



## BEST PRACTICES

# Building and Developing on Alluvial Fans

### WHY IS THIS AREA BEING MAPPED OR REMAPPED?

The first step in reducing flood risk is knowing your risk. Flood risks change over time, and some flood hazard data is outdated and no longer accurately represents flood risks that communities face. Moreover, the technology used to determine flood hazards has improved drastically. Using the latest data developed by newer technology will result in flood maps that will help communities plan for the next disaster.

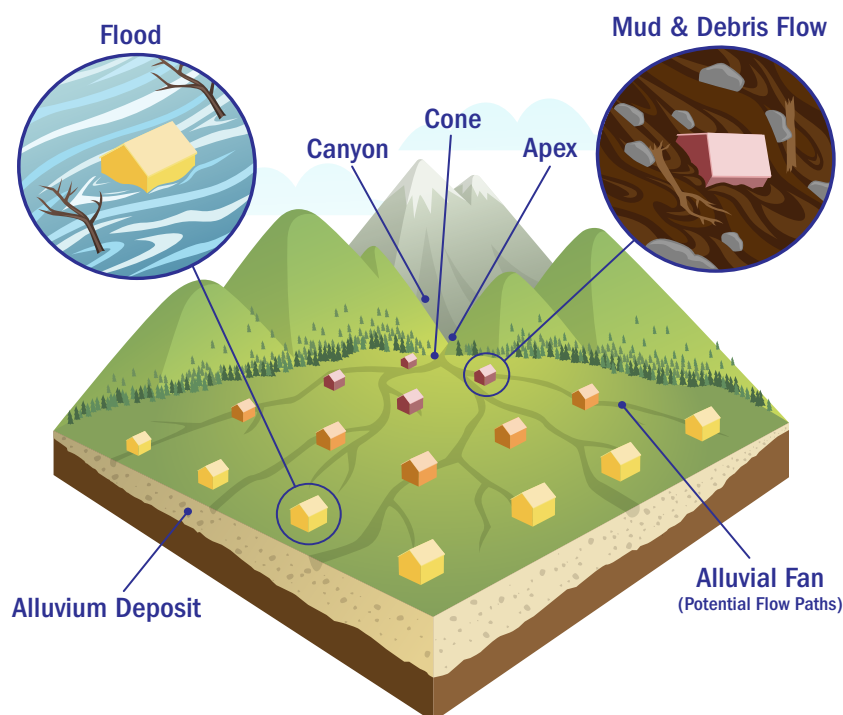
Alluvial fans pose unique flood hazards, including high-velocity flows, scour, erosion, and debris transport, and most uniquely — unpredictable flood paths and depths. Additionally, it is important to denote on a flood map where an alluvial fan and key features exist in order to appropriately regulate development in this high-risk area. It is important to note that there are

additional requirements and typically higher standards for developing on alluvial fans, whether they are mapped or not.

### WHO NEEDS THIS INFORMATION?

This information will be most helpful for local community leaders, floodplain administrators, building code officials, architects, developers, and even property owners on an alluvial fan. This document will help you better understand the following topics:

- Why flood maps are updated
- Risks and hazards associated with alluvial fans
- Best practices for developing on an alluvial fan
- Actions you can take to reduce the risk of future flood damage



## STEPS FOR AVOIDING LOSS OF LIFE AND PROPERTY IN AN ALLUVIAL FAN

### STEP ONE: Map the Alluvial Fan

*Do Flood Insurance Rate Maps (FIRMs) show enough detail to determine whether an alluvial fan exists?*

FIRMs map areas of flood risk and sometimes include the delineation of alluvial fans as Zone AO. They often do not include enough detail, such as key features that define an alluvial fan. If a community's flood map does not identify those key features, it is up to the architect or designer to obtain reliable data to assess any risks associated with a particular development, and then to design a structure that can withstand those risks. This information can come from regional and local studies, topographic maps, aerial photos, historical data, and other local expertise.

### STEP TWO: Avoid Any Development in an Alluvial Fan

Alluvial fans can cause dangerous and unpredictable flooding and debris flow, putting people and property at risk. Like all development, when you build on an alluvial fan you are disrupting the natural drainage and flood processes, which not only places that new development in harm's way, but can also increase risks for homes or businesses that lie further down the fan. This not only perpetuates fan formation but creates uncertainty and unpredictability regarding flood hazards. If an alluvial fan is identified, and is currently undeveloped, the community should consider designating this high-risk area as open space.

Communities can use a variety of strategies to regulate development in alluvial fans, such as:

- Designating active fan areas as open space and only allowing trails and other passive uses,
- Purchasing existing homes and businesses located on active fans through an acquisition program
- Adopting land use regulations to deny new development and/or significant redevelopment.

While building or developing on an alluvial fan is strongly discouraged, a comprehensive approach to managing existing and any potential new development should include a variety of resources, including flood mapping, community planning, building regulations, and incorporating large-scale structural projects to mitigate any future hazards.

### STEP THREE: Mitigate Your Risk

*How should a community manage existing and new development on alluvial fans?*

Any actions being taken should focus on decreasing the flood and debris hazard and physically protecting existing structures from future damage. To protect life and property, the following strategies should be considered when planning mitigation activities on an alluvial fan.

#### Mapping:

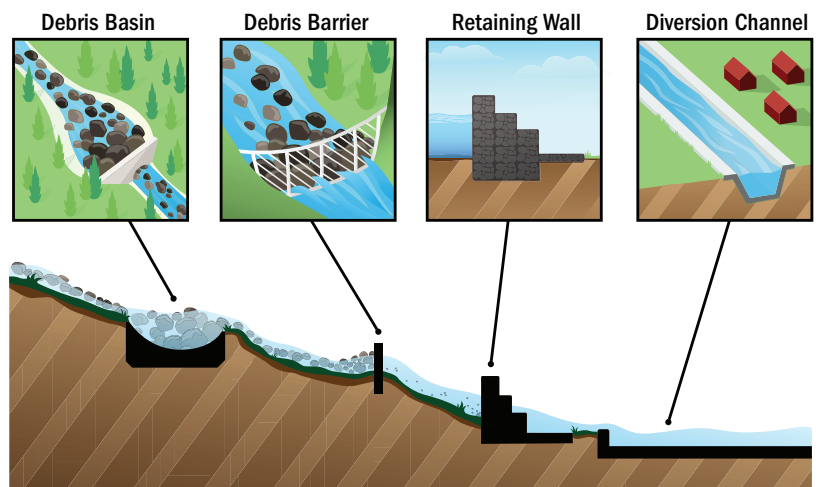
The first step in mitigating your risk is to fully understand it by conducting detailed local or regional studies to better identify and understand alluvial fan hazards, especially in densely developed areas, or those areas targeted for development. It is also important to add alluvial fan areas to a community's regulatory flood map, specifically identifying fan apexes and meandering flow path zones. This data should include information such as depth and velocity grids to help inform developers on foundation selection and design criteria.

#### Planning/Regulatory:

In the most dangerous areas of the alluvial fan, communities should purchase existing properties and convert them to open space and prohibit new construction and reconstruction. In these areas, use strict floodplain management, zoning, and subdivision regulations similar to the no-rise requirement in floodways to prohibit or limit growth in high-risk areas. Additionally, communities should adopt and enforce strict floodplain management and building code requirements for substantial improvements in Special Flood Hazard Areas (SFHAs) and in alluvial fan areas to ensure that they exceed the minimum requirements.

### Large-scale Mitigation:

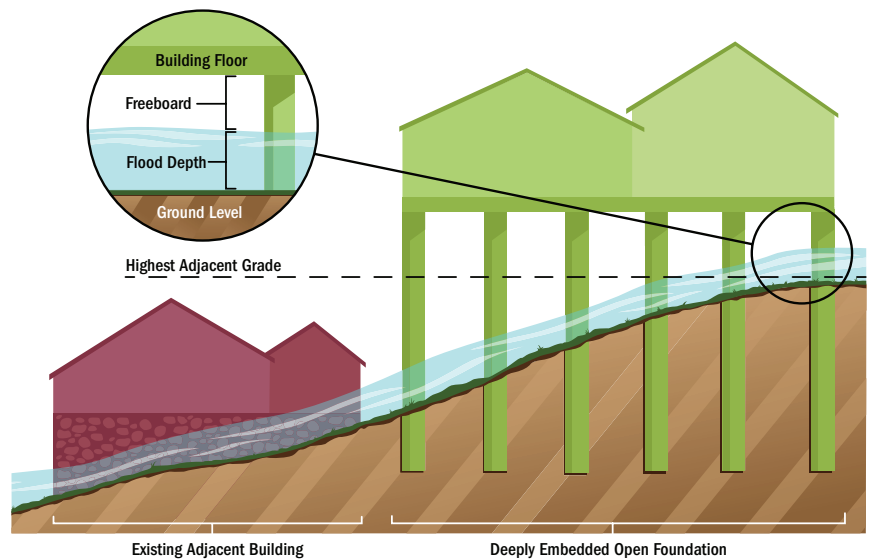
If development already exists on an alluvial fan, ensure there are proper warning systems and evacuation plans in place that anticipate flash flooding or debris events. Another option is to strongly encourage whole-fan and/or local protection to be structurally designed to mitigate the risk of hazards to existing development on an alluvial fan. Whole-fan mitigation activities include large structural measures such as levees, channels, detention basins, and debris basins, which divert water and debris flow around the entire fan to avoid developed areas. Local protection efforts include debris fences, dikes, and channels, which reduce the formation of new flow paths and relocate existing flow paths to avoid developed areas. A combination of whole-fan and local protection activities will reduce the risks that property owners face on an alluvial fan, though it is important to know that it does not eliminate all risk. As with all risks, it is important to educate homeowners and business owners of the risks associated with an alluvial fan so they can make informed decisions regarding their property.



Conceptual sketch depicting neighborhood-scale flood, debris, and mudflow protecting measures for communities located in alluvial fan area.

### Individual Mitigation:

There are also things that an individual homeowner can do to lower the risk to their property, though they may be required to obtain a building and/or floodplain development permit before any development or redevelopment begins. This will ensure that any development complies with building codes and regulations and does not increase risk on the alluvial fan. Encouraged activities include elevating buildings on open foundations or armored fill, reinforcing the uphill side of structures against debris impact, and potentially building floodwalls or berms around the property, provided it does not negatively impact the floodplain and downstream properties. For any new construction or substantial improvement property owners must follow all floodplain management and building code requirements.



Conceptual sketch showing elevated open space foundation for new housing development in alluvial fan area.

## **STEP FOUR: Consider Building Codes When Permitting Development or Redevelopment**

*What building codes and standards are required for structures in alluvial fans?*

### **Building Codes and Standards**

The International Residential Code (IRC) and International Building Code (IBC) form the basis for most building codes adopted in the United States. Each community's building codes can vary from these model codes, so coordination with local building officials is necessary to confirm which requirements apply in a given community. The IRC provides prescriptive solutions with minimal need for a designer or architect. The IBC can be used to design homes, but it is used primarily for buildings and commercial structures not included within the IRC scope. FEMA has deemed that the latest published editions of the IRC and IBC, including adoption of flood provisions contained in Appendix G, meet or exceed NFIP requirements for buildings and structures.

### **International Residential Code**

The IRC includes requirements for new construction and substantial improvements in floodplains, including Zone AO, but does not cover specific provisions for alluvial fans. The IRC does allow for the American Society of Civil Engineers (ASCE) 24 standards to be used as an alternative to IRC provisions in areas with higher flood risks, such as alluvial fans and areas of significant flood depth and/or velocity.

### **International Building Code: ASCE 24**

The IBC requires the use of the flood design standard ASCE 24 for new construction and substantial improvements in the floodplain. ASCE 24 prohibits new development or substantial improvements in alluvial fan areas unless a whole-fan mitigation system is in place. Additionally, building foundations in inactive portions of alluvial fans must account for the potential effects of scour and velocity. Where allowed, all construction in alluvial fans must meet ASCE 24 requirements and either meet or exceed NFIP requirements for development in a floodplain.

### **How does the National Flood Insurance Program (NFIP) address development on alluvial fans?**

The NFIP identifies alluvial fan hazards on Flood Insurance Rate Maps (FIRMs) as Zone AO and provides information on flood depths and flood velocities. Construction requirements for structures located in Zones AO include they be adequately anchored to prevent flotation, collapse, or lateral movement resulting from flooding and debris, elevation of the lowest floor (including basement) above the highest adjacent grade, use of flood damage-resistant materials below the lowest floor, properly installed flood openings in foundation enclosures, and providing adequate protection from high-velocities or debris loads.

### **What are some best practices for individual buildings on an alluvial fan?**

ASCE 24 requirements offer a higher standard of practice for building in an alluvial fan, even if they are not required. If ASCE 24 is not required, developers should consider the hazards posed by alluvial fans to make informed design and construction decisions. Foundations should be deeply embedded and include open pile or column foundations that are enhanced to resist scour, high-velocity flood and mudflow, and debris impact. In addition to proper foundation design, the site should be graded to convey sheet flow or include up-fan flood control structures to divert flow. This may provide some protection, but control structures should not divert flow onto other properties.

## **STEP FIVE: Protect Your Home or Business**

### **Ensure ASCE 24 Compliance**

Wherever you build, do so in the safest way possible. Ensuring that your property meets or exceeds ASCE 24 requirements is the first step in lowering flood risk to your home or business. These standards, along with any higher standards adopted by your local community, are designed to protect your home while not putting another home or business in harm's way.

### **Buy Flood Insurance**

Property owners in alluvial fans are encouraged to purchase and understand flood insurance. The National Flood Insurance Program (NFIP) flood insurance policies cover direct physical damage as the result of flooding defined in the Standard Flood Insurance Policy. This does not include landslides, earth movement, or other land subsidence. Whole-fan, local, and individual protective works do not reduce premiums unless they result in the removal of the land from the SFHA through the Letter of Map Revision (LOMR) process.

### **Build a Ready Kit**

Alluvial fan flooding events can be very dangerous and often occur with limited notice. After an emergency, you may need to survive on your own for several days. Being prepared means having your own food, water and other supplies to last for several days.

A disaster supply kit is a collection of basic items your household may need in the event of an emergency. Visit [ready.gov/kit](https://www.ready.gov/kit) for more information about what you should include in your ready kit.

### **Make a Plan**

Make a plan so you know what to do and where to go to protect yourself and your household from flooding. Sign up for your community's warning system and evacuate if told to do so. Learn and practice evacuation routes and make plans to stay with family or friends, or check with local authorities for public sheltering options. Never walk or drive through floodwaters. If trapped in a building, go to the highest level with a window. Visit [ready.gov/floods](https://www.ready.gov/floods) for more information.

### **Do not Develop a Basement**

Basements are quite common in most communities and are a desired feature for many who are looking to purchase a home, however, local requirements generally do not allow for development of properties with basements in high-risk flood areas — including alluvial fans. When developing or conducting substantial improvements to a structure, consult building officials on requirements and best practices regarding basements in high-risk flood zones. Flood insurance may be significantly higher for homes or businesses with basements in the SFHA.

## **WHERE CAN I GET MORE INFORMATION?**

**You can find more information on FEMA's website, or follow any of the links below:**

*Alluvial Fans: Hazards and Management*

[fema.gov/media-library-data/20130726-1504-20490-3060/fema165.pdf](https://www.fema.gov/media-library-data/20130726-1504-20490-3060/fema165.pdf)

*Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures, Appendix D Alluvial Fan Flooding*

[fema.gov/media-library-data/20130726-1506-20490-2593/fema259\\_complete\\_rev.pdf](https://www.fema.gov/media-library-data/20130726-1506-20490-2593/fema259_complete_rev.pdf)

*Flood Resistant Provisions of the 2018 International Codes.*

[fema.gov/media-collection/flood-resistant-provisions-2018-international-codes-2018](https://www.fema.gov/media-collection/flood-resistant-provisions-2018-international-codes-2018)

*Highlights of ASCE 24, Flood Resistant Design and Construction*

[fema.gov/sites/default/files/2020-07/asce24-14\\_highlights\\_jan2015.pdf](https://www.fema.gov/sites/default/files/2020-07/asce24-14_highlights_jan2015.pdf)

*Quick Reference Guide: Comparison of Select NFIP & 2018 I-Code Requirements for Special Flood Hazard Areas.*

[fema.gov/sites/default/files/2020-07/fema\\_quick-ref-guide-nfip-2018-icodes-reqs-flood-areas.pdf](https://www.fema.gov/sites/default/files/2020-07/fema_quick-ref-guide-nfip-2018-icodes-reqs-flood-areas.pdf)

*Guidance for Alluvial Fan Structural Counter Measures: Planning and Design*

[silverjackets.nfrmp.us/Portals/0/doc/Nevada/Bruce\\_Phillips\\_Alluvial\\_Fan\\_Workshop.pdf](https://silverjackets.nfrmp.us/Portals/0/doc/Nevada/Bruce_Phillips_Alluvial_Fan_Workshop.pdf)