LANDSLIDES

and the

ACP

An in-depth examination of the threat landslides pose to the Atlantic Coast Pipeline

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ALLEGHENY-BLUE RIDGE ALLIANCE

Allegheny-Blue Ridge Alliance

Protecting the heritage, resources and economy of the Allegheny-Blue Ridge region

The Allegheny Blue-Ridge Alliance (ABRA) is a coalition of organizations that is dedicated to promoting and protecting the environmental integrity of the central Appalachian region of Virginia and West Virginia.

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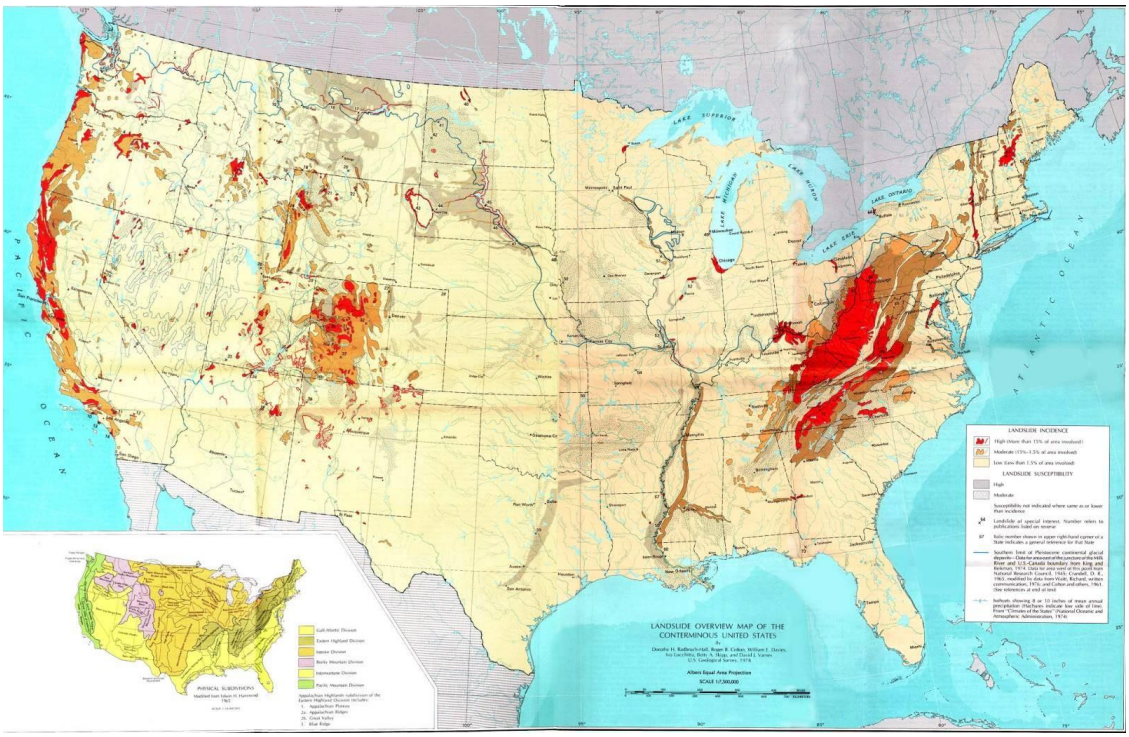
Landslides are a prominent risk to the communities of the central Appalachian region in Virginia and West Virginia. This is due to incredibly steep slopes, an uncommon propensity for high intensity rain events, shallow surficial soils and relatively sparse vegetation. Because of these factors, the central Appalachian region is one of the most naturally landslide prone areas and has one of the highest incidences of landslides in the United States (see maps below).

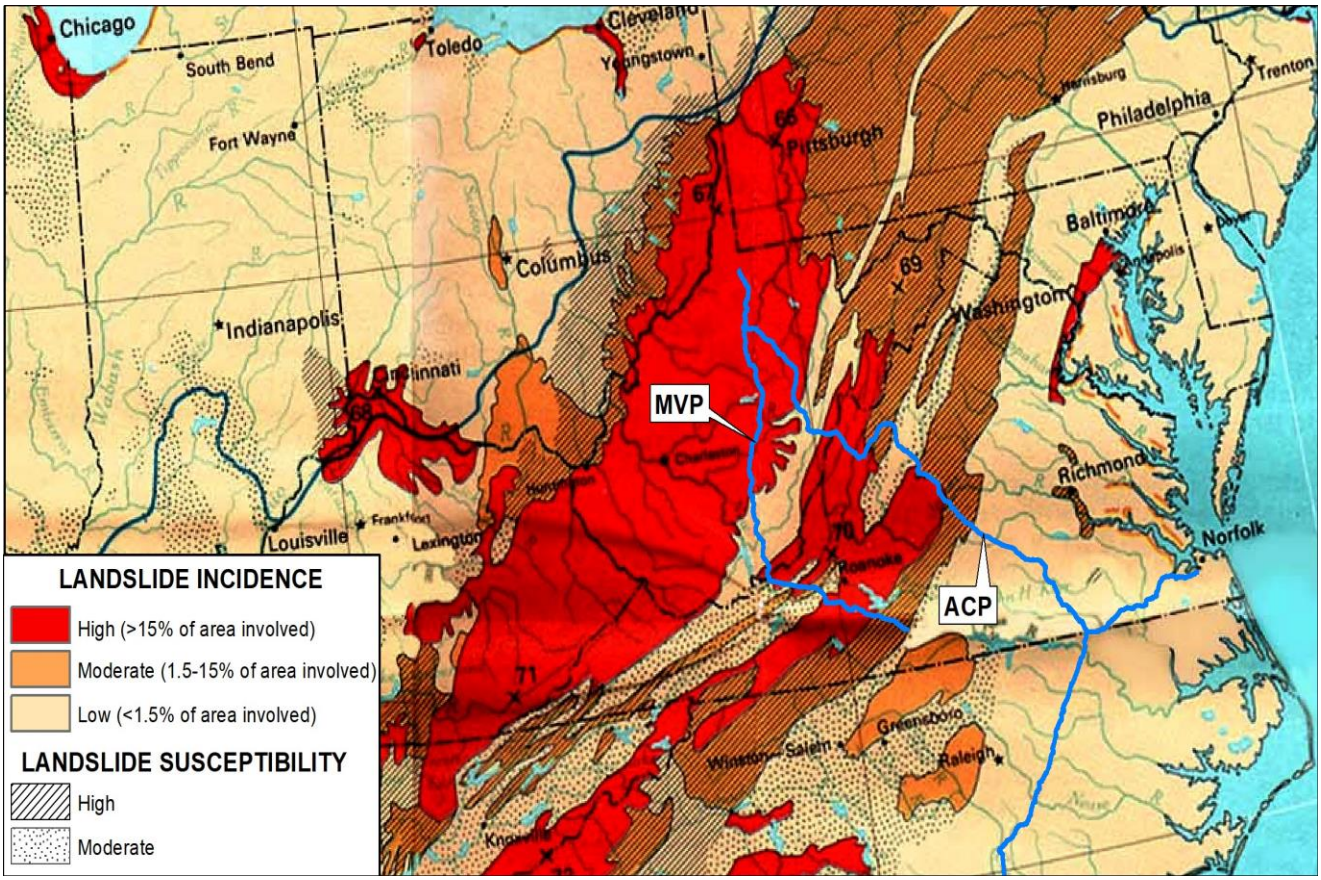


US Geological Survey (USGS) Map - frequency of, and susceptibility to, landslides. Red areas have the highest rates of landslide incidence (15%+ of area involved). Areas with dashes reflect high landslide susceptibility.[1]

This circumstance was underscored by Hurricane Camille, which in 1969 stalled over the Blue Ridge Mountains and dropped between 12.5 - 31” of rain in just 8 hours. The resulting landslides and flooding took the lives of 125 people in Nelson County, Virginia alone.[2]

The proposed route of the Atlantic Coast Pipeline (ACP) and Supply Header Project (SHP), a joint project of Dominion Energy, and Duke Energy (organized as Atlantic Coast Pipeline, LLC, hereafter referred to as “Atlantic”) would traverse more than 150 miles of terrain that is landslide prone, one-fourth of the entire length of the ACP.

The potential for landslides along the ACP route, and the threat they present to affected communities and water supplies due to sediment runoff and debris flows, were inadequately evaluated by the regulatory agencies responsible for issuing the project’s required permits. This report examines the hazards accompanying landslides and pipeline construction and evaluates the issue as it specifically relates to the ACP.



A close up of the USGS map above, with MVP and ACP routes overlaid

Recipe for Instability

Most landslides are caused by numerous contributing factors that act together and trigger a slope failure. Bedrock structure, the mass strength properties of bedrock and surficial materials, groundwater conditions, and vegetation cover all influence slope stability. The primary cause of landslides is gravity's downward force on the weakened materials that compose a sloping section of land. While some landslides tend to be slow moving, such as Sinking Creek Mountain in Craig County, Virginia (one of the one of the largest landslide complexes in eastern North America– and possibly the least noticeable), [3] the most destructive slides occur after a significant event like an earthquake or heavy rainfall, as happened in Nelson County, Virginia during Hurricane Camille.

Landslide risk is calculated using factors that combine to trigger a slope failure – including stormwater runoff, unstable soils and steepness of slopes. [4] ACP would cross over 84 miles of slopes greater than 20 percent and SHP would cross over 24 miles of slopes greater than 20 percent. In West Virginia, ACP crosses 30.4 miles of slopes ranging from 20 percent to 35 percent and 11.6 miles of slopes greater than 35 percent; in Virginia it crosses 28.8 miles of slopes ranging from 20 percent to 35 percent and 12.5 miles of slopes greater than 35 percent.

Constructing pipelines and access roads in steep terrain or high landslide incidence areas will increase the potential for landslides to occur.[5] Slope instability hazards increase with steeper slopes. The steeply sloping ridgelines have potential for natural landslides, but likely would have more potential for project-induced landslides. In West Virginia, 73 percent of the AP-1 mainline route (Harrison County,

WV to the VA/NC line) would cross-areas with a high incidence of and high susceptibility to landslides. In Virginia, approximately 28 percent of the AP-1 mainline route would cross areas with a high incidence of and high susceptibility to landslides.[6] 18 percent of the pipeline corridor would perpendicularly traverse steep terrain that Atlantic proposes cross via the cut and fill method. These side slopes are susceptible to natural landslides, making the potential for project-induced landslides high.

One area that has potential slope stability hazards for pipeline construction is the 2,900 feet of sloping ridge on the northwest flank of Cloverlick Mountain in Pocahontas County, West Virginia, which includes the potential for:

1) Failure of temporary spoils during the construction period;

2) Failure of the restoration fill (backfill) during the decades after the construction period; and

3) Failure of excess temporary spoils during the decades after the construction period. [7]

Steep slope saturation is a primary trigger of landslides. [8] Excessive stormwater can prompt landslides because it alters soil pressure within a slope, and the subsequent instability from water saturation causes the colluvium material (loose, unconsolidated sediments) to succumb to downward gravitational forces. While significant rain events are almost always sufficient to cause a landslide, precipitation is by no means the only requirement for landslides to occur. According to the United States Geological Survey (USGS), any area composed of very weak or fractured materials resting on a steep slope can and likely will experience landslides.

The areas most prone to instability are exemplified by bare or sparse vegetative

cover, non-cohesive soils, low infiltration rates, and/or moderate-to-steep slopes. The potential for soils to be eroded by water is evaluated based on the K factor and slope. The K factor represents a relative quantitative index of the susceptibility of bare soil to particle detachment and transport by water, and is one of the factors used to calculate soil loss. K factor values range from 0.02 to 0.69. Soils with a K value of greater than 0.35 are considered unstable, especially when exposed to rainfall. Based on the K factor, 4,337.4 acres along the projects' routes would be susceptible to instability affected by pipeline construction, including 3,653.3 acres for ACP[10] and 684.1 acres for SHP.[11] Additional principal factors in this equation include the absence or removal of vegetation, as well as construction activity in steep, mountainous areas, and varied geology.[12] Because the central Appalachians embody all of these causative factors, the mountains are particularly unstable.

An Appalachian Peculiarity

The most catastrophic landslides in Virginia and West Virginia have coincided with periods of intense precipitation. In the last century alone, seven major cyclonic storms (hurricanes, Nor'easters, etc.) have impacted the Appalachian Mountains of Virginia, West Virginia and North Carolina. Across the region, these high-precipitation events have caused thousands of landslides, hundreds of fatalities, and billions of dollars of damage in their wake.[13] According to the American Geosciences Institute, landslides in the United States annually kill twenty-five to fifty people and cause between $2.3 and $4.7 billion in property damage (all estimates are in 2019 dollars), but that range is not measured uniformly by a single agency so these figures are

likely underestimated.[14]

Since 1900, the mountains of West Virginia and Virginia have faced abundant instances of high intensity rain events that have helped trigger landslides. Notable regional historic storm events include the 1916 Cabin Creek Flood in West Virginia (71 fatalities and $117 Million in damage), [15] 1949 Rockingham County, VA and Petersburg, WV flooding (3 fatalities and $21.5 Million in damage), [16] Hurricane Hazel in 1954 (12 fatalities and $143 Million in damage), [17] Hurricane Camille in 1969 (Virginia's deadliest natural disaster, taking 154 total lives and $978 Million in damage),[18] Tropical Storm Agnes in 1972 (13 fatalities and $772.7 Million in damage in Virginia),[19] the Election Day Floods of 1985 (60 total fatalities and $3.46 Billion in damage between WV and VA), [20] June 27th, 1995 flooding and landslides in Madison County, VA (3 fatalities and $156 Million in damage), [21] Hurricane Fran in 1996 (10 fatalities and $636 Million in damage between WV and VA), [22] Hurricane Isabel in 2003 (10 fatalities and $2.6 Billion in damage between WV and VA), [23] and the widespread flooding across West Virginia and Virginia in June of 2016 (23 fatalities and $363 Million in damage).[24]

These storms each dropped between 6-31 inches of rain in a matter of hours, or anywhere from 180-827% of the region's monthly average precipitation **on a single day**. The saturation of steep slopes by such large amounts of precipitation led to thousands of subsequent landslides and disastrous flooding, billions of dollars in total damage, extended recovery efforts, and permanent trauma to impacted communities. According to Dr. Scott Eaton, a professor of geology and environmental science at James Madison University who studies the frequency of

landslides and catastrophic storms in Appalachia, **these conditions occur in the Central Appalachian Mountains roughly every three years.**[25]

Responsible Land Management in Landslide Prone Areas

Besides the obvious threat to public safety, landslides cause destruction of infrastructure, homes and businesses; disruption of transportation routes; and disruption and contamination of water supplies through sedimentation.[26] Although the physical cause of many landslides cannot be removed, thorough geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards.[27]

Landslide damage poses significant risk to public health and safety—and is a continuing problem in this part of the world. As such, preventative measures must be employed to the utmost, especially when considering the stability impacts posed by human development in landslide-prone areas. [28] According to the USGS, the effects of landslides on people and structures can, and should, be lessened by restricting, prohibiting, or imposing conditions on human activity in high-hazard areas. [29]

Local governments and zoning commissions can reduce risks of landslide impact through responsible land-use regulations. Identifying areas prone to future landslide hazards can help citizens, government, and project planners when determining appropriate parameters for development in high hazard areas. Every location is unique, but it is important to note that in many instances the most appropriate prevention is to restrict development altogether in areas especially prone to instability.

Landslide Mitigation and the Atlantic Coast Pipeline

The construction and operation of a 42-inch pipeline through high-risk, mountainous terrain significantly increases the existing susceptibility to catastrophic landslides. Throughout the project planning and permitting phases, this increased risk was inadequately considered by Atlantic and the regulatory agencies that approved the project. The ACP route as currently proposed would cross a region that is dangerously prone to landslides — regardless of how well intended the company's "mitigation" attempts are.

To control the high-hazard slopes encountered along the ACP route, and to support the feasibility of constructing the project through such risky areas, Atlantic has relied upon what it calls its "Best-In-Class" Steep Slopes Program.[30] * This "Best-in-Class" (BIC) program for steep slope hazard "mitigation" during construction and operation of the ACP was announced in 2016. The BIC program purports to go above and beyond the regulatory requirements. Atlantic claims it will set the new industry standard for best management practices on high risk projects and "proactively address sediment and erosion control on steep slopes (greater than 30% and longer than 100 feet)". [31] However, Atlantic simultaneously acknowledges that sedimentation impacts to water resources will be anywhere from 200-800% of normal during the project's construction phase, and, again, "the physical cause of landslides cannot be removed."[32]

The guiding literature in the industry for best practices when building pipelines across high risk slopes and, in fact, the literature that underpins the BIC program's

* Dominion and the Federal Energy Regulatory Commission (FERC) have both denied public access to any BIC slope location data and existing site-specific plans for BIC program implementation, despite FOIA requests by ABRA. ABRA is now considering legal action against FERC to obtain this information.

feasibility, comes from two industry-produced reports. The first report, *Mitigation of Land Movement in Steep and Rugged Terrain,* [33] produced in 2016 by Golder Associates, is widely considered the preeminent source for best practices in avoiding and mitigating stability problems when building pipelines in hazardous terrain. It is based on lessons learned from constructing pipelines in West Virginia. The report was prepared for the Interstate Natural Gas Association of America (INGAA), an industry trade group that advocates for the natural gas pipeline industry in North America. The second report, *Improving Steep-Slope Pipeline Construction to Reduce Impacts to Natural Resources,* [34] is a collaborative effort between The Nature Conservancy and eight natural gas companies, including Dominion Energy and Southern Company Gas (a former partner in the ACP), and EQT Midstream Partners (the principal partner in the Mountain Valley Pipeline (MVP)).

The principal "best practices" that both of these reports endorse in <u>specific sequential order</u> are:

1. The importance of identifying landslide and erosion hazards and incorporation of that information into the design, planning and construction phases of the project;
2. The critical role of route selection around identifying and avoiding hazards that may impact pipelines;
3. The need to incorporate site-specific construction and mitigation measures in the project's planning; and
4. The continual understanding that risk will always be inherent to the high-hazard terrain and environmental factors, regardless of what measures are taken to mitigate

the hazards posed by construction impacts.

A Mockery of the Process

These guiding reports have been essential for the BIC program passing regulatory muster, but using these studies to underpin the BIC program is only effective if the procedures laid out in them are followed precisely. According to both reports, it is crucial that, *prior to route selection and design*, complete geohazard assessments be performed that take into account both bedrock and colluvium slope failures, as follows: [35]

- A general pipeline corridor should be considered, with ample options for route alternatives, rather than committing to a favored route and designing geohazard assessments to validate it.[36]
- Additionally, once it is decided that developers have planned the most sensible route possible in terms of hazards, resources, distance, etc., site-specific plans for high-hazard areas must be produced prior to construction approval for regulatory, third party, and public critique.[37]

Throughout the project's existence, Atlantic has instead reversed this process by committing to a preferred route from the outset, and then controlling the parameters of their analysis to defend the poor route choice. Rather than comprehensively recognizing and quantifying the extreme stability risks during the route selection and design phase, Atlantic promised to completely evaluate the risks at a later stage of the project, after the initial permitting process was completed.† Such

† Atlantic has already had to make 300+ minor route adjustments because of these issues.

reversal of this process is likely why the geotechnical analysis was not finished until late 2017, almost two years after project outset.[38]

This impropriety caught up with Atlantic in January 2016, when the US Forest Service rejected the initial route of the ACP across federal land, citing the negative impacts the project would have on certain plant and animal species in the Monongahela and George Washington National Forests.[39] As a result, the ACP was re-routed through areas that had been previously rejected by Atlantic in a 2015 resource report (based on desktop surveys) because of steeper, more hazardous terrain, much of which was more heavily-laden with karst topography than the originally favored route.[40] In part because these route alternatives were designed, weighed, and committed to before a full understanding of the geohazards was obtained, the Forest Service was unable to fully analyze the hazards associated with the new route, despite repeated requests from the agency for more information. Had Atlantic legitimately followed the proper sequencing of industry best practices, it is quite possible the data would have identified the currently proposed route as unacceptably hazardous.

The inadequacy of Atlantic's high-hazard plan(s) was one of four key reasons the U.S. Court of Appeals for the Fourth Circuit vacated the Forest Service's Special Use Permit in 2018, a decision that has been appealed by Atlantic to the U.S. Supreme Court. However, the case in front of the Supreme Court did not consider the adequacy of the high-hazard plans; so, regardless of how the Justices rule in *Forest Service v. Cowpasture,* the issue remains unresolved.

Advancements in Landslide Science and Technology

The Final Environmental Impact Statement for ACP claims the current route is the result of Atlantic "incorporating a route alternative to avoid the debris flows and other features identified by the USGS" in order to "minimize impacts on potentially unstable soil and debris flows resulting from Hurricane Camille." The current route nonetheless continues to cross a portion of Nelson County with tremendous landslide hazards and dense historic impacts from Hurricane Camille.[41]

Debris flow chutes after Hurricane Camille, in Nelson County[42]

Dr. Anne Witt, a geohazards specialist with the Virginia Department of Mines Minerals and Energy, is in the midst of a study funded with grants from the Virginia Department of Emergency Management (VDEM) and the Federal Emergency Management Agency (FEMA) called, “Enhancement of Landslide Hazard Risk in State and Local Hazard Mitigation Plans.” [43] Her newly available data set raises questions about the lengths to which Atlantic has gone, and about the quality of data that Atlantic has used to avoid the unstable slopes impacted by Camille. Dr. Witt’s work relies upon Light Image Detection and Ranging (LIDAR) technology, which allows for precise mapping of landslide features, identification of potential landslide initiation and inundation areas, and more focused and efficient fieldwork by geologists.[44]

Prior to Dr. Witt’s data becoming available in 2018, the original number of estimated landslides in Nelson county and western Albemarle county resulting from Hurricane Camille was somewhere between 1,000 and 1,500.[45] Since the new data sets from Dr. Witt’s LIDAR imagery have been made available, the observed number of landslides resulting from Camille has more than tripled, to 5,980. This preliminary number is expected to be higher in the final version of the study, due to be completed in 2021.[46]

Coming Home To Roost

To date, less than 25 miles of the ACP has been completed through the mountainous portion of the route, and all of this has taken place on only moderately steep slopes in central West Virginia. However, Dominion has already self-reported over a dozen slope failures that either resulted from construction activity or were left out of the geohazard surveys (see Figures 1 and 2 below).

Figure 1: landslide on ACP at milepost 1.7, view from above. Photo credit: ABRA Pipeline Airforce

Figure 2: landslide on ACP at milepost 1.7, view from below. Photo Credit: FERC

These problems have occurred along less-hazardous sections of the route that lack the sustained steep slopes of the terrain to the east. [47] Should ACP construction proceed into the steeper terrain in eastern West Virginia and western Virginia, the likelihood of additional slope failures will increase.

This expectation is bolstered by the experience to date with problematic construction of the Mountain Valley Pipeline. MVP has reported at least 65 slope failures in terrain less steep than that found in the remaining mountainous portion of the ACP route (see Figure 3 below, showing a large slide at MVP mile-post 1.5 in Wetzel County, West Virginia).[48] Furthermore, on April 8th, 2020, in a stretch of the MVP with recurrent stability problems,[49] FERC inspectors confirmed "the installed pipe shifted due to the movement of the slips in at least three places."[50] Had pressurized gas been flowing through a finished MVP, this land movement could have caused a rupture and explosion similar to that of the Revolution pipeline, a 40-mile pipeline across Pennsylvania's Allegheny Mountains, which exploded in 2018 when a landslide ruptured the pipe less than a week after it went into service.[51]

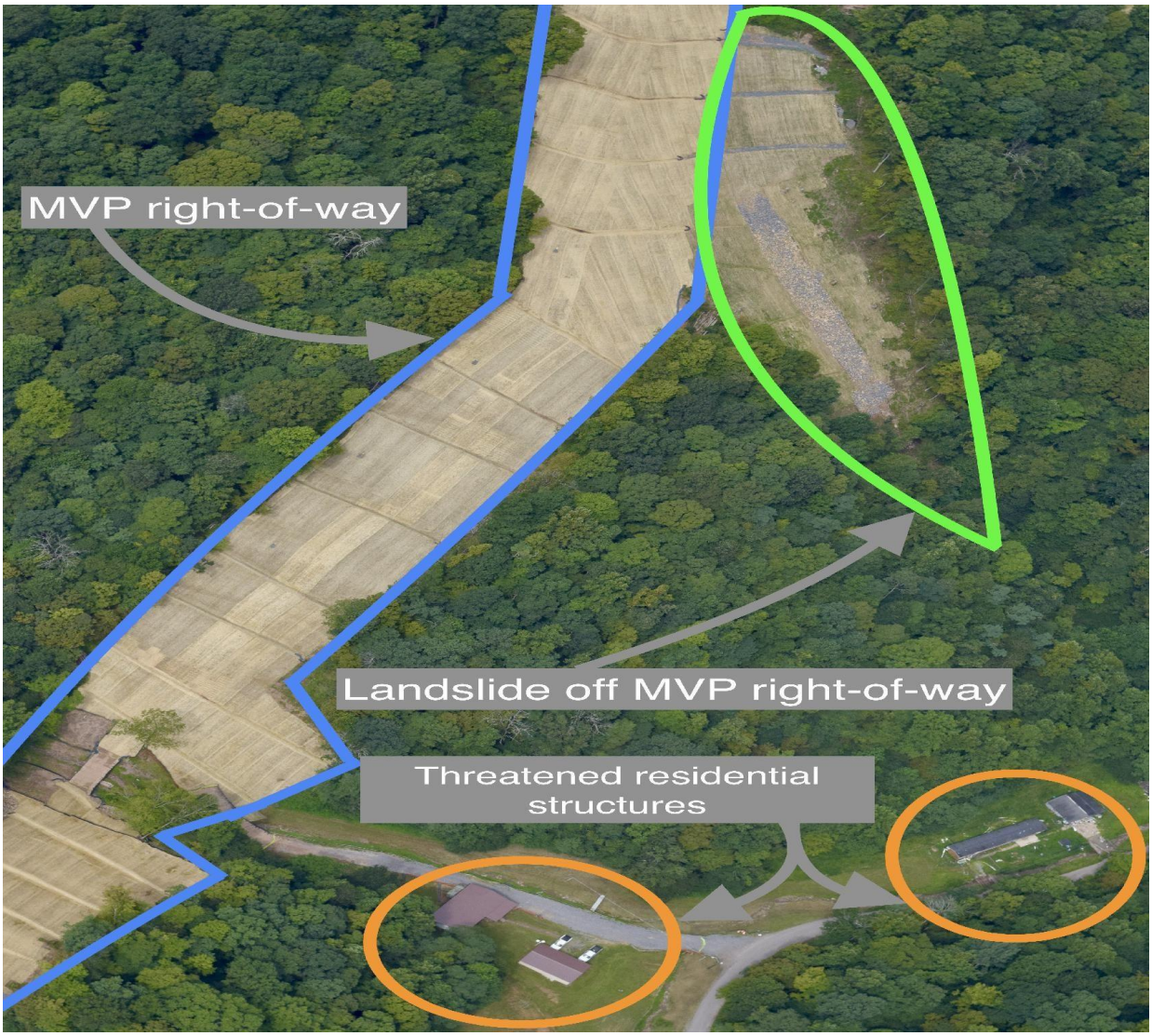


Figure 3: Landslide on MVP at milepost 1.5. Photo Credit: ABRA Pipeline Airforce

Regulators Awake From Their Slumber

With the Revolution failure in mind, the problems observed during construction along both the ACP and MVP come at a time where there is heightened concern about the threat landslides pose to pipeline safety. After landslides caused explosions in at least six Appalachian pipelines between 2018-2019,[52] federal regulators finally expressed alarm. In response to the string of landslide related explosions, the Pipeline

and Hazardous Materials Safety Administration (PHMSA) published a public safety bulletin called “Pipeline Safety: Potential for Damage to Pipeline Facilities Caused by Earth Movement and Other Geological Hazards.” [53] This guidance aims to remind pipeline operators of the serious dangers that landslides pose to both existing pipelines and those currently under construction. Within that bulletin, PHMSA says landslide conditions “can pose a threat to the integrity of pipeline facilities if those threats are not identified and mitigated.”

In light of PHMSA’s bulletin, and considering the newly available LIDAR data revealing geohazards along the ACP route discovered **after** the project was approved, the question is raised of whether the safety regulations can be met by the project should the pipeline ever go into service. For example, in 49 CFR 192.103, PHMSA requires “the design of any new pipelines…must consider load that may be imposed by geological forces.” Given that the project route was approved through terrain where a complete understanding of the hazards is only just now coming into view, it is difficult to conclude that either Atlantic or regulators have complied with their obligations under the law to protect public safety.

Conclusions

The mountains of central Appalachia are acutely susceptible to landslides. Given their frequency of high intensity precipitation events, steep slopes, thin soils, sparse vegetation and unique geology, landslides are naturally a problem in these mountains. This risk is only exacerbated by human impacts. The proposed route of the ACP presents unavoidable, known, and incredibly high-risk landslide hazards.

Building a 42” pipeline through these mountains cannot be done without unintended, dangerous consequences. The likelihood of slope failures and landslides resulting from project construction is high. Very high.

ABRA believes the threat of landslides along the ACP route has been underestimated and underappreciated by Atlantic, as well as by the regulatory agencies that approved the project’s construction. The central Appalachians will continue to be extremely landslide-prone, and development will only increase the frequency of landslides, and intensify the consequences experienced by already-fearful communities. The Atlantic Coast Pipeline cannot be reliably and safely built through terrain like that of the Central Appalachian Highlands. For this reason alone, the project should not have been approved and should not be built.

Regulators, legislators and other officials at the federal, state and local levels who have had a role in making or influencing decisions on the construction of the Atlantic Coast Pipeline are strongly urged to reexamine and correct those decisions that helped launch this project. It is not too late to avoid the catastrophe that the ACP will surely bring to the Appalachian Highlands should its construction proceed, and operations begin.

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