides, but all but three will be obviated by shifting the trail alignments. In the two remaining conflicts (Conflict #3, slide polygon 22; conflict #5, Trail A11c/ polygon 44; Conflict #6, Trail A15/ polygon 43), the trail alignment cannot be moved far enough to totally avoid the young landslide. At these locations, we will institute some of the aggressive, best-management-practice, mitigation measures recommended by USFS (2006).

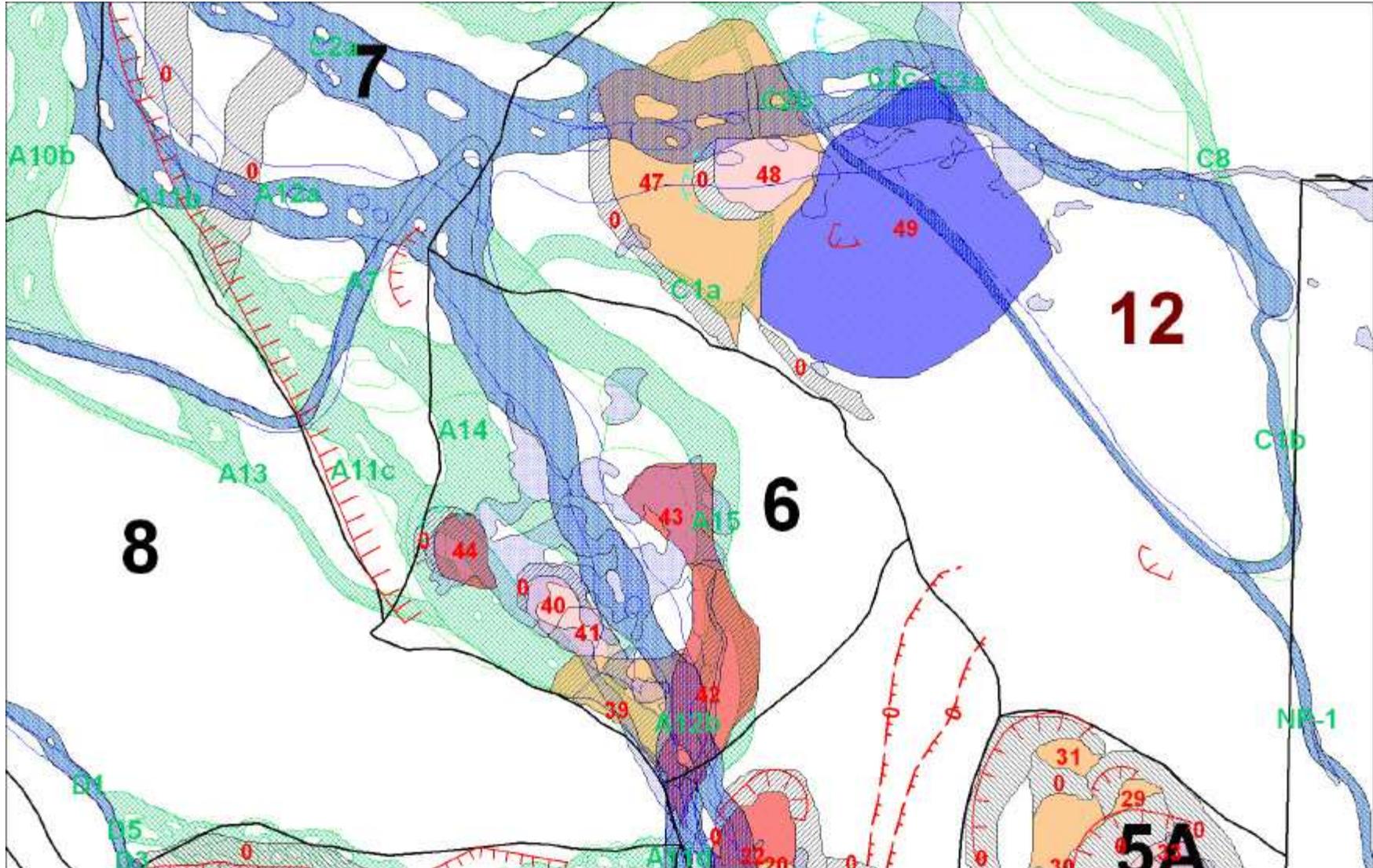


Fig. 10-4. Realignment of trails and snowmaking in GHUs 6, 7, 8, and 12. Green colors and labels indicate trails; dashed outline, design of 25-OCT-2006; crosshatch pattern, design of 30-NOV-2007. Blue colors indicate snowmaking; blue outline, design of 21-JUN-2007 (basis of our hydrology studies); crosshatch pattern, design of 25-OCT-2007. Landslides are labeled with red polygon numbers and colored as to age (red, Qlsy, pink, Qlsiy; orange, Qlsi; blue, Qlso). Red lines with hachures are prominent scarps