

Landslides: Federal Role in Research, Assessment, and Response

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Landslides: Federal Role in Research, Assessment, and Response

Landslide hazards may occur across the United States and its territories, and landslide risks may be increasing. A *landslide* is a movement of a mass of rock, debris, or soil down a slope. Mountainous, hilly, or cliff terrains (e.g., vertical shorelines, roadcuts, surface mining walls) are most susceptible to landslides. Landslides are most often triggered by rainfall, particularly rainfall on burned, steeply sloped terrain (e.g., a post-wildfire debris flow). Earthquakes or volcanic activity that cause ground motion also can trigger a landslide. Landslides may harm people and damage property; in addition, they may block roads, waterways, and water drainage systems, leading to further damage and economic losses. Landslide risks may increase in the near future due to increased development in hazardous regions and the potential for more frequent weather-related hazards (e.g., intense rainstorms, hurricanes, wildfires) that may trigger landslides.

The U.S. Geological Survey's (USGS's) Landslide Hazards Program (LHP) is the only federal program dedicated to landslide hazard science and applications. Other federal agencies involved in landslide science and applications as components of larger programs include the National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration, federal land management agencies, U.S. Department of Transportation, and Federal Emergency Management Agency.

The National Landslide Preparedness Act (NLPA; P.L. 116-323, 43 U.S.C. §§3101 et seq.) directed the Secretary of the Interior, acting through the Director of the USGS, to establish a National Landslide Hazards Reduction Program (NLHRP). NLHRP activities include identifying, mapping, assessing, and researching landslide hazards; responding to landslide events; and coordinating with state, local, territorial, and tribal entities to reduce landslide risks. In particular, the act required development of a national strategy for landslide risk reduction that includes goals and priorities for the NLHRP and an interagency plan that details programs, projects, and budgets to implement the national strategy. For FY2021 to FY2024, Congress authorized annual funding of \$25 million for the USGS to carry out the NLHRP; \$11 million for NSF for landslide research grants; and \$1 million for NOAA to support debris-flow early warning systems.

The USGS submitted the *National Strategy for Landslide Loss Reduction* to Congress in January 2022. As of August 2025, some of the National Strategy has not been fully implemented, and the USGS has not completed an interagency plan detailing projects and budgets. Congress may consider whether to engage in oversight of the National Strategy and the implementation of NLHRP activities, goals, and priorities. In FY2021-FY2024, Congress appropriated less than the amounts authorized for the USGS to implement the NLHRP; appropriations were authorized through FY2024. Congress may consider whether appropriations levels have been sufficient for the agencies to coordinate and implement the NLHRP. Bills in the 119th Congress would reauthorize and amend NLPA (S. 1626, as ordered to be reported with an amendment favorably; H.R. 2250, as ordered to be reported in the nature of a substitute by unanimous consent; and H.R. 3816, as introduced). Congress may consider whether to reauthorize appropriations beyond FY2024 and amend the NLHRP.

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Introduction

Landslide *hazards* may occur across the United States and its territories, especially where there are steep slopes that rock, soil, and other debris may slide down.¹ Earthquakes, volcanoes, and especially rainfall may trigger a landslide or amplify landslide hazards.² Landslide hazards also may trigger other hazards that may cause damage or disruption, such as dammed waterways, tsunamis, or flooding. Landslides are estimated to cause billions of dollars in damage and multiple fatalities and injuries each year in the United States.³ Landslide *risks* may increase in the near future for two primary reasons: (1) increased development in hazardous regions, such as mountainous, hilly, or cliff terrains (i.e., more people and property in harm's way), and (2) more frequent and extreme weather-related events that may trigger more landslides (e.g., increasing frequency and/or magnitude of intense rain storms and wildfires forecast by some studies).⁴

Federal agencies are involved in landslide science and applications in different ways.⁵ The U.S. Geological Survey's (USGS's) Landslide Hazards Program (LHP) is the only federal program dedicated to landslide hazard science and applications.⁶ Some other federal agencies are involved in landslide science and applications as components of larger programs. The National Oceanic and Atmospheric Administration (NOAA) supports landslide science and applications, especially regarding atmospheric or oceanic triggers for landslides (e.g., hurricanes, rain, snowstorms, coastal erosion) or landslide-caused tsunamis. In particular, NOAA's National Weather Service (NWS) may integrate landslide warnings into flood watches and warnings based on weather forecasts and LHP landslide hazard assessments. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) support research about landslide hazards and risks.

The federal land management agencies support science and applications for landslide hazards on federal lands.⁷ The U.S. Army Corps of Engineers (USACE) assesses and responds to landslide hazards impacting its engineering and construction activities. The U.S. Department of

¹ *Hazard* refers to the natural event, such as the land sliding down a hill in a landslide.

² U.S. Geological Survey (USGS), Landslide Hazards Program (LHP), "Landslides 101," <https://www.usgs.gov/programs/landslide-hazards/landslides-101>; Lynn M. Highland and Peter Bobrowsky, *The Landslide Handbook: A Guide to Understanding Landslides*, USGS, USGS Circular 1325, 2008, <https://www.usgs.gov/publications/landslide-handbook-a-guide-understanding-landslides> (hereinafter Highland and Bobrowsky, *Landslide Handbook*).

³ Landslide losses in terms of fatalities and direct and indirect economic losses are difficult to estimate on an annual basis and for the entire nation, because the occurrence of landslides, numbers of fatalities, and economic losses are highly variable in time and location. In addition, data on the occurrences and impacts of landslides are incomplete or not reported. Benjamin B. Mirus et al., "Landslides Across the USA: Occurrence, Susceptibility, and Data Limitations," *Landslides*, vol. 17 (December 19, 2020), pp. 2271-2285, <https://doi.org/10.1007/s10346-020-01424-4>.

⁴ *Risk* refers to the potential for damage from a hazard, such as a house being destroyed by a landslide. See Federal Emergency Management Agency (FEMA), "Determining Risk," <https://hazards.fema.gov/nri/determining-risk>. See also Jonathan W. Godt et al., *National Strategy for Landslide Loss Reduction*, USGS, Open File Report 2022-1075, 2022, p. 2, <https://pubs.usgs.gov/of/2022/1075/ofr20221075.pdf> (hereinafter Godt et al., *National Strategy*).

⁵ *Science* may include research, monitoring, observations, modeling, and data/computer services in support of scientific efforts to understand natural hazards. *Applications* may include preparedness, planning, training and outreach, assessment, response, mitigation, and recovery from natural hazards and the impacts of natural hazards.

⁶ USGS, *FY2023 USGS Budget Justifications (Greenbook)*, p. 82, <https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/FY23-USGS-Greenbook.pdf>; USGS, LHP, "What We Do: Landslide Hazards Program," <https://www.usgs.gov/programs/landslide-hazards/what-we-do-landslide-hazards-program>.

⁷ Federal land management agencies include the National Park Service, the Bureau of Land Management, and the Fish and Wildlife Service in the Department of the Interior and the U.S. Forest Service in the Department of Agriculture. CRS Report R42656, *Federal Land Management Agencies and Programs: CRS Experts*, coordinated by Mark K. DeSantis.

Transportation supports applications and offers financial and technical assistance to state and local departments of transportation for landslide hazards impacting their transportation activities. The Federal Emergency Management Agency (FEMA) supports science, applications, and financial and technical assistance to communities for landslide hazards.

In addition to federal agencies, state and local entities (e.g., geological surveys, land management agencies, transportation departments, and emergency response agencies) support science, applications, and assistance for landslide hazards in their communities. State and local entities may seek assistance or coordination with federal agencies for their landslide hazard activities.

The National Landslide Preparedness Act (NLPA; P.L. 116-323, 43 U.S.C. §§3101 et seq.) directed the Secretary of the Interior, acting through the Director of the USGS, to establish a National Landslide Hazards Reduction Program (NLHRP; 43 U.S.C. §3102), advance subsidence and groundwater research (43 U.S.C. §3103), and establish a 3-dimensional (3D) elevation program (3DEP; 43 U.S.C. §3104).⁸ LHP plans to lead the implementation and coordination of the NLHRP and expand its landslide science and application activities. 3DEP, within the USGS National Geospatial Program, aims to map the nation's topography and built environment to better identify landslide hazards and risks (and for many other purposes).⁹

This report provides an overview of landslide types, hazards, causes, and impacts, as well as a discussion of landslide susceptibility and risk in the United States. The report describes the federal role in landslide hazards and the plans and efforts to implement the NLHRP. Congress may consider evaluating whether the NLHRP and related activities are sufficient to reduce landslide risks.

Landslide Types, Hazards, Causes, and Impacts

A *landslide* is a movement of a mass of rock, soil, and/or debris down a slope. Landslides may be divided into four types based on the mode of slope movement—falls, topples, slides, spreads, or flows—and the type of materials in the slide—rock, soil, water, and other debris (see text box titled “Examples of Landslide Types and Their Impacts on Communities”):

1. *Slow-moving landslides* consist of slow-moving or spreading rock or soil that generally does not threaten people but may damage property.
2. *Rock falls* consist of rocks falling from cliffs, roadcuts, excavations, or other steep walls, often where there is exposed and typically loose rock. Rock falls may harm people and damage property, especially near roads or railroads.
3. *Rock or debris avalanches* consist of rapid and often large landslides of mostly rock and soil in mountainous regions. Rock/debris avalanches may be hazardous to people or property in mountainous regions.

⁸ For more on the National Landslide Preparedness Act (NLPA; P.L. 116-323, 43 U.S.C. §§3101 et seq.), see CRS In Focus IF13077, *National Landslide Preparedness Act and the Status of Landslide Risk Reduction*, by Linda R. Rowan. For more on the 3D elevation program (3DEP), see CRS In Focus IF13079, *The 3D Elevation Program (3DEP) and Its Role in Mapping Hazards and Resources*, by Linda R. Rowan.

⁹ USGS, “3D Elevation Program,” <https://www.usgs.gov/3d-elevation-program>; Vicki Lukas and William J. Carswell Jr., *The 3D Elevation Program—Landslide Recognition, Hazard Assessment, and Mitigation Support*, USGS, January 2017, <https://doi.org/10.3133/fs20163094>; USGS, “Program Benefits and Uses,” <https://www.usgs.gov/3d-elevation-program/program-benefits-and-uses>. Dewberry Engineers, *3D Nation Requirements and Benefits Study*, 2022, https://www.dewberry.com/docs/default-source/documents/3d-nation-elevation-requirements-and-benefits-study/3d_nation_study_final_report.pdf?sfvrsn=252afcfb_2.

4. *Debris flows* (also called *mudflows* or *mudslides*) consist of slurries of rock, soil, water, and debris that may flow rapidly downhill over long distances, especially along stream channels. Debris flows may harm people and damage property.¹⁰

Examples of Landslide Types and Their Impacts on Communities

Four photographs showing the four different types of landslides and examples of the damage they may cause.

Photograph (1): Example of a slow-moving landslide in Denali National Park, Alaska, that transitioned into a faster moving landslide due to permafrost thaw. A slow-moving landslide below the roadbed required road maintenance every two to three years since the 1960s. In 2021, the road dropped approximately 14 vertical feet (drop-off shown in photograph) as the landslide began moving downhill at over 10 inches per day over a two-week period.

Photograph (2): Example of a rock fall and rock slide in Clear Creek Canyon, CO, in 2005. The event closed the road for weeks to clean up debris and repair the road. The closure contributed additional economic losses related to transportation. Also shown is a rock curtain (metallic screen), a commonly applied barrier for hazardous rock surfaces.

Photograph (3): Example of a rock/debris avalanche, the Thistle landslide, near Thistle, UT, in 1983. The landslide dammed the Spanish Fork River, backing up water that flooded the town of Thistle. Roads and a rail line had to be re-routed. The rail line was re-routed by excavating through an adjacent mountain and building a protective tunnel.

Photograph (4): Examples of landslides and debris flows near La Conchita, CA, in 1995 and 2005. The 1995 landslide damaged homes and left an unstable debris apron above the community. In 2005, a rapidly moving debris flow (a remobilization of the 1995 landslide, estimated to have flowed 30 feet per second on the steeper slope and 15 feet per second on the flatter slope through the community) damaged more homes and caused fatalities.



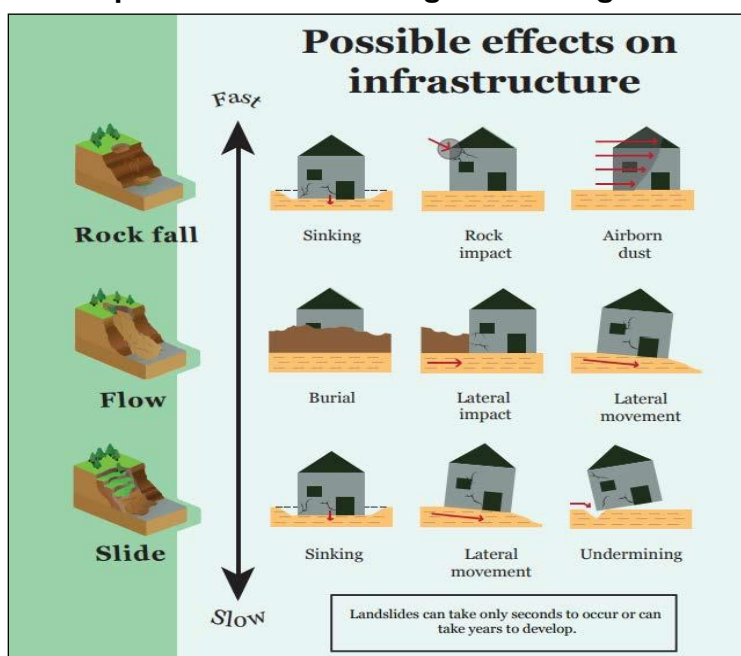
Sources: Photograph (1) from Jonathan W. Godt et al., *National Strategy for Landslide Loss Reduction*, USGS, Open File Report 2022-1075, 2022, p. 9, <https://pubs.usgs.gov/of/2022/1075/ofr20221075.pdf>; and National Park Service, “Denali National Park Closes Section of Park Road Due to Landslide Activity,” <https://www.nps.gov/dena/learn/news/road-closure-pretty-rocks-2021.htm>. Photographs (2), (3), and (4) from Lynn M. Highland and Peter

¹⁰ Godt et al., *National Strategy*, p. 2. See also Highland and Bobrowsky, *Landslide Handbook*, and USGS, LHP, “Landslides 101,” <https://www.usgs.gov/programs/landslide-hazards/landslides-101>.

Bobrowsky, *The Landslide Handbook - A Guide to Understanding Landslides*, USGS, USGS Circular 1325, 2008, <https://www.usgs.gov/publications/landslide-handbook-a-guide-understanding-landslides>; and Randall W. Jibson, *Landslide Hazards at La Conchita, California*, USGS, Open-File Report 2005-1067, 2005, <https://pubs.usgs.gov/of/2005/1067/pdf/OF2005-1067.pdf>.

Landslides may happen without any warning and the event may be over in seconds to minutes. Alternatively, a slow-moving landslide may occur over days or longer and allow communities to receive a warning about potential risks. Landslides may be caused by topographic (e.g., steep slope), geologic (e.g., loose rock), atmospheric (e.g., precipitation rates), or anthropogenic conditions (e.g., roadcut or mining excavation creating an engineered steep slope). Earthquakes, volcanoes, hurricanes, intense rainfall, and wildfires may trigger or contribute to the magnitude of a landslide.¹¹ Landslides may cause additional hazards that lead to more potential risk, such as blocked roadways or railways and dammed waterways. **Figure 1** shows examples of the types of damage to a building that different types of landslides could cause.

Figure 1. Examples of Potential Damage to Buildings from Landslides



Source: USGS, University of Puerto Rico, Mayagüez, and Natural Hazards Center, *Landslide Guide for Residents of Puerto Rico*, 2020, https://hazards.colorado.edu/uploads/documents/PuertoRico_LandslideGuide_2020.pdf.

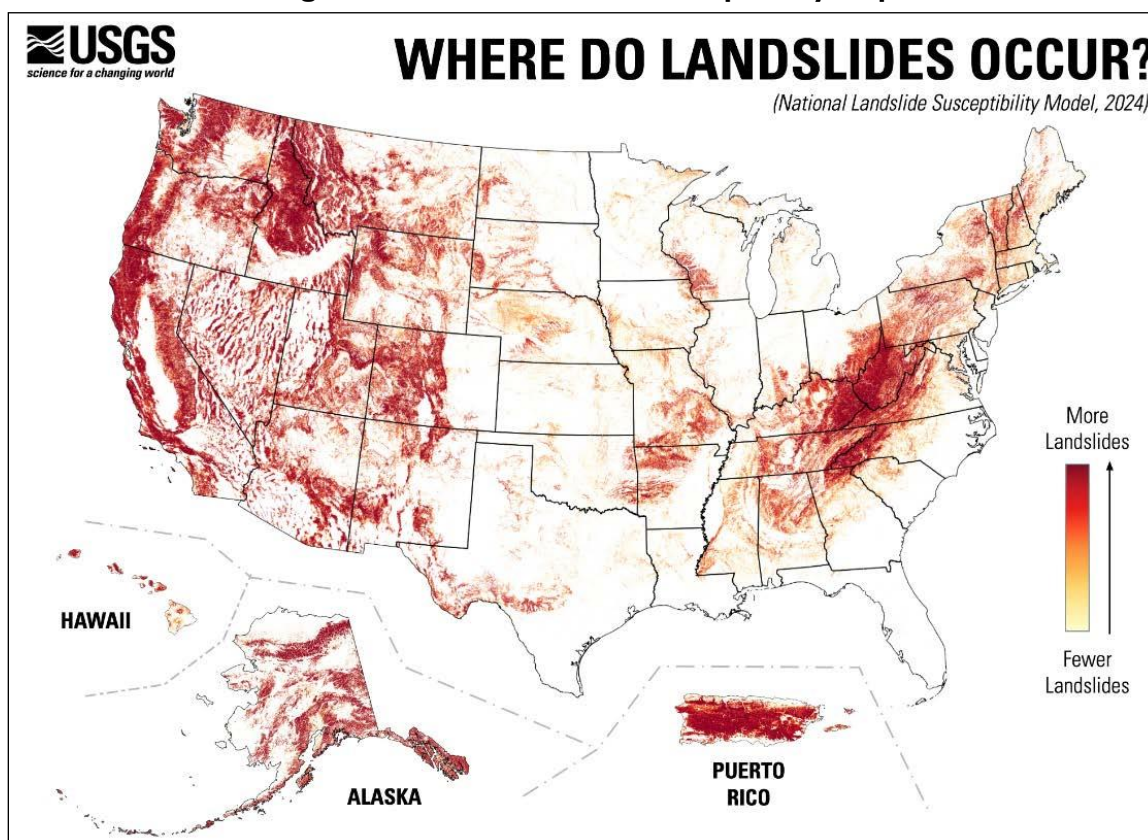
Landslide Susceptibility and Risk in the United States

Landslides in the United States and its territories are most likely to start in mountainous, hilly, or cliff terrains. Such landslides are most often triggered by water (e.g., intense rainfall events), but

¹¹ A landslide at Mount St. Helens volcano associated with the volcano's 1980 eruption in Washington is among the largest known subaerial landslides. The slide traveled at 70-150 miles per hour for over 14 miles. The landslide was triggered by an earthquake and an eruption. USGS, "What Was the Largest Landslide in the United States? In the World?" <https://www.usgs.gov/faqs/what-was-largest-landslide-united-states-world>.

may be triggered by earthquakes, volcanic activity, melting glaciers, and other causes. Landslides near populated areas or infrastructure may cause damage and represent the highest landslide risks. In general, the USGS has identified areas in the United States and its territories that are susceptible to landslide hazards and FEMA has identified areas that face potential landslide risks. The USGS landslide hazard susceptibility map shows areas of steep slopes where landslides may be more likely to begin (**Figure 2**). The map does not depict areas that may have the most damaging impact on a community, nor does it show where the landslides may travel to and deposit rock, soil, and other debris. FEMA used an older USGS susceptibility map as a starting point to estimate landslide risk in the National Risk Index.¹² The National Risk Index defines *landslide risk* as a combination of landslide hazard likelihood, the size and vulnerability of the community in the path of the hazard, and the potential for damage from the hazard. **Figure 3** shows the expected annual loss from a landslide estimated by county in the United States and its territories from FEMA's National Risk Index.¹³

Figure 2. Landslide Hazard Susceptibility Map

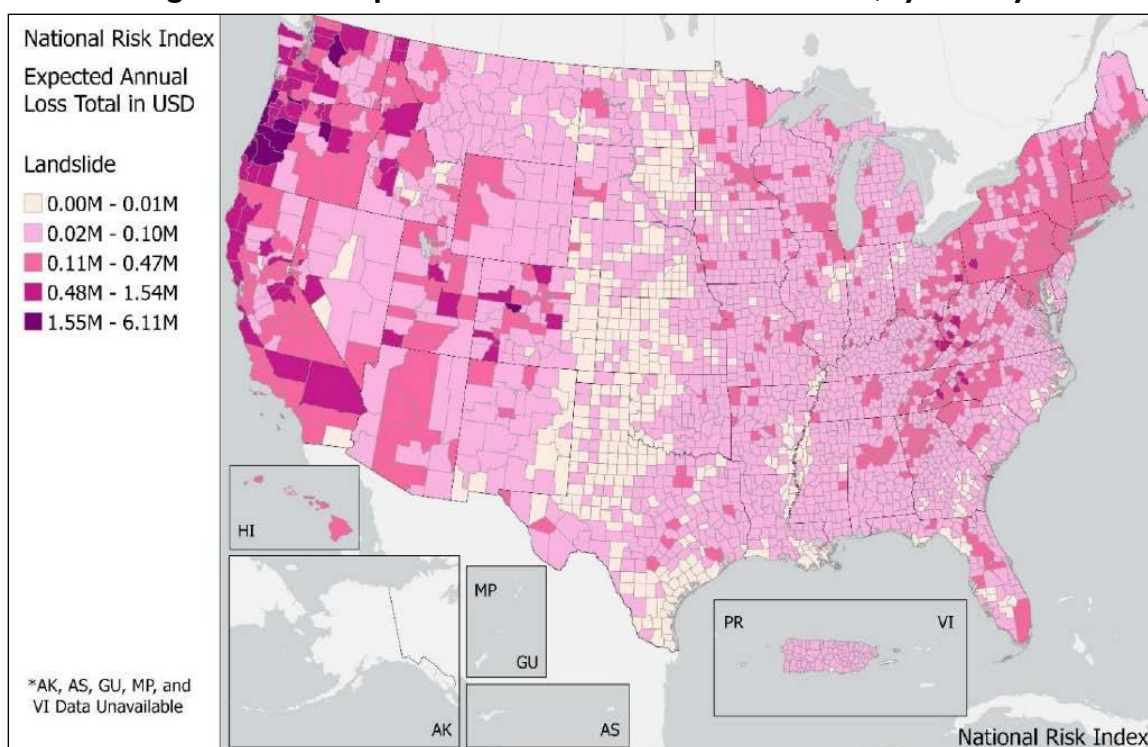


Source: USGS, "U.S. Landslide Inventory and Susceptibility Map," <https://www.usgs.gov/tools/us-landslide-inventory-and-susceptibility-map>.

Notes: Visit the source website listed above for additional links to an interactive map of landslide susceptibility, a downloadable GIS database, and technical documents explaining the development of the inventory and susceptibility map.

¹² FEMA, "The National Risk Index," <https://hazards.fema.gov/nri/>.

¹³ Expected annual loss for landslide hazards is one component of risk that is calculated and displayed on FEMA's National Risk Index. To see other risk components, other hazards, or more detailed data about a county or region, see FEMA, "The National Risk Index," <https://hazards.fema.gov/nri/map>.

Figure 3. Total Expected Annual Loss from a Landslide, by County

Source: FEMA, *National Risk Index, Technical Documentation*, March 2023, p. 15-14, Figure 92, https://www.fema.gov/sites/default/files/documents/fema_national-risk-index_technical-documentation.pdf.

Notes: Loss is given in U.S. dollars (USD), and all amounts are converted to January 2022 dollars. M = million. The expected annual loss from a landslide is calculated based on the estimated landslide occurrence, building value, and population. Light gray shaded areas, including Alaska (AK), American Samoa (AS), Guam (GU), Northern Mariana Islands (MP), and the Virgin Islands (VI), do not have enough data to calculate risk. HI = Hawaii; PR = Puerto Rico. See FEMA, *National Risk Index, Technical Documentation*, March 2023, pp. 4-6 and 15-1 to 15-14, for more information about the calculations, data, and data limitations. **Figure 3** is based on an older USGS landslide susceptibility map, as described in the 2023 FEMA technical documentation, not the 2024 USGS susceptibility map shown in **Figure 2**.

Federal Roles in Landslide Hazards and Risks

Various federal agencies perform landslide science and/or application activities that in general are small components of larger programs with objectives broader than landslides. These federal activities existed before the 2021 enactment of the NLPA. Below is an overview of some of the existing federal programs the NLPA aims to coordinate to promote landslide risk reduction by establishing the NLHRP.¹⁴

¹⁴ The NLPA lists the Secretaries of the Interior, Agriculture, Army, Commerce, Homeland Security, and Transportation and the Director of the National Science Foundation (NSF) as departments/agencies to coordinate within the NLHRP. Some amendments to the NLPA in bills introduced in the 119th Congress (e.g., S. 1626, H.R. 2250, and H.R. 3816) would add the administrator of the National Aeronautics and Space Administration (NASA) to the Interagency Coordinating Committee on Landslide Hazards. This section includes an overview of NASA's landslide activities.

U.S. Geological Survey

The USGS Natural Hazards Mission Area, within the Department of the Interior, includes program line items for science and applications for landslides (LHP), as well as earthquakes (Earthquake Hazards Program, or EHP), volcanoes (Volcano Hazards Program, or VHP), and coastal hazards (Coastal and Marine Hazards and Resources Program), among others.¹⁵ The mission area works with many partners to research, monitor, assess, and respond to natural hazards. Since before the NLPA was enacted, LHP has conducted targeted research, developed methods and tools for targeted landslide hazard assessments and forecasts, provided technical assistance in some landslide emergencies, and conducted outreach to some affected communities.¹⁶ LHP works with EHP and VHP on earthquake- or volcano-triggered landslide hazards, respectively, and with the USGS Coastal and Marine Hazards and Resources Program on coastal- and marine-triggered landslide hazards.¹⁷ LHP works with federal, state, and local partners to reduce landslide losses.¹⁸

National Oceanic and Atmospheric Administration

NOAA, in the Department of Commerce, conducts targeted research, develops methods and tools for landslide hazard assessments and forecasts, provides technical assistance in landslide emergencies, and conducts outreach to affected communities.¹⁹ For example, NOAA's Office of Oceanic and Atmospheric Research conducts some landslide-related research, primarily where oceanic or atmospheric conditions may trigger a landslide or where a landslide may trigger an oceanic or atmospheric hazard (e.g., a landslide-triggered tsunami). The National Weather Service (NWS) also plays a role in landslide warnings. Weather events may trigger landslides, and the NWS integrates information about potential landslides, especially debris flows, into flood or flash-flood watches and warnings for a given area.²⁰ The USGS worked with the NWS to test

¹⁵ USGS, "Natural Hazards Mission Area, Programs," <https://www.usgs.gov/mission-areas/natural-hazards/programs>.

¹⁶ USGS, "Landslide Hazards Program," <https://www.usgs.gov/programs/landslide-hazards>. Before enactment of the NLPA, the USGS formed LHP under the USGS Organic Act, 1879 (43 U.S.C. §31) and other authorities, such as the Disaster Relief Act of 1974 (P.L. 93-288). The Earthquake Hazards Program is the USGS component of the multiagency National Earthquake Hazards Reduction Program (NEHRP), established by Congress in 1977 (P.L. 95-124). The Volcano Hazards Program leads the National Volcano Early Warning and Monitoring System established by Congress in 2019 in Title V, Section 5001 (43 U.S.C. 31k), of the John D. Dingell Jr. Conservation, Management, and Recreation Act (P.L. 116-9). These three programs have similar objectives for coordinated research, monitoring, assessment, response, and recovery for geologic hazards, such as landslides, earthquakes, and volcanoes. See also CRS Report R43141, *The National Earthquake Hazards Reduction Program (NEHRP): Overview and Issues for Congress*, by Linda R. Rowan, and CRS In Focus IF11987, *The National Volcano Early Warning and Monitoring System*, by Linda R. Rowan.

¹⁷ USGS, "Coastal and Marine Hazards and Resources Program," <https://www.usgs.gov/programs/cmhrp>.

¹⁸ USGS, "Partners," <https://www.usgs.gov/programs/landslide-hazards/partners>.

¹⁹ CRS Report R47636, *National Oceanic and Atmospheric Administration (NOAA): Organization Overview and Issues for Congress*, by Eva Lipiec.

²⁰ National Weather Service (NWS) debris-flow watches and warnings are similar to flash-flood or flood watches and warnings. See NWS, "Flood Warning vs. Watch," <https://www.weather.gov/safety/flood-watch-warning>. A *watch* is issued when conditions are favorable to cause a debris flow. A *warning* is issued when a debris flow is imminent or occurring. NWS, *Post Wildfire Flash Flood and Debris Flow Guide*, August 2015, <https://www.wrh.noaa.gov/lox/hydrology/files/DebrisFlowSurvivalGuide.pdf>. See also NOAA, "Landslide Monitoring," <https://dev-02-www-drupal10-climatetk.woc.noaa.gov/tools/landslide-monitoring>.

pilot debris-flow early warning systems in Northern California (1985-1995) and Southern California (2005-2008).²¹

National Science Foundation

NSF does not have a specific award program for landslide research, but it may award research grants for landslide-related research.²² NSF organizes its competitive and meritorious research grant program into directorates and offices across general areas of science and engineering plus others areas such as integrative activities, international science, and technology and innovation. For example, the Geosciences Directorate may award a research grant to better understand landslide processes. The Engineering Directorate may award a research grant to develop innovative engineering principles for landslide mitigation. The Social, Behavioral, and Economic Sciences Directorate may award a research grant to understand how people perceive landslide risks or how people react to a landslide warning.

In addition, NSF awards cooperative agreements and grants to research facilities that may support landslide research. In some cases, NSF grant awardees and research facilities work with the USGS and other federal agencies on landslide research activities.²³

National Aeronautics and Space Administration

NASA supports (1) satellite missions that collect landslide data; (2) an open, global landslide inventory; (3) a Cooperative Open Online Landslide Repository, where scientists and citizen scientists can share landslide reports; and (4) landslide modeling efforts.²⁴ The modeling efforts include a Landslide Hazard Assessment for Situational Awareness model, a landslide susceptibility map, and a Global Landslide Catalog. According to NASA, the Landslides @ NASA team is a project of NASA's Global Precipitation Measurement Mission (GPM). GPM provides global observations of rain and snow among other conditions; these observations contribute to landslide hazard assessments where intense rainfall and high soil moisture may generate a landslide. Among other satellite missions that may contribute to landslide research and response, the recently launched NASA-ISRO Synthetic Aperture Radar (NISAR) mission aims to measure changes on Earth's surface, including changes caused by landslides.²⁵

²¹ Guzzetti et al., "Geographical Landslide Early Warning Systems," *Earth-Science Reviews*, vol. 200 (January 2020), <https://www.sciencedirect.com/science/article/pii/S0012825219304635>.

²² For an overview of NSF, see CRS Report R46753, *The National Science Foundation: An Overview*, by Laurie Harris.

²³ For example, the Puerto Rico Landslide Hazard Mitigation Project is a partnership between the USGS, the Natural Hazards Center at the University of Colorado Boulder (i.e., an NSF-funded research facility), and the University of Puerto Rico, Mayagüez. The USGS provided funding for this project from supplemental appropriations in response to hurricane and earthquake disasters in Puerto Rico that triggered nearly 40,000 landslides (Further Additional Supplemental Appropriations for Disaster Relief Requirements Act, 2018 [P.L. 115-123, Division B], and USGS, "2018 Supplemental Appropriations Activities," <https://www.usgs.gov/supplemental-appropriations-for-disaster-recovery-activities/2018-supplemental-appropriations>). Natural Hazards Center, "Puerto Rico Landslide Hazard Mitigation Project," <https://hazards.colorado.edu/news/research-projects/puerto-rico-landslide-hazard-mitigation-project>.

²⁴ NASA, "Landslides @ NASA," <https://gpm.nasa.gov/landslides/>. For an overview of NASA, see CRS Report R47891, *National Aeronautics and Space Administration (NASA): A Primer*, by Rachel Lindbergh.

²⁵ The NASA-ISRO Synthetic Aperture Radar mission is a joint effort between NASA and the Indian Space Research Organization (ISRO). NASA, "NISAR," <https://science.nasa.gov/mission/nisar/>; ISRO, "Indian Space Research Organisation, Department of Space," <https://www.isro.gov.in/>.

In addition to satellite missions, the Disasters Program within NASA's Earth Science Division advances science for disaster resilience and response, including for landslides.²⁶ In 2024, NASA established a new Disaster Response Coordination System within the Disasters Program to support disaster response organizations around the world with NASA science, technology, and expertise.²⁷

Federal Emergency Management Agency

FEMA, in the Department of Homeland Security, provides resources for planning, preparedness, response, recovery, and mitigation related to landslide hazards and landslide risks. It also identifies and calculates landslide risks nationwide (**Figure 3**).²⁸ FEMA's National Flood Insurance Program (NFIP) may cover mudflows, a landslide type most often associated with intense rainfall and flooding (see "Landslide Types, Hazards, Causes, and Impacts"), under certain circumstances. FEMA provides guidance to reduce mudflow risks and for recovery assistance under the NFIP.²⁹ FEMA also provides hazard mitigation assistance to communities and homeowners for landslide and other hazards through the Hazard Mitigation Assistance Program.³⁰

Federal and Tribal Land Management Agencies

Various federal land management agencies have roles related to landslide science and applications to deal with landslide hazards and risks on lands they administer. The U.S. Forest Service, in the Department of Agriculture, is responsible for research, assessment, response, and recovery related to landslide hazards and risks on Forest Service lands.³¹ The National Park Service, Bureau of Land Management, Fish and Wildlife Service, and Bureau of Indian Affairs, all in the Department of the Interior, are responsible for assessment, response, and recovery related to landslide hazards and risks on their respective federal or tribal lands. In addition, within the Department of the Interior, the Office of Surface Mining Reclamation and Enforcement is responsible for research, assessment, response, and recovery related to landslide hazards and risks on abandoned mine lands projects.³²

Federal Highway Administration

The Federal Highway Administration (FHWA), within the Department of Transportation, provides technical and financial assistance to state and local governments. This support may include research, assessment, response, and recovery related to landslide hazards and risks on the

²⁶ NASA, "Advancing Science for Disaster Resilience," <https://appliedsciences.nasa.gov/what-we-do/disasters>.

²⁷ NASA, "NASA Announces New Disaster Response Coordination System," <https://appliedsciences.nasa.gov/our-impact/news/nasa-announces-new-disaster-response-coordination-system>; NASA, "Disaster Response Coordination System," <https://appliedsciences.nasa.gov/what-we-do/disasters/disasters-response-coordination-system>.

²⁸ For example, FEMA, "Hazard Mitigation Planning," <https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning>; FEMA, "Landslide," <https://community.fema.gov/ProtectiveActions/s/article/Landslide>; FEMA, "The National Risk Index," <https://hazards.fema.gov/nri/map>.

²⁹ FEMA, "Understanding Mudflow and the NFIP," January 2018, https://www.fema.gov/sites/default/files/2020-05/FINAL_Background_Understanding_Mud_and_the_NFIP_2018.pdf; and FEMA, "National Flood Insurance Program Summary of Coverage," https://www.nh.gov/insurance/consumers/documents/summary_cov.pdf.

³⁰ FEMA, "Hazard Mitigation Assistance Grants," <https://www.fema.gov/grants/mitigation>.

³¹ USDA, "Forest Service," <https://www.fs.usda.gov/>.

³² U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, "About OSMRE," <https://www.osmre.gov/about>.

nation's highways (Federal Aid Highway Program) and various federally and tribal-owned lands (Federal Lands Highway Program).³³ For example, the Federal Lands Highway Program's Unstable Slope Management Program conducts research to mitigate landslide hazards on federal lands highways, and the FHWA's Emergency Relief Program provides federal aid for disaster-damaged highways and bridges.³⁴

U.S. Army Corps of Engineers

USACE, within the Department of Defense, is responsible for engineering, assessment, response, and recovery related to landslide hazards and risks impacting military and civilian USACE projects. Most civilian projects consist of planning, construction, and operation of water resources infrastructure, such as maintaining navigable channels, reducing flood and storm risks, and conducting environmental restoration activities.³⁵ USACE civilian projects may face landslide risks, such as blocked waterways or eroding cliffs near infrastructure (see "Landslide Types, Hazards, Causes, and Impacts"), and USACE works to reduce these risks.

National Landslide Preparedness Act

In 2021, Congress passed the NLPA (P.L. 116-323, 43 U.S.C. §§3101 et seq.). Among its provisions, the NLPA directs the Secretary of the Interior, acting through the Director of the USGS, to establish the NLHRP to identify, map, assess, research, prepare, and respond to landslide hazards.³⁶ Pursuant to the law, the USGS is to coordinate these activities with existing USGS programs (primarily the LHP); other federal entities; and state, local, territorial, or tribal (SLTT) entities.³⁷

Two other sections in the NLPA called for the USGS, through existing programs, to (1) advance the identification, mapping, research, and monitoring of subsidence and groundwater resource accounting (43 U.S.C. §3103) and (2) establish a program to be known as 3DEP (43 U.S.C. §3104). *Subsidence*, the caving or sinking of land, typically occurs when groundwater is withdrawn, although other processes may cause subsidence.³⁸ Subsidence may contribute to landslide hazards. The USGS maintains groundwater data for the nation that may be accessed for subsidence monitoring.³⁹ 3DEP acquires nationwide lidar and other data to provide a national

³³ U.S. Department of Transportation, Federal Highway Administration (FHWA), "About FHWA," <https://highways.dot.gov/about/about-fhwa>. For more on the FHWA, see CRS Report R47022, *Federal Highway Programs: In Brief*, by Robert S. Kirk; and CRS Report R44332, *Federal-Aid Highway Program (FAHP): In Brief*, by Robert S. Kirk.

³⁴ U.S. Department of Transportation, FHWA, "Geologic and Geotechnical Services," <https://highways.dot.gov/federal-lands/geotechnical>; U.S. Department of Transportation, FHWA, "Emergency Relief Program," <https://www.fhwa.dot.gov/programadmin/erelief.cfm>. See also CRS Report R47724, *Emergency Relief Program for Disaster-Damaged Highways and Bridges*, by Ali E. Lohman.

³⁵ U.S. Army Corps of Engineers (USACE), "About Us," <https://www.usace.army.mil/About/>; and CRS Report R46320, *U.S. Army Corps of Engineers: Annual Appropriations Process*, by Anna E. Normand and Nicole T. Carter.

³⁶ USGS, "National Landslide Preparedness Act," <https://www.usgs.gov/programs/landslide-hazards/science/national-landslide-preparedness-act>.

³⁷ USGS, "Landslide Hazards Program," <https://www.usgs.gov/programs/landslide-hazards>.

³⁸ USGS, "Land Subsidence," <https://www.usgs.gov/water-science-school/science/land-subsidence>.

³⁹ USGS, "USGS Groundwater Data for the Nation," <https://waterdata.usgs.gov/nwis/gw>.

baseline of consistent high-resolution topographic elevation data, which may help to identify landslide hazards and risks.⁴⁰

National Landslide Hazards Reduction Program

The NLPA directed the Secretary of the Interior, acting through the Director of the USGS, to establish the NLHRP to identify, map, assess, and research landslide hazards; respond to landslide events; and coordinate with SLTT entities for landslide hazards preparedness and response. NLHRP coordination includes the following components:

- National strategy for landslide hazards, risk reduction, and response
- Interagency plan to implement the national strategy
- Interagency Coordinating Committee on Landslide Hazards (ICCLH)⁴¹
- Advisory Committee on Landslides (ACL)⁴²

The USGS submitted a *National Strategy for Landslide Loss Reduction* to Congress in January 2022.⁴³ During its first meeting in February 2023, the ICCLH discussed creating an interagency plan to implement the National Strategy, including programs, projects, and budgets. The ICCLH intends to move forward with coordinating and preparing such a plan.⁴⁴ The USGS established an ACL in 2023, and the ACL held meetings in 2025.⁴⁵

The NLHRP objectives are to identify, map, assess, research, plan, prepare for, warn, and respond to landslide hazards and to reduce landslide risks nationwide. The USGS, primarily through LHP, leads the NLHRP.⁴⁶ LHP has been expanding its landslide science and application activities to carry out the USGS components of the NLHRP.⁴⁷

In addition to committees, strategies, and plans, the NLHRP includes the following activities:

⁴⁰ USGS, “3D Elevation Program,” <https://www.usgs.gov/3d-elevation-program>. See also CRS In Focus IF13079, *The 3D Elevation Program (3DEP) and Its Role in Mapping Hazards and Resources*, by Linda R. Rowan.

⁴¹ The Interagency Coordinating Committee on Landslide Hazards includes the following or their designee: Secretaries of the Interior, Agriculture, Army, Commerce, Homeland Security, and Transportation, and Directors of the National Science Foundation, Office of Science and Technology Policy, and Office of Management and Budget (P.L. 116-323, 43 U.S.C. §§3101 et seq.). LHP has established an Interagency Coordinating Committee on Landslide Hazards. USGS, FY2024 Budget Justifications, <https://www.doi.gov/sites/doi.gov/files/fy2024-usgs-greenbook.pdf-508.pdf>, p. 72. Correspondence between CRS and the USGS, April 2023.

⁴² The USGS filed a charter for the ACL to Congress on September 30, 2024. The advisory committee is to have no fewer than 11 members. The members may be representatives of state or local entities, such as geological surveys, transportation departments, and emergency management agencies, plus institutions of higher education and industry standards development organizations (P.L. 116-323, 43 U.S.C. §§3101 et seq.). The ACL is scheduled to become inactive two years after the date the charter is filed unless it is renewed in accordance with the provisions of Section 14 of the Federal Advisory Committee Act (P.L. 92-463). See also USGS, “Advisory Committee on Landslides (ACL),” <https://www.usgs.gov/programs/landslide-hazards/advisory-committee-landslides-acl>.

⁴³ Godt et al., *National Strategy*. The NLHRP directs the USGS, in coordination with the advisory committee, to publish a national strategy for landslide hazards, risk reduction, and response in the United States and its territories within one year of enactment and every five years thereafter (P.L. 116-323, 43 U.S.C. §§3101 et seq.).

⁴⁴ Correspondence between CRS and the USGS, April 2023.

⁴⁵ USGS, “Advisory Committee on Landslides (ACL),” <https://www.usgs.gov/programs/landslide-hazards/advisory-committee-landslides-acl>.

⁴⁶ USGS, “What We Do—Landslide Hazards Program,” <https://www.usgs.gov/programs/landslide-hazards/what-we-do-landslide-hazards-program>.

⁴⁷ The USGS has stated that “the entirety of the USGS contribution to the NLHRP is within the activities of the LHP.” Correspondence between CRS and the USGS, April 2023.

Research and Assessment⁴⁸

- Identify, map, assess, and research landslide hazards
- Establish a National Inventory of Landslide Hazards
- May provide research grants for landslide research to institutions of higher education and other eligible entities through NSF directorates or offices
- May provide external cooperative grants to SLTT entities to research, map, assess, and collect data on landslide hazards within their jurisdictions through a cooperative landslide hazard mapping and assessment grant program organized by the USGS

Planning and Preparedness⁴⁹

- Use research and assessment activities to develop planning and preparedness resources for federal agencies and SLTT entities to reduce landslide losses

Warning and Response⁵⁰

- Expand debris-flow early warning systems
- Support emergency response efforts, including data collection and further research to understand the causes and impacts of landslide hazards
- Prepare publicly available significant landslide event reports that identify community impacts and recommend ways to reduce landslide losses based on lessons learned from the event and other data

The NLPA authorized annual appropriations for FY2021 to FY2024 of \$25 million for the USGS, \$11 million for NSF, and \$1 million for NOAA to carry out the NLHRP (see “Issues for Congress” for more information about authorizations and appropriations).

Implementation of the National Strategy for Landslide Loss Reduction

The National Strategy describes goals and actions to reduce the nation’s risk from landslide hazards.⁵¹ The goals and requisite actions can be divided into the activity categories described above, namely research and assessment, planning and preparedness, and warning and response. The status of the implementation of activities in these three categories are described below. In the USGS FY2024 Budget Justifications, the USGS indicated that implementation of some NLHRP activities would proceed at a slower pace in FY2024 and the addition of inundation models in USGS post-fire debris-flow hazard assessments would be delayed for two or more years.⁵² The

⁴⁸ The NLPA directs the Secretary of the Interior, in coordination with existing USGS activities; other federal agencies; and state, local, tribal, and territorial (SLTT) entities, to carry out these program activities (P.L. 116-323, 43 U.S.C. §§3101 et seq.).

⁴⁹ The NLPA directs the Secretaries of the Interior, Agriculture, Army, Commerce, Homeland Security, and Transportation and related SLTTs to carry out these program activities (P.L. 116-323, 43 U.S.C. §§3101 et seq.).

⁵⁰ The NLPA directs the Secretaries of the Interior, Commerce, and Homeland Security and related SLTTs to carry out these program activities (P.L. 116-323, 43 U.S.C. §§3101 et seq.).

⁵¹ Godt et al., *National Strategy*.

⁵² USGS, *FY2024 Budget Justifications and Performance Information*, <https://www.doi.gov/sites/doi.gov/files/fy2024-usgs-greenbook.pdf-508.pdf>, p. 70 (hereinafter USGS, *FY2024 Budget Justifications*).

USGS FY2025 Budget Justifications noted that the USGS is proceeding with NLHRP activities.⁵³ President Trump’s FY2026 budget request for the USGS would reduce funding for the Natural Hazards Mission Area, which includes the LHP, from \$203 million in FY2025 to \$157 million in FY2026.⁵⁴ As of August 2025, the USGS and the Administration have not provided specific details about how the reduction in funding might affect specific programs within the mission area.

Research and Assessment

Actions to achieve the research and assessment goals in the National Strategy include (1) the characterization of the societal risks posed by landslide hazards; (2) the expansion of research and development to better understand where, when, and why landslide hazards arise; and (3) the development of a publicly accessible national landslide hazards and risk database. To facilitate carrying out these actions for the entire nation, LHP plans to integrate the USGS 3DEP data products on topography, vegetation, and the built environment plus NASA and NOAA satellite data products on precipitation, soil moisture, land-cover, and land-surface deformation to develop characterizations, understanding of landslide processes, and assessments.⁵⁵ For example, LHP can use the 3DEP data products on topography to identify some past landslide events and steep slopes with high landslide potential to develop a landslide susceptibility map for Alaska. In addition, LHP aims to use other earth observations, cutting edge technology, machine learning, and high-performance computing to develop characterizations, understanding of landslide processes, and assessments.

National Landslide Inventory Database and Susceptibility Map

According to the National Strategy, LHP plans to add data and expand the National Landslide Inventory Database so that it covers the nation in a consistent, systematic, and accessible way.⁵⁶ Version 3 of the National Landslide Inventory Database, released online on February 27, 2025, contains more data and other updates.⁵⁷ LHP updated a landslide susceptibility map (**Figure 2**) using the landslide inventory database and other data.⁵⁸ LHP aims to add more data and, with respect to the National Landslide Hazard Risk Reduction Working Group and the cooperative grants, to expand the inventory (see “Cooperative Grant Program, Working Group, and Research Grants”). In particular, LHP plans to work with SLTT entities to systematically include more local data into a publicly accessible national database. As noted in the National Strategy, LHP aims to create a common platform for leveraging expertise that exists within individual agencies, sharing best practices, developing collaborative products, and providing input on priorities for cooperative grants.

⁵³ USGS, *FY2025 Budget Justifications and Performance Information*, <https://www.doi.gov/media/document/fy-2025-u-s-geological-survey-greenbook>, p. 81-83 (hereinafter USGS, *FY2025 Budget Justifications*).

⁵⁴ Office of Management and Budget, *Technical Supplement to the 2026 Budget: Appendix*, 2025, pp. 530-533, https://www.whitehouse.gov/wp-content/uploads/2025/05/appendix_fy2026.pdf.

⁵⁵ See also NASA, “Mapping Landslide Hazards,” <https://appliedsciences.nasa.gov/what-we-do/disasters/landslides>.

⁵⁶ Godt et al., *National Strategy*, p. 14. An updated inventory would satisfy the NLPA direction to establish a national landslide inventory.

⁵⁷ USGS, LHP, “Maps,” <https://www.usgs.gov/programs/landslide-hazards/maps>; USGS, “Landslide Inventories Across the United States (ver. 3.0, February 2025),” February 27, 2025, <https://www.usgs.gov/data/landslide-inventories-across-united-states-ver-30-february-2025>.

⁵⁸ USGS, “U.S. Landslide Inventory and Susceptibility Map,” <https://www.usgs.gov/programs/landslide-hazards/what-we-do-landslide-hazards-program>.

Cooperative Grant Program, Working Group, and Research Grants

The National Strategy calls for the LHP to develop and maintain a cooperative landslide hazard mapping and assessment grant program awarded to SLTT entities to advance research and assessment, particularly to enhance the National Landslide Inventory Database with SLTT data and other research results. Congress appropriated \$1 million to the USGS in FY2023 and FY2024 specifically for the cooperative grant program.⁵⁹ The USGS established an external grants program and awarded grants to state agencies in FY2024 and FY2025.⁶⁰ The USGS established a National Landslide Hazard Risk Reduction Working Group—consisting of SLTT entities, other organizations, and public or private sector entities—to (1) leverage expertise that exists within individual agencies, (2) share best practices, (3) develop collaborative products, and (4) provide input on priorities for cooperative grants.⁶¹

Subject to appropriations, NSF may provide grants for landslide research as a component of the NLHRP.⁶² NSF was authorized appropriations to establish research grants for landslides for \$11 million annually from FY2021 to FY2024. NSF budget documents indicate that actual amounts awarded for specific grants, if any, would not be available until awards are completed.⁶³ Congress did not appropriate funds for any specific landslide research grants at NSF in FY2021-FY2024. Explanatory statements accompanying FY2022 and FY2023 NSF appropriations encouraged the foundation to award meritorious landslide research grants in support of the NLHRP.⁶⁴ NSF is part of the ICCLH and, similar to the role NSF plays in the NEHRP, the foundation may identify research results or potential results of awarded grants that advance landslide science and contribute to achieving the objectives of the NLHRP. In addition, NSF research facilities may contribute to and coordinate with federal agencies and SLTT entities on NLHRP activities.⁶⁵

Planning and Preparedness

The National Strategy calls for LHP, with other federal agencies and SLTT entities, to (1) provide guidance, tools, and training to include landslide information in hazard planning and (2) develop

⁵⁹ USGS, *FY2025 Budget Justifications*, p. 81.

⁶⁰ USGS, LHP, “External Grants Overview,” <https://www.usgs.gov/programs/landslide-hazards/science/external-grants-overview>; USGS, “External Grants - Projects,” <https://www.usgs.gov/programs/landslide-hazards/external-grants-projects>; USGS, “USGS Seeks Landslide Risk Reduction Proposals,” <https://www.usgs.gov/news/technical-announcement/usgs-seeks-landslide-risk-reduction-proposals>.

⁶¹ USGS, “National Landslide Risk Reduction Working Group,” <https://www.usgs.gov/programs/landslide-hazards/national-landslide-hazard-risk-reduction-working-group>.

⁶² The USGS National Strategy to implement the USGS components and partnerships of the NLHRP does not discuss the NSF research grant component of the NLHRP.

⁶³ For example, NSF, *FY2022 Budget Request to Congress*, May 28, 2021, <https://nsf.gov-resources.nsf.gov/about/budget/fy2022/pdf/fy2022budget.pdf> (see p. Authorizations – 7).

⁶⁴ For example, the FY2023 explanatory statement accompanying Division B of P.L. 117-328 stated, “NSF is encouraged to fund grants for meritorious landslide research, data collection, and warning systems in fulfillment of the National Landslide Preparedness Act (Public Law 116–323) and the National Earthquake Hazards Reduction Program Reauthorization Act (Public Law 115–307). NSF is further encouraged to prioritize funding for the deployment of early warning systems in States with high levels of both landslides and seismic activities.” Explanatory Statement, *Congressional Record*, vol. 168, No. 198 (December 20, 2022), p. S7951. Congress also encouraged NSF to support landslide research grants as part of the NLHRP in the explanatory statement accompanying Division B of P.L. 117-103. U.S. Congress, House Committee on Appropriations, *Consolidated Appropriations Act, 2022*, Legislative Text and Explanatory Statement Book 1, p. 304.

⁶⁵ NSF, “Facilities,” <https://www.nsf.gov/about/partners/facilities.jsp>.

landslide outreach initiatives to improve public knowledge and preparedness planning.⁶⁶ Other specific plans in the National Strategy to enhance preparedness include developing landslide preparedness curricula and training modules for federal entities and SLTT entities; developing guidelines on the design of landslide-related emergency management exercises, and creating a “Landslide Ready” program, similar to the NWS TsunamiReady, that recognizes community-level planning for future landslides.⁶⁷

Warning and Response

The National Strategy envisions developing and operating a nationwide landslide surveillance system that can be integrated with existing USGS earthquake and volcano monitoring and NWS weather monitoring. LHP plans to coordinate with other federal, state, or local systems and provide situational awareness about landslide potential, so that stakeholders are able to prepare, plan for, and respond to landslide hazards.

The National Strategy plans for the USGS, with partners, to (1) expand the USGS and NWS effort on debris-flow potential as part of NWS flash-flood forecasting; (2) warn about other types of landslides induced by rainfall and soil conditions; and (3) develop systems to identify locations with elevated landslide potential.⁶⁸ A debris-flow or other landslide early warning system may be improved by successful integration of technology, such as the USGS ground-based landslide monitoring sensors and real-time alerting technology with satellite-based detection and weather forecasts to improve landslide surveillance capabilities.⁶⁹

The NLPA calls for the expansion of the debris-flow early warning system; in particular, expanding the early warning system for post-wildfire debris flow in recently burned areas across the western United States. The act calls for an expansion of post-wildfire debris-flow early warning systems, in part, because past flows have caused significant losses (see text box titled “Montecito, CA: Post-Wildfire Debris Flow”) and warning systems may help to reduce future losses.

Montecito, CA: Post-Wildfire Debris Flows

The Montecito, CA, post-wildfire debris flows in 2018 caused 23 fatalities, at least 167 injuries, and 408 damaged homes. These losses are among the highest attributed to a landslide disaster in the United States since the beginning of the 21st century. Studies suggest that these conditions may occur more frequently in the future, leading to the potential for more post-wildfire debris flows and that, because of the growth of communities in such hazardous areas, more communities are vulnerable to potentially more frequent debris-flow hazards.

One of the largest wildfires in U.S. history, the Thomas fire, started on December 4, 2017, and burned through the Santa Ynez Mountains, the Los Padres National Forest, and parts of Santa Barbara and Ventura Counties in California. The fire increased the susceptibility of steep slopes of burned landscape to debris flows.

On January 9, 2018, before the fire was contained, a burst of intense rainfall (about 0.6 inches of rain in 5 minutes) fell on the burned area above Montecito, CA. The intense rainfall triggered a series of debris flows that mobilized

⁶⁶ The NLPA directs the Secretary of the Interior to coordinate landslide hazard and risk preparedness for communities with the Secretaries of the Army, Commerce, Homeland Security, and Transportation and the heads of other relevant federal agencies, in consultation with SLTTs. Beyond the activities of NSF and NOAA, this cooperation allows greater coordination with existing programs that deal with landslides at NASA, USACE, the Department of Transportation, and FEMA (see “Federal Roles in Landslide Hazards and Risks”).

⁶⁷ NWS, “NWS TsunamiReady Program,” <https://www.weather.gov/TsunamiReady/>.

⁶⁸ NOAA-USGS, *NOAA-USGS Debris-Flow Warning System - Final Report*, Circular 1283, 2005, <https://pubs.usgs.gov/circ/2005/1283/>. For more information about debris flows, see CRS Report R47618, *Post-Wildfire Debris Flows: Federal Role in Assessment and Warning*, by Linda R. Rowan and Eva Lipiec.

⁶⁹ Godt et al., *National Strategy*, pp. 14-16.

24 million cubic feet of sediment (including boulders greater than 18 feet in diameter) at velocities as high as 35 miles per hour. The photographs below show examples of the debris flows' impact on communities:

1. A house constraining the lateral extent of the overbank debris flow from San Ysidro Creek
2. Debris plugging an 8-foot diameter culvert in Buena Vista Creek
3. Debris flow crashing through a house near Buena Vista Creek
4. Debris flow separating into two flows around a bridge on Cold Spring Creek



Sources: Photographs from Jason W. Kean, USGS public domain, and text based on Jason W. Kean et al., "Inundation, Flow Dynamics, and Damage in the 9 January 2018 Montecito Debris-Flow Event, California, USA: Opportunities and Challenges for Post-wildfire Risk Assessment," *Geosphere*, vol. 12, no. 4 (June 7, 2019), <https://doi.org/10.1130/GES02048.1>; Benjamin B. Mirus et al., "Landslides Across the USA: Occurrence, Susceptibility, and Data Limitations," *Landslides*, vol. 17 (December 19, 2020), <https://doi.org/10.1007/s10346-020-01424-4>; U.S. Department of Agriculture, Forest Service, *Thomas Burned Area Report*, FSH 2509.13, January 16, 2018, https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd573382.pdf; National Weather Service, "Flash Flood & Debris Flow Event, Montecito, California January 9, 2018," <https://noaa.maps.arcgis.com/apps/MapJournal/index.html?appid=541c23aa483b48978d1bc9904a6b14d>.

Landslide Monitoring

The USGS has had or currently maintains landslide monitoring sites in Alaska, California, Colorado, North Carolina, Oregon, Washington, and Puerto Rico.⁷⁰ Not all of these sites are active or collecting data in real time. Some of the sites gather data about rainfall and soil conditions to inform USGS efforts to identify thresholds for landslide potential. This aims to allow the NWS to issue landslide warnings based on weather conditions that exceed these thresholds. LHP has not expanded monitoring as envisioned in the National Strategy. Congress directed the USGS to conduct landslide and tsunami assessment and monitoring in Prince William Sound, AK, and appropriated about \$4 million annually for this purpose in FY2022,

⁷⁰ USGS, LHP, "Landslide Monitoring Stations," <https://www.usgs.gov/programs/landslide-hazards/science/landslide-monitoring-stations>, accessed October 23, 2024.

FY2023, and FY2024 (see text box titled “Prince William Sound, AK, Landslide and Tsunami Hazard Monitoring System”).⁷¹

Debris-Flow Hazard Assessments and Warnings

The National Strategy aims for LHP to improve and expand post-fire debris-flow assessments (PFDs).⁷² PFDs model the likelihood of a debris flow in a burned area for a given rainfall intensity (**Figure 4**).⁷³ The USGS provided 483 PFDs in western states between 2013 and 2023 and has increased its coverage of burned area in these western states on an annual basis.⁷⁴ LHP plans to expand PFDs to other states and to provide more assessments for more post-fire areas.⁷⁵

The National Strategy plans for LHP with the NWS to expand the debris-flow early warning system in western states. For vulnerable landscapes where PFDs have identified debris-flow risks, the USGS and the NWS may deploy a debris-flow early warning system. A typical system consists primarily of rain gages and streamgages transmitting real-time data about rain or stream flow intensity, respectively. The USGS has worked with the NWS to test debris-flow early warning systems in Northern California (1985-1995) and Southern California (2005-2008).⁷⁶ The USGS indicated that it planned to expand the debris-flow warning system in other parts of California and other western states in partnership with the NWS in FY2024 and FY2025.⁷⁷

⁷¹ USGS, *FY2024 Budget Justifications*, pp. 70-72, and S.Rept. 118-83.

⁷² Godt et al., *National Strategy*.

⁷³ USGS Landslide Hazards Program, “Emergency Assessment of Post-Fire Debris-Flow Hazards,” https://landslides.usgs.gov/hazards/postfire_debrisflow/.

⁷⁴ USGS, *FY2025 Budget Justifications*, p. 82, and USGS Landslide Hazards Program, “Emergency Assessment of Post-Fire Debris-Flow Hazards,” https://landslides.usgs.gov/hazards/postfire_debrisflow/.

⁷⁵ See also CRS Report R47618, *Post-Wildfire Debris Flows: Federal Role in Assessment and Warning*, by Linda R. Rowan and Eva Lipiec; CRS Insight IN12507, *Federal Assessments and Warnings of Potential Post-Fire Debris Flows: Examples from the January 2025 Los Angeles County Wildfires*, by Linda R. Rowan and Eva Lipiec.

⁷⁶ Guzzetti et al., “Geographical Landslide Early Warning Systems,” January 2020, *Earth-Science Reviews*, vol. 200, <https://www.sciencedirect.com/science/article/pii/S0012825219304635>.

⁷⁷ USGS, *FY2024 Budget Justifications*, p. 71; correspondence between CRS and USGS, April 2023; and USGS, *FY2025 Budget Justifications*, p. 82.

Prince William Sound, AK, Landslide and Tsunami Hazard Monitoring System

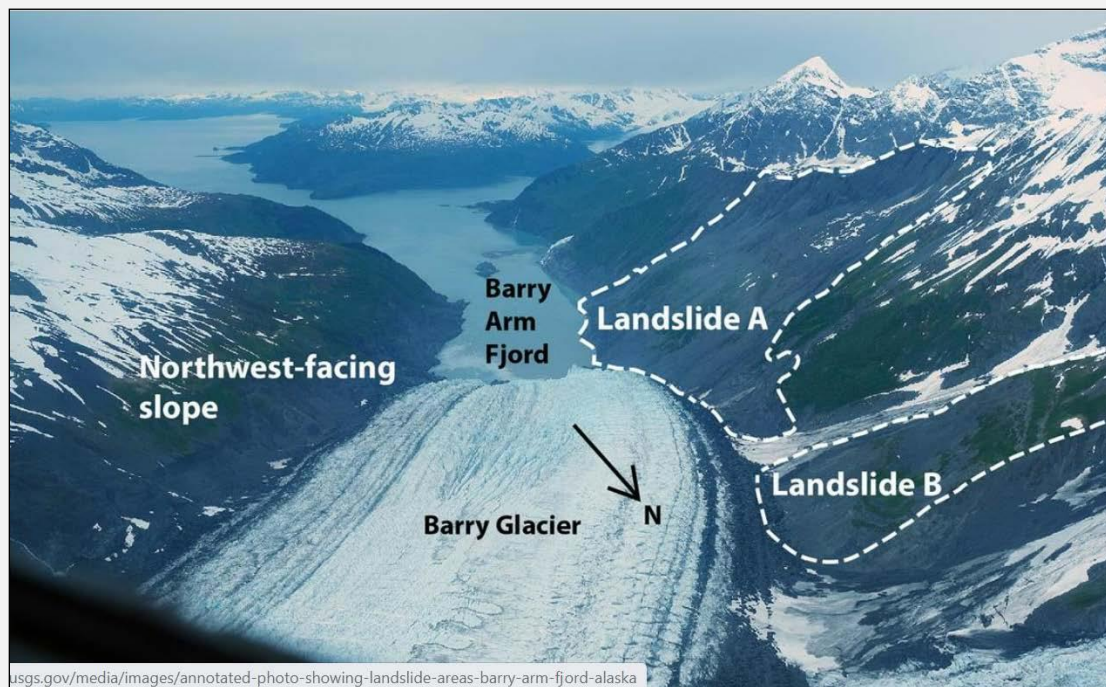
Congress directed about \$4 million in annual appropriations for the U.S. Geological Survey (USGS) Landslide Hazards Program in FY2022, FY2023, and FY2024 to research, assessment, and monitoring related to the Prince William Sound Landslide and Tsunami Hazard Monitoring System.

The Barry Arm landslide (landslide A in photograph), located in the northwestern corner of Prince William Sound, Alaska, is the largest recorded landslide in Alaska (about 650 million cubic yards) and has the potential to cause significant damage and loss. Rapid, catastrophic failure of the landslide could generate a tsunami that would be life-threatening for anyone near the shoreline in Barry Arm, Harriman Fjord, and parts of Port Wells. Significant risks also exist in other, outer locations of western Prince William Sound, including the town of Whittier, Alaska.

Several landslides with variable rates of movement, often related to the melting and retreat of the Barry Glacier, have been documented since the early 1910s. Slow movement of landslide A has been documented over several decades. Increased movement (velocities up to about 85 feet per year versus 2-4 feet per year) was observed during a period of rapid retreat of the Barry Glacier from 2010 to 2016. Movement velocities returned to a lower level as the retreat of the Barry Glacier slowed.

An Interagency Science Team, including the U.S. Geological Survey, Alaska Division of Geological and Geophysical Surveys, Alaska Earthquake Center, and National Oceanic and Atmospheric Administration National Tsunami Warning Center, monitors landslide movement and the potential for landslide or tsunami hazards to harm people or damage property. As conditions warrant, the Interagency Science Team provides updates about potential landslide and tsunami hazards risks as conditions warrant to federal, state, and local authorities, emergency managers, and others.

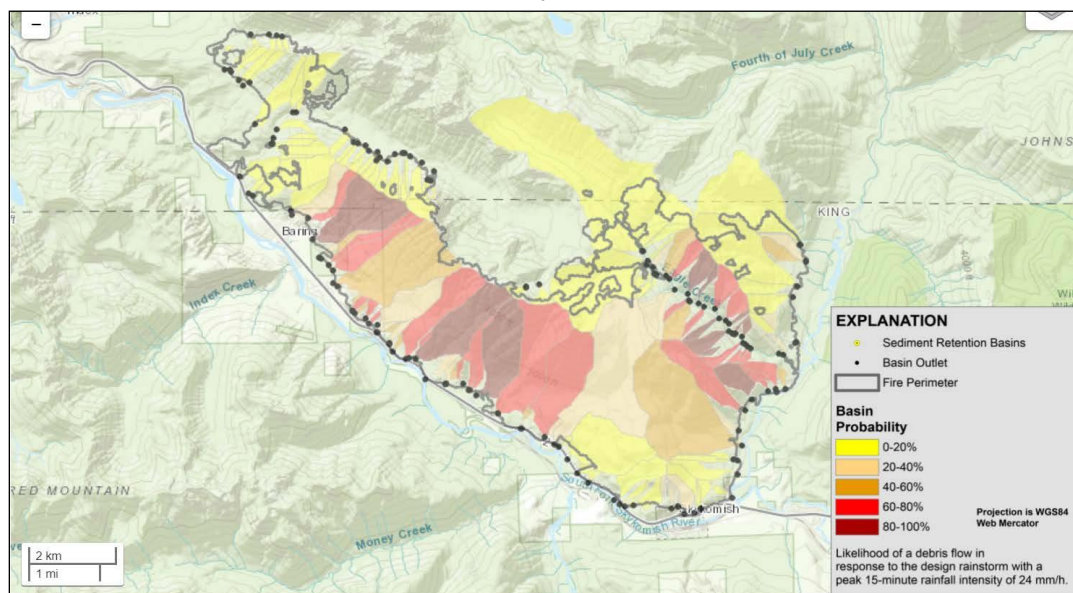
In 2024, the system detected landslides at Surprise Inlet in a different area of Prince William Sound in near real time, demonstrating how such systems can enhance detection. The landslides were likely triggered by intense rainfall and produced small non-damaging tsunami waves. The landslide detections indicate how an early warning system extended regionally may allow for public alerts regarding tsunami waves potentially associated with such landslides.



Sources: Alaska Division of Geological and Geophysical Surveys, “Barry Arm Landslide and Tsunami Hazards,” <https://dggs.alaska.gov/hazards/barry-arm-landslide.html>. Photograph taken by Gabriel Wolken, June 26, 2020, and annotated by the USGS. Photograph is USGS public domain. Ezgi Karasözen et al., “2024 Surprise Inlet Landslides: Insights from a Prototype Landslide-Triggered Tsunami Monitoring System in Prince William Sound, Alaska,” *Geophysical Research Letters*, vol. 52, no. 13 (July 2, 2025), <https://doi.org/10.1029/2025GL115911>.

Figure 4. Example of Post-Fire Debris-Flow Hazard Assessment for Bolt Creek Fire, WA

Bolt Creek, Mt. Baker-Snoqualmie National Forest, WA



Source: USGS, Landslide Hazards Program, "Bolt Creek (Mt. Baker- Snoqualmie National Forest, WA)," https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=451.

Notes: The map depicts the likelihood of a debris flow in response to a rainstorm with a peak 15-minute rainfall intensity of almost one inch per hour in the area that was burned in the Bolt Creek fire in September 2022. The extent of the fire is indicated by the medium-gray outline. The basins colored in the darkest red have an 80%-100% probability of a debris flow starting in response to the modeled rainstorm. More information about the Bolt Creek fire is available from InciWeb, "Bolt Creek Fire," <https://inciweb.nwcg.gov/incident-information/wanws-bolt-creek-fire>.

Response and Recovery

The National Strategy aims for LHP, with partners, to (1) improve response actions by having USGS technical experts on site for a landslide hazard emergency and (2) provide publicly available reports of significant landslide events.⁷⁸ The National Strategy defines *significant landslide events* as those that are part of a presidentially declared disaster under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (P.L. 100-707) or those determined to be significant by the ICCLH. Significant landslide event reports will likely include descriptions of the event and its societal effects, as well as recommendations for assessing and communicating risk, disseminating warnings, and improving preparedness and response efforts. The USGS lists some landslide event summaries online.⁷⁹

Issues for Congress

Congress may consider whether the NLHRP is being implemented to the extent and in a time frame sufficient to reduce landslide risks nationwide and to meet the intended aims of the NLPA. As required in the NLPA, the USGS submitted a National Strategy to implement the NLHRP to

⁷⁸ Godt et al., *National Strategy*.

⁷⁹ USGS, "Landslide and Debris Flow Event Summaries," <https://www.usgs.gov/programs/landslide-hazards/science/landslide-and-debris-flow-event-summaries>.

Congress and established an ICCLH. Some of the other components of the NLHRP have not been implemented. Some such elements are planned, partially completed as part of existing projects, or delayed, according to the USGS.⁸⁰

The NLPA required an interagency plan to be submitted to Congress with the National Strategy, within one year of enactment (i.e., by January 5, 2022). No interagency plan has been submitted to Congress; the ICCLH discussed such a plan in February 2023.⁸¹ An interagency plan could help inform Congress about the time, staff, and resources needed to implement the NLHRP. Congress could consider whether to direct the agencies on the ICCLH to prioritize planning and submission of such a plan.

The NLPA authorized \$25 million annually for the USGS, \$11 million for NSF, and \$1 million for NOAA to carry out the NLHRP for FY2021-FY2024. The NLPA's authorization of appropriations for the NLHRP ended on September 30, 2024. Congress may consider whether to reauthorize appropriations for the NLHRP. Congress did not appropriate any specific landslide funds for NSF and NOAA for the NLHRP. Congress appropriated about \$8 million in FY2020, \$9 million in FY2021, \$14.4 million in FY2022, \$14.4 million in FY2023, and \$14.0 million in FY2024 for the USGS LHP. Congress provided these annual appropriations for LHP, which is tasked with implementing the USGS component of the NLHRP, and in some cases directed appropriations to specific NLHRP and other landslide activities. Congress may consider whether the amount and directed spending of annual appropriations were sufficient to implement the USGS-led activities of the NLHRP and whether to appropriate any funds to other agencies that are part of the NLHRP.

Some bills in the 119th Congress would reauthorize and amend NLPA (S. 1626, as ordered to be reported with an amendment favorably; H.R. 2250, as ordered to be reported in the nature of a substitute by unanimous consent; and H.R. 3816, as introduced).⁸² The bills would provide funding from amounts appropriated or otherwise made available to the USGS: \$35 million would be made available annually for NLHRP until FY2030, of which not less than \$10 million would be for early warning systems. The bills would extend authorization of appropriations of \$11 million annually for NSF and \$1 million annually for NOAA until FY2030. Some amendments to the NLPA in S. 1626, H.R. 2250, and H.R. 3816 include

- adding the administrator of NASA to the ICCLH;
- adding definitions of “Tribal organization,” “Native Hawaiian Community,” “atmospheric river,” “atmospheric river flooding event,” and “extreme precipitation event”;
- directing the NLHRP to include tribal entities in some landslide project partnerships; and
- directing agencies to consider the impact of atmospheric river and other extreme precipitation events on landslide hazard assessments, warnings, and other activities.

⁸⁰ USGS, *FY2024 Budget Justifications*, p. 71; correspondence between CRS and the USGS, April 2023; and USGS, *FY2025 Budget Justifications*, p. 81.

⁸¹ The ICCLH discussed a detailed interagency plan that would include projects, programs, and budgets to implement the NLHRP at its first meeting in February 2023. Correspondence between CRS and the USGS, April 2023.

⁸² H.R. 3816, Weather Act Reauthorization Act of 2025, includes Title VIII, National Landslide Preparedness Act Reauthorization. For more on H.R. 3816, see CRS In Focus IF12698, *Weather Act Reauthorization Act of 2025 (H.R. 3816)*, by Eva Lipiec and Caitlin Keating-Bitonti.

Congress may consider the status of implementation of NLHRP as it deliberates reauthorization, amendments, and whether to provide appropriations for NLHRP programs.

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