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DEPARTMENT OF PUBLIC WORKS

LAND DEVELOPMENT DIVISION
FLOOD CONTROL SECTION

FLOOD CONTROL ON ALLUVIAL FANS

MARCH, 1988

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PRELIMINARY REPORT --- FLOOD CONTROL METHODS ON ALLUVIAL FANS

TABLE OF CONTENTS

	Page
Introduction	3
Characteristics of Alluvial Fans	4
Flood Protection on Alluvial Fans	4
Flood Insurance on Alluvial Fans	4
List of References for Desert Project	7
Apppendix I--Borrego Valley Alluvial Fan Maps	8
Appendix II--Nonstructural Methods Types of Protection Defined	10
Appendix IIA--Procedures for Site Evaluation (Nonstructural Projects)	19
Appendix III--Criteria for Design Using Structural Methods	21
Appendix IV--Federal Flood Insurance on Alluvial Fans	22
ATTACHMENTS	23-25

COUNTY OF SAN DIEGO
DEPARTMENT OF PUBLIC WORKS

LAND DEVELOPMENT DIVISION
FLOOD CONTROL SECTION

PRELIMINARY REPORT --- FLOOD CONTROL METHODS ON ALLUVIAL FANS

INTRODUCTION

This report describes applications of Federal regulations for flood control on alluvial fans primarily in the 70-square-mile valley around Borrego Springs, California.

The Federal Emergency Management Agency (FEMA) has new Flood Insurance Studies for alluvial fans with maps that show contours of predicted flood depth and velocity.

The present rule requires all buildings in Borrego Valley to be raised by two feet above the natural ground. The new studies will reduce this requirement in most areas through more sophisticated analysis of alluvial fan flooding.

Construction in these areas must take special precautions to protect lives and property from flash floods. Many storms in past years have caused extensive damage to homes, businesses, roads and agriculture in this area.

County building permit approval, Federal bank loans and flood insurance are all contingent on builders' compliance with FEMA regulations. Builders should review flood regulations (and maps) to determine requirements for their site.

PRELIMINARY REPORT --- FLOOD CONTROL METHODS ON ALLUVIAL FANS

CHARACTERISTICS OF ALLUVIAL FANS

An alluvial fan is a desert phenomenon where streams emerge from canyons and deposit sand and rock in a cone-shaped formation fanning out from the canyon mouth (Fig A and B).

The Federal Emergency Management Agency (FEMA) has prepared Flood Insurance Studies (FIS) identifying alluvial fan areas with calculated depth and velocity. Alluvial fan maps (based upon the FIS) are available from the County Department of Public Works, or Planning and Land Use. Appendix I provides the basis for development of Borrego Valley Alluvial Fan Maps.

Construction in these areas must take special precautions to protect property and lives from flash-flood damage. County building permit issuance and Federal Bank financing are contingent upon compliance with FEMA regulations.

FLOOD PROTECTION ON ALLUVIAL FANS

Nonstructural

Nonstructural methods apply where proposed construction will not cause a major change to the natural alluvial fan process. When buildings and other obstructions to flow are spaced so that flood and sediment flow can go around them without a major disturbance, then the alluvial process can continue. Appendix II provides criteria for construction using nonstructural methods.

Structural

Structural methods use flood control structures such as channels, levees or other facilities. Appendix III provides criteria for design using structural methods.

FLOOD INSURANCE ON ALLUVIAL FANS

The Federal government makes flood insurance available in San Diego County contingent on County regulation of development in flood hazard areas. The insurance is available everywhere in the unincorporated area. In areas designated as alluvial fans on the Federal Flood Insurance Rate Maps (FIRMS), flood insurance is required for Federally approved loans on houses and other structures. Appendix IV provides additional information.

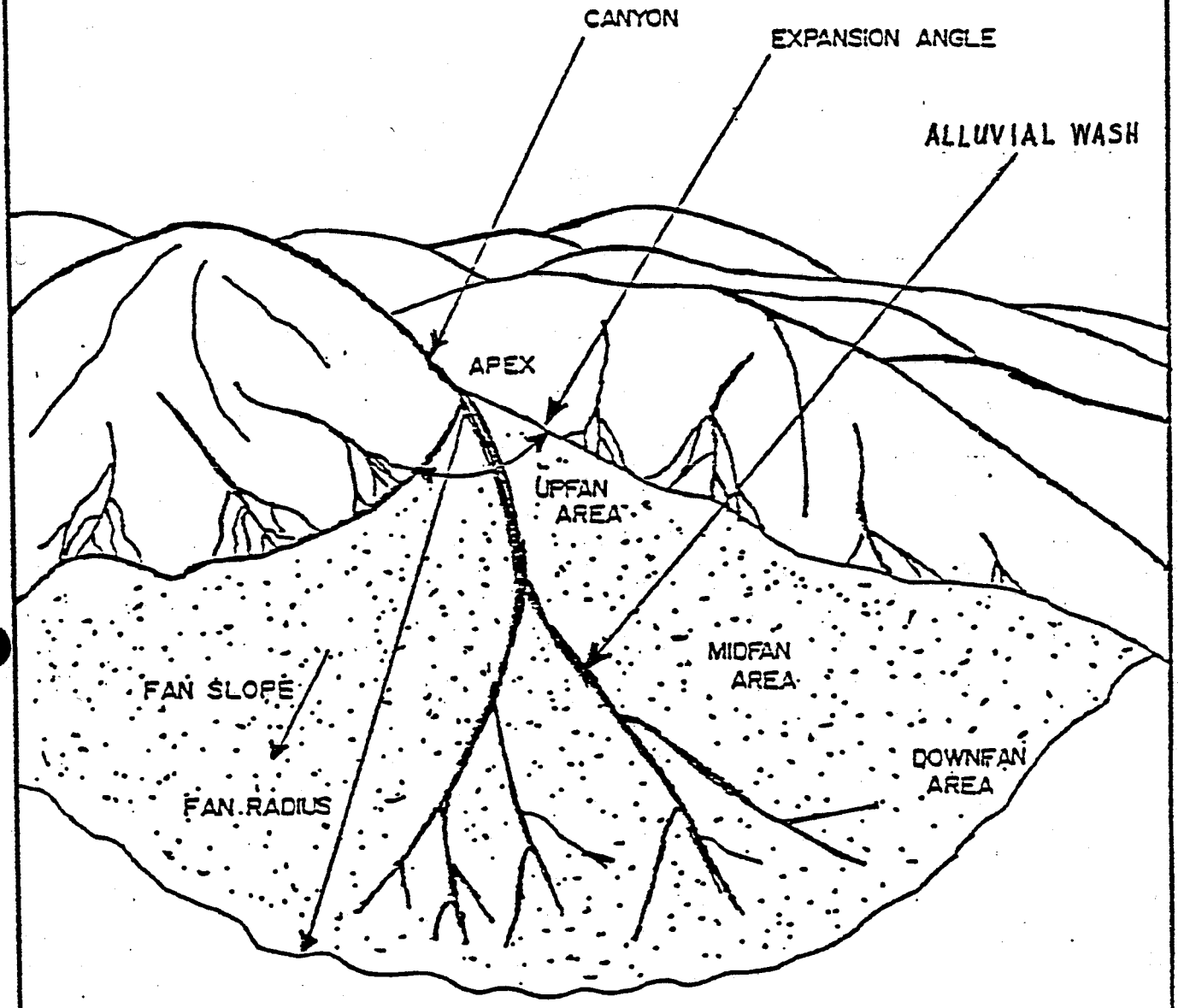


FIGURE A
Definition Sketch of Alluvial Fan Characteristics

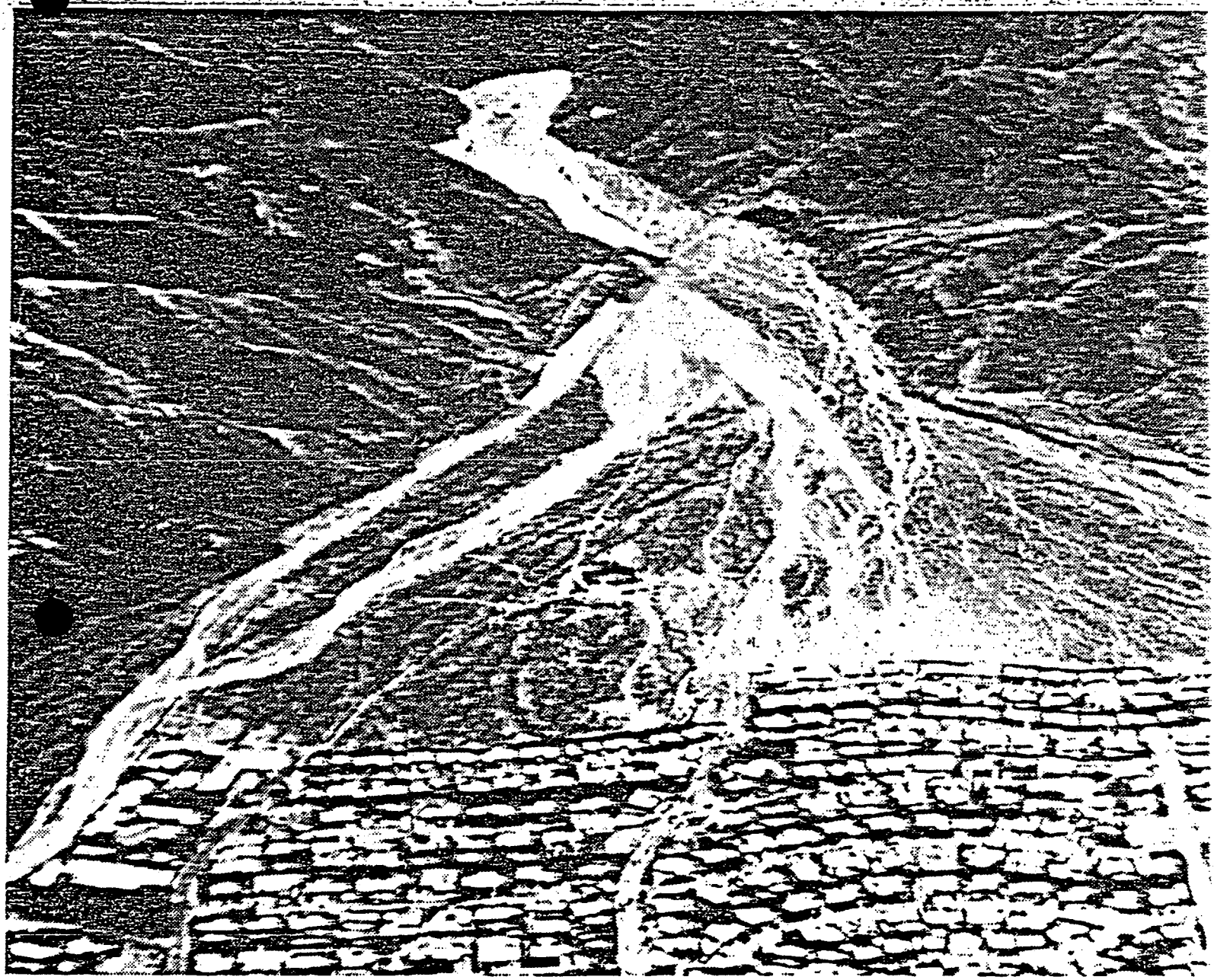


Figure B. Alluvial Fan near Palm Springs, CA.

List of Reference Data for Desert Project

1. County
   1.1 (Note book) Previous studies for Jacumba-Letters, Photos.
   1.2 (Project) HEC runs in Boundary Creek.
   1.3 Storm Report-Tropical Storm Kathleen Sept 9-10 1976
   1.4 Storm Report-Tropical Storm Doreen Aug 15-17 1977
   1.5 Storm Report-Feb 1980
   1.6 Rain & Streamflow History-Eastern S.D. Co. July 1985
   1.7 Base Maps 1" = 2000' N.Borrego, S.Borrego, Jacumba, index
   1.8 (Draft) Flood Control on Alluvial Fans
   1.9 Borrego Valley General Plan for Flood Control Improvements July, 1972

2. FEMA
   2.1 Design Manual for Retrofitting Flood-Prone Residential Structures Sept 1986
   2.2 Manufactured Home Installation in Flood Hazard Areas Sept 85
   2.3 Flood Plain Management Tools for Alluvial Fans Vol.1 Documentation Vol.2 Findings Nov 1981
   2.4 Flood Insurance Study Guidelines and Specifications for Study Contractors Sept 1985
   2.5 Borrego Valley Alluvial Fan Map

3. US Army Corps of Engineers
   3.1 (Draft Report) Engineering Standards for Flood Protection of Single Lot Development (no date)

4. Pima County, AZ.
   4.1 Floodplain Management Ordinance
   4.2 Symposium on Alluvial Fan Management (Arizona Floodplain Management Association)

5. Dawdy, David R.
   5.1 Analysis of Alluvial Fan Flooding
   5.2 New FEMA Guidelines for Alluvial Fan Flooding
   5.3 Report on Borrego Valley Flood Map Oct 1986

6. Woodward-Clyde (Ram's Hill)
   6.1 Plan Map Ram's Hill
   6.2 Design Concept, Flood Control Facilities
   6.3 Design Memo, Geo. Tech & Engr. Service F/C Facilities
   6.4 Soil-Cement Mix Design
   6.5 Final Report of Construction Inspection

7. Riverside County, CA
   7.1 Alluvial Fans Novel Flood Challenge Civil Engineering Magazine Nov 1984

APPENDIX I

BORREGO VALLEY ALLUVIAL FAN MAP

Purpose: To provide a land development planning map that shows the flood hazard potential in Borrego Valley.

1. Base Map

USGS, 2,000-scale, 40-foot contours, 1955 photography updated for recent development, roads and park boundaries.

2. Alluvial Fan Overlay

The alluvial fan boundaries, velocity and depth contours are based on the Flood Insurance Study for San Diego County and superimposed on the 2,000-scale maps for the ten alluvial fans that are mapped.

The Flood Insurance Study (FIS) for Borrego Valley was reviewed by the County Department of Public Works and Mr. David Dawdy, retained as consultant by the County.

Specific modifications were recommended to the Federal Emergency Management Agency (FEMA).

These modifications are included in the alluvial fan map used by the County.

3. Existing Alluvial Washes

Existing alluvial washes delineated on the alluvial fan map show the location of previous flood flows. The 1955 USGS maps, 1977 aerial photos, 1985 orthophoto maps and slides were used to define the flow paths. Comparison of the 1955 USGS maps and the 1985 orthophoto map show the flood flow lines have been in the same location for the past 30 years in most instances. The alluvial washes are usually in the upper part of the alluvial fans where the slopes are steeper and single channel flow occurs.

4. Alluvial Fan Boundaries and Intersections

Alluvial fan boundaries (between fans with flow direction that is essentially parallel) have been defined as part of the basic alluvial fan study.

Fan intersections are located at the downstream end of a fan, where it intersects with a second fan with flow directions that are approximately perpendicular. The intersection locations are determined by review of contour maps and photographs of past flooding. Flow characteristics are best defined with a typical floodplain analysis. Further information is given in Par. 6 below.

5. Alluvial Aprons

Alluvial aprons are formed by alluvial deposits with essentially the same characteristics as alluvial fans but generally are in smaller watersheds where the flow lines tend to be straighter. Alluvial aprons are designated on the Borrego Valley Alluvial Fan Map. Since the alluvial fan map is oriented toward County activities, the apron areas designated on the map are adjacent to the identified alluvial fans and outside of the Park boundaries.

6. Flood Plains

A floodplain map has been prepared for the intersection of of the downstream end of the western fans. The floodplain has been determined using the same methods as applied to over 250 miles of watercourse in San Diego and thousands of miles throughout the United States.

Detailed cross sections and computer analysis are used to determine flood plain elevations, area of flooding, velocities, etc. Orthophoto topographic maps (200 feet per inch, 5-foot contours) provide the basis. General information is provided in the County pamphlet "FLOOD PLAIN MANAGEMENT."

A floodway has not yet been defined. No significant construction in the floodplain is allowed without definition of a floodway. In some (maybe most) sections of the floodplain, a "density" floodway may be more appropriate than the typical floodway-floodplain-fringe.

A special consideration in desert floodplains is that many areas are subject to alluvial-fan flooding from tributaries in addition to the central floodway. Designs must allow for both types of floods.

APPENDIX II

NONSTRUCTURAL METHODS -- TYPES OF PROTECTION DEFINED

The criteria given in this appendix are the minimum recommended for foundation protection. The variable nature of desert flooding makes determination of protection difficult.

The criteria defined may not provide protection from all future flood events. As part of any construction project, more stringent criteria for foundation protection may be used. The option of developing a more detailed flood hazard analysis is also available.

Nonstructural methods apply to areas where the land use criteria is one-half acre or bigger, and where flow depths are 2 feet or less. For greater depths, or more dense land use, special studies are required.

1. FLOOR ELEVATION

   The top of the floor is raised above the surrounding ground an amount equal to or greater than the depth shown on the alluvial-fan map. (Figure II-1, II-3, II-4).

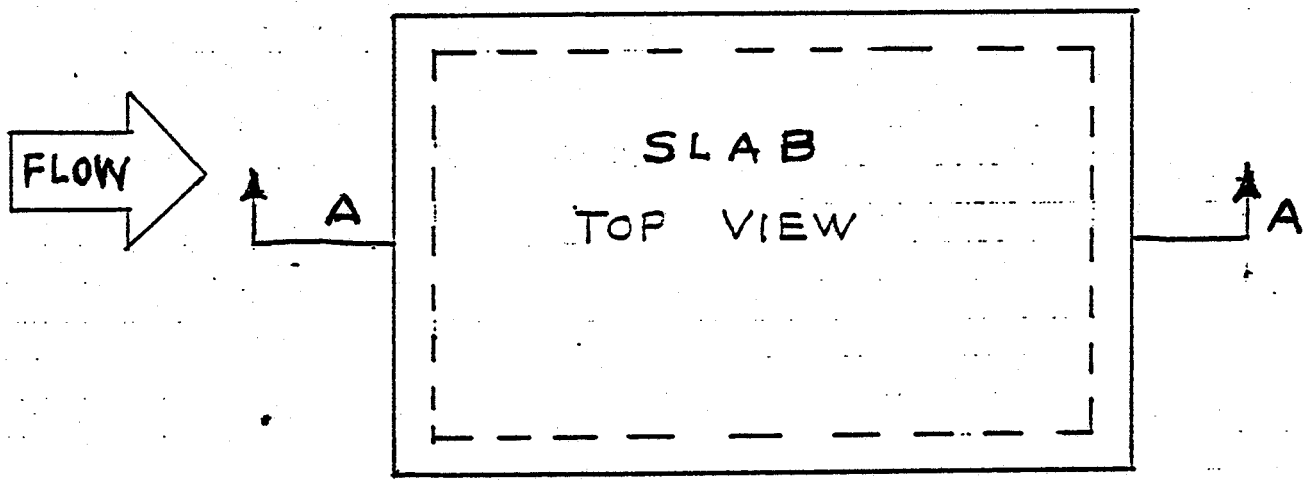
2. OBSTRUCTION OF FLOW

   Less than one-half of lot width, measured perpendicular to direction of alluvial fan flow, may be obstructed. Less than one-quarter of the lot area may be covered by structures of any kind, such as walls, garages, plantings, etc., that obstruct flow. Refer to Figure II for typical examples of flow patterns.

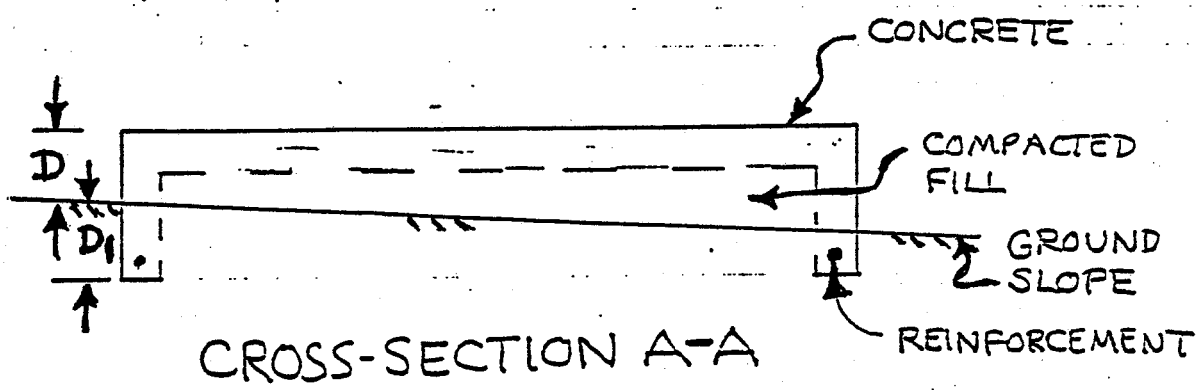
3. FOUNDATIONS

   A. Structures

      Structures must be constructed in such a way that foundations will be protected from erosion. Refer to Figures II-1 through II-5 for typical examples of foundation protection.

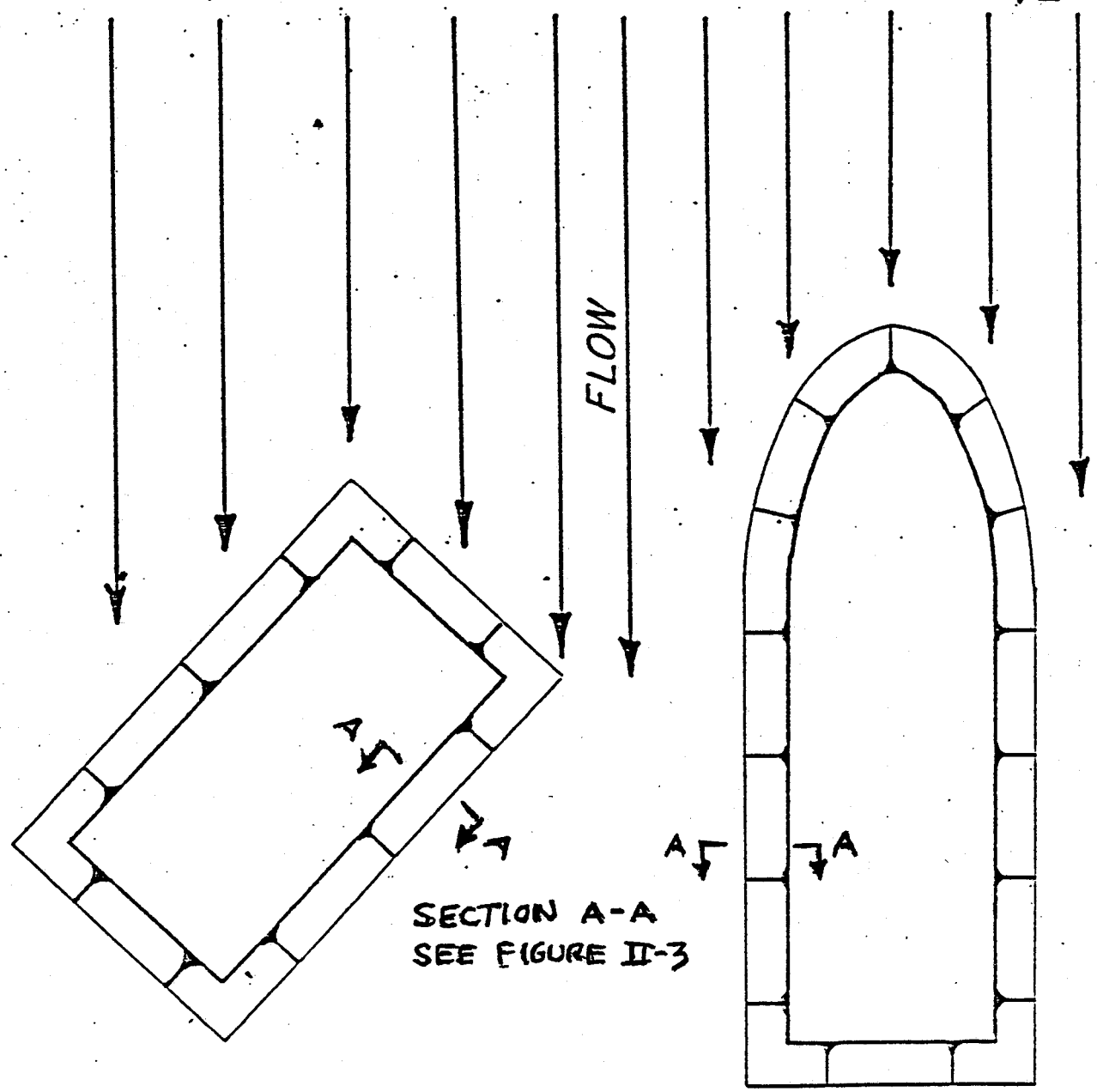


D = Depth shown on Alluvial-Fan Map.
Special Study Required where D > 2.5 feet.



This represents minimum flood protection for alluvial-fan areas not affected by existing alluvial washes. Special study required in locations affected by washes.

FIGURE II-1. FOUNDATION PROTECTION



CONFIGURATIONS OF FILLS TO MINIMIZE DEBRIS IMPACT

FIGURE II-2.

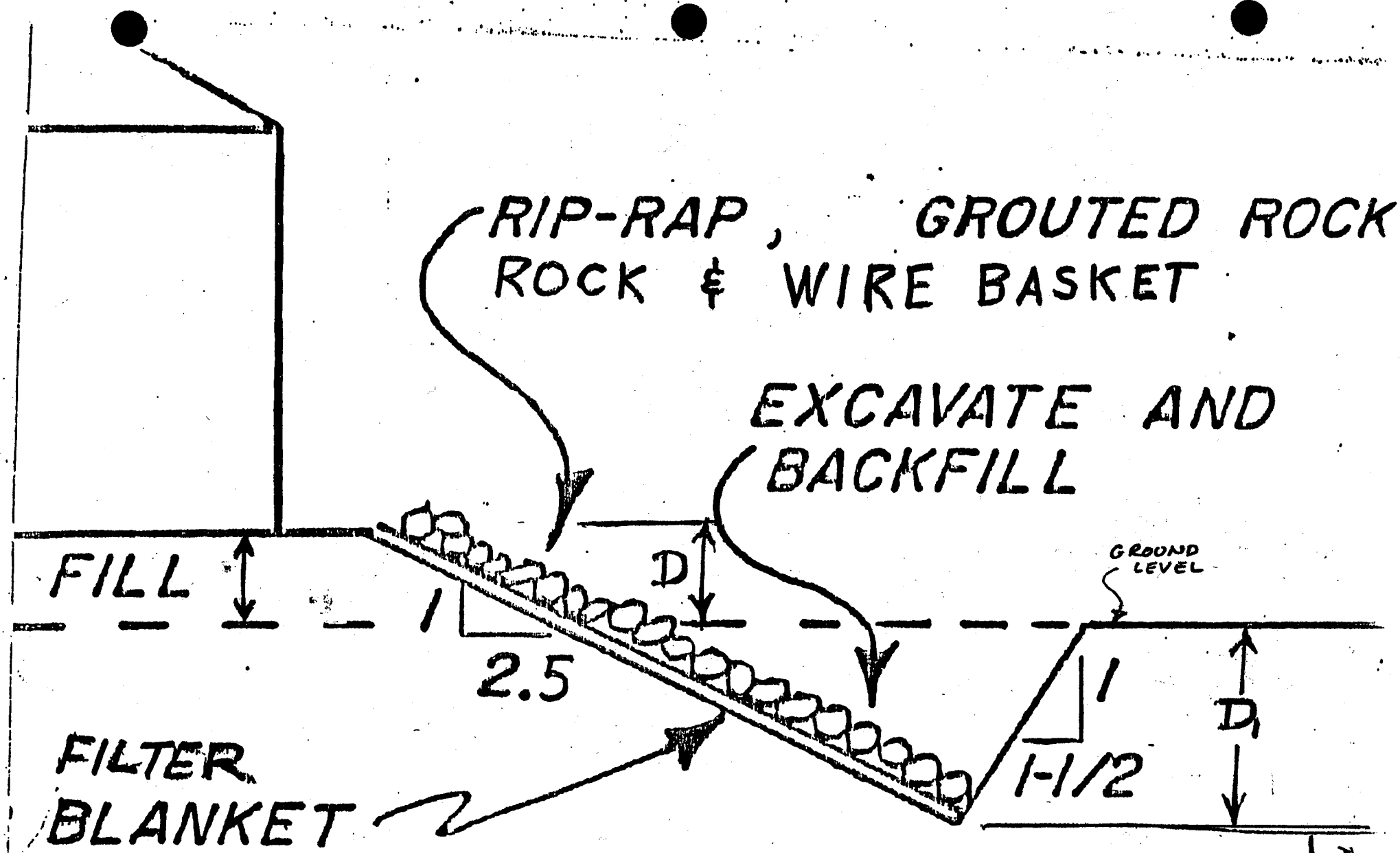


FIGURE II-3. SECTION A-A (FIG II-2)

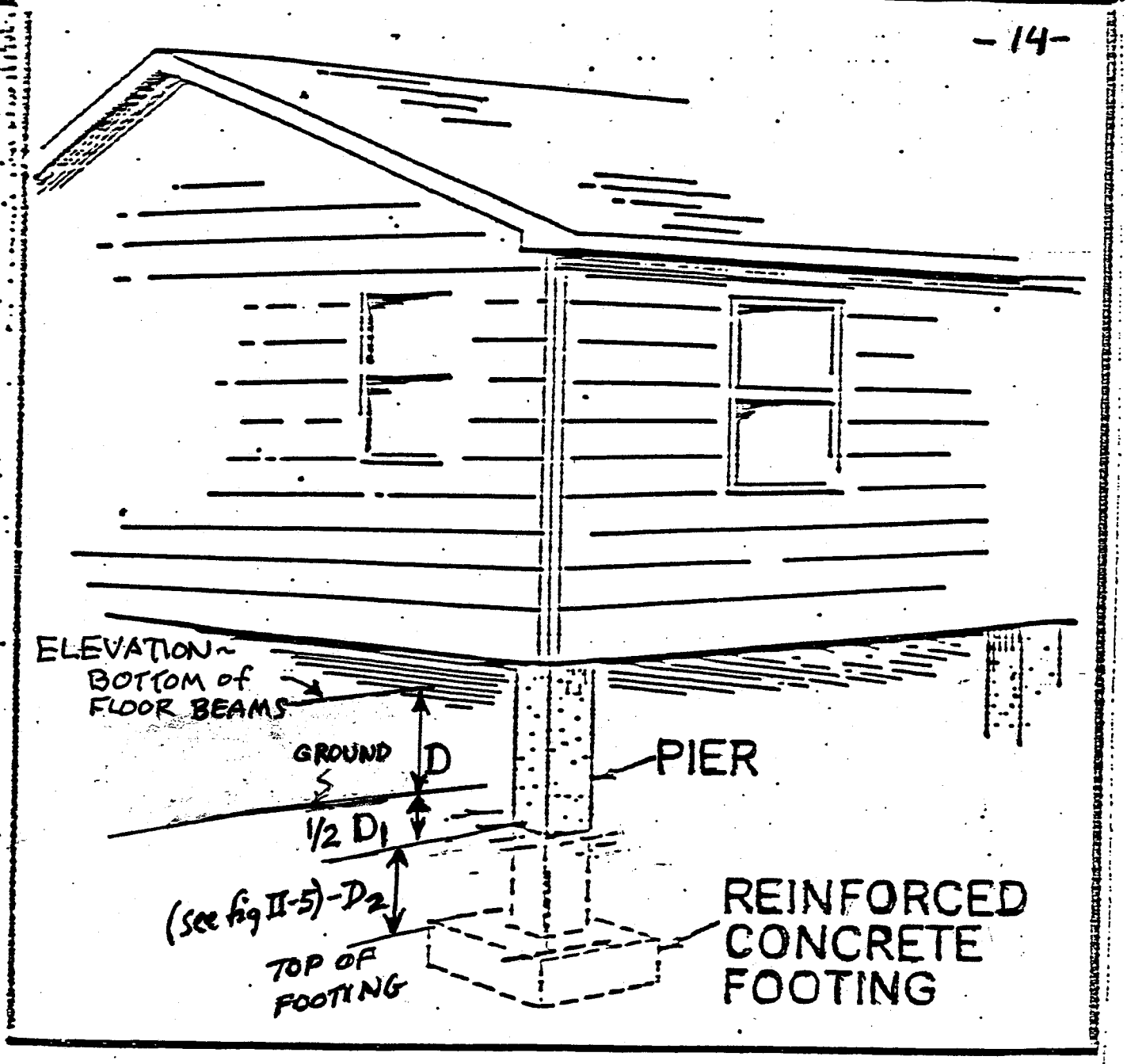
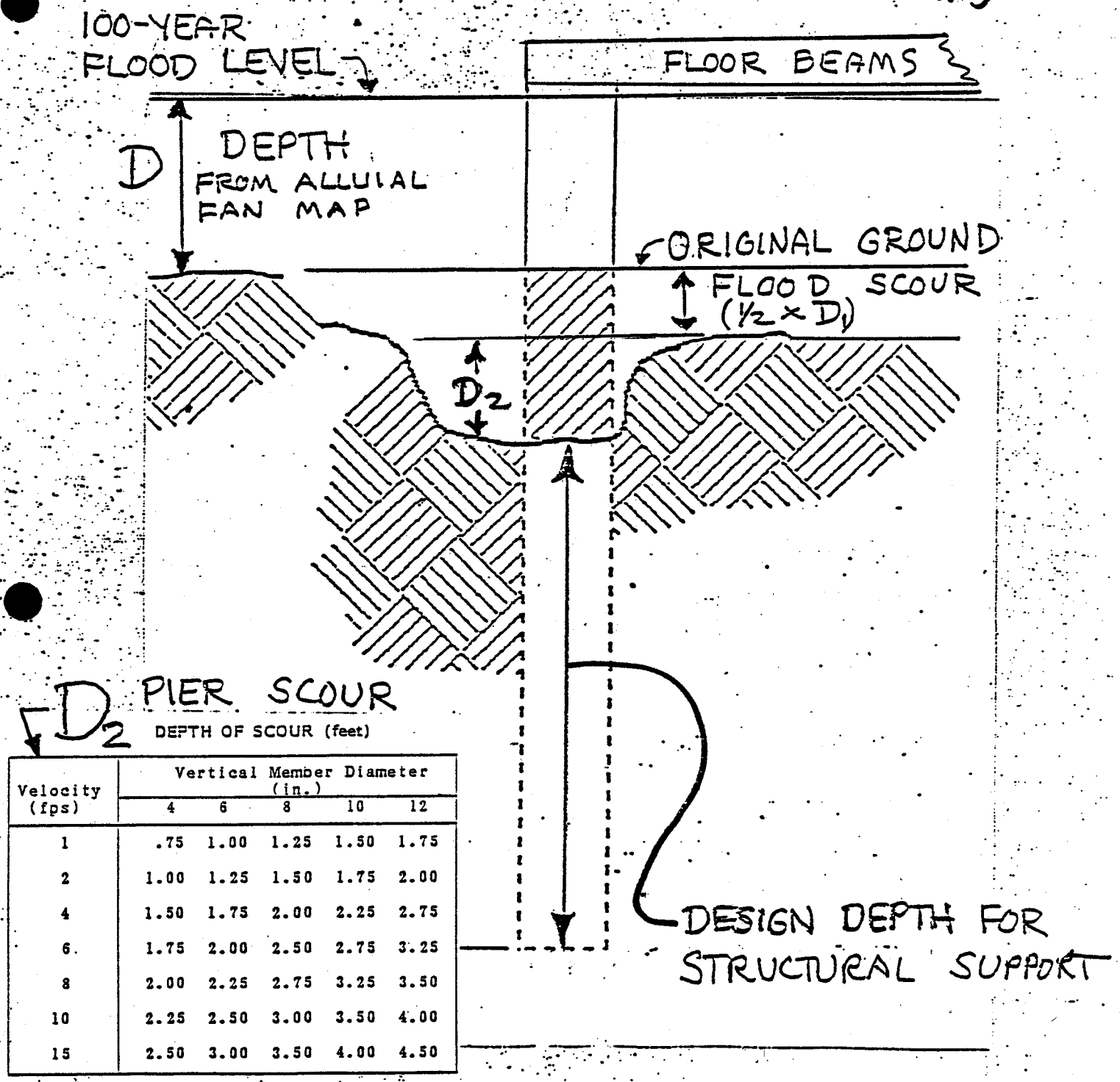


FIGURE II-4. *The sole method of support for piers is a reinforced concrete footing.*



Velocity (fps)	Vertical Member Diameter (in.)				
	4	6	8	10	12
1	.75	1.00	1.25	1.50	1.75
2	1.00	1.25	1.50	1.75	2.00
4	1.50	1.75	2.00	2.25	2.75
6	1.75	2.00	2.50	2.75	3.25
8	2.00	2.25	2.75	3.25	3.50
10	2.25	2.50	3.00	3.50	4.00
15	2.50	3.00	3.50	4.00	4.50

Figure II-5. Addition of Scour Depths for Pilings.

B. Depth of Erosion Protection

Footings for slab foundations must be constructed to a depth below the highest natural ground adjacent to foundation, as shown in Figure II-1.

The necessary depth of construction for these footings is based on the Borrego Valley Alluvial Fan Map. The flood depth (D) shown for the particular location is converted to a construction depth (D1) based on the velocity shown on the map, using the following table:

Velocity (V)	Construction Depth (D1)
4 feet/second	D1 = D
6 feet/second	D1 = D
7 feet/second	D1 = D x 1.4
8 feet/second	D1 = D x 1.8
More than 8 ft/sec -- Special Study Required	

Where: D = Depth shown on the Alluvial Fan Map (feet)
D1 = Depth below ground (feet)
V = Velocity shown on Alluvial Fan Map (ft/sec)

Erosion protection made of rock, gabiens or riprap must be installed to the depth D1. (Figures II-2 and II-3.)

Where the highest natural ground adjacent to foundation is not a satisfactory standard, special surveys may recognize existing hills, swales or other features.

C. Pilings and Piers

Pilings and/or piers may be used to elevate structures on alluvial fans. The lowest part of the floor beams must be above the 100-year flood elevation. Pilings and piers must have adequate depth for structural requirements (reference 2.1 and 2.2).

To include the effects of erosion, the following items must be added to pier depth (in addition to structural requirements):

1. The depth (D) (as shown on the alluvial fan map).

2. An amount equal to 1/2 x D1 (as shown on Figure II-4) to allow for general flood scour.

3. An amount equal to D2 (as shown in Figure II-4 and II-5) to allow for additional scouring around the base of the pier (or piling).

Piers (as shown in Figure II-4) must have the entire footing below the potential erosion level.

4. SPECIAL HAZARDS

A. Existing Alluvial Washes

Major washes on alluvial fans and alluvial aprons are shown on the alluvial fan map (scale 1" = 2,000'). Exact locations of washes are also found by on-site inspection and from the orthophoto contour maps (scale 1" = 200').

Projects that impact alluvial washes must intercept the flood water, carry it around the structure, and reintroduce it in a manner similar to previous conditions, without adversely affecting downstream properties.

B. Alluvial Fan Boundaries

The boundaries between adjacent parallel alluvial fans require special treatment because there is usually a discontinuity in the velocity depth contours. The higher velocity-depth contour must be used at the boundary. Structures within 200 feet of an adjacent fan (that has higher velocity-depth contours) must pro-rate between the higher and lower values. Note that fan boundaries usually mark the location of existing alluvial washes.

C. Alluvial Fan Intersections

The alluvial fans in the western part of Borrego Valley intersect the Coyote Creek alluvial fan at nearly right angles. Flows then proceed southeasterly to the Borrego Sink. Intersection areas require special evaluation of flood flows because of the increased flood hazards. A flow path for the flood waters must be maintained, and additional setbacks are required for development. Major intersections are shown on the alluvial fan map.

D. Alluvial Aprons

Non-structural flood protection methods for alluvial fans also apply to aprons. Areas designated as alluvial aprons on the Borrego Valley Alluvial Fan Map are considered to have 1 foot depth and 8 feet/second velocity.

For large developments such as Rams Hill, structural methods are required as defined in Appendix III.

APPENDIX II-A

PROCEDURE FOR SITE EVALUATION --- (NONSTRUCTURAL PROJECTS)

1. PERMIT APPLICATION (FORM DPL 291)

Permit Application submitted at Department of Planning and Land Use includes lot location, foundation details, and house plans.

2. FLOOD HAZARD REVIEW

A. Mark location on Alluvial Fan Flood Map. Topographic maps scaled 1" = 200' may be used for additional information.

B. If property NOT affected by an existing alluvial wash (or alluvial fan intersection) and is in an area where contours are generally parallel, determine D and V from the Alluvial Fan Flood Map and mark on the plans. Final plans must show the elevated floor and foundation protection in accordance with this appendix.

C. If the proposed building site IS affected by an alluvial wash (or fan boundary) or the site is in an area with uneven ground, then the 200-scale maps should be reviewed to obtain a better understanding of ground elevation patterns and past flow paths. The 200-scale map has 5-foot contours that have an accuracy of approximately 2-1/2 feet. The spot elevations have an accuracy of approximately 1-1/4 feet. Two options are available:

1. Move the building site to a safe location on the lot.

   a. If the lot is large, the 200-scale maps may be sufficient for selection of a safe site.

   b. Where more specific survey information is needed, a Licensed Surveyor can make a more detailed map (typically 1-foot contours, 1" = 50 feet).

2. Modify the wash or fan-boundary with channels, flow diversion structures, etc. A study by a Registered Civil Engineer is required. (See Part 4 "Engineer's Study" below.)

D. Before construction can be approved, plans must be marked with requirements determined in "B" or "C" above, and the note "Elevation Certificate Required". Appropriate foundation protection must be specified.

3. REVIEW BY BUILDING INSPECTION (ON SITE)

A. Site Review--normally, the Owner and Building Inspector are at this field review. If a special survey or study is needed (2C), then it is recommended that the Surveyor or Civil Engineer also be at this review. If the Inspector or Owner determines that the site is on ground that has a local depression or rise, then a survey (2C1b) may be required.

B. Foundation Inspection--Inspector will see that floor is constructed above the highest adjacent natural ground by the depth amount determined from the Alluvial Fan Flood Map and marked on the plans during the Department of Public Works review.

C. Before final inspection, a licensed Surveyor (or Civil Engineer) will certify an Elevation Certificate. A copy of the Elevation Certificate will be returned to the Department of Public Works before final inspection.

4. ENGINEER'S STUDIES

A. Where property is affected by an existing alluvial wash (or fan boundary), a Licensed Civil Engineer will make a special study, including:

1. Extent of Flood Hazard

a. Drainage area above project in square miles.
b. 100-year flood flow for alluvial fan or apron.
c. Size of Wash near Project Area (Depth x Width).
d. Estimated Wash Flood Flow in Cubic Feet Per Second With Depth and Velocity.

2. Proposed Flood Control Improvements

a. Designated flow area on lot.
b. Channels or Protection Structures.
c. Pad Elevation.
d. Erosion Bank Protection.

NOTE: Flow must not be diverted as it leaves property.

B. The improvements must be adequate to keep the proposed floor elevation above the 100-year flood level.

C. Proposed flood control improvements must be shown on the plans and approved by the Department of Public Works before construction starts. Elevations of flow areas, building floor, and surrounding ground must be clearly specified.

APPENDIX III

CRITERIA FOR DESIGN USING STRUCTURAL METHODS

1. PRELIMINARY DESIGNS FOR STRUCTURAL IMPROVEMENTS

The developer shall provide the County calculations and plans for recommended structural measures. Plans will show improvement dimensions, such as channel size, and show type of erosion protection if necessary. Calculations will include sediment-transport analysis or other basis for improvements.

A. Identification of Measures

Structural flood protection measures (dam, levee, channel, etc., or a combination) will be defined and listed for County review.

NOTE: Debris basins are generally not feasible due to maintenance cost, failure hazards and location of State Park boundaries. No facilities will be considered in the State Park unless specific permission is obtained.

B. Alternatives Analysis

1. Review General Plan for Flood Control Improvements.

2. Prepare brief summary of flood characteristics, geologic features, existing development, proposed development, existing flood protection measures, and other possible alternatives for protection.

C. Provide County Staff with the Following Products

1. 1" = 200' scale work maps showing alternative general plans for flood control using County topographic maps.

2. Evaluation summary for each alternative based on the criteria above.

3. Design criteria: hydraulics, sediment transport, and erosion protection.

4. Computations and specific methods for developing recommendations.

APPENDIX IV

FEDERAL FLOOD INSURANCE ON ALLUVIAL FANS

1. REQUIREMENT

The Federal Insurance Administration (FIA) requires flood insurance for all loans in areas of special flood hazards as shown on Flood Insurance Rate Maps (FIRMs). The Federal Emergency Management Agency (FEMA) will soon issue FIRMs for the Borrego Valley area. Most of this area is alluvial fan area and will be shown within a special flood hazard area (i.e., FIRM Zone A).

2. INSURANCE RATE

The flood insurance rate depends upon the elevation difference between the lowest floor and the highest adjacent natural ground. Elevation differences are rounded to the nearest higher whole number and will determine whether the Zone AO or the cheaper AOB rate applies. (See attached page GR29, Special AO Rating Rule, and page POST10, Zone AO Rates for Post-FIRM Construction, from the National Flood Insurance Program (NFIP) Flood Insurance Manual.)

3. ELEVATION CERTIFICATE

An Elevation Certificate is required on new construction for zone AO and to qualify for the cheaper AOB rate.

4. REFERENCES

For further information, refer to the NFIP Flood Insurance Manual, or telephone:

NFIP National Office, Lanham MD --- 1-800-638-6620
NFIP Region IX, Petaluma CA ------- 1-707-765-1363
(John Bessermin)
FEMA Region IX, San Francisco CA -- 1-415-556-9840
(Ray Lenaburg)

Notes: A. Above NFIP offices are staffed by Computer Sciences Corporation contract personnel.
B. Region IX includes Arizona, California, Nevada, Hawaii.

Attachments: Pages GR29 and POST10, NFIP Flood Insurance Manual

Flood Insurance Manual

National Flood Insurance Program
Revised January 1986

SPECIAL AO, AH RATING RULE

For FIRM Zones AO and AH, the Flood Plain Management Standard for communities is as follows:

FIRM Zone AO — requires that the lowest floor of the building be at or above the Base Flood Depth printed on the community's FIRM. Depth numbers are shown as (1 ft.), (2 ft.), or (3 ft.). When the depth number is not printed on the FIRM, a depth of at least 2 ft. is an acceptable standard unless modified by community ordinance or state law. The lowest floor elevation is the measured distance between the highest adjacent grade next to the building and the lowest floor of the building. Highest adjacent grade is the highest natural elevation of the ground surface (prior to construction) next to the proposed walls of the building.

> FIRM Zone AH — requires that the lowest floor of the building be at or above the Base Flood Elevation printed on the community's FIRM.

To qualify for Zone AOB/AHB rating, the insurance applicant must attach to the Application form a letter signed by a responsible community official certifying that the building's lowest floor is elevated to or above the community's approved Flood Plain Management Standards, or a certification from a licensed engineer that states that the building's lowest floor is elevated as high as or higher than the community's Flood Plain Management Standards.

If the building qualifies, enter AOB or AHB in the space for FLOOD INSURANCE RATE MAP ZONE in section 9 of Application form, and use the AOB or AHB rates.

ZONES AO and AH

REGULAR PROGRAM
POST-FIRM CONSTRUCTION

The Zone rates below apply to all types of Post-FIRM buildings in the Regular Program located in Zones AH and AO.

TYPE OF CERTIFICATION	BUILDING COVERAGE		CONTENTS COVERAGE	
	Basic Limits	Additional Limits	Basic Limits	Additional Limits
With Certification				
Certified Compliance With Community Flood Plain Management Standards – AOB/AHB Rating (see Pages GR18 and 19)				
All Building Types – No Basement				
Single Family	.15	.06	.15	.11
2-4 Family	.15	.06	.15	.11
Other Residential	.15	.06	.15	.11
Non-Residential	.15	.06	.15	.11
No Certification				
AO/AH Rating				
All Building Types – No Basement				
Single Family	.45	.15	.55	.15
2-4 Family	.45	.15	.55	.15
Other Residential	.55	.30	.55	.15
Non-Residential	.55	.30	1.10	.25

All Building Types – With Basement* – Submit For Rating (Limited Coverage)

The Elevation Certificate is required on new construction for Zones AH and AO.

*Submit to NFIP for rating. See instructions on POST2

Finished or unfinished enclosed areas underneath lowest elevated floor. See DB6 and 7 for guidelines for proper rating of elevated buildings. See Index – "Building – Coverage for Basement" and "Contents – Coverage in Basement"