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July 17, 2003

Mr. Tom Kennedy
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Telluride, CO 81435

RE: Idarado Project

Dear Tom:

This report, prepared on behalf of Idarado, considers certain 1041 review implications for development on the Idarado property and demonstrates compliance with the review standards contained in the County Land Use Code (LUC) governing 1041 reviews. This report analyzes portions of the Idarado property in which development is contemplated which may be subject to certain geologic hazards. These areas may encounter snow avalanches, rockfalls and debris flows[1]. I am generally familiar with the review and specific review standards of the LUC relative to the studies addressed in this report.

In 2001, as part of the Idarado Legacy Annexation proposal with the Town of Telluride, I prepared a report dated February 1, 2001. Because the lot plan and building envelopes have changes since 2001, I intend that this report update my prior study. My updated results are summarized on Table 1 which refers to 37 building locations plotted by Foley Associated on a 1" = 300'-scale map originally dated "6-27-03." Any substantial changes to this map or the proposed building envelopes may invalidate the results of this letter report. I have reviewed the Foley mapping and agree that it accurately portrays the areas I deem as being affected by hazards associated with snow avalanches, rockfall, and debris flows. I am also addressing certain questions and comments by Jonathan White of the Colorado Geological Survey (CGS) which he made in a March 20, 2001 letter to Steven R. Ferris of the Town of Telluride.

Changes to the Plan

The revised development plan, a copy attached, has eliminated building sites at the Kentucky Placer. It also eliminates several sites on the east end of the development near the old mill building (Mine Camp) which were affected by snow avalanches and rockfall, therefore hazards previously delineated in the area are no longer of concern to this proposed development. There is considerably less density, particularly in the areas of Liberty Bell and Mine Camp, thus reducing overall risk associated with the project. The exposure to hazards of the other lots or groups of lots are summarized below by area and topographic setting.

1. EXPOSURE TO HAZARDS AND MITIGATION CONCEPTS

The "Far West," (Lots L-1 – L-9 and P-1 and P-2)

These are located immediately east of the Lone Tree Cemetery at the base of colluvial slopes subject to rockfall and small snow avalanches. The building envelopes are situated on a low-gradient bench north of Colorado Avenue. Lots L-3 – L-5, L-7, and L-8 will be located immediately south of small snow avalanche areas and probably are beyond the range of flowing

[1] *Other geologic hazards or geophysical constraints to this proposed development, if any, are beyond the scope of my work.*

avalanches with any destructive potential; they may be reached by powder clouds associated with dry-snow avalanches, depending on final building locations within the envelopes. Building envelopes L-6 – L-9 are affected by rockfall. Envelopes P-1 and P-2 are south of and below Colorado Avenue which will serve to catch rock; they do not require rockfall or avalanche mitigation.

Mitigation for *snow avalanches* will probably not be required on any of the lots in this group, depending on final building locations within the envelopes. If avalanche protection is required for the design-magnitude[2] avalanche event, it would consist of site-specific design for minor avalanche forces and/or stagnation pressures. Mitigation for *rockfall* should consist of a single fence designed to absorb rockfall energy. This fence should be located on the north side of Liberty Bell Lane approximately 50 feet (vertically) above the upper road cut. This fence must be designed for rockfall energies and bounce heights which must be specified. The fence should be designed and installed prior to residential construction. The fence would have a length of approximately 700 feet. I agree with the recommendations of Mr. Jonathan White of the Colorado Geological Survey and do not recommend rockfall protection for each individual residential site.

Royer Gulch alluvial fan (Lots P-3 through P-11, and P-16 through P-22)

This fan has developed primarily from deposition of floods and debris-flows which have occurred since valley deglaciation about 15,000 years ago. This fan, which shows topography and sedimentology typical of debris flows, extends continuously for an east-west distance of about 1,600 feet. However, because flows are now confined laterally by a steep trench approximately 30 feet wide and 10 feet deep until the "The Falls" access road crosses it (see Figure 4), a much smaller portion of the fan is now threatened by debris flows. This conclusion about the portion of the fan exposed to debris flows differs from that of Jonathan White of the CGS in that I feel the deep channel position will reduce the active debris flow width, even assuming the inevitable channel blockage during a flow. A larger part of the fan area is within the runout zone of dry-snow and powder avalanches.

The active *debris-flow area* is about 500 feet wide and affects building envelopes P-17 and P-18. This active debris flow area terminates at proposed "Pandora Lane," where the cut and fill of this road will stop the debris. Muddy flood flows will accompany large debris flows and thus may extend the flood area both laterally (in an east-west direction) and distally (toward the south). The muddy flood flows, in contrast to the debris flows, will not contain a large percentage of solid material thus will not produce impact damage to buildings (other than at sites P-17 and P-18). *Dry-snow and powder avalanches* become fluidized as they fall over waterfalls above "The Falls" subdivision. During design-magnitude events, building envelopes P-16 through P-19 will be impacted by the design avalanche which can produce stagnation pressures of flowing-snow impact requiring special building design (see below). Destructive avalanche energy will be dissipated by the time Pandora Lane is reached although buildings on lots P-7 through P-11 will be momentarily enveloped in a low-density, non-destructive powder cloud.

Mitigation for debris flows must be addressed on a site-specific basis. Channelization of these muddy, debris-laden torrents through construction of a central drainage channel will not be practical below The Falls access road or Colorado Avenue because the channel gradient will encourage deposition, channel blockage, and lateral spreading of the flows, even if a "straight-shot" channel is planned. Furthermore, culverts (including large box culverts) would become blocked and will force flows to back up and spill laterally over the "active" portion of the fan. There are, however, methods for addressing this issue and mitigating the impacts without changing the channel. The site-specific debris flow design at each building should include reinforcing the lower walls and foundations for debris static loads, and impact of rocks and other objects entrained in the flow. This will be necessary on building envelopes P-17 and P-18 and might be required on P-16 and P-18 if the topography is modified during construction such that lateral spreading of the flows becomes more likely. *Mitigation for snow avalanches* must also be

[2] *The design-magnitude avalanche for residential buildings has a return period of 100 years in San Miguel County.*

addressed on a site-specific basis and will consist of building reinforcement on the uphill, north-facing surfaces, for impact and stagnation pressures resulting from the design avalanche. This must be addressed on sites P-17 and P-18, possibly on P-16 and P-19. The avalanche loads will not be large at the building locations because they will be located near the end of the runout zone where energy will have been largely dissipated through friction, however the exposed walls, roofs and other surfaces will receive loads in excess of normal horizontal-loading requirements specified in the Uniform Building Code (UBC).

Mitigation for rockfall will be required on site P-22. This should consist of a rockfall energy dissipating fence above the house site.

The "Far East" (Lots P-13 through P-15, BV-1 through BV-4,, and P-23 and P-24)

These sites, all located between Royer Gulch and Marshall Creek are exposed to some degree of *rockfall hazard* which appears to result primarily from the Entrada Sandstone, and Telluride Conglomerate units (Figures 1, 2, and 3). Other sedimentary units produce lesser rockfall hazards. An aerial inspection of the terrain on July 15, 2003 did not suggest a significant risk of a widespread collapse of the volcanic San Juan Formation (predominately a tuff breccia) which would produce a large rock avalanche capable of spreading over the slopes and valley floor. My inspections on foot during 1999 and 2000 confirm this conclusion as do the photographs in Figures 1, 2, and 3 which indicate eroded "cone-shaped" outcroppings which are wider at the base than at the top, a generally more stable shape. No evidence was found for rock avalanche deposits on the slopes above the valley floor, suggesting that none have occurred at this site during the past ≈15,000 years, since valley deglaciation. These conclusions *may* contrast with the concerns expressed by the CGS about the "potential for a catastrophic rockmass failure that would result in a rock avalanche that would fan out over the valley floor and overwhelm and rockfall mitigation structure." Rockfall from the San Juan Formation is certainly capable of reaching the sites to be developed but should present no greater risk than rockfall from the lower sedimentary Entrada and Telluride units previously discussed. Rockfall can cross Colorado Avenue in this area, reaching the 6 sites on the south end of the "Far East" portion of the development but will contain substantially reduced energy toward the end of their runout. *Snow avalanches* are also possible even though the slope is south facing and heavily timbered with aspen trees. Avalanches will be small, and possess reduced destructive force at building sites BV-1 through BV-4 . *Small debris flows* are also possible. Flows originate at the tops of small gullies and steep colluvial slopes at the tops of these gullies. Debris flows can reach building envelopes BV-1 through BV-4.

Mitigation for rockfall should consist of energy-absorbing rockfall fences above the individual sites or a continuous row of fence approximately 1,600 feet long completely protecting sites BV-1 through BV-4 and therefore protecting the sites below them. Buildings can also be protected by shorter fences above each site, however, because adjacent sites and those on the north side of Colorado Avenue may benefit from fences, it may be difficult to distribute the cost of these expensive structures fairly between various property owners. *Snow avalanche mitigation* for the relatively small avalanches that can occur here must be independent of rockfall mitigation and must be specified on a site-specific basis; this would consist of minor reinforcement of lower building walls on sites BV-1 through BV-4. *Debris-flow mitigation* will also consist of site-specific lower building reinforcement at sites BV-1 through BV-4, although the design criteria for avalanche and debris flow mitigation will differ.

Table 1 summarizes the hazard exposure and mitigation concepts which are feasible at the various building envelopes proposed.

SITES	TYPE OF HAZARD	CONCEPTUAL MITIGATION REQUIRED
L-3 – L-5, L-7, L-8	Snow Avalanche	Direct building reinforcement (possibly not needed)
L-6 – L-9	Rockfall	Rockfall fence above Liberty Bell Lane
P-17 and P-18	Debris Flow	Reinforced lower walls and foundations
P-16 – P-19	Snow Avalanche	Building reinforcement for dry flowing/power avalanches
P-22	Rockfall	Energy-absorbing fence above site
BV-1 – BV-4 P-12 and P-15, P-23 and P-24	Rockfall	Energy-absorbing fence above site
BV-1 – BV-4	Snow Avalanche	Building reinforcement for dry flowing/power avalanches
BV-1 – BV-4	Debris Flow	Reinforced lower walls and foundations

I will be involved in the development of design criteria and guidelines to achieve the project mitigation measures. These criteria will include reinforced walls, energy-absorbing fences, and/or other mitigation techniques. Mitigation criteria should be considered by a professional engineer (P.E.) registered in the State of Colorado.

2. SUMMARY AND CONCLUSIONS

Most of the sites proposed for development are exposed to some level of hazard from rockfall, debris flows, or snow avalanches. Some sites are exposed to multiple hazards. Although design-standards for mitigation have not yet been developed and may differ somewhat from those calculated in the studies of 1999 – 2001, experience gained during those studies suggest that mitigation will be feasible on the currently proposed sites. The avalanche and possibly debris flow and rockfall exposure in the old "Mining Camp" site near the mill have been completely avoided by eliminating development in that area and development in the Liberty Bell area has been substantially reduced in density.

Assuming the suggested mitigation methods are used and the required site-specific loading criteria and other engineering criteria are derived and used, the project can proceed. This can be done without subjecting property owners, guests, and others to a level of risk that is outside the standards accepted in similar areas of geophysical hazard in the United States and Europe and will be in conformance with the LUC review requirement.

Sincerely,

Arthur I. Mears

Arthur I. Mears, P.E.
Avalanche-control engineer

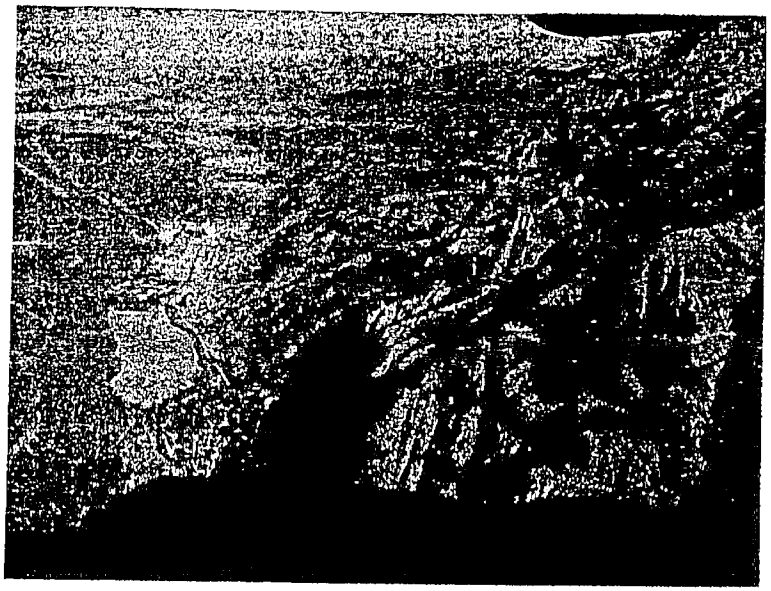

FIGURE 1. Looking west. Sedimentary formations capped by volcanic San Juan Formation

FIGURE 2. Royer Gulch (left) and Marshall Creek (right).

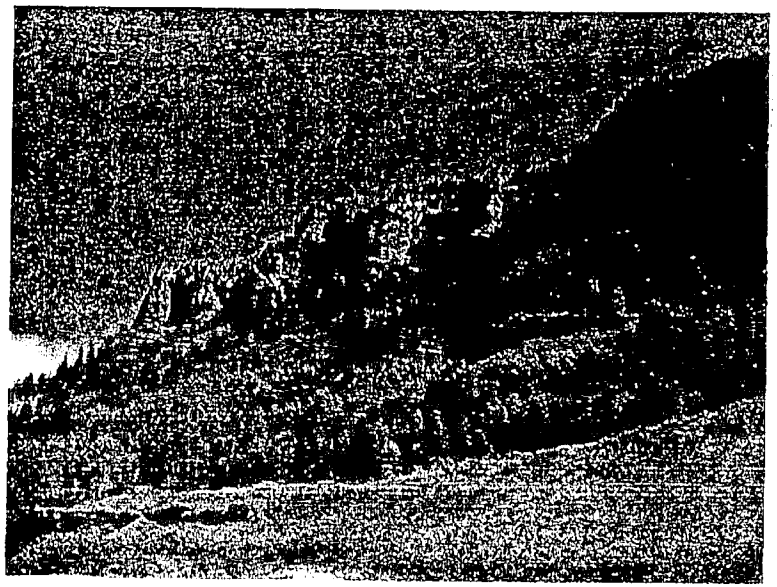

FIGURE 3. From Colorado Ave., looking west toward slopes shown in Figure 2.

FIGURE 4. Looking down Royer Gulch toward 30" culvert below "The Falls" access road.

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11 August 2003

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RE: Idarado Project – mitigation design concepts, feasibility, and effectiveness of methods

Dear Tom:

This letter is a supplement to my 17 July 2003 letter. I will be discussing mitigation concepts in greater detail by discussing the relative mitigating effect that could, in my opinion, be achieved by each method. This is broken down by proposed building site and type of hazard (snow avalanche, rockfall, debris flow). As noted on 17 July, the proposed building locations were plotted by Foley Associates on a 1" = 300'-scale map originally dated "6-27-03." Any substantial changes to this map or the locations of the proposed building envelopes may invalidate this letter report.

1. Sites L-3 – L-5, L-7, L-8 (sites *possibly* affected by snow avalanches)

All 5 sites are located near the lower limit of small potential snow avalanches on nearly flat surfaces where avalanche energy will have become largely dissipated through friction. A small risk from the design-magnitude (100-year return period) avalanche may exist, depending on building position. Avalanche risk to these residential buildings from the design-magnitude avalanche can be eliminated and the persons inside protected by reinforcing the uphill-facing building walls, doors, and windows for moderate avalanche impact and depositional loads. Loads will be moderate and will be addressed on a site-specific basis during final design. The architect and/or structural engineer will address the strengths and horizontal load distributions, sizes of reinforced structures, and impact factors to be utilized. These parameters will be specified and available for the structural engineer after final building positions and orientations are known.

2. Sites L-6 – L-9 (sites exposed to rockfall)

These sites are exposed to rockfall and should be protected by a specially-designed rockfall-energy dissipating fence. The height and strength of this fence will be based on a statistical distribution of design rock size, energy, speed, and bounce height which will be determined by a rockfall simulation computer model which will be completed at the time a house is being designed and located. Based on my site observations of the rockfall source, rock type and likely size, the roughness of the slope, and the potential fence location, I feel the rockfall hazard at the buildings can be *virtually* [1] eliminated by a specially designed fence. This fence will be sufficiently high (6 to 10 feet) and strong to catch rolling, bounding, and sliding rocks.

[1] *Some very small probability exists that the capacity of any mitigation system will be exceeded; this probability is so small it is usually disregarded in engineering and planning.*

3. Sites P-17 and P-18 (exposed to debris flows)

These two building sites are located near the bottom of the Royer Gulch debris-flow area. At the proposed building locations, flows with estimated return periods of 30 to 100 years will have advanced approximately 400 feet on a slope of 15% (8.5°) and therefore will have dissipated most of the kinetic energy through friction. Buildings will be best protected by building reinforced stem walls, and lower building walls. These lower building surfaces (probably 3 – 5 feet high) must be reinforced for the hydrostatic loads of the debris and possibly the impact load of slow-moving boulders 1 – 2 feet in diameter embedded in fairly shallow flows. These stem walls and impact walls will be easily designed through applications of standard engineering procedures. As with the rockfall sites discussed above in "2," the risk to buildings and occupants will be *virtually* eliminated as long as the design criteria and the final building design both follow up-to-date procedures.

4. Sites P-16 – P-19 (exposed to powder avalanches)

These four sites are within range of powder avalanches[2] at the bottom of the Royer Gulch avalanche path and alluvial fan. The powder blast pressures will probably exceed typical wind loads but can be easily resisted in design. At least one building in San Miguel County (in "The Falls Subdivision") has been designed and built to resist powder avalanche forces at the east edge of the Royer Gulch avalanche approximately 800 feet north of these sites. I have also provided design powder-avalanche loads for several other buildings in North America. Building design for powder avalanches does not necessary alter building appearance noticeably. Special windows are generally used, wall structure is strengthened, and roofs are more securely attached. Because powder avalanche loads will be modest the mitigation should be easily achieved and the risk to persons in the buildings can be virtually eliminated.

5. Site P-22 (exposed to rockfall)

This site, located immediately west of the Royer Gulch avalanche and debris flow, is exposed to rockfall hazard and can be best protected by an energy-absorbing fence similar to those discussed in "2," above. Site-specific design of this fence will virtually eliminate the hazard to the building and occupants.

6. Sites BV-1 – BV-4 (exposed to rockfall)

These four site have the largest exposure to rockfall and present the greatest risk of underdesign in any rockfall mitigation system. For this reason, a 2-phase system might be used, including (a) a rockfall energy dissipating fence approximately 1,600 feet long above the four houses, and (b) site-specific uphill wall reinforcement at the four buildings to absorb the energy of any rocks not completely stopped by the fence. The special building walls might consist of any deformable structure (gabions, planter boxes, etc.) possibly 4 – 6 feet high to dissipate rock momentum gradually. Heights of these structures will depend on site-specific design. The combination of "a" and "b" should virtually eliminate risk to structures and occupants.

7. Sites P-12 – P-15, P-23, P-24 (exposed to rockfall)

These six sites are located below Colorado Avenue, below the four sites discussed in "6," and also below the rockfall fence described in "6." The combination of rockfall fence and site-specific mitigation of the four upper buildings as well as the increased distance into the rockfall runout will virtually eliminate the hazard at these four sites.

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[2] *Powder Avalanche: A low-density, defuse, deep mixture of air and fine snow particles that accompanies some large dry-snow avalanches. The destructive energy of a powder avalanche is substantially less than the denser flowing snow but energies typically exceed those associated with wind gusts and must be accommodated in design.*

8. Sites BV-1 – BV-4 (exposed to snow avalanche)

These four sites are also exposed to various types of snow avalanches[3]. Mitigation for the snow avalanches will consist of reinforcing lower building walls for impact and depositional avalanche loads and minor reinforcement upper building surfaces for powder avalanches. Powder-avalanche reinforcement will be minor and may not be needed. These steps will virtually eliminate the hazard from snow avalanches.

9. Sites BV-1 – BV-4 (exposed to debris flows)

These four sites are exposed to minor debris flows that originate in small basins below the cliffs and follow channels to the sites. Building locations within the indicated envelopes may eliminate the hazard. Flows will be small and possess little volume or energy. Building stem walls and possibly lower walls should be reinforced for static debris flow depositional loads and impact of small rocks, similar to the recommendation in "3," above. This will virtually eliminate the hazard.

All mitigation techniques must be developed on a site-specific basis after exact position and orientation of each structure and building is determined. Final building locations may alter some of these recommendations. The long rockfall fences discussed in "2" and "7" can be used to protect groups of buildings. Large rockfall fences manufactured by GeoBrugg have been known to stop small debris flows and small snow slides as well as rockfall and probably would serve to protect sites BV-1 – BV-4 from debris flows and small snow avalanches. Building sites L-7 and L-8, which also have rockfall and avalanche exposure, may also be protected from the small avalanches by the rockfall fence.

However, as with any natural geophysical phenomena (e.g., floods, earthquakes, weather events) there exists some small probability that the mitigation methods proposed will fail. This risk of "under-design" would be similar to other such risks we normally accept in everyday life (e.g., roof collapse under snow load in a new building, brake failure in a new automobile, etc.). No one denies that such failures are *possible*, but we normally accept them. I believe they should also be accepted in this application as long as the best available methodologies and technologies are used in development of design mitigation parameters.

We will require that all mitigation concepts discussed will be incorporated into final design and that this design be completed by an engineer registered in Colorado.

Please contact me if you have any questions.

Sincerely,

Arthur I. Mears

Arthur I. Mears, P.E.
Avalanche-control engineer

[3] *Dry-snow, powder, and wet-snow avalanches will all be possible on this aspen-covered hillslope. However, none will be large or possess high destructive energy.*

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August 21, 2003

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RE: Idarado Project – Response to 18 August 2003 letter by Karen Berry to Michael Rozycki

Dear Tom:

In this letter I will be responding to certain issues raised by Karen Berry of the Colorado Geological Survey (CGS letter) about snow avalanche, rockfall, and debris flow hazards and mitigation at the proposed Idarado project.

1. Previous Work

As you know, I have submitted previous reports on these hazards on 17 July 2003 and 11 August 2003. In these reports I addressed comments and concerns which were made in a 20 March 2001 letter by Mr. Jonathan White of the CGS.

a. Rockfall at Lots L-6 – L-9. This area was originally planned for relatively high-density housing (approximately 72 units). Originally, site-specific rockfall mitigation was proposed at each building. The area is currently planned for lower-density residential housing (9 lots) and, as suggested by Mr. White, will be protected by a single, continuous fence. This fence will protect all buildings, access roads, and pedestrian use near the buildings from rockfall.
b. Royer Gulch Debris-flow alluvial fan. In this area below Colorado Avenue, I believe the active debris flow area is limited in width due to the channel configuration. I am not certain my opinion on width differs from Mr. White's because he did not specify the width of the debris deposition area.
c. Slopes between Royer Gulch and Marshall Creek. Mr. White suggested this area might be subject to rock avalanches, which, if it should occur, could "overwhelm rockfall mitigation." My past and current field inspections found no evidence that rock avalanches have occurred. Furthermore, my aerial reconnaissance (which was suggested by Mr. White and completed last month) identified relatively stable "cone-shaped" bedrock features within the volcanic San Juan Formation which do not appear susceptible to toppling failure and large-scale rock avalanches (see my 17 July letter.) The proposed building sites on BV-1 through BV-4 will be protected by an engineered rockfall energy-absorbing rockfall fence approximately 1,600 feet long located approximately 100 feet above the buildings. This will protect the buildings and terrain below these buildings from rockfall.

In addition to the above specific comments, Idarado has reduced the scope of the planned development substantially. The "Mine Camp" site (25 lots), which was exposed to rockfall and avalanche, has been eliminated. The Bridal Veil sites were reduced from 5 sites to 4, thus reducing the overall exposure in that area. The Pandora sites have been reconfigured, resulting in the reduction of lots within the Royer Gulch debris flow area from 6 to 2 lots. The Liberty Bell sites, which I understand were planned for higher-density housing, have been reduced

substantially in number. The Kentucky Placer sites have been eliminated. These changes to the scope of this project reduce the hazard exposure simply because fewer sites would be exposed. All sites that remain exposed, will, in my opinion, be protected by appropriate structural mitigation.

2. Exposure of roads and driveways

Driveways to sites BV-1 – BV-4 will be protected from rockfall by the 1,600-foot long fence discussed earlier. Extreme avalanche events, with return periods of 30 – 100 years may reach the driveways to these sites. Avalanches with similar return periods may reach Liberty Bell Lane. It would be difficult and/or impractical to design mitigation to protect these roads and driveways from the long-return-period avalanches and, in my opinion, would not be necessary. Because of these long avalanche return periods and the minimal traffic volume on these driveways the risk will be statistically insignificant and should, in my opinion, be accepted as it is in other areas throughout the state and country.

3. Debris-flow exposure on sites BV-1 – BV-4

The building envelopes for these lots are partially located within the identified debris-flow areas. However, these particular debris flows originate in small, steep drainage basins with little debris supply. Flows will be shallow, move at less than 10 feet/sec at the building sites, and can easily be mitigated by special stem-wall construction. Details cannot be provided until final design is underway, but, based on my experience in numerous cases, mitigation would not be difficult.

4. Debris-flow exposure on P-16 and P-19

These lots could be within the outer lateral range of debris flows and muddy floods from Royer Gulch. Landscaping adjacent to these sites may eliminate the debris flow exposure entirely. If some exposure to debris flows does exist after roads and final landscaping is done, these buildings can be protected by methods discussed in "3" (above).

5. Change in hazard due to fire

I have stated in previous (2000, 2001) reports that debris-flow and/or avalanche hazards could be increased as the result of forest fire or landslides. The extent of any future fire or landslide activity, if any, is unknown and cannot be addressed objectively. Hazard evaluation and mitigation procedures I am familiar with always address the current conditions. Most of the steep terrain above the sites considered are south-facing. The slopes support sparse conifer forests, aspen, shrubs, grasses. Talus is common and bedrock crops out locally. These south-facing slopes are not, in my opinion, as subject to fire-induced change as the typically more heavily forested north-facing slopes below which development *is not* planned.

I hope my comments have addressed some of Karen Berry's concerns. Please contact me if I can provide further help.

Sincerely,

Arthur I. Mears

Arthur I. Mears, P.E.
Avalanche-control engineer