USGS Post Event Investigation—1 December 2018 M 7.0 Anchorage Earthquake

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SUMMARY OF OVERFLIGHT

On 1 December 2018 between 10 am and 2 pm, the USGS conducted a post-earthquake overflight to observe impacts related to large ground deformations following the 2018 M 7.0 Anchorage earthquake. Adrian and I flew with pilot Turner Pahl of Alpine Air Alaska in a R44 helicopter from Merrill Field (Photo 1). We collected positions and photographs of ground deformations across the Anchorage bowl from McHugh Creek to Susitna River. The flight was fairly turbulent and covered 225 km between McHugh Creek, Wasilla, and the Susitna River (Photo 2). We did not inspect any features on the ground.

During our overflight we used USGS Ground Failure probability maps to guide our investigation. These maps are available at the USGS Latest Earthquakes event page. We also inspected known sites of large translational landslides triggered by the 1964 great Alaska earthquake. During the flight we checked preliminary reports of road failures and other ground deformations and mass movements reported by the news and social media. We kept three objectives in mind during the overflight:

1. Locate, photograph, and assess large ground failures, including landslides and liquefaction;
2. Assess secondary hazards like landslide dams and incipient cracks that may develop into future slope failures;
3. Check for reactivation of large translational slides triggered in 1964.

Although our reconnaissance observations require further field inspection to assess slope failure mechanisms, five general types of ground failure stood out: (1) ground failure involving engineered materials, often impacting roadways and railroad grades; (2) slumps, ground cracks and earth flows in natural materials; (3) debris avalanches on steep slopes, often underlain by glacial deposits; (4) liquefaction related deformation and vents, including lateral spreads and sand boils; and (5) rockfalls and snow avalanches in steeper terrain of the Chugach Mountains.

Assessing the potential reactivation of 1964 ground failures was a primary objective as we set out on the overflight. From the air we saw no obvious evidence for ground

Photo 1. Pilot Turner Pahl flew an Alpine Air Raven R-44 helicopter to conduct our overflight of post-earthquake ground failures in the Anchorage-Matanuska-Susitna region. (Credit: Rob Witter, USGS)

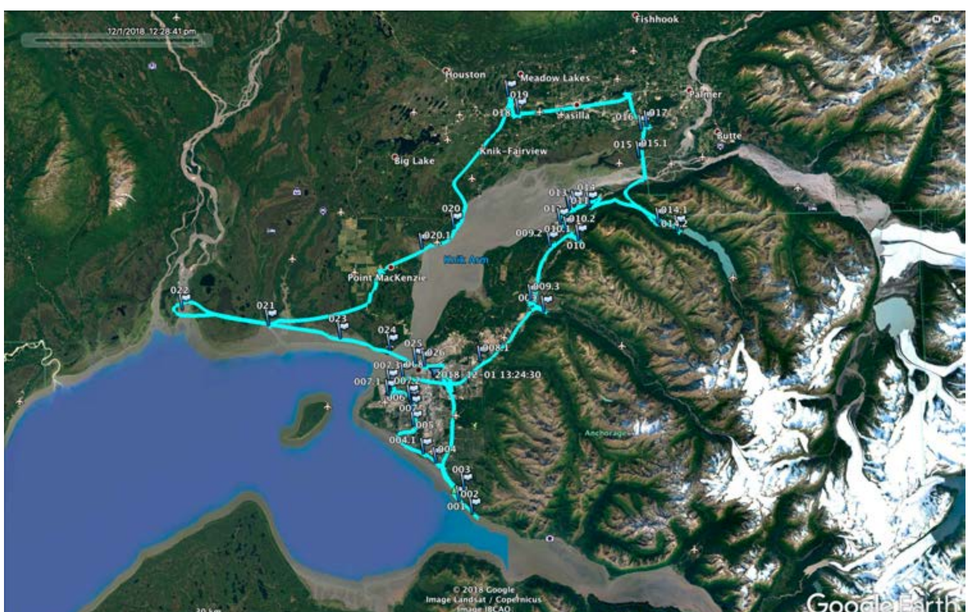

Photo 2. Flight path flown on 1 December 2018; blue flags mark locations of sites inspected from the air (map developed using Google Earth).

cracking along headscarps or the toes of large translational slides that failed in 1964. We infer that shaking during the 2018 Anchorage earthquake did not cause large (>1 m) displacements of landslides that moved during the 1964 earthquake.

We flew over Earthquake Park and along the entire Turnagain Heights landslide and observed no large displacements at the top of the bluff or bulges along the tidal flats that would indicate resurgence during the 1 December 2018 earthquake. However, because the hummocky ground at Earthquake Park is obscured by trees and has many steep slopes that might obscure deformation, we could not rule out small (<1 m) cracks that might indicate movement of these slides. We plan further field investigations to look for slope failure in Earthquake Park and examining other locations that failed in 1964 to assess reactivation of those features.

Overflights of other areas that failed in 1964 also showed a lack of movement in 2018, including Sunset Park, the former Native Hospital site, and Buttress Park. We speculate that the duration of shaking during the 2018 Anchorage earthquake stopped short of pushing deep seated translational slide blocks to failure.

Secondary hazards caused by earthquake-triggered ground failures include landslide dams blocking rivers and incipient cracks that may promote further slope instability after initial movement. We did not observe landslides that dammed streams along three drainages over which we flew, including Eagle River, Peters Creek, and Eklutna River. However, we cannot rule out the possibility that landslides have blocked these water courses upstream of our survey. Also, we recommend additional reconnaissance of a large rockfall on the east slope of Rainbow Peak along Turnagain Arm to assess the possibility of stream obstruction (Photo 3).

Another type of failure we observed at the top edges of steep valley slopes were deep cracks. These incipient failures may be important secondary hazards to consider as days pass after the earthquake. Some residents have reported that cracks above steep slopes have widened in the days since the earthquake. These cracks should be monitored for further movement in the coming weeks (Photo 4).

Ground failure in engineered materials occurred along roadways and railroad grades throughout the area we surveyed. Many of these failures were identified in the hours after the earthquake and reported in the news and social media. The Alaska Daily News published striking photos of slumped and lateral spreading of road embankment, including the north bound offramp of Minnesota Road and International Airport Way in Anchorage and the collapse of Vine Road near Wasilla (Photo 5). Some road failures occurred in engineered fills placed on or adjacent to low-lying ground, possibly saturated and filled with organic sediment, silt, or sand.

Photo 3. Large rockfall on east-facing slope of Rainbow Peak, about 8 miles east of Potter Marsh along the Seward Highway. This rockslide has fallen into a valley and may have impounded a stream. Secondary hazards include landslide dams that may break and cause flooding. (Credit: Vin Robinson)

We also identified damage to the Alaska Railroad due to slumping and lateral spreading along bluffs near Oceanside and Chugiak. Failures in the railroad grade occurred along low bluffs of Cook Inlet and Knik Arm shorelines that slumped toward the coastal flats where significant liquefaction was evident (Photo 6). We suspect that these landslides initiated in natural materials underlying coastal bluffs and propagated upslope to impact the railroad. Most of the ground failures appeared to be slumps, earthflows, and lateral spreads possibly induced by liquefaction.

Photo 4. Ground cracks present the potential for future slope failure during aftershocks or heavy rainfall. These cracks occur at the top of a steep valley wall on the south side of Potter Creek in south Anchorage. GPS position: 61.437615872°, -149.449646563° (Credit: Rob Witter, USGS)

Photo 5. Lateral spreading disruptured Vine Road near Wasilla. Many failures of engineered materials occurred on or adjacent to saturated lowlands filled with organic sediment, silt, or sand. GPS position: 61.437615904°, -149.449646520° (Credit: Rob Witter, USGS)

Some municipal facilities appeared to perform well during the earthquake suffering little or no ground deformations that could be resolved from our overflight. We flew over the Municipal Light & Power facility, which showed no evidence for large ground failures from the air. We also inspected the Eklutna Dam at the west end of Eklutna Lake, which appeared intact and undamaged (Photo 7). We will share oblique aerial photos of these sites. However, comprehensive assessments of the earthquake impacts to these facilities require detailed field surveys that are beyond the scope of our reconnaissance overflight.

Photo 6. Complex earthflow slumping along Alaska Railroad overlooking tidal flats along Knik Arm near Mirror Lake. Failure of these low bluffs may have involved liquefaction. GPS position 61.437615866°, -149.449646677° (Credit: Rob Witter, USGS)

We identified debris avalanches on steep slopes underlain by glacial deposits at Point Woronzoff, and along the Eagle River and Eklutna River valleys (Photo 8). These slope failures appeared to be superficial sloughs of sand and gravel deposits that spread downhill into broad debris aprons at the base of hillslopes. Freshly exposed glacial deposits in steep slopes elsewhere mantled by snow made these ground failures easy to recognize.

Liquefaction-related deformation and venting of saturated sediment occurred on tidal flats along Turnagain Arm, Cook Inlet, Knik Arm, and the Little Susitna River delta. We did not fly over the Sand Lake neighborhood where localized liquefaction impacted residential buildings. The most voluminous liquefaction occurred at the Little Susitna River delta where vented liquefied sediment blotted the coastal plain like large ink stains (Photo 9). Often the source of the sediment appeared to be a white dot that marked the

Photo 7. Eklutna Dam where we observed no evidence for ground deformation from aerial reconnaissance. Municipal utilities appeared to perform well during the earthquake. GPS position: 61.420135314°, -149.220729256° (Credit: Rob Witter, USGS)

Photo 8. Debris avalanches on bluffs composed of glacial outwash sediment along the Eklutna River. GPS position: 61.420186150°, -149.220729332° (Credit: Rob Witter, USGS)

source vent. Further geotechnical study is needed to evaluate the role of liquefaction in failure of coastal bluffs adjacent to sand blows observed in tidal flats.

The 2018 Anchorage earthquake released rockfalls and avalanches in the Chugach Mountains. The largest rockfall, reported by local eyewitnesses, may be the rock avalanche on the east face of Rainbow Peak, located ~8 miles east of Potter Marsh. This rockfall and avalanches in the higher terrain near Girdwood are documented by the Chugach National Forest Avalanche Information Center (http://www.cnfaic.org/site/observations/rainbow-peak/). During our overflight, we observed two large rockfalls along Seward Highway between Potter Marsh and McHugh Creek. Small rockfalls also occurred in the higher terrain above Eklutna Valley and in the peaks overlooking the Glenn Highway near the Knik Arm bridge.

Our overflight identified numerous ground failures caused by the 2018 Anchorage earthquake that we will continue to evaluate for failure mechanism and assess as secondary hazards. To accompany this summary, we have prepared geographic representations (.kml files) of our observations as a flight track and waypoints marking large ground failures, which can be viewed in Google Earth. We have shared preliminary findings with the Alaska State Division of Geological and Geophysical Surveys to assist with the design of detailed topographic lidar surveys of impacted areas. Our preliminary observations also were presented in coordination calls with EERI, NEHRP, and a briefing with Alaska Senators Murkowski and Sullivan.

Photo 9. Sediment vented by earthquake-triggered liquefaction at the mouth of the Little Susitna River. GPS position: 61.420135331°, -149.220729268° (Credit: Adrian Bender, USGS)

CONCLUSIONS AND RECOMMENDATIONS

We conclude this summary with a list of preliminary findings and recommendations for further work.

1. We observed no large (> 1m) displacements along the margins of landslides that failed in 1964. However, we recommend further examination in the field to assess the presence or absence of small displacements caused by reactivation of slide blocks.
2. We know of one large rockfall on the east slope of Rainbow Peak between Anchorage and Girdwood. Additional observations (National Guard overflight?) are needed to determine whether the rockfall has obstructed the stream and impounded water, which might present additional flooding hazards.
3. Numerous ground cracks occur at the crests of steep slopes along Potter Creek, Eagle River, Peters Creek, and possibly other deep valleys in the area impacted by ground shaking. These cracks present secondary landslide hazards that could be triggered by aftershocks or heavy rainfall and should be monitored to assess continued movement.
4. Next steps in our assessment includes overlaying the locations of large ground failures with geologic map of the Anchorage-Matsu area to evaluate landslide materials and possible failure mechanisms.
5. Our findings will be shared with local, state and federal partners, including:
    a. Alaska Division of Geological & Geophysical Surveys to support lidar acquisition;
    b. Earthquake Engineering Research Institute to support geotechnical and engineering inspections;
    c. Alaska Earthquake Center to support education and outreach;
    d. Alaska’s Congressional Delegation.