Borrego Springs Alluvial Fan
Active and Inactive Area Mapping,
County of San Diego, California

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Outline

• Where is Borrego Springs, California?
• History of flood events at Borrego Springs
• Mapping of active vs. inactive alluvial fan areas
  • Geomorphic mapping approach
  • Hydraulic characteristics
  • Integration of geomorphic- and hydraulic engineering-principles
• Comparison with flood hazard delineation map (FEMA FIRM)
Where is Borrego Springs, California?

YOU ARE HERE
(Rancho Mirage)
Borrego Valley

- Alluvial Fans
  - Coyote Canyon
  - El Vado Canyon
  - Henderson Canyon
  - Borrego Palm Canyon
  - Fire Canyon
  - Hellhole Canyon
  - Dry Canyon
  - Culp-Tubb-Loki Canyons

- Borrego Springs
  - Del Anza Golf Course

- San Jacinto Fault Zone
  - “Coyote Creek Fault”
History of Recent Flooding at Borrego Springs

- 1976: Hurricane Kathleen
- 1977: Del Anzo Golf Course Flood
- 1979: Borrego Palm Canyon Flood
- 1982: Del Anzo Golf Course Flood
- 2000: Borrego Springs Flood
- 2004: Del Anzo Golf Course Flood
1976 Hurricane Kathleen Flooding
1977 Del Anza (Golf Course) Flooding
1979 Borrego Palm Canyon Flash Flood
2000 Borrego Springs Flooding
2004 Del Anza (Golf Course) Flooding
Adopted Flood Hazard Approach and Mitigation Strategies

• 1987: FEMA develops the first FIRMS for Borrego Springs
• 1989: Borrego Valley Alluvial Fan Hazard Map adopted
• 2013?: FIRMS updated

• Mitigation strategies:
  • Base Floor Elevation (BFE) above highest adjacent grade, minimum to Zone AO depth value
  • 50 % of housing lot is open space to provide drainage
  • Position structures so as not to divert damaging flows to other properties
Alluvial Fan Active vs. Inactive Area Mapping

• County of San Diego requested DRI perform this work
• DRI instructed to follow FEMA Appendix G: “Guidance for Alluvial Fan Flooding Analyses and Mapping”
• Geomorphic mapping approach
• Hydraulic characteristics
• Integration of geomorphic- and hydraulic engineering-principles
Geomorphic Map of the Borrego Valley Study Area
Percent Slope Map of the Borrego Valley Study Area
Low-Gradient Alluvial Fan Landforms (Qa1 – Qa4)

A:
- Low-gradient, alluvial plain
- Floodplain 1953-2006
- Sparse-mod vegetation
- Anastomosing and braided distributary channels

B:
- Gravelly, sand lag
- No varnish
- Stratified sediment
- No soil development

A:  
- Low-gradient, alluvial plain
- Sparse-mod vegetation with plant mounds
- Linear orientation of plant mounds controls flow direction

B:  
- Gravelly, sand lag
- Incipient varnish
- Moderately-developed soil (redder soil color)
High-Gradient Alluvial Fan Landforms (Qf1a – Qf4a, Qf5)

A:
- High-gradient, alluvial fan
- Well-vegetated
- Braided channel network

B:
- Gravelly, sand lag
- No varnish
- Non-stratified sediment
- No soil development
- Incipient soluble salt

Qf2a

A:
- High-gradient, alluvial fan
- Well-developed desert pavement and varnish
- Elevated position above channels and alluvial plain units

B:
- Desert pavement and varnish with underlying Av horizon
- Incipient varnish
- Redder soils – long-term landform stability

Qf4a
High-Gradient Alluvial Fan Landforms (Debris Flow: Qf1b – Qf4b)

A:
• High-gradient, alluvial fan
• Debris flow deposits of boulders and blocks
• Boulder levees
• Braided channel network

B:
• Imbrication of boulders
• Woody debris relict of 2005 flood
• Incipient varnish

A:
• High-gradient, alluvial fan
• Debris flow deposits of boulders and blocks
• Incipient varnish

B:
• Lobes with boulder levees
• Bar-and-swale
• Braided channel network
• Incipient varnish
## Hydraulic Characteristics of Active vs. Inactive Alluvial Fan Surfaces

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Active Surfaces</th>
<th>Inactive Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Channel Continuity</strong></td>
<td>Continuous; Distributary</td>
<td>Discontinuous; Tributary</td>
</tr>
<tr>
<td><strong>Channel Capacity</strong></td>
<td>Decreasing Downstream</td>
<td>No Trend</td>
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<tr>
<td><strong>Channel Flow or Sheet Flood</strong></td>
<td>Channel Flow</td>
<td>Sheet Flood</td>
</tr>
<tr>
<td><strong>Debris Flow Occurrence</strong></td>
<td>Yes</td>
<td>Minor to None</td>
</tr>
<tr>
<td><strong>Channel Movement</strong></td>
<td>Frequent</td>
<td>Rare</td>
</tr>
</tbody>
</table>
Active versus Inactive Alluvial Fan Areas of the Borrego Valley Study Area
Flood Hazard versus Active/Inactive Alluvial Fan Area Maps
Summary

• 90% of the 61 mi² of the Borrego Springs Study Area contain geomorphically and hydraulically active alluvial fan landforms.

• Results generally confirm existing flood hazard delineation map produced by Boyle Engineering (1989), which FEMA currently uses as a basis to assign flood insurance risk zones in Borrego Valley.
Adopted Mitigation Strategies

• Mitigation strategies:
  • Base Floor Elevation (BFE) above highest adjacent grade, minimum to Zone AO depth value
  • 50 % of housing lot is open space to provide drainage
  • Position structures so as not to divert damaging flows to other properties
  • Flood walls surrounding some structures
Adopted Mitigation Strategies

House elevated above surrounding grade

50% open space

*note older house to the left is not elevated
Adopted Mitigation Strategies

Flood walls surrounding houses
Adopted Mitigation Strategies

House elevated on piers
Adopted Mitigation Strategies?!
Questions?

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