APPENDICES

APPENDIX A BIBLIOGRAPHY

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Amortization Period. The length of time used to repay a debt or mortgage or to depreciate an initial cost.

Amortization Rate. The price or rate of premium per unit of time that is paid by a borrower for repayment of a debt or mortgage or by a purchaser to depreciate an initial cost.

Backflow Preventer ('Check Valve'). A device that allows liquids to flow in only one direction in a pipe. Backflow preventers are used on sewer pipes to prevent a reverse flow during flooding situations.

Backwater Effect. The rise in water surface elevation caused by some obstruction such as a narrow bridge opening, buildings or fill material that limits the area through which the water must flow. Also referred to as 'heading up.'

Base Flood. A term used in the National Flood Insurance Program to indicate the minimum size flood to be used by a community as a basis for its floodplain management regulations; presently required by regulation to be that flood which has a one-percent chance of being equaled or exceeded in any given year. Also known as a 100-year flood or one-percent chance flood.

Base Flood Elevation (BFE). The elevation for which there is a one-percent chance in any given year that flood levels will equal or exceed it. The BFE is generally based on statistical analysis of stream flow records for the watershed and rainfall and runoff characteristics in the general region of the watershed, and application of hydraulic backwater models.

Base Floodplain. The floodplain that would be inundated by a one-percent chance (100-year) flood.

Basin. The total area from which surface runoff is carried away by a drainage system. Other comparable terms are 'drainage area,' 'catchment area,' and 'watershed.'

Building. See 'structure.'

Building Code. The regulations adopted by a local governing body setting forth standards for the construction, addition, modification and repair of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public.

C.F.S. Cubic feet per second. Used to describe the amount of flow passing a given point in a stream channel. One cubic foot per second is equivalent to approximately 7.5 gallons per second.

Channel. A natural or artificial watercourse with definite bed and banks to confine and conduct flowing water.

Channel Capacity. The maximum flow which can pass through a channel without overflowing the banks.

Check Valve. See 'backflow preventer.'

Community. Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization which has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Cross Section. A graph or plot of ground elevation across a stream valley or a portion of it, usually along a line perpendicular to the stream or direction of flow.

Degree of Protection. See 'level of protection.'

Designated Floodway. The channel of a stream and that portion of the adjoining floodplain designated by a regulatory agency to be kept free of further development to provide for unobstructed passage of flood flows.

Design Flood. Commonly used to mean the magnitude of flood used for design and operation of flood control structures or other protective measures. It is sometimes used to denote the magnitude of flood used in floodplain regulations.

Emergency Program. The phase of the National Flood Insurance Program which a community enters prior to the completion of an individual community flood insurance study. It is intended to provide a first layer amount of insurance at federally-subsidized rates on all existing structures and new construction begun prior to the effective date of a Flood Insurance Rate Map, in return for the community's adoption of general floodplain management regulations. See also 'National Flood Insurance Program.'

Enabling Statute. A State law that transfers some of the police power residing in the State to localities within it for the purposes of zoning, subdivision, regulations, building codes, and the like.

Encroachment. Any physical object placed in a floodplain that hinders the passage of water or otherwise affects flood flows, e.g. landfills, buildings.

Erosion. The wearing away of the land surface by running water, wind, ice, or other geological agents.

Existing Construction. As used in reference to the National Flood Insurance Program, any structure already existing or on which construction or substantial improvement was started prior to the effective date of a community's floodplain management regulations.

Flash Flood. A flood that reaches its peak flow in a short length of time (hours or minutes) after the storm or other event causing it. Often characterized by high velocity flows.

Flood or Flooding. Temporary inundation of normally dry land areas from the overflow of inland or tidal waters, or from the unusual and rapid accumulation or runoff of surface waters from any source. The rise in water may be caused by excessive rainfall, snowmelt, natural stream blockages, wind storms over a lake or any combination or such conditions.

Flood Control. Keeping flood waters away from specific developments or populated areas by the construction of flood storage reservoirs, channel alterations, dikes and levees, bypass channels, or other engineering works.

Flood Crest. The maximum stage or elevation reached or expected to be reached by the waters of a specific flood at a given location.

Flood Duration. The length of time a stream is above flood stage or overflowing its banks.

Flood Fighting. Actions taken immediately before or during a flood to protect human life and to reduce flood damages such as evacuation, emergency sandbagging and diking, and provision of assistance to flood victims.

Flood Forecasting. The process of predicting the occurrence, magnitude and duration of an imminent flood through meteorological and hydrological observations and analysis.

Flood Frequency. A statistical expression of the average time period between floods equaling or exceeding a given magnitude. For example, a 100-year flood has a magnitude expected to be equaled or exceeded on the average of once every hundred years; such a flood has a one-percent chance of being equaled or exceeded in any given year. Often used interchangeably with 'recurrence interval.'

Flood Fringe. The portion of the floodplain outside of the floodway but still subject to flooding. Sometimes referred to as 'floodway fringe.'

Flood Hazard Boundary Map (FHBM). An official map of a community, issued or approved by the Federal Emergency Management Agency, Federal Insurance Administration, on which the boundaries of the floodplain and special flood hazard areas have been designated. This map is prepared according to the best flood data available at the time of its preparation, and is superseded by the Flood Insurance Rate Map after more detailed studies have been completed.

Flood Insurance Rate Map (FIRM). An official map of a community issued or approved by the Federal Emergency Management Agency, Federal Insurance Administration, that delineates both the special hazard areas and the risk premium zones applicable to the community.

Flood Insurance Rate Zone. A zone identified on a Flood Insurance Rate Map (FIRM) as subject to a specified degree of flood, mudslide (i.e., mudflow) or flood-related erosion hazards, to which a particular set of actuarial rates and floodplain management requirement applies.

Flood Insurance Study (FIS). A study, funded by the Federal Emergency Management Agency, Federal Insurance Administration, and carried out by any of a variety of agencies and consultants, to delineate the special flood hazard areas, base flood elevations, and NFIP actuarial insurance rate zones. The study is based on detailed site surveys and analysis of site-specific hydrologic characteristics.

Floodplain. Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually low land adjacent to a river, stream, watercourse, ocean or lake.

Floodplain Management. The operation of a program of corrective and preventive measures for reducing flood damage, including but not limited to flood control projects, floodplain land use regulations, floodproofing of buildings, and emergency preparedness plans.

Floodplain Regulations. General term applied to the full range of codes, ordinances and other regulations relating to the use of land and construction within floodplain limits. The term encompasses zoning ordinances, subdivision regulations, building and housing codes, encroachment laws and open area (space) regulations.

Flood Profile. A graph showing the relationship of water surface elevation to a specific location, the latter generally expressed as distance above the mouth of a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific magnitude of flooding, but may be prepared for conditions at any given time or stage.

Floodproofing. Any combination of structural and nonstructural additions, changes, or adjustments to properties and structures which reduce or eliminate flood damage to lands, water and sanitary facilities, structures, and contents of buildings.

Floodway. The channel of a watercourse and those portions of the adjoining floodplain required to provide for the passage of the selected flood (normally the 100-year flood) with an insignificant increase in the flood levels above that of natural conditions. As used in the National Flood Insurance Program, floodways must be large enough to pass the 100-year flood without causing an increase in elevation of more than a specified amount (one foot in most areas).

Flood Warning. The issuance and dissemination of information about an imminent or current flood.

Freeboard. A factor of safety expressed in feet above a design flood level for flood protective or control works. Freeboard is intended to allow for all of the uncertainties in analysis, design and construction which cannot be fully or readily considered in an analytical fashion.

Groundwater Recharge. The infiltration of water into the earth. It may increase the total amount of water stored underground or only replenish supplied depleted through pumping or natural discharge.

Hazard Adjustment. See 'structural' and 'nonstructural floodplain management measures.'

Hydrodynamic Loads. Forces imposed on structures by floodwaters due to the impact of moving water on the upstream side of the structure, drag along its sides, and eddies or negative pressures on its downstream side.

Hydrograph. A graph that charts the passage of water as a function of time. It shows flood stages, depicted in feet above mean sea level or gage height, plotted against stated time intervals.

Hydrology. The science of the behavior of water in the atmosphere, on the earth's surface, and underground.

Hydrostatic Loads. Those loads or pressures resulting from the static mass of water at any point of floodwater contact with a structure. They are equal in all directions and always act perpendicular to the surface on which they are applied. Hydrostatic loads can act vertically on structural members such as floors, decks, and roofs, and can act laterally on upright structural members such as walls, piers, and foundations.

Impact Loads. Loads induced by the collision of solid objects on a structure carried by floodwater. Debris can include trees, lumber, displaced sections of structures, tanks, runaway boats, and chunks of ice. Debris impact loads are difficult to predict accurately, yet reasonable allowances must be made for them in the design of potentially affected structures.

Infiltration. The flow of fluid into a substance through pores or small openings. The word is commonly used to denote the flow of water into soil.

Level of Protection. The greatest flood level against which a protective measure is designed to be fully effective; often expressed as a recurrence interval (e.g., 100-year level of protection) or as an exceedance frequency (e.g., one-percent chance of exceedance).

Lowest Floor. Under the NFIP, this term means the lowest floor of the lowest enclosed area (including basement). The lowest floor is required to be placed at or above the Base Flood Elevation if elevated foundation construction techniques are employed. Exception: An unfinished or flood resistant enclosure, useable solely for parking of vehicles, building access or limited storage would not be considered a building's lowest floor if the enclosure met all applicable floodplain management design and use requirements.

Mean Sea Level. The average height of the sea for all stages of the tide over a nineteen year period, usually determined from hourly height observations on an open coast or in adjacent waters having free access to the sea.

National Flood Insurance Program (NFIP). The program under which communities may be eligible for federal flood insurance on the condition that the communities enact satisfactory floodplain management regulations.

New Construction. As used in reference to the National Flood Insurance Program, any structures on which construction or substantial improvement was started on or after the effective date of a community's floodplain management regulations.

Nonstructural Floodplain Management Measures. Those measures employed to modify the exposure of buildings to floods, e.g. floodproofing, land use planning, warning schemes, and insurance, as opposed to structural measures such as dams, levees, and channel modifications.

Non-Velocity Coastal Flood Area. Any area that is subject to inundation by tidal waters which has lower velocity or wave components then a Coastal High Hazard Area.

One-Hundred Year Flood. A flood having a one-percent chance of being equalled or exceeded in any given year.

Permeability. The property of soil or rock that allows passage of water through it.

Primary Cost. The cost of providing the basic floodproofing feature -- elevation, flood shield, floodwall or levee.

Probable Maximum Flood. The most severe flood that may be expected from a combination of the most critical meteorological and hydrological conditions that are reasonably possible in the drainage basin. It is used in designing high-risk flood protection works and siting of structures and facilities that must be subject to almost no risk of flooding. The probable maximum flood is usually much larger than the 100-year flood.

Profile. A graph or plot of the water surface elevation against distance along a channel. Also termed 'flood profile' if drawn for a specific flood or level of flooding.

Recurrence Interval. A statistical expression of the average time between floods equalling or exceeding a given magnitude (see flood frequency).

Regulatory Flood Datum (RFD). Established plane of reference from which elevation and depth of flooding may be determined for specific locations of the floodplain. It is the Base Flood plus a freeboard factor of safety established for each particular area which tends to compensate for the many unknown and uncalculable factors that could contribute to greater flood heights than that computed for a Base Flood.

Regulatory Floodplain. That portion of the floodplain subject to floodplain regulations (usually the floodplain inundated by the one-percent chance flood).

Regulatory Floodway. The channel and that portion of the adjacent land area that is required through regulations to pass flood flows without increasing the water surface elevation more than a designated height.

Regular Program. The phase of the National Flood Insurance Program that makes available increased amounts of flood insurance, with new and substantially improved structures being rated on an actuarial or actual risk basis.

Reservoir. A natural or artificially created pond, lake or other space used for storage, regulation or control of water. May be either permanent or temporary.

Riverine. Relating to, formed by, or resembling a river (including tributaries), stream, brook, etc.

Runoff. That portion of precipitation which is not intercepted by vegetation, absorbed by the land surface or evaporated, and thus flows overland into a depression, stream, lake or ocean (runoff called 'immediate subsurface runoff' also takes place in the upper layers of the soil).

Secondary Cost. The cost associated with floodproofing activities, other than providing the basic floodproofing features, that are necessary to prevent a structure from being damaged by flooding.

Seepage. The passage of water or other fluid through a porous medium, such as the passage of water through an earth embankment or masonry wall.

Special Flood Hazard Areas. Areas in a community that have been identified as susceptible to a one-percent or greater chance of flooding in any given year. A one-percent-probability flood is also known as the 100-year flood or the base flood. Special Flood Hazard Areas are usually designated on the Flood Hazard Boundary Map (FHBM) as Zone A. After detailed evaluation of local flooding characteristics, the Flood Insurance Rate Map (FIRM) will refine this categorization into Zones A, AE, AH, A0, A1-30, VE, and V1-30.

Standard Project Flood. A term used by the U.S. Army Corps of Engineers to designate a flood that may be expected from the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. The peak flow for a standard project flood is generally 40 to 60 percent of the probable maximum flood for the same location.

State Coordinating Agency. The agency of the state government designated by the Governor of the state at the request of the Administrator to coordinate the flood insurance program in that state.

Stream. A body of water flowing in a natural surface channel. Flow may be continuous or only during wet periods. Streams which flow only during wet periods are termed 'intermittent streams.'

Structural Floodplain Management Measures. Those physical or engineering measures employed to modify the way floods behave, e.g., dams, dikes, levees, channel enlargements and diversions.

Structure. A walled and roofed building, including a gas or liquid storage tank, that is principally above ground and affixed to a permanent site, as well as a mobile home on foundation.

Subdivision Regulations. Ordinances or regulations governing the subdivision of land with respect to such things as adequacy and suitability of building sites, utilities and public facilities.

Subsidence. Sinking of the land surface, usually due to withdrawals of underground water, oil, or minerals.

Subsidized Rates. The rates which involve subsidizations by the Federal Government to encourage the purchase of flood insurance on existing structures at reasonably affordable costs.

Substantial Improvement. A term used in connection with the National Flood Insurance Program for determining when its regulations must be applied to actions involving existing structures. It means any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure either: (a) before the improvement or repair is started; or (b) if the structure has been damaged, and is being restored, before the damage occurred.The term does not, however, include either (1) any project for improvement of a structure to comply with existing state or local health sanitary, or safety code specifications which are solely necessary to assure safe living conditions or (2) any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

Underseepage. Seepage along the bottom of a structure, floodwall, or levee or through the layer of earth beneath it.

Variance. A grant of relief by a community to a person from the terms of a floodplain management regulation permitting construction in a manner otherwise prohibited by the regulation and where specific enforcement would result in unnecessary hardship. Specific requirements may vary depending on state zoning enabling legislation or community ordinances.

Watercourse. A natural or artificial channel in which a flow of water occurs either continually or intermittently.

Watershed. An area from which water drains to a single point; in a natural basin, the watershed is the area contributing flow to a given place or a given point on a stream.

Water Surface Elevation. The heights, usually in relation to mean sea level, reached by flows of various magnitudes and frequencies at pertinent points in the floodplain.

Water Table. The uppermost zone of water saturation in the ground.

Wetlands. Areas that are inundated or saturated at a frequency and for a duration sufficient to support a prevalence of vegetative or aquatic life requiring saturated or seasonally saturated soil conditions for growth and reproduction.

Zoning Ordinance. An ordinance under the State or local government's police power which divides an area into districts and, within each district, regulates the use of land and buildings, height and bulk of buildings or other structures, and the density of population.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Types of Assistance:

- National Flood Insurance Program
- Flood Hazard Boundary Maps and Flood Insurance Rate Maps
- Seminars for building inspectors and other municipal officials
- Planning assistance for developing local regulations to meet the program's floodplain management requirements
- Engineering assistance on structure location and construction
- Flood map evaluations and appeals
- Information on flood characteristics

Contact Offices:

Region I:

Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

J.W. McCormack
Post Office & Courthouse Building,
Room 442
Boston, Massachusetts 02109
(617) 223-4741

Region II:

New Jersey, New York, Puerto Rico and Virgin Islands

26 Federal Plaza Room 1337
New York, New York 10278
(212) 264-8980

Region III:

Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia

Liberty Square Building
(Second Floor)
105 South Seventh Street
Philadelphia, Pennsylvania 19106
(215) 597-9416

Region IV:

Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee

Gulf Oil Building,
Suite 700
1371 Peachtree Street, N.E.
Atlanta, Georgia 30309
(404) 347-2391

Region V:

Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin

300 S. Wacker Drive - 24th Floor
Chicago, Illinois 60606
(312) 353-8661

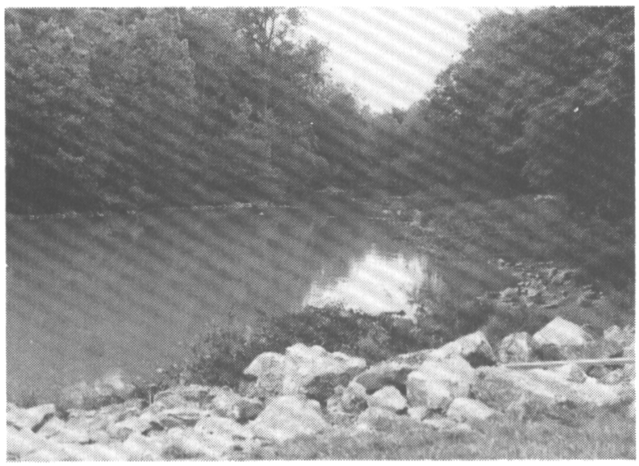
Region VI:

Arkansas, Louisiana, New Mexico, Oklahoma and Texas

Federal Regional Center
800 N. Loop, 288
Denton, Texas 76201-3698
(817) 387-5811

Region VII:

Iowa, Kansas, Missouri and Nebraska
911 Walnut Street, Room 300
Kansas City, Missouri 64106
(816) 374-5912



Region VIII:

Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming

Federal Regional Center
Building 710, Box 25267
Denver, Colorado 80225-0267
(303) 235-4811

Region IX:

Arizona, California, Hawaii, and Nevada

Building 105
Presido of San Francisco, California 94129
(415) 556-8794

Region X:

Alaska, Idaho, Oregon, and Washington

Federal Regional Center
130 228th Street, Southwest
Bothell, Washington 98021-9796
(206) 481-8800

U.S. ARMY CORPS OF ENGINEERS (COE)

Types of Assistance:

- Floodplain delineation.
- Technical assistance on individual sites on flood depth, velocity, flood frequency, and duration.
- Structural information on floodwalls and levees.
- Assistance during flooding with materials, equipment and personnel.
- Post flooding assistance for the rehabilitation of damaged public facilities and protective works.

Division Offices:

North Atlantic Division
90 Church Street
New York, NY 10007
212/264-7483

North Central Division
536 S. Clark Street
Chicago, Illinois 60605
312/353-6531

South Atlantic Division
510 Title Bldg.
30 Pryor Street S. W.
Atlanta, GA 30303
404/221-6702

Ohio River Division
550 Main Street
Cincinnati, Ohio 45201
513/684-3012

Southwestern Division
Main Tower Bldg.
1114 Commerce St.
Dallas, Texas 75242
214/767-2310

North Pacific Division
220 N.W. 8th Avenue
Portland, OR 97208
503/221-3823

South Pacific Division
630 Sansom Street
Room 1216
San Francisco, CA 94111

New England Division
424 Trapelo Road
Waltham, MA 02154
617/894-2400, Ext. 545

Lower Mississippi Valley
1400 Walnut Street
Vicksburg, MS 39180
601/634-5843, Ext. 385

Pacific Ocean Division
Bldg, 230
Fort Shafter, HI 96858
808/438-2883

Missouri River Division
12565 W. Center Road
Omaha, NE 68101
402/221-7270

U.S. Army Corps of Engineers (COE) continued

District Office Locations:

Flood Plain Management Services Program representatives in each of the following Corps District offices can provide additional information concerning flood proofing techniques.

Office, Chief of Engineers
Department of the Army
Washington, DC 20314

Lower Mississippi Valley Division

U.S. Army Engineer District, Memphis
B314 Clifford Davis Federal Building
Memphis, TN 38103

U.S. Army Engineer District, New Orleans
P.O. Box 60267
New Orleans, LA 70160

U.S. Army Engineer District, St. Louis
210 Tucker Blvd. N.
St. Louis, MO 63101

U.S. Army Engineer District, Vicksburg
P.O. Box 60
Vicksburg, MS 39180

Missouri River Division

U.S. Army Engineer District, Kansas City
700 Federal Building
601 E. 12th Street
Kansas City, MO 64106

U.S. Army Engineer District, Omaha
6014 USPO and Courthouse
Omaha, NE 68102

North Atlantic Division

U.S. Army Engineer District, Baltimore
P.O. Box 1715
Baltimore, MD 21203

U.S. Army Engineer District, New York
26 Federal Plaza
New York, NY 10278

U.S. Army Engineer District, Norfolk
803 Front Street
Norfolk, VA 23510

U.S. Army Engineer District, Philadelphia
U.S. Custom House
2nd and Chestnut Streets
Philadelphia, PA 19106

North Central Division

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

U.S. Army Engineer District, Chicago
219 S. Dearborn Street
Chicago, IL 60604

U.S. Army Engineer District, Detroit
P.O. Box 1027
Detroit, MI 48231

U.S. Army Engineer District, Rock Island
Clock Tower Building
Rock Island, IL 61201

U.S. Army Engineer District, St. Paul
1135 USPO and Customhouse
St. Paul, MN 55101

North Pacific Division

U.S. Army Engineer District, Alaska
Pouch 878
Anchorage, AK 99506

U.S. Army Engineer District, Portland
P.O. Box 2946
Portland, OR 97208

U.S. Army Engineer District, Seattle
P.O. Box C-3755
Seattle, WA 98124

U.S. Army Engineer District, Walla Walla
Building 602, City-County Airport
Walla Walla, WA 99362

Ohio River Division

U.S. Army Engineer District, Huntington
502 8th Street
Huntington, WV 25701

U.S. Army Engineer District, Louisville
P.O. Box 59
Louisville, KY 40201

U.S. Army Engineer District, Nashville
P.O. Box 1070
Nashville, TN 37202

U.S. Army Engineer District, Pittsburg
William S. Moorhead Federal Building
1000 Liberty Avenue
Pittsburg, PA 15222

South Atlantic Division

U.S. Army Engineer District, Charleston
P.O. Box 919
Charleston, SC 29402

U.S. Army Engineer District, Jacksonville
P.O. Box 4970
Jacksonville, FL 32232

U.S. Army Engineer District, Mobile
P.O. Box 2288
Mobile, AL 36628

U.S. Army Engineer District, Savannah
P.O. Box 889
Savannah, GA 31402

U.S. Army Engineer District, Wilmington
P.O. Box 1890
Wilmington, NC 28402

South Pacific Division

U.S. Army Engineer District, Los Angeles
P.O. Box 2711
Los Angeles, CA 90053

U.S. Army Engineer District, Sacramento
650 Capital Mall
Sacramento, CA 95814

U.S. Army Engineer District, San Francisco
211 Main Street
San Francisco, CA 94105

Southwestern Division

U.S. Army Engineer District, Albuquerque
P.O. Box 1580
Albuquerque, NM 87103

U.S. Army Engineer District, Fort Worth
P.O. Box 17300
Fort Worth, TX 76102

U.S. Army Engineer District, Galveston
P.O. Box 1229
Galveston, TX 77553

U.S. Army Engineer District, Little Rock
P.O. Box 867
Little Rock, AR 72203

U.S. Army Engineer District, Tulsa
P.O. Box 61
Tulsa, OK 74121

U.S. Army Engineer District, Huntsville
P.O. Box 1600, West Station
Huntsville, AL 35806

SOIL CONSERVATION SERVICE (SCS)

Types of Assistance:

- Floodplain delineation and characteristics
- Engineering and technical assistance
- Planning assistance and public information
- Post-flood relief
- Flood warning systems and preparedness

Contact Offices:

Information can be obtained from the SCS state office or county office. Consult your local telephone directory under U.S. Government, Department of Agriculture.

UNITED STATES GEOLOGICAL SURVEY (U.S.G.S.)

Types of Assistance:

- River level and discharge records
- Floodplain information

Contact Office:

The United States Geological Survey has an office in every state. Contact with these offices can be made through the Geology Department of your closest state university.

DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Type of Assistance:

- Historic weather records
- Hydrologic data
- Flood warning assistance
- Public Information
- Storm surge data

Contact Offices:

National Oceanic & Atmospheric Administration
Eastern Region, National Weather Service
585 Stewart Avenue
Garden City, New York 11530
(516)/222-1616

National Oceanic & Atmospheric Administration
Southern Region, National Weather Service
819 Taylor Street
Rm. 10E09
Fort Worth, Texas 76102
(817)/334-2668

National Oceanic & Atmospheric Administration
Central Region, National Weather Service
601 E. 12th Street
Rm. 1836
Kansas City, MO 64106
(815)/374-5463

National Oceanic & Atmospheric Administration
Western Region, National Weather Service
Box 11188 Federal Bldg.
125 S. State Street
Salt Lake City, UT 84147
(801)/524-5122

National Oceanic & Atmospheric Administration
Alaskan Region, National Weather Service
Box 23, 701 C. Street
Anchorage, AL 99513
(907)/271-5116

National Oceanic & Atmospheric Administration
Pacific Region, National Weather Service
Prince Kuhio Federal Bldg, Room 4110
Box 50027
300 Ala Moana Blvd.
Honolulu, Hawaii 96850
(808)/546-5680

REGIONAL AUTHORITIES

Types of Assistance

There are several regional authorities which provide technical assistance in areas related to floodproofing such as

- Floodwater control method designs and evaluations
- Technical assistance
- Flood characteristics
- Floodplain regulations
- Dissemination of public information
- Post-flood disaster relief assistance.

INTERSTATE COMPACT COMMISSIONS

Delaware River Basin Commission
P. O. Box 7630
West Trenton, NJ 08628
(609) 883-9500

Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102
(717) 238-0423

TENNESSEE VALLEY AUTHORITY

Tennessee Valley Authority
Flood Plain Management Branch 190
Liberty Building Knoxville, TN 37902
(615) 632-4451

STATE CONTACTS FOR THE NATIONAL FLOOD INSURANCE PROGRAM

Types of Assistance:

- NFIP information
- Floodplain regulations
- Floodplain management information

Contact Office:

The following is a list of state office contacts for the National Flood Insurance Program:

Alabama

Department of Economic & Community Affairs
State Capitol Building
P.O. 2939
3465 Norman Bridge Road
Montgomery, Alabama 36105-0939
(205) 284-8735

Alaska

Department of Community & Regional Affairs
Municipal & Regional Assistance Division
949 East 36 Avenue, Suite 400
Anchorage, Alaska 99508
(907) 561-8586

Arizona

Department of Water Resources
Flood Control Branch
99 East Virginia, 2nd Floor
Phoenix, Arizona 85004
(602) 255-1566

Arkansas

Arkansas Soil & Water Conservation Commission
#1 Capitol Mall - Suite 2D
Little Rock, Arkansas 72201
(501) 371-1611

California

Department of Water Resources
P.O. Box 388
Sacramento, California 95802
(916) 445-6249

Colorado

Colorado Water Conservation Board
State Centennial Bldg., Room 823
1313 Sherman Street
Denver, Colorado 80203
(303) 866-3441

Connecticut

State Dept. of Environmental Protection
Water Resources Unit
165 Capitol Avenue
Hartford, Connecticut 06106
(203) 566-7245

Delaware

Dept. of Natural Resources & Environmental Control
Division of Soil & Water Conservation
Richardson & Robbins Building
89 Kings Highway - P.O. 1401
Dover, Delaware 19903
(302) 736-4411

District of Columbia

Department of Consumer Regulatory Affairs
614 H. St., N.W.
Washington, D.C. 20001
(202) 727-7577

Florida

Department of Community Affairs
Division of Resource Planning and Management
2571 Executive Ctr. Circle
East Tallahassee, Florida 32301
(904) 488-8466

Georgia

Department of Natural Resources
19 Martin Luther King, Jr. Drive, S.W.
Room 400
Atlanta, Georgia 30334
(404) 656-3214

Guam

Director, Office of Civil Defense
P.O. Box 2877
Agana, Guam 96910
011-671-477-9841

Hawaii

Hawaii Board of Land & Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809
(808) 548-7539

Idaho

Department of Water Resources
State House
Boise, Idaho 83720
(208) 334-4470

Illinois

Illinois Dept. of Transportation
Division of Water Resources
Local Floodplain Programs
300 North State Street, Room 1010
Chicago, Illinois 60610
(312) 793-3864

Indiana

Department of Natural Resources
608 State Office Building
Indianapolis, Indiana 46204
(317) 232-4160

Iowa

Iowa Dept. of Water, Air and Waste Management
Wallace State Office Building
Des Moines, Iowa 50319
(515) 281-5029

Kansas

Kansas State Board of Agriculture
Division of Water Resources
109 Southwest Ninth Street
Topeka, Kansas 66612-1283
(913) 296-3717

Kentucky

Department of Natural Resources
Division of Water
18 Reilly Road
Fort Boone Plaza
Frankfort, Kentucky 40601
(502) 564-3410

Louisiana

Louisiana Dept. of Urban & Community Affairs
P.O. Box 44455 - Capitol Station
Baton Rouge, Louisiana 70804
(504) 925-3730

Maine

Bureau of Civil Emergency Preparedness
State House
187 State Street
Augusta, Maine 04330
(207) 289-3154

Maryland

Maryland Water Resources Administration
Tawes State Office Building D-2
Annapolis, Maryland 21401
(301) 269-3826

Massachusetts

Massachusetts Water Resources Commission
State Office Building
100 Cambridge Street
Boston, Massachusetts 02202
(617) 727-3267

Michigan

Water Management Division
Michigan Department of Natural Resources
P.O. Box 30028
Lansing, Michigan 48909
(517) 373-3930

Minnesota

Department of Natural Resources
Floodplains/Shoreline Management Section
Division of Waters
444 LaFayette Road
St. Paul, Minnesota 55101
(612) 296-9226

Mississippi

Mississippi Research & Development Center
3825 Ridgewood Road
Jackson, Mississippi 39211
(601) 982-6376

Missouri

Department of Natural Resources
1101 R. Southwest Boulevard
P.O. Box 1368
Jefferson City, Missouri 65102
(314) 751-4932

Montana

Montana Department of Natural Resources & Conservation
Engineering Bureau
32 South Ewing Street
Helena, Montana 59601
(406) 444-6646

Nebraska

Nebraska Natural Resources Commission
P.O. Box 94876
Lincoln, Nebraska 68509
(402) 471-2081

Nevada

Division of Emergency Management
Capitol Complex
Carson City, Nevada 89710
(702) 885-4240

New Hampshire

New Hampshire Office of State Planning
2 1/2 Beacon Street
Concord, New Hampshire 03301
(603) 271-2231

New Jersey

New Jersey Dept. of Environmental Protection
Division of Water Resources
P.O. Box CN 029
Trenton, New Jersey 08625
(609) 292-2296

New Mexico

State Engineer's Office
Rataan Memorial Building
Santa Fe, New Mexico 97501
(505) 827-6140

New York

Department of Environmental Conservation
Flood Protection Bureau
50 Wolf Road, Room 422
Albany, New York 12233
(518) 457-3157

North Carolina

North Carolina Dept. of Natural Resources and Community Development
Division of Community Assistance
512 North Salisbury Street
P.O. Box 27687
Raleigh, North Carolina 27611
(919) 733-2850

North Dakota

State Water Commission
900 East Boulevard
Bismarck, North Dakota 58505
(791)224-2750

Ohio

Ohio Dept. of Natural Resources
Floodplain Planning Unit
Fountain Square
Columbus, Ohio 43224
(614) 265-6755

Oklahoma

Oklahoma Water Resources Board
12th Floor
Northeast 10th & Stonewall
Oklahoma City, Oklahoma 73105
(405) 271-2533

Oregon

Department of Land Conservation & Development
1175 Court Street, N.E.
Salem, Oregon 97310
(503) 378-2332

Pennsylvania

Department of Community Affairs
551 Forum Building
Harrisburg, Pennsylvania 17120
(717) 787-7400

Puerto Rico

Puerto Rico Planning Board
P.O. Box 41119, Minillas Station
D-Diego Avenue
Santurce, Puerto Rico 00940
(809) 726-7110

Rhode Island

Office of State Planning
Statewide Planning Program
265 Melrose Street
Providence, Rhode Island 02907
(401) 277-2656

South Carolina

South Carolina Water Resources Commission
3830 Forest Drive
P.O. Box 4440
Columbia, South Carolina 29240
(803) 758-2514

South Dakota

Department of Military & Veteran Affairs
Division of Emergency and Disaster Services
State Capitol
Pierre, South Dakota 5750l
(605) 773-3231

Tennessee

Department of Economic & Community Development
Local Planning Division
1800 James K. Polk Office Building
505 Deaderick Street
Nashville, Tennessee 37219
(615) 741-2211

Texas

Texas Dept. of Water Resources
P.O. Box 13087, Capitol Station
1700 North Congress Avenue
Austin, Texas 78711
(512) 475-2171

Utah

Office of Comprehensive Emergency Management
1543 Sunnyside Avenue
Salt Lake City, Utah 84108
(801) 533-5271

Vermont

Agency of Environmental Conservation
Division of Water Resources
State Office Building
Montpelier, Vermont 05602
(802) 828-2761

Virgin Islands

Disaster Preparedness
Office Box 1208
St. Thomas, Virgin Islands 00801
(809) 774-6555

Virginia

Virginia State Water Control Board
P.O. Box 11143
2111 North Hamilton Street
Richmond, Virginia 23230
(804) 257-0075

Washington

Department of Ecology
Mail Stop PV11
Olympia, Washington 98504
(206) 459-6288

West Virginia

West Virginia Office of Emergency Services
Capitol Building
Room EB-80
Charleston, West Virginia 25305
(304) 348-3831

Wisconsin

Department of Natural Resources
Floodplain-Shoreland Management Section
P.O. Box 7921
Madison, Wisconsin 53707
(608) 266-1926

Wyoming

Wyoming Disaster & Civil Defense Agency
P.O. Box 1709
Cheyenne, Wyoming 82003
(307) 777-7566

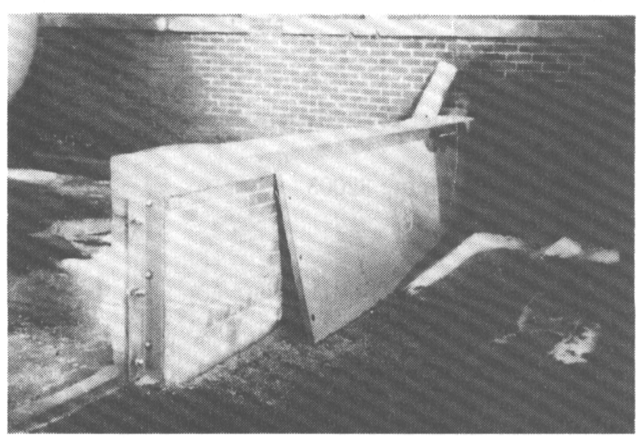
LOCAL AGENCIES

Types of Assistance

- Floodplain Maps
- Building, zoning, subdivision, ordinance to guide development in the floodplain
- Primary source of informing the public about projects
- Provide assistance and planning on interpretation of state and federal regulations.

Contact Offices:

These offices vary depending on jurisdictional boundaries of cities, counties, townships, etc.. Therefore, the manual user is directed to consult your local telephone directory under local Government for assistance.



A. INTRODUCTION

This appendix presents concepts and criteria for the design and evaluation of floodproofing measures. The appendix begins with a discussion of the various forces, or structural loads, that must be understood to formulate preliminary floodproofing plans. Section C then presents criteria that describe the desired level of performance for various floodproofing methods. These performance criteria are applicable to all methods developed in Chapter III, which presents design guidelines for (1) elevated structures, (2) closures and flood shields, and (3) floodwalls and levees, and in Chapter IV, which describes emergency measures and utility protection.

Before proceeding with a presentation of design loads, it is desirable to acquaint the reader with the effects floodwater may have on a structure. This information provides some insight into the rationale that has been applied in the development and application of flood protection alternatives.

The *Flood Emergency and Residential Repair Handbook* (developed by the Federal Emergency Management Agency) identifies seven major effects of floodwater: hydrostatic pressure, buoyancy, battering, pulsating water, translation, scouring and overturning as shown on Figure D-1 and described below:

- Hydrostatic Pressure. Extreme pressure can be exerted on the walls of a building that is subjected to saturated soil and/or inundation. At a depth of 5 feet, water exerts over 300 pounds of pressure per square foot of surface. This pressure can result in major structural failure if certain combinations of adverse natural and structural factors are combined. Hydrostatic pressures may be alleviated by allowing waters to enter the structure.

- Buoyancy/Uplift. An object in water is buoyed by an upward force equal to the weight of the water displaced. Therefore, each cubic foot of water displaced by the structure exerts enough force to float about 62 pounds. The average 1-story house with basement could reach a buoyant condition and begin to float out of the ground when outside water has reached about 3 feet above the basement floor (assuming total soil saturation). Hydrostatic loads generally lead to basement floor or wall failure before a buoyant condition is reached. Effective anchoring systems can greatly improve a structure's resistance to buoyant forces. Although buoyancy is a concern for non-residential structures, use of heavier construction materials contributes to increased resistance to uplift forces.

- Battering. The battering force exerted by rushing water, waves, or floating objects in the water represent a major flood hazard in many areas. Battering forces can destroy any type of structure including masonry or concrete structures that have limited lateral strength. Reinforcing steel, used in conjunction with concrete wall structures, can greatly improve resistance to battering forces.

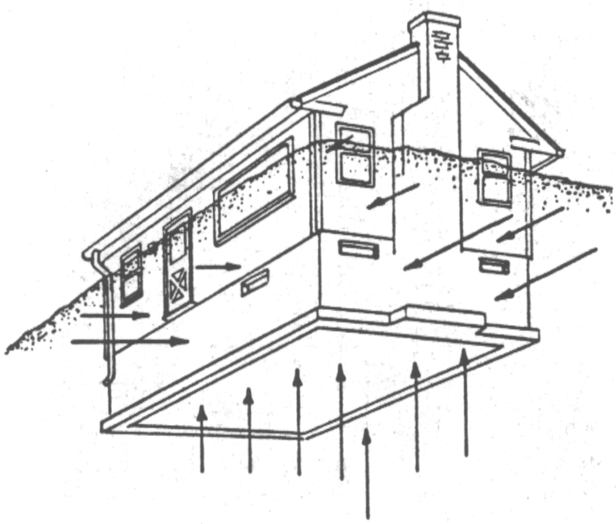
- Pulsating Water. Pulsating water action is most pronounced when it enters a structure. Water rushing in is stopped by an opposite wall and returned towards the point of entry. Furnishings and structural elements may be seriously damaged by these pulsating waters.

- Translation. Translation refers to the physical movement of a structure off its foundation by the forces exerted from flood waters. If forces exerted by the surrounding water are unevenly distributed, the structure may rotate. Buoyant forces may make a structure more vulnerable to translation. An effective sill anchoring system can protect against translation or lifting forces.

- Scouring. Scouring action may remove stablizing soil and eventually undermine a structure. Scouring can be caused by high velocity and/or wave action. The affect is often amplified at the corners of the structure. Scouring at corners may be alleviated by soil stabilization, vegetation, or buried structural wing walls.

- Overturning. Rushing water or wave action can combine with buoyant forces or a bottom snagging effect to turn a structure onto its side.


BUOYANCY


HYDROSTATIC PRESSURE


BATTERING

Figure D-1.
Effects of Floodwater

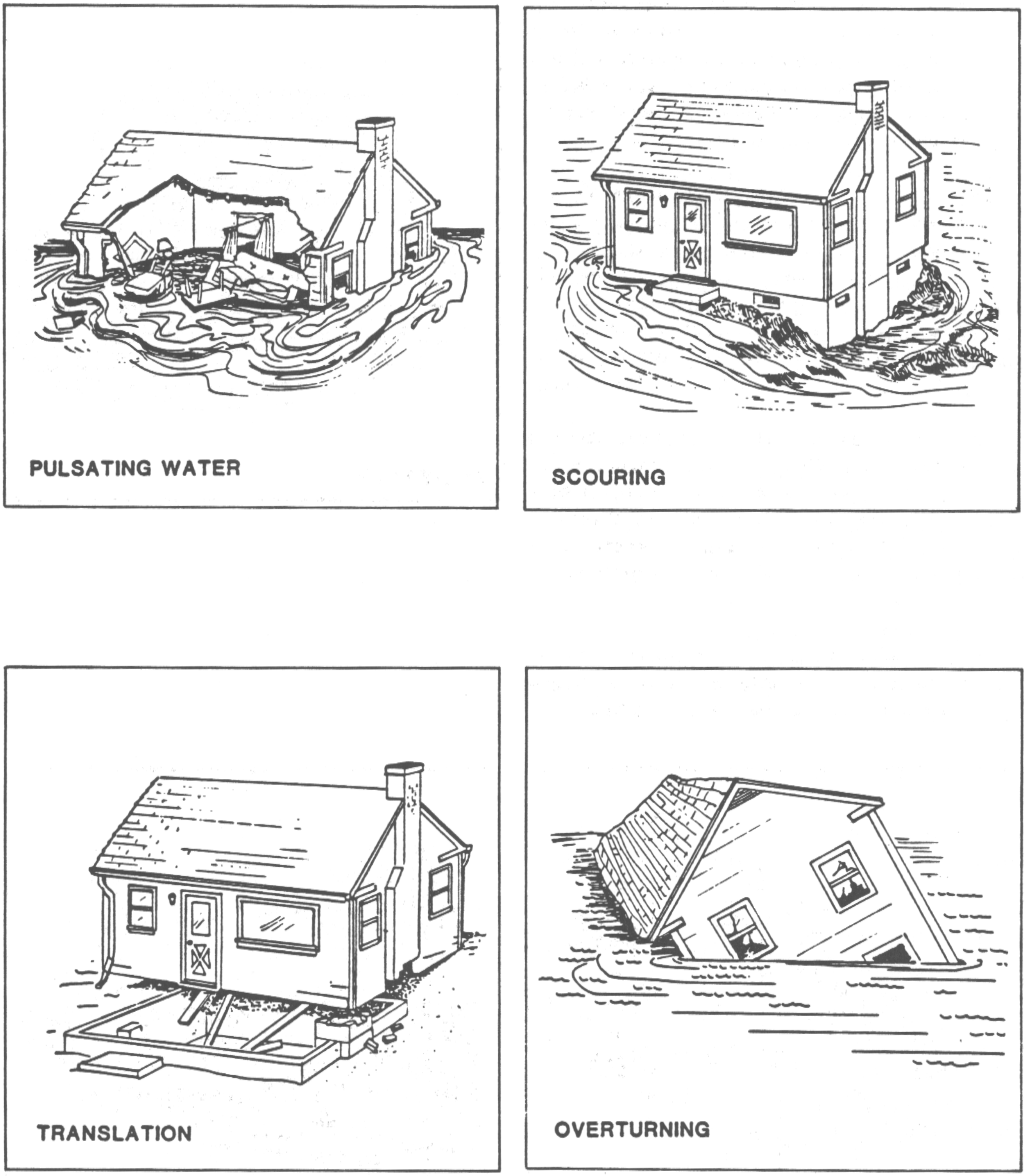


Figure D-1. (cont.)
Effects of Floodwater

B. DESIGN LOADS

Before describing the technical parameters of various floodproofing techniques, it is important that there is an understanding of the type and magnitude of forces to which a floodproofed structure may be subjected to. The *design load* for a structure may be defined as the minimum loading condition that the structure and all associated service systems should be designed to resist. Much of the following presentation on design loads has been based on guidance provided in *Flood-Proofing Regulations,* as published by the Corps of Engineers. For the purpose of this manual, calculation of design load will include the following factors:

1. DEAD LOAD (D). Dead load includes the weight of all permanent construction including: (a) the weight of the structure itself, (b) the weight of all permanent construction materials, (c) the weight of permanent equipment, and (d) forces resulting from prestressing.

2. GRAVITY LIVE LOAD (L). Gravity live loads result from both the occupancy (floor) and the environment (roof) of the building, as stipulated in the applicable building code.

3. RESTRAINT LOADS (R). Restraint loads result from expansion, contraction, creep, swelling and shrinkage of structural components; and forces associated with movement resulting from differential settlement.

4. WIND LOADS (W). The flowing wind exerts velocity pressures on a structure in its path. A horizontal pressure is usually assumed to act normal to the gross area of the vertical projection of the exposed or windward wall; and because wind flowing over and about a structure speeds up, it also tends to create a suction or outward pressure on the leeward wall and sidewalls. Likewise, an upward suction or uplift can be experienced by the roof system.

Basic wind design data and procedures to be followed in applying wind loadings to all structures are furnished in several building codes including the Southern Building Code Congress International Standard Building Code; the Building Officials and Code Administrators (BOCA) Code; and the Uniform Building Code. Each code employs a slightly different procedure for computation of the applied loads used in structural analysis and design; and each code contains explicit procedures for evaluating the magnitude and effect of applied wind pressures and how they should be combined in the sizing of various structural framing members and systems.

The recommended basic wind speed in a non-coastal or riverine flood site should be no less than the Annual Extreme Fastest-Mile Speed 30 feet above ground, 50-Year Mean Recurrence Interval, when combined with other flood loading forces. Obviously, the chances are remote that a higher mean recurrence interval would occur in combination with severe flooding situations. (Coastal floodplain situations are much more severe and the 100-year Mean Recurrence Interval is usually employed.)

5. FLOODWATER LOADS (F). Extreme pressure can be exerted on all surfaces of a structure that are exposed to flood waters. These pressures can result in cracking, displacement or collapse of walls, floors and horizontal framing members of a structure. With the exception of impact loads (see Item 6 below) flood water forces can be classified into hydrostatic and hydrodynamic loads. Sections 602.0 and 604.0 of the Corps of Engineers' publication *Flood-Proofing Regulations* are reproduced in part below to define these loads:

a) Water Loads

Water loads, defined herein, are loads or pressures on surfaces of the buildings and structures caused and induced by the presence of flood waters. These loads are of two basic types: hydrostatic and hydrodynamic.

1) Hydrostatic Loads: Hydrostatic loads are those caused by either free or contained water occuring above or below the ground surface. These loads are equal to the product of the water pressure times the surface area on which the pressure acts. The pressure at any point is equal to the product of the unit weight of water (62.5 pounds per cubic foot) multiplied by the height of water above the point or by the height to which confined water would rise if free to do so. Hydrostatic pressures at any point are equal in all directions and always act perpendicularly to the surface on which they are applied. Hydrostatic loads are subdivided into the following types:

- Vertical Loads: These are loads acting vertically downward on horizontal or inclined surfaces of buildings or structures, such as roofs, decks or floors, and walls, caused by the weight of flood waters above them.

- Lateral Loads: Lateral hydrostatic loads are those which act in a horizontal direction, against verical or inclined surfaces, both above and below the ground surface and tend to cause lateral displacement and overturning of the building, structure, or parts thereof.

- Uplift: Uplift loads are those which act in a vertically upward direction on the underside of horizontal or sloping surfaces of buildings or structures, such as basement slabs, footings, floors, decks, roofs and overhangs.

2) Hydrodynamic Loads: Hydrodynamic loads are those induced on buildings or structures by the flow of floodwater around the building or structure or parts thereof, above ground level. Such loads may occur below the ground level when openings or conduits exist that allow free flow of floodwaters. Hydrodynamic loads are basically of the lateral type and relate to direct impact loads by the moving mass of water, and to drag forces as the water flows around the obstruction. (Where application of hydrodynamic loads is required, the loads should be computed or estimated by recognized and authoritative methods.)

- Conversion to Equivalent Hydrostatic Loads: ... for cases when water velocities do not exceed 10 feet per second, dynamic effects of the moving water may be converted into equivalent hydrostatic loads by increasing the depth of water to the Design Flood level) by an amount dh, (*Figure D-2*), on the headwater side and above the ground level only, equal to:

  $dh = aV^2/2g$, where

V is the average velocity of the water in feet per second; (fps);
g is the acceleration of gravity (32.2 fps);
a is the coefficient of drag or shape factor. (The value of a, unless otherwise evaluated, shall not be less than 1.25).

The equivalent surcharge depth dh is added to the depth (at the Design Flood Level)... and the resultant pressures applied to, and uniformly distributed across, the vertical projected area of the building or structure which is perpendicular to the flow. Surfaces parallel to the flow or downstream surfaces should be considered subject to hydrostatic pressures for depths to the (Design Flood level) only.

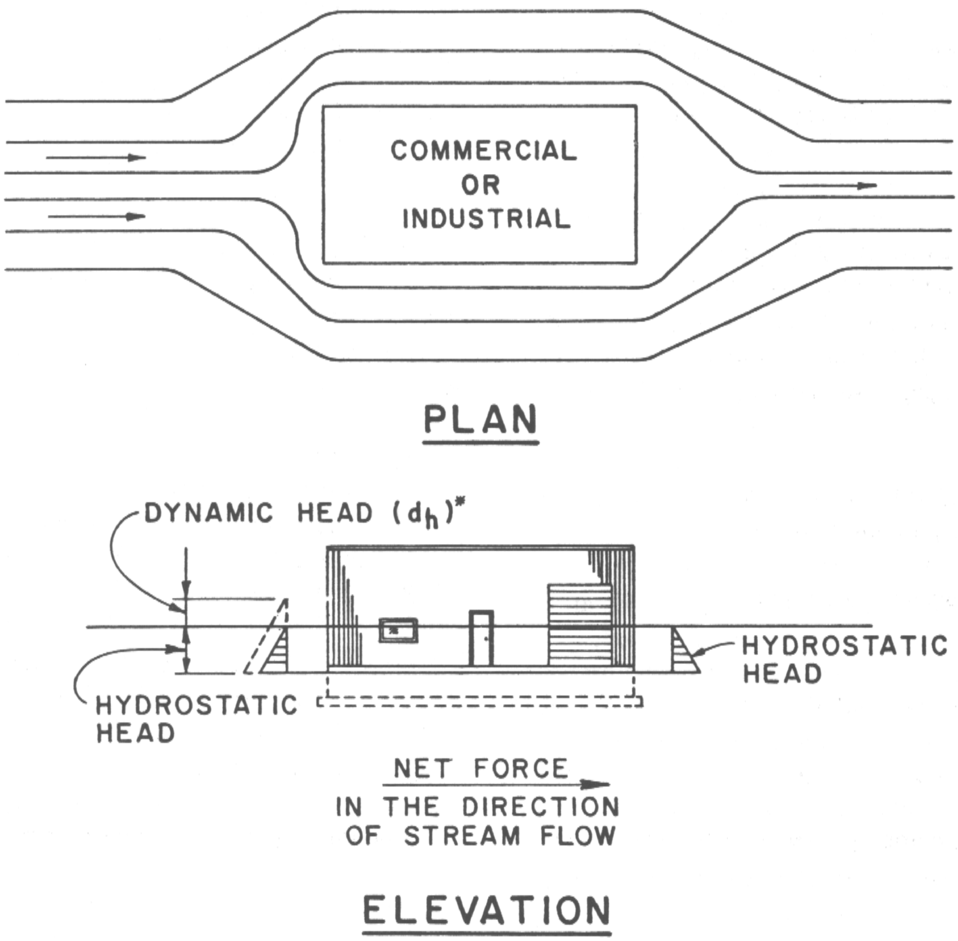


FIGURE D-2
DYNAMIC EFFECTS OF MOVING WATER

* EXAMPLE: FOR FLOODWATER VELOCITY 8FPS, dh=(1.25×8^2) 2x32.2= 1.24 feet

b) Intensity of Loads: The application of the loads defined above should be made in the design calculations in the manner described as follows:

- Vertical Loads: Full intensity of hydrostatic pressures caused by a depth of water (at the Design Flood level) applied on all surfaces involved.

- Lateral Loads: Full intensity of hydrostatic pressures caused by a depth of water (at the Design Flood level) applied over all surfaces involved, both above and below ground level, except that for surfaces exposed to free water, the design depth should be increased by one foot.

- Uplift: Full intensity of hydrostatic pressures caused by a depth of water (at the Design Flood level) acting on all surfaces involved, unless provisions are made to reduce uplift intensities.

Hydrostatic loads should be used in the design of buildings and structures exposed to water loads from stagnant floodwaters. For buildings and structures, or parts thereof, that are exposed and subject to flowing water having velocities greater than five (5) feet per second, hydrostatic and hydrodynamic loads shall apply.

c) Reduction of Uplift Pressures: Uplift forces, in conjunction with lateral hydrostatic forces, constitute the most adverse flood related loading on buildings and structures and elements thereof. Their combined effect determines to a major extent the requirements for weight and anchorage of a structure as a whole to assure its stability against flotation, sliding, and overturning. When uplift forces are applied to structural elements of a building or structure, such as footings, walls, and particularly basement slabs, they generally constitute the critical loading on such elements. Economical solutions to flood-proofing buildings and structures may be aided by the use of impervious cutoffs, foundation drainage, and sumps and pumps.

6. FLOOD IMPACT LOADS (FI). Flood impact loads are imposed on a structure by solid objects that are propelled by moving floodwaters. Although it is difficult to predict the exact magnitude of probable impact loads, representative values must be included in the design of floodproofed buildings and structures. Impact loads are defined in Section 603.0 and 605.0 of *Flood-Proofing Regulations* as described below:

a) Impact Loads: Impact loads are those which result from floating debris, ice and any floatable object or mass carried by floodwaters striking against buildings and structures or parts thereof. These loads are of three basic types: normal, special and extreme.

- Normal Impact Loads: Normal impact loads are those that relate to isolated occurrences of loss, ice blocks or floatable objects of normally encountered sizes striking buildings or parts thereof.

- Special Impact Loads: Special impact loads are those that relate to large conglomerates of floatable objects, such as large trees or broken up ice floes and accumulation of floating debris, either striking or resting against a building, structure, or parts thereof.

- Extreme Impact Loads: Extreme impact loads are those that relate to large floatable objects and masses such as runaway barges or collapsed buildings and structures, striking the building, structure, or component under consideration.

Impact loads should be considered in the design of buildings, structures, and parts thereof, as follows:

- Normal Impact Loads: A concentrated load acting horizontally at the Design Flood level or at any point below it, equal to the impact force, produced by a 1,000-pound mass traveling at the velocity of the floodwater and acting on a one (1) square foot surface of the structure.

- Special Impact Loads: Where special impact loads are likely to occur, such loads shall be considered in the design of buildings, structures, or parts thereof. Unless a rational and detailed analysis is made ... the intensity of load shall be taken as 100 pounds per foot acting horizontally over a one-foot wide horizontal strip at the Design Flood level or at any level below it. Where natural or artificial barriers exist which would effectively prevent these special impact loads from occurring, the loads may be ignored in the design.

- Extreme Impact Loads: It is considered impractical to design buildings having adequate strength for resisting extreme impact loads. Accordingly, except for special cases when exposure to these loads is highly probable and the resulting damages are extremely severe, no allowances for these loads need be made in the design.

7. SOIL LOADS AND PRESSURE. Soil loads play a key role in the design of floodproofed structures. Active soil forces are generally expressed in terms of equivalent heavy fluid pressures. Various soil types have their own equivalent fluid pressure, with values ranging from 30 pounds per square foot (psf) to 120 psf. The applicability of soil loads to floodproofing and allowable soil pressures are adapted from *Flood-Proofing Regulations* as follows:

a) Soil Load(s). Full consideration should be given in the design of buildings, structures, and parts thereof, to the loads or pressures resulting from the presence of soils against or over the structure. Loads or pressures should be computed in accordance with accepted engineering practice, giving full consideration to the effects that the presence of floodwater, above or within the soil, has on loads and pressures. When expansive soils are present, special provisions may be made in foundation and wall design and construction to safeguard against damage due to this expansiveness.

b) Allowable Soil Pressures: Under flood conditions, the bearing capacity of submerged soils is affected and reduced by the buoyancy effect of the water on the soil. For foundations of buildings and structures, the bearing capacity of soils should be evaluated by a recognized acceptable method. Expansive soils should be investigated with special care. Soils that lose all bearing capacity when saturated, or become 'liquefied', should not be used for supporting foundations.

8. EARTHQUAKE LOADS (EQ). Earthquake loads should be treated as specified in the applicable local building code.

C. PERFORMANCE CRITERIA

The performance criteria included in this section of the manual represent objectives that should be achieved in the design of floodproofed non-residential structures and associated service systems. These criteria are applicable to the permanent and contingent techniques described in Chapter I including: (1) elevation on fill or supporting columns, piles, posts, piers, or wall section, (2) watertight construction (through the use of interior and exterior membranes or sealants; integrally waterproofed concrete construction; and/or a full range of closure and flood shield assemblies), and (3) the use of floodwalls and earth levees.

It should be noted that the performance criteria are generally structured to indicate the desired attributes of a floodproofed structure without reference to specific construction techniques or materials. This format has been selected to facilitate and encourage the development of a full range of traditional and innovative designs that are equally effective in reducing flood damages.

Provisions included in the following criteria represent the minimum design requirements for floodproofing of non-residential structures. It must be understood that these criteria are generally limited to design factors that are directly related to flooding conditions. Therefore, the following performance criteria can only be used in association with all applicable local building codes and regulations.

Where applicable, the criteria listed in this section accord with the Corps of Engineers' *Flood-Proofing Regulations*.

1. CRITERIA 1 - STRENGTH:

a) Elevation on Posts, Piers, or Walls and Watertight Structures. All elevated and watertight buildings (including all closure, flood shield assemblies, utilities and service systems) should be designed to resist the following loads (as defined in Part B of this appendix) acting simultaneously:

LOADING	SAFETY FACTORS OVERTURNING	SAFETY FACTORS SLIDING	CONDITION
(Eq. 1.11) D + L + R + F + S	1.5	1.5	Design Flood
(Eq. 1.12) D + L + R + F + FI + S	1.5	1.5	Design Flood + Impact
(Eq. 1.13) D + L + R + W + F + FI + S	1.5	1.5	Design Flood + Impact + Wind
(Eq. 1.14) .9D + R + W + F + S	1.33	1.33	Uplift and hydrostatic
(Eq. 1.15) .9D + R + W + F + FI + S	1.33	1.33	Uplift and hydrostatic

where,

D - Dead loads,

L - Live loads, as defined in the applicable building code for the structure.

R - Loads resulting from expansion, contraction, creep, swelling and shrinkage of structural components. Also includes forces due to movements resulting from differential settlement.

W - Wind loads (see applicable local code),

F - Flood loads caused by the Design Flood which include both hydrostatic and hydrodynamic forces,

FI - Flood impact loads,

S - Soil loads.

Structures on fill should be designed to resist the above loads with the exclusion of F and FI from the load equations.

b) Floodwalls. Floodwalls should be designed to resist the following loads (as defined in Part B of this appendix) acting simultaneously:

LOADING	SAFETY FACTORS OVERTURNING/SLIDING		CONDITION
(Eq. 1.21) D+S+F	1.75	1.3	Design Flood
(Eq. 1.22) D+F+FI+S	1.5	1.1	Design Flood + Impact
(Eq. 1.23) D+W+F+FI+S	1.5	1.1	Design Flood + Impact + Wind
(Eq. 1.24) D+F* +S	1.0	1.1	Flood to top of wall
(Eq. 1.25) D+S+EQ	1.5	1.1	Normal load + Earthquake
(Eq. 1.26) D+W	1.3	1.1	Construction phase
(Eq. 1.27) D+S	2.0	1.5	Normal condition

* Assumes that the hydrostatic head of water pressure is equal to the height of the wall.

c) Commentary

The loading cases defined in Item 1.1 are to be used in association with *working stress* design methods. If *load factor* design analysis is used (as required in instances where the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI-318-71) is applicable) load factors should be applied as stated in the applicable standard; and flood loads (F) should be combined with the live loads (L), or incorporated as though it were a live load for loading conditions (1.11) and (1.14). In all other loading cases, flood loads (F) and flood impact loads (FI) are to be combined with wind loads (W) or factored as equivalent to W.

The load cases described in items (1.11) and (1.12) provide an appropriate margin of safety against excessive damage or structural collapse when subjected to the design flood. The margins of safety applied to floodproofed structures are intended to be no less than those applied to structures that are not subjected to flooding. These criteria are deemed as satisfied if stresses and deflections do not exceed the limits specified in applicable codes, and all loads specified herein. Maximum load values and member stresses must be calculated to include the combined effects of all normal loads required by applicable local codes, and those related to flood conditions.

It is assumed that the flood loads (F) may act on a structure for a period of days, and overstress conditions are not permissible. Flood Impact (FI) loads (from normal impact sources) are short-term loads. Therefore, the margin of safety against load combinations containing FI need not exceed that provided against wind or earthquake loads. If a structure is subject to special or extreme impact loads, no overstress should be used. The combination of earthquake and flood loads should not be considered simultaneously due to the low probability of occurence.

2. CRITERIA 2 - STABILITY

a) Elevation on Posts, Piles, Piers, or Walls and Watertight Structures. All structures elevated on posts, piles, piers or walls and all watertight structures should be designed to provide a minimum safety factor of 1.5 against structure failure from sliding or overturning; and should have enough dead load weight to resist anticipated hydrostatic pressures, including uplift, from floodwater at the Design Flood level with a minimum safety factor of 1.33.

b) Floodwalls. All floodwalls should be designed with appropriate safety factors associated with each loading case as given above in Criteria 1.

c) Levees and Elevation on Fill. Fill material should be selected, placed and compacted in layers to ensure stability and impermeability during a Design Flood. Levee and elevated fill design should recognize the effects of saturation from floodwaters on slope stability, and uniform and differential settlement.

The applicable loading cases to be considered in the embankment and foundation design of low-level levees are as follows:

- End of Construction
- Sudden Drawdown
- Critical Flood Stage
- Steady Seepage from Full Flood Stage
- Earthquake

The end of construction case evaluates both the riverside and landside slopes at a point where the soil, usually impervious, has not yet had time to drain since being loaded. Excess pore water pressure is often present. The sudden drawdown case evaluates embankment stability where a prolonged flood saturates a major portion of the structure and then falls faster than the soil can drain. Excess pore water pressure can result and the riverside slope can possibly become unstable.

The critical flood state and the steady seepage from full flood are similar loading conditions. The first evaluates embankment stability for some intermediate prolonged flood stage which saturates the embankment resulting in a steady seepage condition, while the latter occurs when the water remains at near full flood sufficiently long enough such that the embankment becomes either fully or partially saturated and steady seepage occurs.

Earthquake loadings are not normally considered in analyzing the stability of levees because of the low probability of earthquakes coinciding with periods of high water. Levees constructed of loose cohesionless materials or founded on loose cohesionless materials are particularly susceptible to failure due to liquefaction during earthquakes. Depending on the severity of the expected earthquake and the importance of the levee, seismic analyses to determine liquefaction susceptibility may be required.

d) Commentary

In cases when it is not practical to provide the required factor of safety against flotation by weight of the structure alone, tie-down or anchorage devices may be used to achieve structural stability. When these devices are used they must be designed to resist significant deterioration during the service life of the structure. Adequate anchorage must also be provided for all sealed conduits, tanks and similar structure of site components that could become buoyant and result in extreme damages during flooding conditions.

3. CRITERIA 3 - SCOUR AND DEBRIS ACCUMULATION

The following provisions apply to facilities that may be subjected to flow velocities in excess of 5 fps, and/or floating debris content.

a) Elevation on Posts, Piles, Piers or Walls. Structures elevated on posts, piles, piers or walls or other similar supports should have clear spacing of support members, measured perpendicular to the general direction of flood flow of not less than eight (8) feet apart at the closest point. The supports should, as far as practicable, be compact and free from unnecessary appendages which would tend to trap or restrict free passage of debris during a flood. Solid walls, or walled-in columns are permissible if oriented with the longest dimension of the member parallel to the flow. Bracing, where used to provide lateral stability should be of a type that causes the least obstruction to the flow and the least potential for trapping floating debris. The potential of surface scour around the supports should be recognized and protective measures provided.

b) Watertight Structures and Floodwalls. Watertight structures and floodwalls should be sited and/or designed to resist undermining of foundation elements as a result of scour and increased structural loads associated with extensive debris accumulation.

c) Levees and Elevation on Fill. Levees and elevated fill areas should be designed to resist the effects of scour. For slopes exposed to flood velocities of less than 5 fps, grass or comparable vegetation may be used to provide adequate protection from scour. For areas subject to higher velocities, stone, concrete or some other durable material shall be used to prevent excessive scour.

d) Commentary. Protection against scour may include paving or riprapping of foundations, levees or earthfill areas. Consideration should also be given to landscaping features or the construction of flood flow diverters or barriers near the upstream side of the structure to reduce flood velocities and the associated impacts of scour and debris accumulation.

4. CRITERIA 4 - PERMEABILITY AND STORM DRAINAGE

a) Watertight Structures. Buildings and associated structures that are protected from the Design Flood by permanent closures, flood shields and related techniques must remain substantially impermeable to water. This requirement applies to the total structure including walls and floors that are below grade elevation. Slight seepage may be allowed in cases where resulting damages would be negligible, and where seepage can be easily collected at a sump and pumped out of the structure. Acceptable seepage rates should not exceed an amount which would result in accumulation of more than four (4) inches of water depth during a 24-hour period, if there were no devices provided for its removal. However, sump pumps would be required to control such seepage.

b) Floodwalls and Levees. Floodwalls and levees should be designed and constructed to minimize seepage through or under the structure during a Design Flood event. Provisions should also be made to collect all seepage and storm water that collects behind the levee or floodwall and pump this water from the dry to the wet side of the structure.

c) Commentary. To meet the requirements stated in item b, watertight construction must incorporate the following minimum design considerations:

- All expansion and construction joints shall be constructed with appropriate waterstops and joint sealing material. To prevent excess seepage at these tension zones, the maximum deflection of any structural floor slab or exterior wall shall not exceed l/500 of its shorter span.
- Structure design may include the use of impervious barriers or cutoffs around the building perimeter to decrease the potential for the development of full hydrostatic uplift pressures and related seepage. These cutoffs must be connected to the impervious membrane of the building walls to operate effectively.

- Watertight closures or shields must be provided for all doors, windows, grilles, vents and other openings that are below the Design Flood level. Whenever structure utility system components extend through the watertight wall, the openings must be sealed to eliminate seepage.

To meet the requirements of item b, it may be necessary to provide impervious cutoffs to prevent seepage beneath the wall or levee. This requirement is critical for structures that are designed on highly pervious foundation materials. It may also be necessary to construct a drainage system parallel to the interior base of the structure to collect seepage through or under the structure and normal surface runoff from the watershed above the structure. All seepage and storm drainage should be diverted to an appropriate number of sumps and pumped to the floodwater side of the structure. Spacing, sizing and determination of depth of sumps should be consistent with the intended drainage system, the estimated amount of seepage and drainage yield. Normal surface runoff into the protected area (during non-flood conditions) may normally be discharged through piles or culverts that are fitted with appropriate backflow prevention valves.

5. CRITERIA 5 - ELECTRICAL SYSTEMS

a) Main Power Disconnect. Provisions should be made to ensure that the main power service to any floodproofed structure can be disconnected at a single location that is readily accessible at the peak of a Design Flood. This main switch should control all electrical circuits throughout the building, with the exception of emergency lighting circuits.

b) Emergency Lighting. For buildings that may require emergency evacuation operations, or that may require personnel to occupy the building during flooding conditions to install or operate floodproofing measures, an emergency lighting system shall be installed. The emergency lighting system should be totally installed above the Design Flood elevation, be equipped with a separate distribution panel; and be powered by a source that will not be affected by the Design Flood.

c) Electrical Equipment. Whenever possible, all major electrical control panels, transformers, stationary equipment, elevator power equipment and similar items should be located above the Design Flood. Moveable electrical equipment may be located below the Design Flood if it is equipped with submersible quick-disconnects; and if provisions are made for elevating the equipment above anticipated flood levels. All electrical equipment that is permanently installed below the design flood elevation should be of the submersible type.

d) Wiring. All wiring installed below the Design Flood level should be suitable for continuous submergence in water, with submersible type splices. All electrical conduits subject to flooding should be self-draining.

e) Sump Pumps. Buildings and structures that require sump pump equipment should provide automatic starting generators located above the Design Flood level. This equipment shall be capable of continuous operation for a minimum period of 125% of the estimated period water will be in contact with the structure during the Design Flood.

6. CRITERIA 6 - HEATING, AIR CONDITIONING AND VENTILATION

a) Location. All heating, air conditioning and ventilation equipment should be located above the Design Flood level whenever possible. When elevation is not feasible, this equipment may be located below the Design Flood in areas that are essentially watertight (see Criteria 4.1).

b) Heating and Air Conditioning. All gas or oil operated systems that are located below the Design Flood level should be equipped with automatic shut-off valves that are activated by rising flood waters. All heating equipment should be vented to a level above the Design Flood.

c) Ventilation. All duct work that is located below the Design Flood level should be installed to ensure positive drainage to a sufficient number of openings provided for that purpose. Sufficient anchorage and strength provisions should be made for any sealed conduit systems. Where duct work extends through a watertight floor or wall, the duct should be equipped with a closure assembly that can be operated from a position above the Design Flood.

d) Fuel Tanks and Lines. Liquid fuel and gas storage tanks should be elevated above the Design Flood Level; or anchored and protected from flotation and floodwater velocity and impact forces. The anchorage system should have a factor of safety of at least 1.5 against flotation. If it is exposed to stream flow or impact, it must be anchored to resist those forces.

All supply lines that are exposed to flood waters should be protected from hydrodynamic and impact forces, and equipped with automatic shut-off valves to prevent liquid or gas fuel spillage in the event of line failure. All storage tanks should be vented to a level above the Design Flood.

7. CRITERIA 7 - PLUMBING SYSTEMS

a) General. All plumbing system components that are installed below the Design Flood level should be designed to minimize loss of stability or tightness that may permit infiltration of floodwaters or permanently impair the function of the system.

b) Sanitary Sewer System. New and replacement sanitary sewage systems should be designed to minimize or eliminate infiltration of floodwaters into the systems and discharge from the systems into floodwaters. On-site waste disposal systems should be located to avoid impairment to them or contamination from them during flooding.

Sanitary sewer systems (including septic tank systems) that must remain in operation during a flood should be designed with a sealed holding tank and necessary mechanical controls to prevent sewage discharge during a flood. The holding tank should be sized to accommodate 150% of the demand that is anticipated for the duration of the Design Flood. All vents should extend above the Design Flood level.

c) Water Supply System. Potable water supply systems should be designed to prevent contamination from floodwater up to the Design Flood level. Private potable wells should not be developed from a water table that is less than 25 feet below the ground surface, or from any source that may be directly polluted by floodwater. Private wells should be protected with a water-tight casing that is sealed at the bottom of the well in an impermeable stratum, or extends several feet into the water bearing stratum. If the pumping system is above ground, it shall be protected by a watertight enclosure or by adequate elevation. All vents should extend above the Design Flood level.

If the source of the water supply is public, the owner of the structure needs to follow the directions of local authorities during flooding conditions. If the function of the facility is critical, the owner may want to consider a water storage system for emergency use.

d) Backflow Prevention. Each storm drainage and sanitary sewer line that enters a structure below the Design Flood level should be provided with an automatic and/or manual backflow prevention device. Approved backflow prevention devices should also be installed on main water service lines at water wells, and/or at building entry locations to protect the water system from floodwater backflow or siphonage that could result from a water line break.

8. CRITERIA 8 - FLOODPROOFING OPERATIONS

a) Efficiency of Installation. All contingent floodproofing measures should be designed and maintained to facilitate safe and efficient implementation upon receipt of flood warning. The installation time requirements can not exceed the advance warning capabilities of the warning system that is in affect for the area.

b) Training and Preparedness Planning. All personnel that are required for the installation and/or operation of contingent floodproofing measures should be trained to minimize the risk of system failure resulting from an improper or incomplete floodproofing response. A comprehensive and detailed floodproofing Preparedness Plan should be developed and maintained to clearly document all floodproofing system maintenance and operational procedures.

9. CRITERIA 9 - RESCUE OPERATIONS

Whenever possible, floodproofed buildings should be designed to provide direct access to land areas that are above the Design Flood through site grading, walkways or similar methods. For structures where this is not feasible, and where flood depths will exceed 2 feet or velocities exceed 3 feet per second, the structure should be designed to prevent the entrapment of building occupants by rising floodwaters. An enclosed refuge space should be provided in an area above the Design Flood that provides sufficient space for all occupants. This space should be provided with an appropriate number of exterior exits to a space that will allow the safe transfer of occupants from the building to rescue vehicles.

APPENDIX E DETERMINATION OF EXPECTED FLOOD DEPTHS USING FLOOD INSURANCE MAPS

The determination of flood-depths at a structure requires a interaction of the flood-hazard boundary map and the stream profile map with field activity to translate flood elevations to flood depths. Both maps are contained within the detailed Flood Insurance Study for a municipality or specific unincorporated areas. The procedure was adapted from the report entitled *Floodplain Regulations-To Encourage Wise Use and Reduce Flood Damage* and subsequent workshop of the Tennessee Valley Authority Office of Community Development.

A. FLOOD-HAZARD BOUNDARY MAP

This map will be used to correlate the location of a structure or structures to the flooding source. The Flood-Hazard Boundary Map (FHBM), Figure F-1, is similar to a city or road map. It has street names, the stream name and flood boundaries. On the stream are reference marks, usually in stream miles, above the mouth, which will be used to find the location of the structure on the profile.

The location of a structure may be determined in stream miles by using the following four steps.

Step 1: Locate the structure on the Flood-Hazard Boundary Map (Figure 1)

a. Identify map features, such as street intersections, which are close to the structures.
b. Select the most prominent ground feature nearest the structure.
c. In the field, measure the distance and direction from the ground feature to the structure either by pacing or through more accurate taping.
d. Check on availability of aerial photographs which can aid in relating ground features to the FHBM and vice versa. These photographs may be available from city or county governments, local engineering firms, the Department of Transportation or the Soil Conservation Service.
e. Transfer location of structure to the FHBM by scaling the distance on the map.

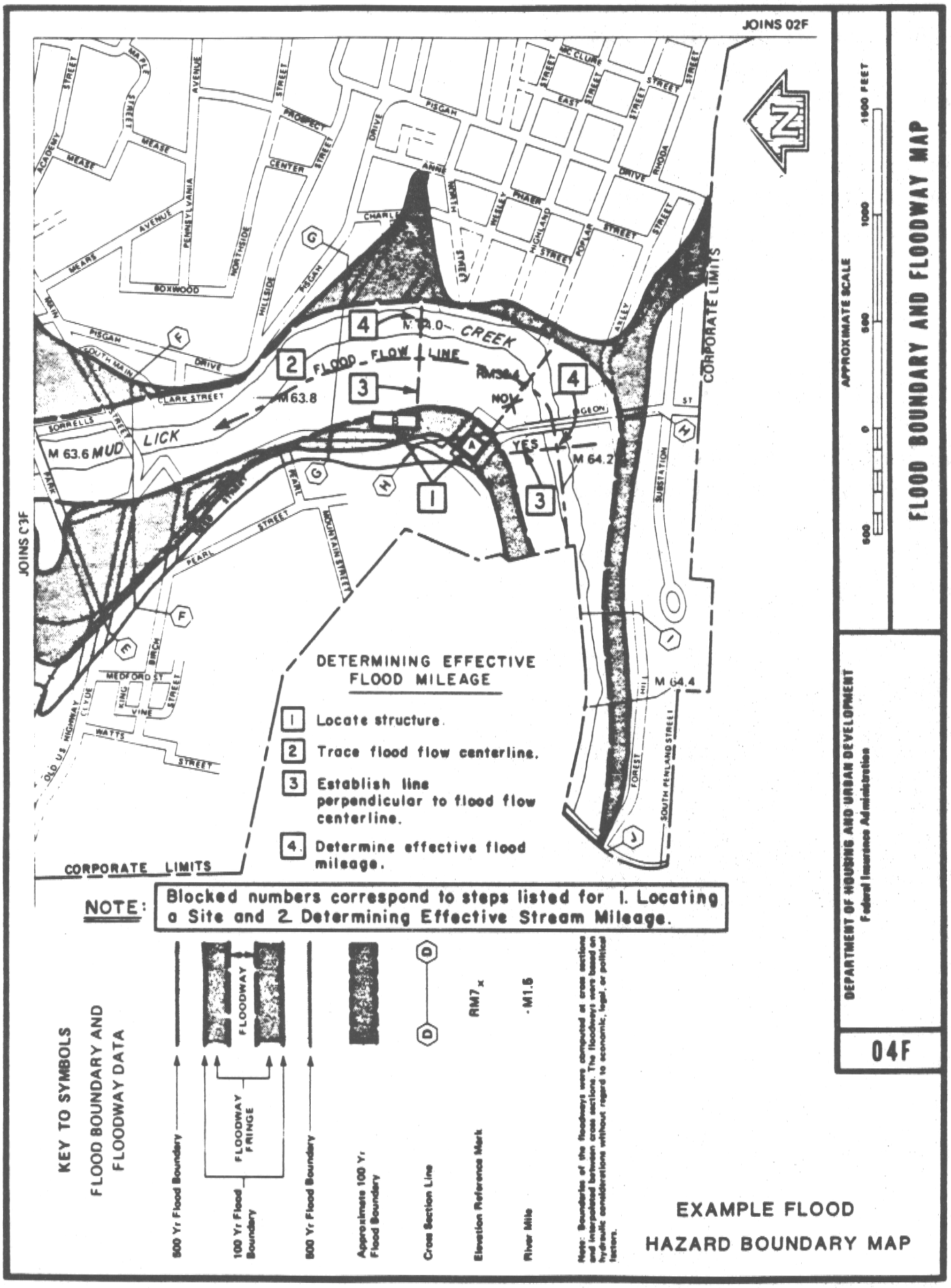

JOINS 02F
JOINS C3F
DETERMINING EFFECTIVE FLOOD MILEAGE
1 Locate structure.
2 Trace flood flow centerline.
3 Establish line perpendicular to flood flow centerline.
4 Determine effective flood mileage.
NOTE: Blocked numbers correspond to steps listed for 1. Locating a Site and 2. Determining Effective Stream Mileage.
KEY TO SYMBOLS
FLOOD BOUNDARY AND FLOODWAY DATA
500 Yr Flood Boundary
100 Yr Flood Boundary
FLOODWAY FRINGE
FLOODWAY
Approximate 100 Yr Flood Boundary
Cross Section Line
Elevation Reference Mark
RM7
River Mile
M1.5
Note: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations without regard to economic, legal, or political factors.
EXAMPLE FLOOD
HAZARD BOUNDARY MAP
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration
04F
APPROXIMATE SCALE
500 0 500 1000 1500 FEET
FLOOD BOUNDARY AND FLOODWAY MAP
MUD LICK CREEK
FLOOD FLOW LINE
M 63.6
M 63.8
M 64.2
M 64.4
CORPORATE LIMITS

FIGURE F-1

Step 2: Trace the floodflow centerline

Draw a line on the map that represents the general direction of *floodflow* (shown as the floodflow line). This line should be approximately in the middle of the flood boundaries.

Step 3: Establish a line perpendicular to the floodflow centerline.

Align a straight edge *perpendicular to the floodflow line* (not the stream necessarily) and intersect the *most upstream* side or corner of the site or building. Notice that for building A two lines (both perpendicular to the floodflow line) have been drawn to illustrate the proper and improper ways for determining the effective stream mileage. When more than one line can be drawn to an upstream side or corner, the most upstream perpendicular line is the appropriate one for determining the effective mileage because it results in the highest applicable flood elevation for the site (flood elevations increase in the upstream direction).

Step 4: Determine the effective flood mileage.

The point where the perpendicular line intersects the centerline of the *stream* determines the effective mileage to be used when obtaining applicable flood elevations from the profile. For location A, measure effective mileage as 64.2 and for location B the effective mileage is 64.0. Very accurate results can be obtained using a precise scale and instrument which results in effective mileages for locations A and B as 64.16 and 63.97, respectively.

B. FLOOD PROFILE

The flood profile is used to determine applicable flood elevations. The flood elevations at the structure can be obtained from the profile after the effective stream mileage has been established from the flood-hazard boundary map. The following steps illustrate how to use the effective mileage and the profile to obtain the flood elevations shown in Figure F-2.

Step 1:

Place a straight edge along the vertical axis which matches the effective mileage and trace a light line where it will cross the profile lines.

Step 2:

At the points where the effective mileage line crosses the flood profile lines, read the pertinent elevation(s) along the horizontal grid or mark them with a horizontal line for future reference.

Step 3:

The profile indicates the 100-year flood elevations for the example as:

Location A = 2593.7 (using next highest foot = 2594)
Location B = 2592.0 (use 2592)

Other flood elevations which can be read from the sample profiles are indicated below (Table 1).

TABLE 1
PROFILE ELEVATIONS

FLOOD FREQUENCY	ELEVATION Location A	ELEVATION Location B
10-Year	**2586.7**	**2583.9**
50-Year	**2591.1**	**2588.3**
500-Year	**2597.4**	**2596.3**

All map and profile readings should be carefully checked before they are used. It is suggested that readings be made by two individuals and the answers compared. Completion of the above process provides a flood elevation which can be used to:

- Determine flood depth
- Establish a construction elevation for a floor or earthfill to meet local ordinance or flood insurance requirements.

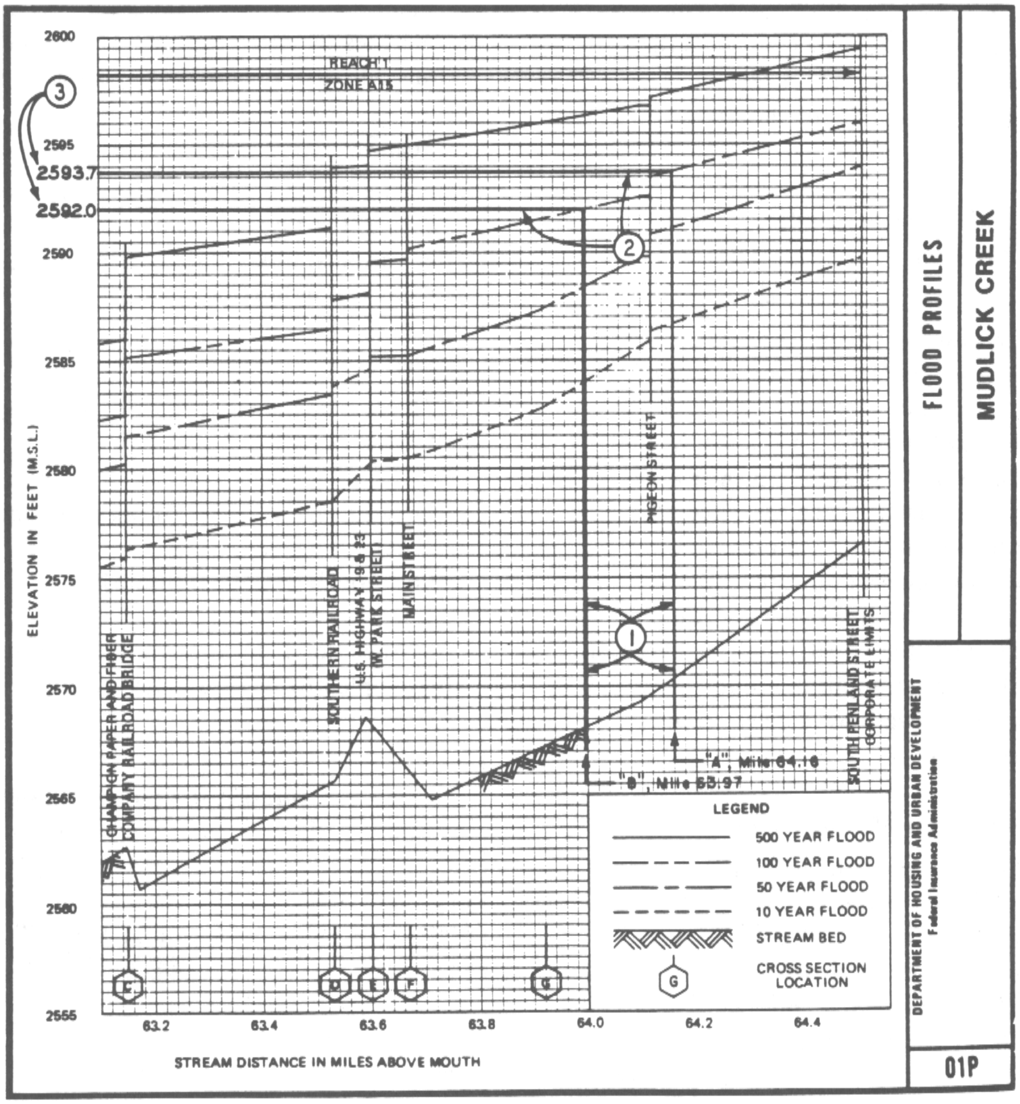


FIGURE F-2

EXAMPLE FLOOD PROFILE

Circled numbers correspond to steps listed for determining applicable flood elevations.

C. DEPTH OF FLOODING

The preceeding methods were used to determine the anticipated elevation of flood waters. A final step must be accomplished to find the elevation of the structure or the depth of the flood water at the structure. This can be accomplished by three different procedures. These include a field survey, the use of a hand-level or the use of a U.S.G.S. topographic map. The reliability of the information decreases in order of their presentation above. Each of the three methods is further defined in the following paragraphs.

1. FIELD SURVEY. A field survey is the most accurate technique for the establishment of flood depths at the structure. The procedure requires the use of land surveying techniques performed by a licensed land surveyor or registered professional engineer. The field survey will use benchmarks (fixed elevations) to align the flood level with reference to the ground at the structure, and therefore, determine the height of water at or upon the structure for a given flood.

2. HAND-LEVEL. This method can be accomplished provided a benchmark or known elevation is within sight of the structure. For example, the elevation at the benchmark was 963 feet and the elevation of the 100-year base flood was 969 feet. A six-foot rod or pole could be placed on the benchmark and a line sighted through the hand-level to a point on the wall of the structure. The imaginary line strikes the structure at a point two feet above the ground level of the structure. Since the imaginary line approximates the 100-year base flood elevation, it can be estimated that the base flood would be two feet high at the structure. Consequently, the two-foot water depth must be used in the consideration of optional floodproofing techniques.

3. U.S.G.S. TOPOGRAPHIC MAPS. Topographic maps illustrate elevations through a series of lines known as contours. Benchmarks and structures (depending upon the original or revised date of the map) are also portrayed on the maps. As in the previous examples, the benchmark of 963 feet would be identified on the map. The base flood level was determined as 969 feet so one would need to locate the 970-foot contour line and trace its path toward the structure. Any site or structure located on the 970-foot contour would probably be safe from the base flood. The structure in the previous example will in all probability be partially situated inside the 970-foot contour and consequently within the potential flood-hazard boundary of the base flood. The actual height of the flood water at the structure, however, can only be estimated by locating the lowest contour that is near the structure in question. Subtracting this contour, assume it is 967, from the 100-year flood elevation 969. The difference, 2 feet, is the flood depth for this structure.

*U.S. Government Printing Office: 2000 — 616-117/95233