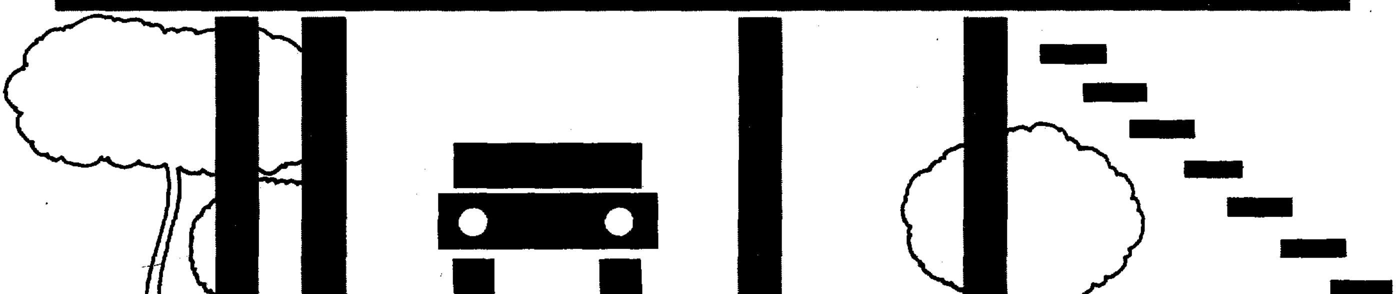
ELEVATED RESIDENTIAL STRUCTURES



Reducing flood damage through building design: a guide manual.

Federal Insurance Administration
National Flood Insurance Program
Department of Housing and Urban Development

ELEVATED RESIDENTIAL STRUCTURES

contents:

ELEVATED RESIDENTIAL FOUNDATIONS

**Reducing Flood Damage Through Building Design:
A Guide Manual**

FOREWORD

This manual is intended for use by designers, home builders, community leaders, local officials, and home owners who wish to build prudently in areas of special flood hazard and to meet the requirements of the National Flood Insurance Program.

A key provision of that program, which is administered by the Federal Insurance Administration (FIA) of the Department of Housing and Urban Development (HUD) calls for wise use of flood plains through the adoption of appropriate flood plain management regulations by local communities. To reduce losses from flooding, one of these appropriate regulations requires all living areas of residences built within the flood plain area (as well as housing substantially rebuilt or improved) to be at or above the base flood level as indicated on FIA's Flood Insurance Rate Map.

This manual provides background information on the National Flood Insurance Program, and the hazards associated with building in the flood plain, a review of existing alternative approaches for housing built on raised foundations, recommended performance criteria for the construction of foundation systems in flood hazard areas and some indications of design solutions.

It is not the intent of this manual to encourage building in flood plains, but rather when such building does or must occur, this manual seeks to provide information which, if effectively and appropriately used, will reduce flood losses.

These examples, guidance, and explanations in this manual reflect information currently available to the Federal Insurance Administration on residential construction subject to flood hazards. To ensure compliance with Federal requirements, readers are urged to consult pertinent regulations promulgated by FIA together with local codes, ordinances and other regulatory measures that may be in effect for more complete information. In order to keep you up to date on new developments in this area, the Federal Insurance Administration may modify the provisions of this manual in the future as new information becomes available, or as the provisions of the program change.

Therefore, we welcome any comments, suggested improvements, or additional information that you may wish to submit.

J. Robert Hunter
Acting Federal Insurance Administrator
Department of Housing and Urban Development
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Washington, D.C. 20410

Introduction

INTRODUCTION:

FLOODS—THE RECURRING MENACE

Our country has been blessed with abundant water resources which we have been able to use to make its land fruitful, to generate power to light our cities and fuel our industry, and to utilize for the recreation of our people. Yet, as we know that water is life-sustaining and enhancing, we have learned that its destructive potential is enormous and tragic.

For flooding is a part of the natural hydrologic cycle of the earth. Driving rains can transform rivers and streams into swollen menaces to both life and property. Violent winds can whip oceans and lakes into furies which devastate the shoreline. A torrential downpour or even a steady prolonged drizzle can turn hillsides and slopes into rivers of mud that can either foul our homes and businesses or literally carry them off. While parts of the State of California are the areas most often associated with this hazard they are by no means the only areas of the country to experience such problems.

Floods have been a fact of life for Americans since the first human settlements on this continent. As early as the sixteenth century Spanish explorers encountered Indian villages in the Mississippi Valley where the rough-hewn houses were constructed above the ground level to protect them from flooding. In our recorded history, there have been more than 10,000 documented floods in our country, and countless others went unrecorded in areas we had yet to occupy.

We know from experience that floods and flood-related damage from erosion or mudslides are a major threat to the security and well-being of our people. Fully 90% of the damage caused by natural disasters in this country is caused by floods despite the efforts we have made at flood control. Since 1925 it is estimated that more than $9 billion tax dollars have been spent on flood protection systems such as dikes, dams, and levees. Yet the average annual loss from floods in recent years has been $1.5 billion; and by the year 2020, it is predicted it would reach $5 billion per year if development continued to expand in flood prone areas in the same manner as in the past.

Part of the explanation for this mounting loss of property is that improper and unsafe development in flood hazard areas has accelerated beyond the point that flood protection is feasible. Often flood control systems have proved to be counter-productive because they have resulted in an increase in losses due to flooding. While they are engineered to protect known flood hazard areas up to a certain limit, their presence has most often encouraged a false sense of security that has led to additional development of flood hazard areas beyond that limit of protection. Flood prone communities across the country have learned the bitter lesson that flood protection systems alone are not the answer to their community's flood problem, and many times contribute to it.

Especially in the last decade, Americans have moved at an increasing rate to coastal and riverine locations which had previously been avoided. Popular because they are picturesque, they have been merchandised as desirable locations to live, work, retire. Nevertheless, the fact remains that many scenic locations are hazardous because they are part of the flood plains—the area intended by nature to accommodate the discharge and overflow of its water ways. When you occupy the flood plain, you run the risk that a body of water will reclaim its right of passage and be very costly in terms of human life and property investment.

THE NATIONAL FLOOD INSURANCE PROGRAM

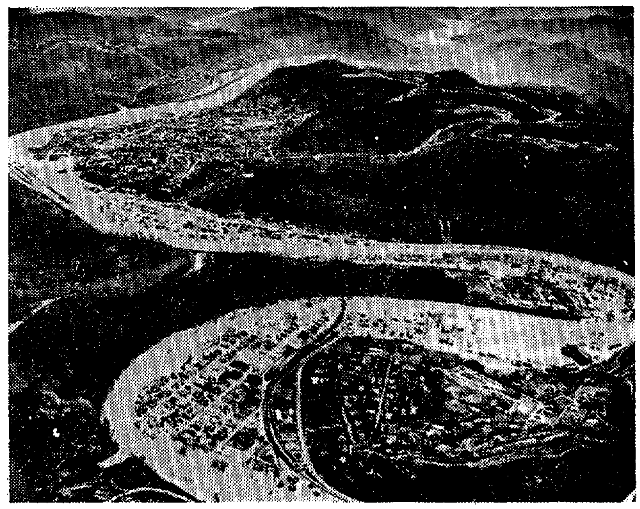
Because that is a price we cannot afford, the National Flood Insurance Program was initiated by the Congress in 1968. Broadened and strengthened by amendments in 1969, 1971, and 1973, the National Flood Insurance Program is designed to fulfill one essential purpose: flood hazard mitigation through reducing the amount of property exposed to damage from flooding. The program is administered by the Federal Insurance Administration (FIA) in the Department of Housing and Urban Development(HUD) and its scope includes all communities identified by FIA as containing flood hazard areas. To date, more than 17,500 communities have been so identified, of the approximately 22,000 estimated to contain such areas.

The National Flood Insurance Program is based on a dual principle: to make flood insurance available to property owners in flood prone areas; and to require sound practices of flood plain management in flood-prone communities.

The program offers the first affordable flood insurance protection for all buildings and their contents located throughout an entire community as long as the community elects to participate in the program. This special federally subsidized insurance coverage for flood losses is made available through local agents under an operating agreement between HUD and the National Flood Insurers Association, a pool of 133 private insurance companies.

In return for the Federal subsidy, the program requires affected communities to prudently regulate new construction and development in special flood hazard areas including all land inundated by flooding up to the level of the flood which has a 1% chance of being equalled or exceeded in any given year. This level is known as the "base flood" or "100-year flood" and is used by virtually every Federal agency in the administration of their programs as they relate to flood plains. In addition, this same standard is required, either by law or regulation, in many states and is used administratively in the operations of virtually every state's programs dealing with the use of flood plains.

The National Flood Insurance Program is administered in two phases: the Emergency Program and the Regular Program.



THE EMERGENCY PROGRAM

The function of the Emergency Program is to make flood insurance readily available to property owners throughout flood-prone communities. The operation of the program is simple and direct. The FIA notifies a community it has been identified as flood-prone by providing the community with a Flood Hazard Boundary Map. Prepared from the best available data, this map is a preliminary delineation of special flood-hazard areas within the community with a definite likelihood of inundation. A community receiving such a map must then either make application to participate in the program or submit data to FIA supporting that it no longer is subject to flooding.

Once a community receives notification from FIA that it is flood-prone, accompanied by a Flood Hazard Boundary Map, it has one year to qualify for the program. The application procedure requires communities to regulate future development in special flood-hazard areas as well as to provide FIA with certain relevant information. When the application is complete and forwarded to FIA, it is normally processed within less than two weeks and, if no further information is required, the community is admitted into the Emergency Program. As soon as that occurs, limited amounts of federally subsidized insurance become available in that community.

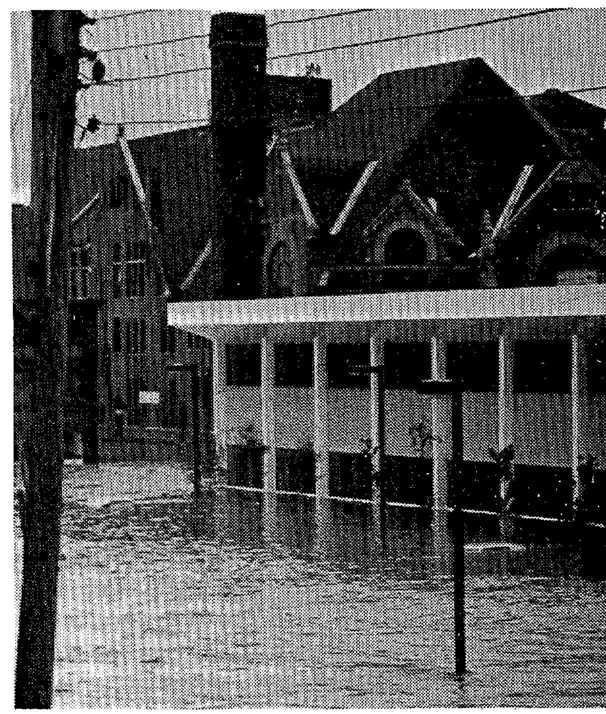
The limits of coverage for the initial or first layer insurance protection available under the Emergency Program are up to $35,000 for single-family structures and up to $100,000 for all other residential and non-residential structures. Contents coverage may be purchased up to $10,000 per unit in residential and up to $100,000 in non-residential structures.

THE REGULAR PROGRAM

Once a community has qualified for the Emergency Phase of the National Flood Insurance Program and subsidized insurance protection is available, an extensive technical Flood Insurance Study of the community's flood-hazard areas is conducted by an engineering contractor for the Federal Insurance Administration in preparation for entering the Regular Program. This detailed study includes development of a Flood Insurance Rate Map and is conducted at no cost to the community. The flood elevations derived from this study and the Flood Insurance Rate Map are the basis on which the actuarial (non-subsidized) insurance rates for the community are established and specific flood plain management regulations formulated.

As soon as this information is assembled, the FIA publishes notice of tentative base flood elevations twice in a local newspaper and once in the *Federal Register*. The community has the right to appeal these elevations to the FIA. After any appeals are resolved they become official base flood elevations for the community.

The final determination of flood elevations and the Flood Insurance Rate Map has two important effects: First, once a community's flood elevations are finalized, a six-month period begins during which the community must adopt additional flood plain management regulations. After adopting these regulations by the end of this period or at any time before that, if the community elects to do so, the community enters the Regular Program and additional flood insurance coverage becomes available, but at actuarial rates. Second, actuarial rates are charged for the additional or second layer coverage to existing structures and for all coverage for new structures. New construction is that which is started after the effective date of the community's FIRM or December 31, 1974, whichever is later.



FLOOD PLAIN MANAGEMENT

The specific flood plain management regulations that must be adopted depend to some degree upon the data developed in the detailed insurance study and provided to the community by FIA. Therefore, these regulations may be adopted incrementally by the community as the necessary data becomes available. For example, throughout the Emergency Program the community is required to apply minimal flood plain management regulations based on the Flood Hazard Boundary Map and is required to reasonably utilize any additional data that may be available from other sources to establish the flood elevations.

However, after the base flood elevations and Flood Insurance Rate Map are available from FIA, the community must adopt regulations which will protect from inundation any new construction that may take place in its special flood-hazard areas up to the magnitude of the base flood. Finally, FIA will provide the riverine flood-prone community with data necessary to establish its floodways. In the case of coastal communities, FIA will provide maps designating coastal high hazard areas for which additional regulations must be adopted to protect new construction and substantial improvement of existing structures. A riverine community must designate its own floodway on an official map and then adopt additional regulatory measures to protect against encroachments on these areas which would interfere with the discharge of flood waters.

Once flood plain management regulations have been adopted, they must be enforced. If they are permitted to lapse or are inadequately enforced the community will be subject to suspension from the program.

CONDITIONAL FEDERAL FUNDING

The incentive to participate in the National Flood Insurance Program is more than just the availability of affordable flood insurance protection. In order to achieve the goal of mitigating flood disasters, the Congress legislated in the Flood Disaster Protection Act of 1973 that nearly all forms of Federal or federally related financial assistance for the acquisition or construction of buildings in the identified flood-hazard areas of flood-prone communities will be conditional upon:

1. Community participation in the program; and
2. The purchase of flood insurance in conjunction with that assistance.

The Act defines Federal or federally related financial assistance to include not only loans and grants from Federal agencies such as Veterans Administration, Federal Housing Administration, U.S. Department of Agriculture and Small Business Administration, but also money provided through federally regulated, supervised or insured financial institutions such as banks, credit unions and savings and loan associations. Therefore, the availability of conventional mortgage financing for structures in the special flood-hazard areas of flood-prone communities is conditional upon participation in this program.

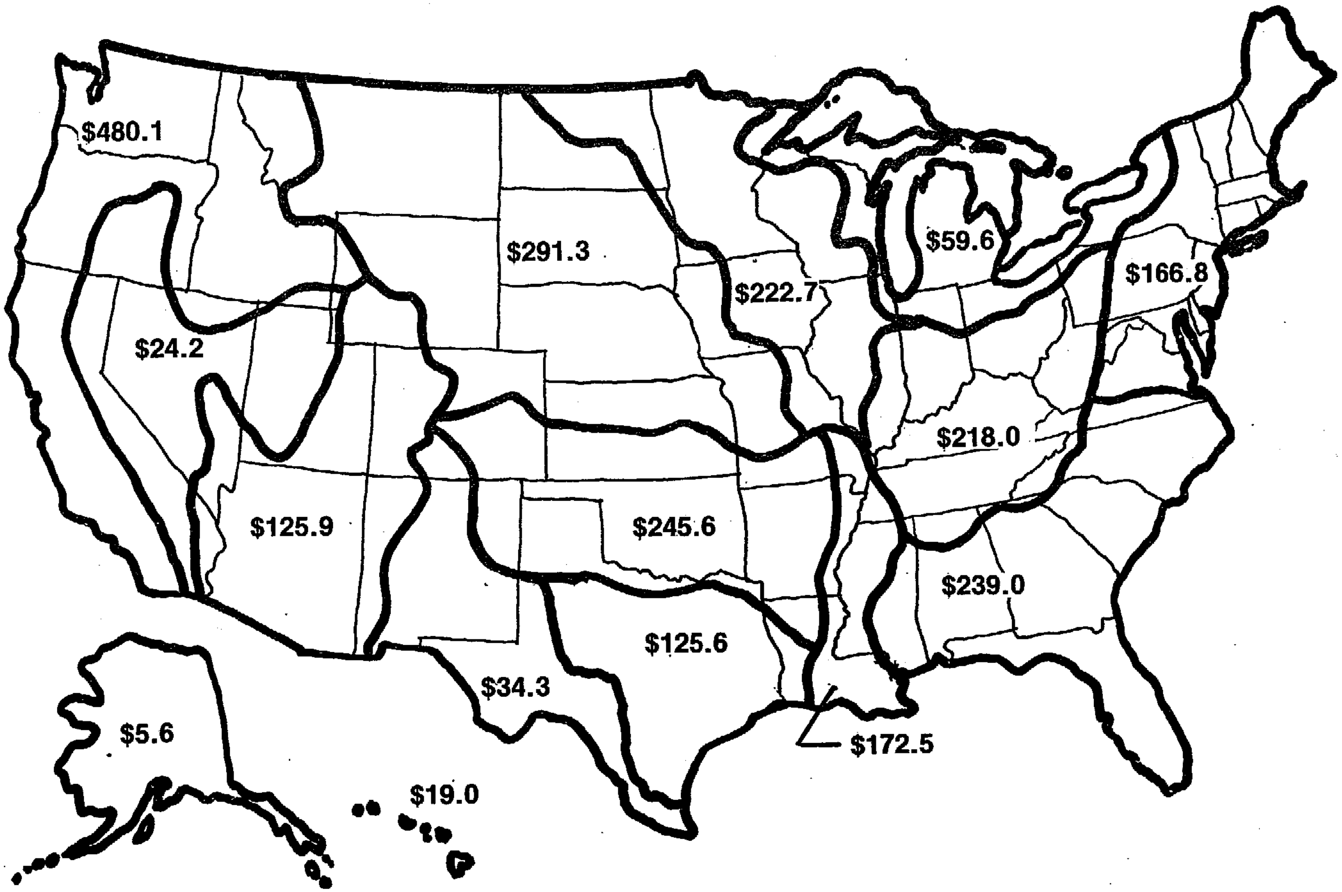
PRUDENT USE OF THE FLOOD PLAIN

The purpose of these regulations and requirements is not to prohibit development in the flood plain but rather to encourage the most appropriate use of flood-prone areas. The long-term benefit of the National Flood Insurance Program will be the prudent use of our land resources in flood-prone areas to protect individuals and communities from devastating flood losses. For example, lowlands stretching along the banks of a river or stream subject to flooding may be unsuitable for high density development, but may be ideal locations for agricultural uses, parks, golf courses, or other open space purposes.

The essential risk of urban development of the flood plain is that it will, in time, reduce the flood water storage area and the permeable land surface available to absorb flood water and block the flow of floodwaters, thus, exposing additional lives and property to the possibility of flooding and, thereby, increase the social and economic costs of paying for flood damage. By controlling development in these areas so that the uses are appropriate to the hazard, the potential for public and private loss can be greatly minimized.

UNITED STATES FLOOD MAP*

* Water Resources Council



ESTIMATED ANNUAL FLOOD DAMAGE — 1980

(In millions of dollars)

Unless flood plain management and building practices are significantly improved by the year 1980, the potential flood damage may exceed 2.5 billion annually.

Elevated Residential Structures

ELEVATED RESIDENTIAL STRUCTURES: RESTRICTIONS AND CONSIDERATIONS

In order to participate in the National Flood Insurance Program a community must agree to require building permits for all proposed construction or other improvements in the Special Flood Hazard Area (SFHA) of the community and to review building permit applications in that area to determine whether the proposed building sites will be reasonably safe from flooding.

Building permits are required only in the identified flood-prone portion of the community—if a map designating these areas has been issued by the FIA. However, if no map has been issued, building permits are required for the entire community. Other requirements include that if a proposed building site is in a location that has a flood hazard, the community must require that the proposed new construction or substantial improvement of existing buildings (including mobile homes) be designed and anchored to prevent flotation, collapse, or lateral movement of the structure. It must require, as well, the use of construction methods and practices that will minimize flood damage and the use of construction materials and utility equipment that are resistant to flood damage.

Moreover, the community must review subdivision proposals and other proposed new developments to make sure they are consistent with the need to minimize flood damage. New public utilities and facilities such as sewer, gas, electrical and water systems must be located and constructed to minimize or eliminate flood damage and adequate drainage must be provided to reduce the exposure of the development to flood hazards.

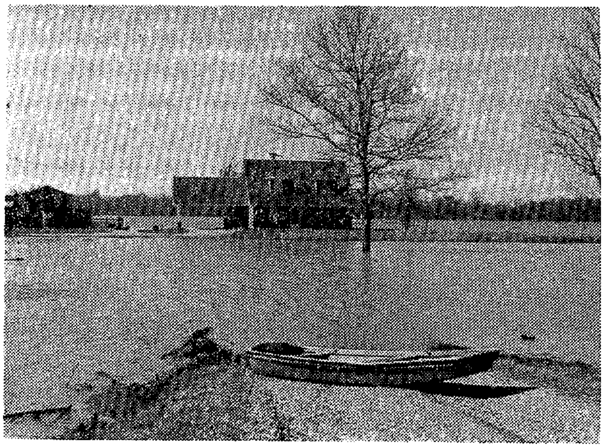
Finally, the community must require that any new or replacement water supply systems and/or sanitary sewage systems be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from these systems into flood waters. Any new or replacement on-site waste disposal systems must be located so as to avoid its impairment or contamination from flooding.

These requirements come into effect the moment a community enters the Emergency Program. When the detailed flood insurance study of the community has been completed and the base flood elevations determined, the community must adopt these additional minimal regulations.

- For residential structures within the area of special flood hazards, the community must require new construction and substantial improvements to existing structures to have the lowest floor (including the basement) elevated to or above the level of the base flood.

- Where the threat of river flooding exists, the community must insure that until a floodway has been designated, no use—including land fill—will be permitted within the flood plain area having special flood hazards unless it can be demonstrated that the proposed use, when combined with all other existing and anticipated uses, will not increase the water surface elevation of the base flood more than one foot at any point.

The reason for these minimum regulations and construction standards is clear. Building houses in flood-hazard areas is risky. The risk is not only to the occupants, to the building and its contents, but also to the utilities and other service systems vital to them. The following specific considerations will help to minimize flood damage.



SITE SELECTION

Whenever possible, avoid encroachment on the flood plain. If, in buying a lot or selecting a site for development, encroachment on the flood plain cannot be avoided, recognize that the risk and severity of flooding generally decrease with the distance from the river channel or from coastal waters. However, this may not always be the case, so it is important to check the level of the base flood in relation to the proposed site. If the base flood level has not been determined, it would be wise to consult local flood history data before making a final site selection. The essential objective in a river flooding situation at a minimum is to locate in the flood fringe, in that area beyond that which is needed to carry off the waters of the base flood.

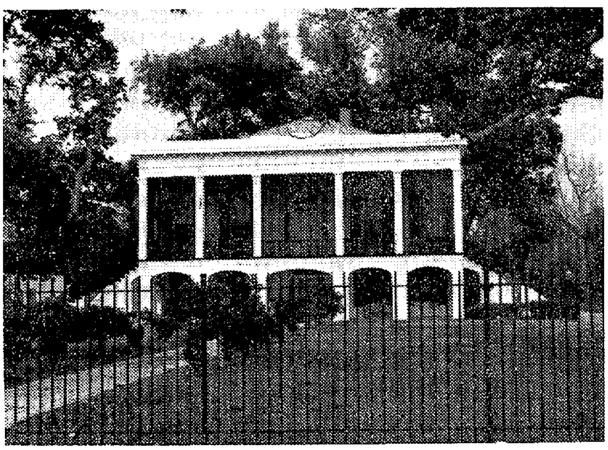
The regulations of the National Flood Insurance Program specifically prohibit building and/or landfill in a floodway, if such has been designated, if the results would obstruct the flow of flood waters and, therefore, increase flood heights. Similarly, building in a coastal high hazard area is also not permitted unless the site is landward of the mean high tide level and the lowest floor is elevated to the level of the base flood on adequately anchored piles. The space below the lowest floor must be kept open and free of obstruction. The lowest structural members of the floor system of a new building in this area, or any part of the outside wall, should be above the base flood elevation.

Development should also be diverted away from identified mudslide or erosion prone areas. Only where site and soil investigation and proposed construction standards assure complete safety for future residents should such sites be considered.

Overall, customary site selection criteria must be utilized to evaluate the suitability of a site. Drainage, height of the water table, soil and rock formations, topography, water supply and sewage disposal capability should be considered along with economic and planning criteria, such as cost, access, and compatible land use.

DESIGN

Design considerations are important not only in terms of protection from flooding, but also in terms of constructing an aesthetically appealing residence that is compatible with its community. The types of interference or damage houses may suffer under flood conditions should be anticipated and designed for to provide safe living accommodations. At the same time, well-designed elevated residences should provide a smooth transition from ground to dwelling, the foundation being integrated with or complementing the structure itself. Creative landscaping using trees, shrubs, and fences can enhance the appearance of elevated structures by softening the effect of potentially harsh or barren exposures. In the case of subdivisions or developments, the design quality of an elevated home will be enhanced if the surrounding neighborhood and community have been designed to accommodate elevated homes.



ENGINEERING FACTORS

The most important engineering consideration is to design an elevated foundation to resist the forces caused by the base flood and the character of its flood waters. A static flood is characterized by slow-moving, slow-rising water. This occurs most typically in the riverine floodway fringe or backwater coastal situation.

Foundations built in these areas must first elevate the building above the level of the base flood, and second, be able to withstand the hydrostatic loads placed upon the foundations. Velocity floods are characterized by rapidly moving and surging water. This condition is typical in exposed coastal and riverine flash flood areas. In this situation, elevated foundations must not only raise the structure above the base flood waters and withstand the hydrodynamic forces of flowing water, but it must also resist the impact of water-borne debris and the scouring effects of wave and tidal action. The foundation should also be constructed so as to offer the minimum possible resistance to flow in order to reduce the dynamic forces without reducing the structural strength of the foundation. (A further discussion of these situations follows in Section 2 of this manual.) In coastal high hazard areas (CHHA) the lowest structural member of the floor system should be above the base flood level.

BUILDING MATERIALS

Replacement of water-damaged building materials and repair of structural damage resulting from material failures are major cost components of flood damage.

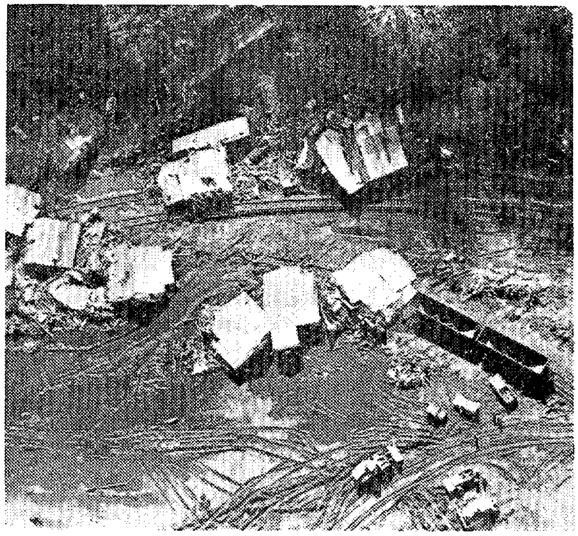
The base flood level is a selected flood design criteria which is actually a compromise between extreme, catastrophic flooding and more regular or even annual riverbank and coastal shoreline flooding. Obviously, floodwaters can and will exceed the level of the base flood, and thus, even residences elevated to the level of that flood will be subject to possible water damage from a greater flood.

An attempt should be made to minimize losses both below and above the level of the base flood. This can be accomplished by selecting building materials and furnishings (such as floor coverings) that are resistant to inundation and by designing and engineering buildings in a manner that will allow them to dry out quickly. A discussion of building materials can be found in the Corps of Engineers' publication No. Ep 1165 2 314, *Flood-Proofing Regulations.*

UTILITIES

Elevating a residential structure above the base flood level will provide added physical safety to the occupants and will lessen the possibility of flood damage to the structure and its contents. However, interruption of utility services because of flood damage may render the residence uninhabitable during flood and post-flood recovery periods.

Elevated structures, therefore, should be serviced by mechanical equipment that is also elevated or flood proofed above the base flood, and by utility systems that are designed to minimize or resist flood damage and infiltration. Owners, builders, developers, and communities that have no alternative but to construct in a flood-hazard area should anticipate utility disruptions and seek comprehensive engineering data and professional guidance to prevent and minimize them.



METHODS OF ELEVATING STRUCTURES

Two general methods are available to raise the lowest floor of a residence to or above the base flood level. One of these requires filling the low-lying area with compacted soil, then building in the conventional manner. The other method requires construction of an elevated foundation to raise the lowest floor of the residence above the base flood level. This manual considers five methods of constructing elevated foundations: Posts, Piles, Piers, Walls, and Pedestals. Each of these methods is reviewed on the following pages and pictorially presented in the section entitled Representative Elevated Residences.

POSTS

Wood posts and steel columns are sometimes used in elevated construction. The posts or columns are placed in either machine drilled or hand dug holes and may be secured in the ground on concrete footings or held in place by either embedment in the ground and/or poured-in-place concrete. The depth of embedment necessary to firmly secure the post depends on the type of soil in which it is placed, its condition and the anticipated scour.

Posts can either extend from grade to or slightly above the base flood level where the first floor deck is constructed, or they may extend through the deck to the roof. Posts extended in the latter manner are a means of tying a structure together to increase wind or lateral resistance. The majority of elevated residences utilizing post construction use wood posts.

PILES

Similar to posts, piles are long, slender shafts of wood, steel, or reinforced concrete driven into the earth to support a horizontal load. The load-bearing capacity of each pile is determined by the frictional resistance between the soil and the pile surface and/or by the end bearing of the pile. Piles should be driven to a designed depth, depending on their use, or to refusal. Again, soil type and anticipated scour are important considerations.

As in post construction, piles may be cut off or extended to a building's roof line. Piles extended to the roof line, however, present alignment problems, which could add to the cost of construction. The majority of pile houses built for flood and less demanding conditions utilize wood piles. The strength and scour resistance of pile construction makes it especially suitable for buildings in coastal and other areas where high-water velocity and surge conditions are common.

PIERS

Piers are vertical supports usually made of reinforced concrete or reinforced masonry (brick or concrete block). Essentially, they are heavy columns set on footings appropriate for the soil conditions and spaced to accommodate the floor framing and loads. They also may be constructed without footings by augering or digging holes and then casting reinforced concrete piers in place. The use of this method depends on whether the soil is capable of developing adequate end bearing.

WALLS

Elevating residences on walls is a relatively simple and effective means of providing flood protection. This approach simply requires that the first habitable floor of a residence be built on foundation walls that extend above grade to the level of the base flood or higher.

It is important the foundation walls be arranged to provide open spaces through which water can flow to equalize pressure. In velocity flood situations, it is important that the foundation walls be parallel to the flow of the flood waters.

If infill walls are used they should be of a knockout variety to prevent the accumulation of debris and thus the potential destruction of the foundation from flood waters. The knockout walls should be designed or anchored so that they will not float away and add to the floating debris which may destroy other structures. Any materials resistant to water damage, such as concrete block, can be used in construction of walls for elevated structures.

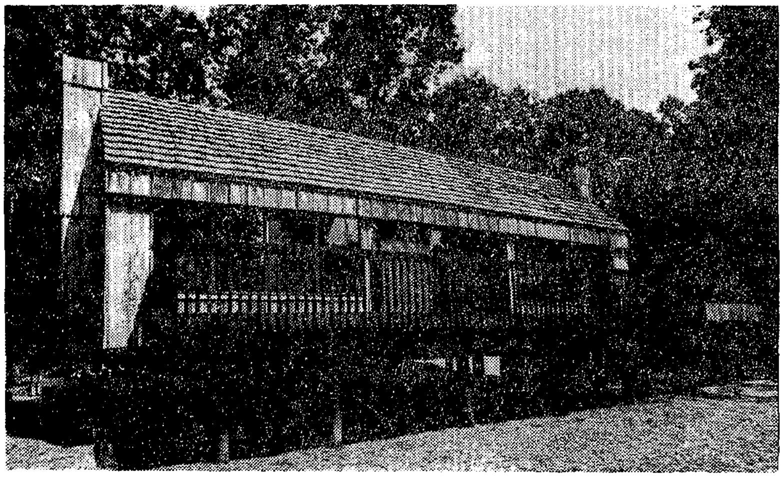
PEDESTALS

The last and least often used method of elevating structures is pedestal construction. A pedestal is a single structural unit that supports a cantilevered floor deck at or above the level of the base flood. Most frequently it is constructed of reinforced concrete or reinforced masonry and set on a spread footing.

Currently pedestal construction is not a common type of elevated foundation, primarily due to higher construction costs.

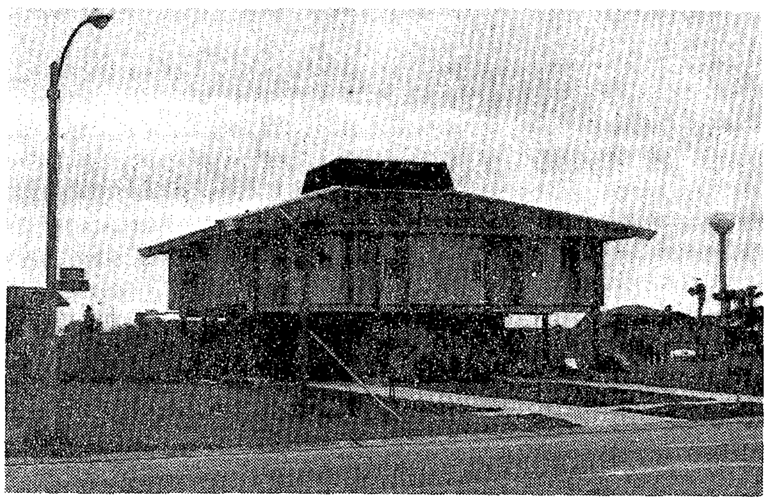
REPRESENTATIVE ELEVATED STRUCTURES

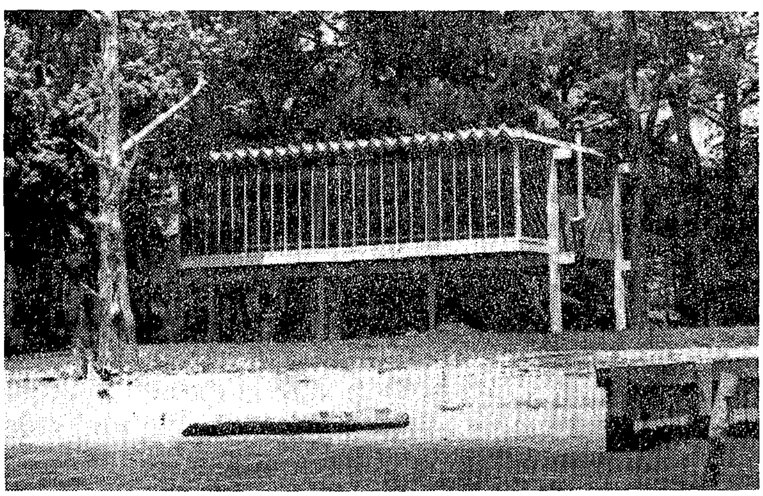
WOOD POSTS



POSTS TERMINATED AT FLOOR
Treated wood posts are placed in holes and held in place by back-filling with tamped earth to form the elevated foundation of this home in Virginia. The posts are terminated at the bottom of the floor joists, and anchored to them by bolted connections.

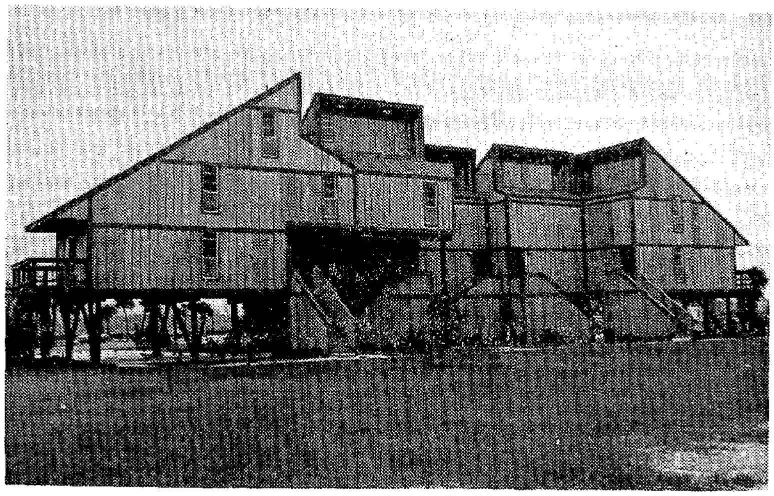
POSTS EXTENDING TO ROOF
In this New Orleans house the posts are anchored to a concrete pile cap with steel angle clips and reinforced with concrete plinth blocks. The wood posts go through to the roof to tie the whole structure together for hurricane-wind protection as well as flood protection.





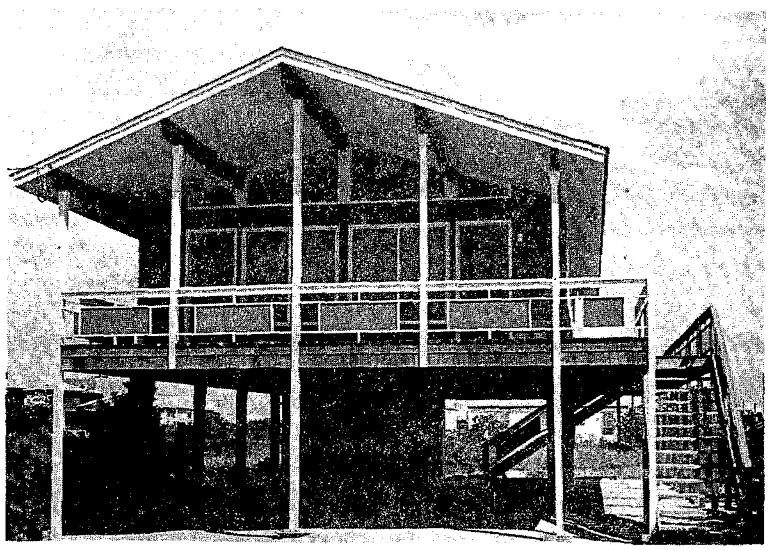
POSTS ENTENDING TO ROOF
Wood posts are extended to the roof in this house on Mobile Bay. The posts are set on concrete footings in the sandy shore soil. The weakness of this design is the placement of mechanical equip-ment under the house where it is exposed to flooding.

POSTS TERMINATED AT FLOOR
These elevated condominium apartments in Mississippi present an interesting form. Note the lateral bracing and the use of stairs to visually shield much of the post foundation.



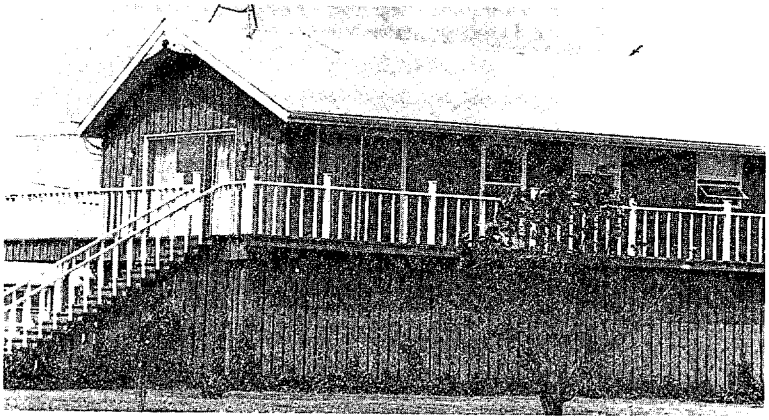
POSTS EXTENDING TO ROOF
This house in Pass Christian, Mississippi, has wood posts that tie the structure together for hurricane protection as well as flooding. Note that severe storms have broken the surrounding trees.

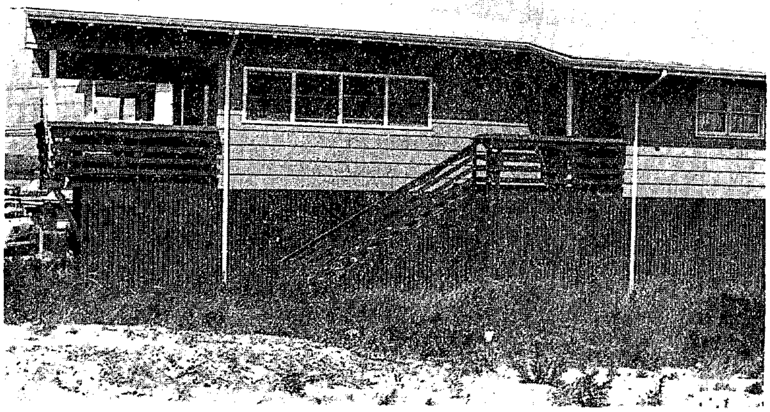
POSTS TERMINATED AT FLOOR
The primary structural support for this Delaware home is provided by posts set in concrete and termininated at the floor. Wood posts extending to the roof support the frontal overhang and first floor deck.



WOOD POSTS

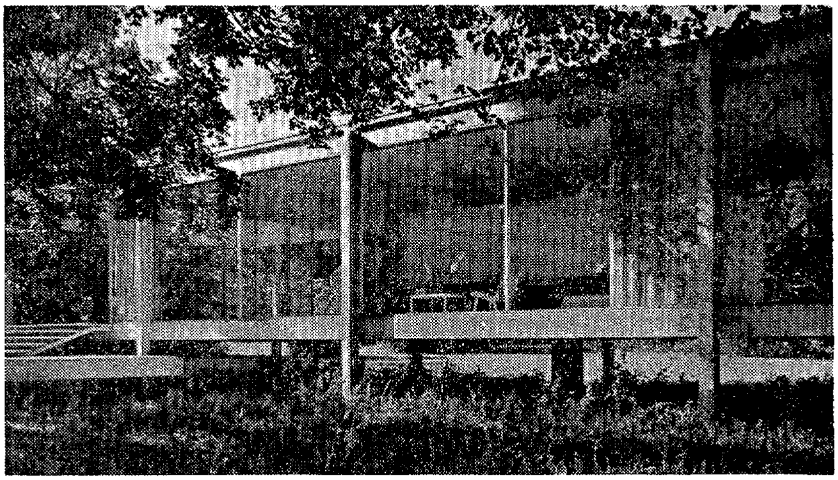
POSTS TERMINATED AT FLOOR
Three elevated residential homes on the Eastern seaboard illustrate different types of breakaway paneling used to screen the elevating wood posts. Note the use of decks on the raised first floors which give added recreational space.

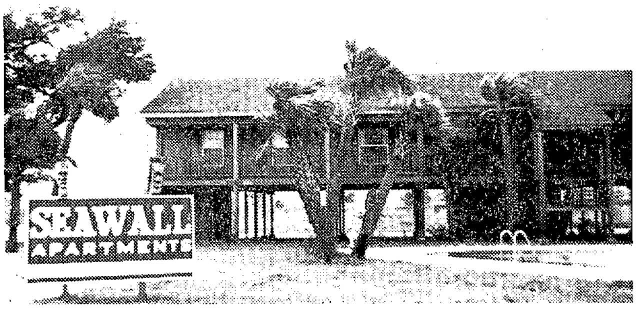


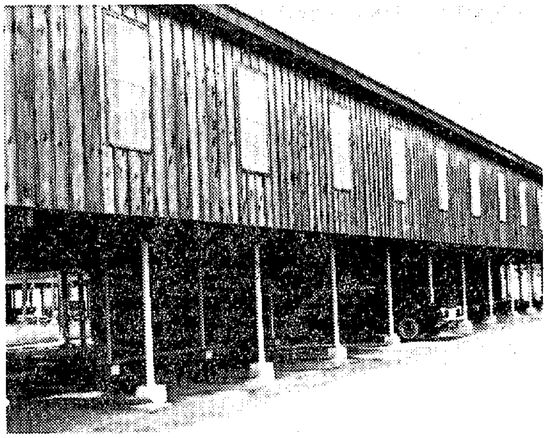


STEEL POSTS

POSTS EXTENDING TO ROOF
Mies van der Rohe designed this house to avoid flood damage from the Fox River in Plano, Illinois. The building is supported on eight steel columns anchored in concrete. The columns are oversized for aesthetic purposes.

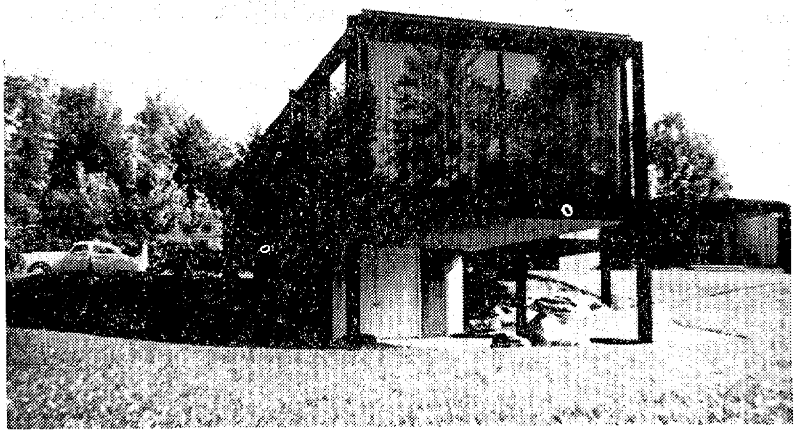






POSTS TERMINATED AT FLOOR
Steel posts anchored to concrete footings elevate these apartments in Long Beach, Mississippi.

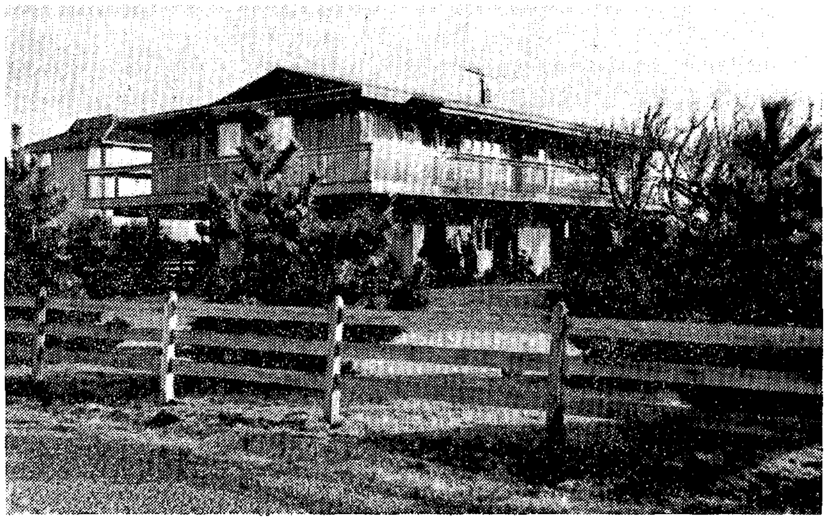
POSTS EXTENDING TO ROOF
This contemporary steel frame Illinois house is elevated above the flood plain on wide flange steel columns. The columns are welded to the frame and anchored in concrete footings.



WOOD PILES

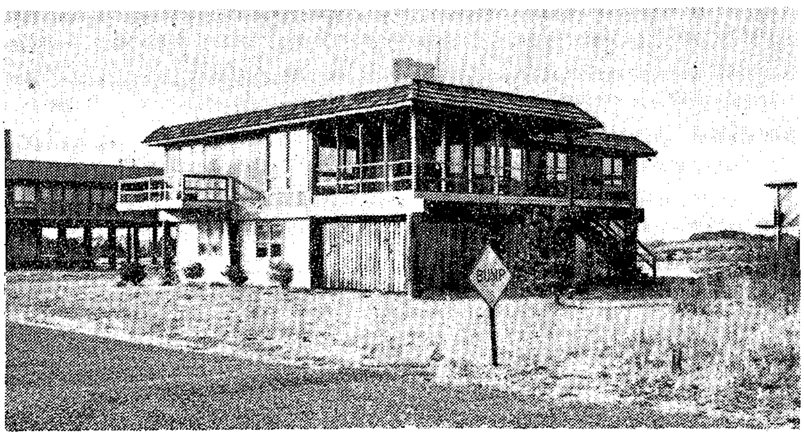
WOOD PILES TERMINATED AT FLOOR

The ground level of this wood pile home on the coastal flood plain was enclosed to provide storage and garage spaces. The infilled spaces and landscaping tend to screen the pile construction.



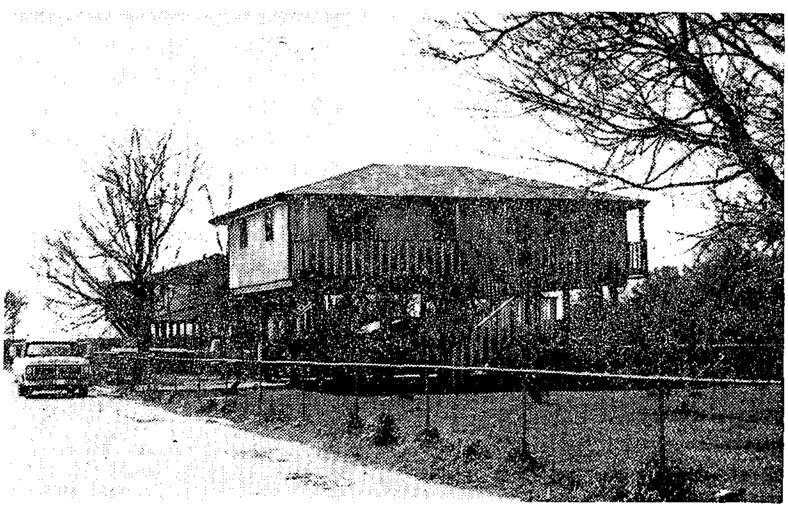
WOOD PILES TERMINATED AT FLOOR

Infill panels and fencing are used effectively to reduce the harsh visual impact of the treated wood piles elevating this structure. The piles were driven approximately 16 feet into the sandy soil of the Delaware coast.



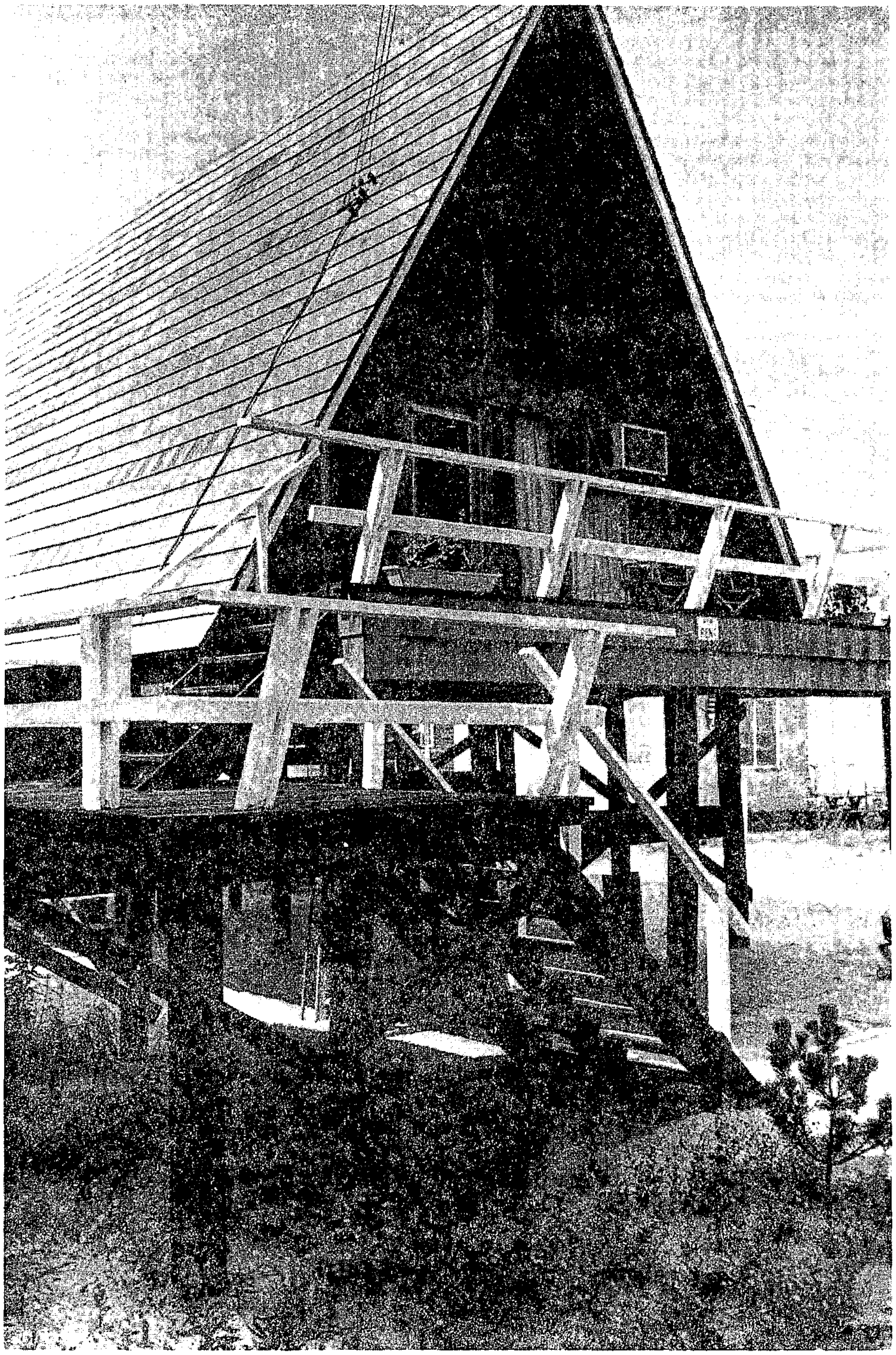
WOOD PILES TERMINATED AT FLOOR

This house is presented to show the particularly high elevation that is required in some parts of the country to prevent flood damage. The first floor of this home in Plaquemines Parish, Louisiana is raised 13 feet on wood piles.



WOOD PILES TERMINATED AT FLOOR

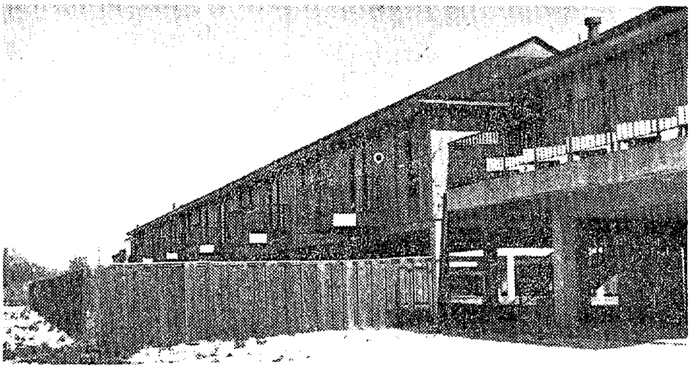
This A-Frame vacation home on the Atlantic seacoast is supported by treated wood piles driven into the soil deep enough to contend with shifting sand and coastal surges.

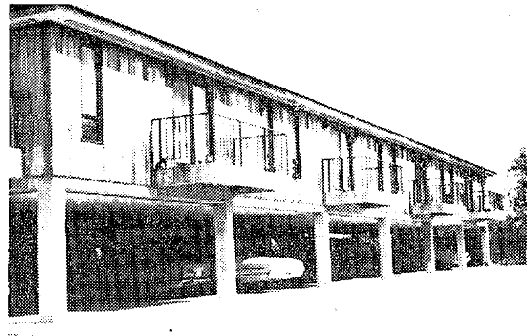


CONCRETE & MASONRY PIERS

CONCRETE PIERS

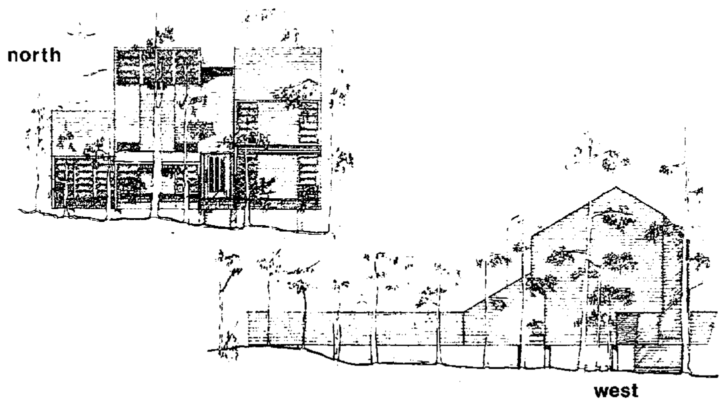
Poured-in-place concrete piers resting on concrete pile caps support the structural concrete deck and wood framing of this apartment complex in Louisiana.





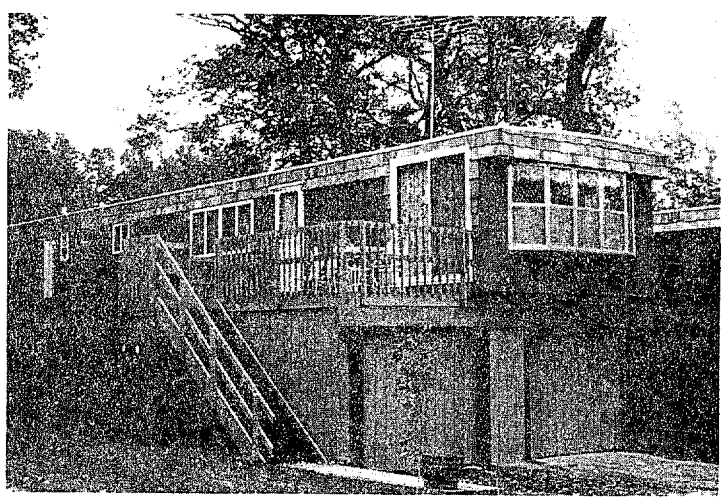
CONCRETE PIERS

This house is a wood-frame structure set on concrete friction piers. A high water table necessitated elevating the structure.

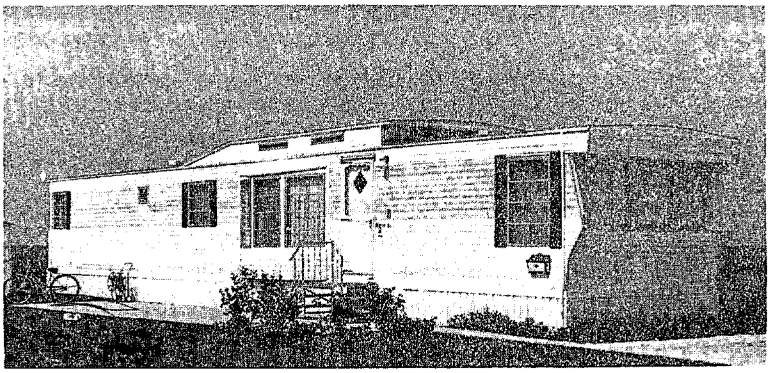


CONCRETE PIERS

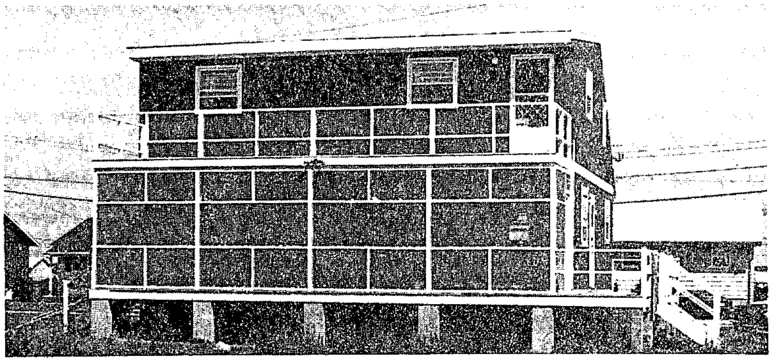
This mobile home in Minnesota rests partially on a small hill at base flood level with predominant support provided by elevating concrete piers. Breakaway wood paneling is used to screen the piers and provide storage and garage space.



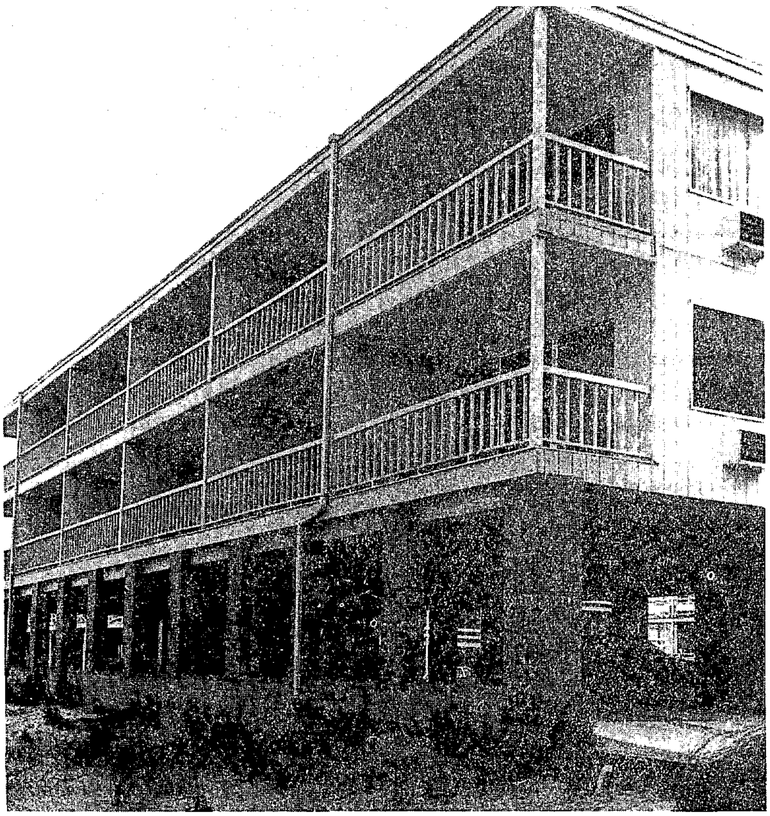
CONCRETE PIER
A mobile home on the Maryland coast needed only minimal elevation to raise the residential structure to base flood level. Elevation was accomplished by masonry blocks which are screened by wood skirting around the base of the structure.



CONCRETE PIER
Poured-in-place concrete piers provide the main support for this elevated two-story home in Rehoboth Beach, Delaware. The screened porch and second story balcony are supported at a 36 inch elevation by concrete block piers.



PIERS
Poured concrete and masonry block piers provide the foundation for an apartment building in Ocean City, Maryland. The structure is elevated by poured-in-place concrete piers faced with decorative brick. Space beneath the elevated first floor is utilized for parking and common storage area.



MASONRY PIERS

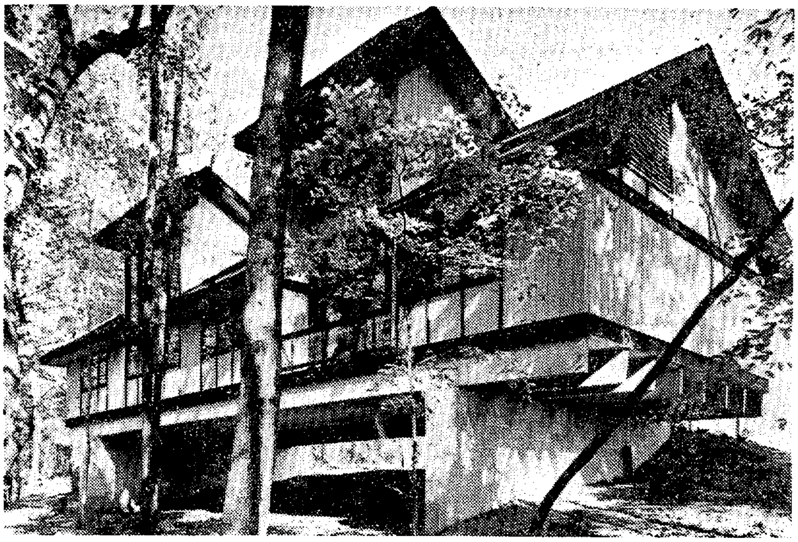
This home is built directly on the Gulf of Mexico and is elevated on masonry piers. Design and landscaping combine to enhance the appearance of the elevated structure. Decades of resistance to flood and storm damage attest to its structural soundness.

MASONRY PIERS

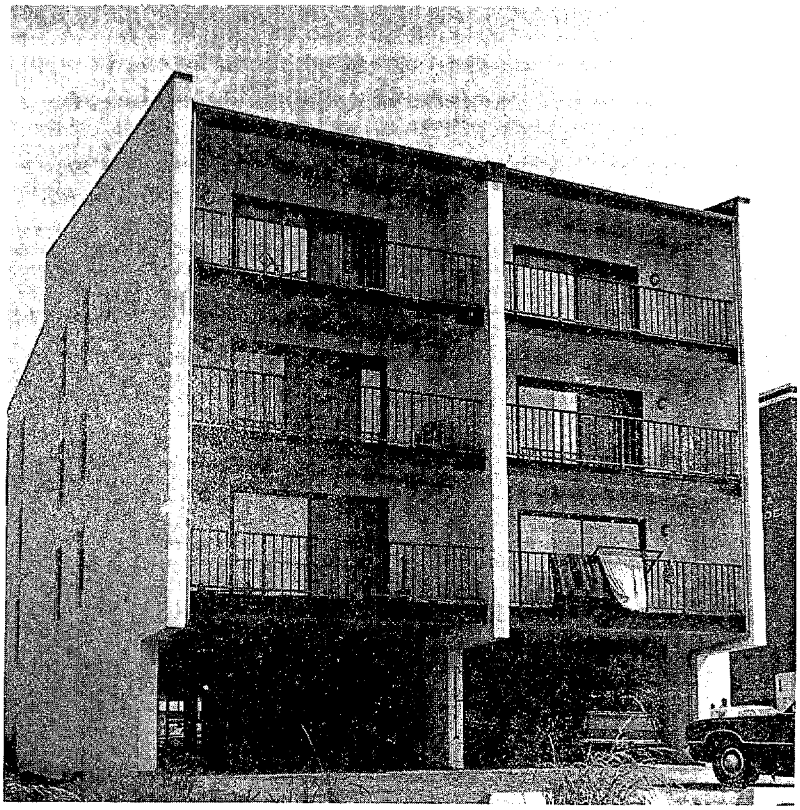
Landscaping and wood infill panels are used in this low-cost vacation home to enclose ground level space and improve the appearance of the elevated construction.

WALLS

CONCRETE BLOCK WALLS
Reinforced concrete block walls support the precast concrete tees used for the floor deck of this architect's office. Fill was used at one end of the building to provide easy entry.

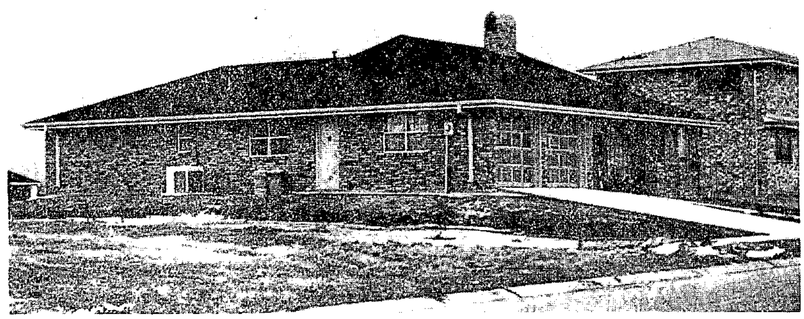


WALLS
The first floor of an Atlantic Coast apartment building is raised above the base flood level with concrete walls that extend the entire height of the structure. The ground floor is used for entry and garage space.

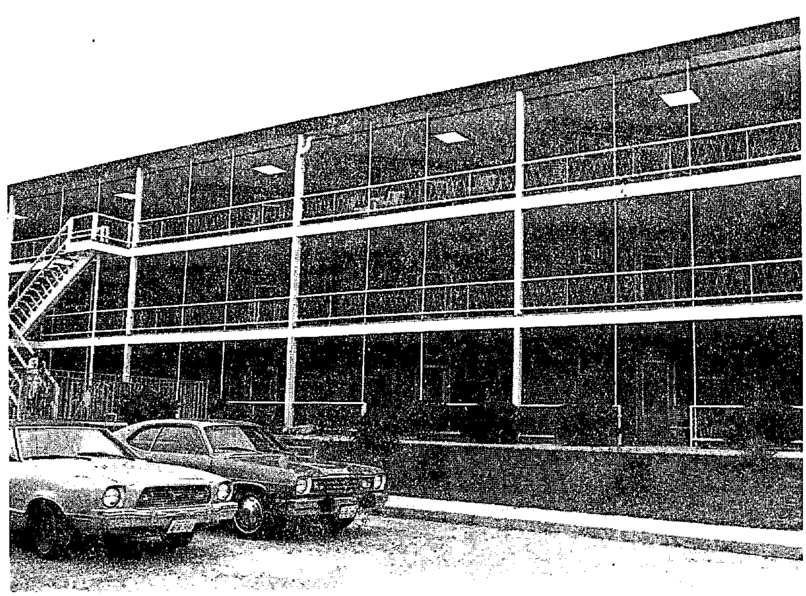


EARTH FILL
Fill elevates this house above the base flood level. This example is typical of modern day construction with fill.

EARTH FILL
Borrowed fill was used to elevate this house on the Atlantic seaboard above the base flood level.



EARTH FILL
The first floor of these garden apartments is elevated on earth fill. Note that the swimming pool for the apartments, shown in the left of the photo, is also elevated above base flood level.



Designing Elevated Foundations

DESIGNING ELEVATED FOUNDATIONS: INTRODUCTION

The first factor to consider in contemplating the design of an elevated foundation is the appropriateness of using a raised building construction strategy. Elevating buildings in flood-hazard areas to reduce flood damage is just one way to build in a manner compatible with the flood risk. Several general considerations bear on the appropriateness of using elevated foundations to minimize flood damage.

Since Congress has made the availability of flood insurance—as well as federal mortgage guarantees, mortgage loans, and other lending by federally insured or regulated financial institutions for construction in flood-hazard areas—conditional upon participation in the National Flood Insurance Program, compliance with the provisions of national flood legislation and local codes will be a major consideration for both the community and the individual homeowner. A thorough review of applicable federal and local regulations should precede design and construction.

Another important consideration is the unique characteristics of the flooding which is likely to occur in a flood-prone area. A coastal, wind-driven flood is different from either a canyon or riverine flood, thus different characteristics need to be considered for adequate protection. The geological characteristics of a flood-prone area and the environmental conditions and causal factors (wind, hurricane, storms, etc.) for potential flooding must be considered in designing an elevated foundation.

Existing protective works or flood control systems are another factor which influence the protective measures appropriate to a specific community or building site. It is important to recognize that flood-control projects have sometimes created a false sense of security which triggered further construction in flood hazard areas. This development has, in effect, increased the flood problem in the United States because structures built in areas having flood protection works are generally not designed to resist and provide protection from the floods that may still occur. Thus, such development may increase the possibility of future flooding if it is not designed to accommodate the flood risk.

It is essential to recognize as well that the cumulative effect of building encroachment in the flood plain will obstruct the passage of flood waters, causing adverse effects not only for local residents, but for entire river basins. By restricting the flow of flood waters, such development raises the flood level locally and upstream, and may also aggravate such other problems as sedimentation, scouring and erosion.

The floodway concept has been developed for riverine areas to promote sound development. The flood plain should be thought of as two separate areas: the floodway, located adjacent to the river channel, is the land area required to carry the floodwaters to the base flood. This area must be kept clear of obstruction. The flood fringe areas extend out from the floodway, and should be developed only with adequate precautions.

Based upon hydrologic and topographic studies, as well as on planning decisions, the limits of the floodway can be established and mapped, insuring that the base flood can be discharged without increasing the water surface elevation more than one foot at any point.

All communities participating in the National Flood Insurance Program are required to adopt flood plain management regulations, once sufficient technical information is available, to prohibit fill, encroachments, new construction and substantial improvement of existing structures within the designated floodway which would result in any increase in flood height during a recurrence of the base flood.

An analogous concept is used for coastal areas. The flood plain is divided into the coastal high hazard or velocity area and the general coastal flood plain. Construction may only occur within a coastal high-hazard area if the structure is elevated on adequately anchored piles to the level of the base flood, and if the space below the structure is kept free of obstruction in order that the impact of wave action and wind-driven water will be minimized.

Lastly, an important consideration is the economic, social, political and especially geographic characteristic of the community in which construction is contemplated. Each community has different conditions, constraints, and pressures which determine how a flood plain is developed. It is at the community level that all these factors interact. It is there that decisions affecting community development and environmental quality are weighed against the types of construction that can safely be placed in flood-hazard areas.

GUIDELINES AND PERFORMANCE CRITERIA

Beyond these general considerations, guidelines and criteria have been developed which, if appropriately used, will reduce flood losses. Specifically, the information which follows has been developed for light-frame residential structures utilizing elevated foundation systems. The construction guidelines describe various techniques which should be preceded by the analysis of local codes and flood conditions. The performance criteria state desired objectives which the residential structure should achieve. These guidelines and criteria should provide useful counsel, but they are not regulatory requirements.

Apart from building on fill, three elevated foundation techniques are widely used today for flood plain construction: wood post, wood pile, and reinforced concrete and masonry piers. For each elevated foundation type, guidelines are presented for design and application. However, caution and professional assistance should be used in the application of these general guidelines to specific situations.

Varying soil types, flood conditions, and environmental factors may require the use of additional or modified construction techniques to effectively utilize any of the three foundation types described.

The concept of specifying requirements in terms of a desired level of building performance is recognized. A National Bureau of Standards publication has described the performance concept as "an organized procedure or framework within which it is possible to state the desired attributes of a material, component or system in order to fulfill the requirements of the intended user without regard to the specific means to be employed in achieving the results."

Performance criteria describe objectives in terms of the desired performance of the building subsystem to be designed. They permit the generation of many alternative solutions which yield this performance, and criteria and test methods are established to assure that the performance requirements are fulfilled.

This method of specifying building requirements is in direct contrast to most prescriptive specifications, which clearly state the materials of which the building element is to be made, its dimension, finish and shape, and how it is to be installed.

The advantage of discussing specifications in terms of performance standards is two-fold: 1) to inform builders, designers, and homeowners who live or are going to build in a flood plain of the general levels of performance the building should achieve during a flood condition; 2) to enable designers and homebuilders to develop creative and innovative solutions to flood problems as long as the performance criteria are satisfied.

DESIGN AND CONSTRUCTION FACTORS

Five specific design and construction factors are applicable to raised structures regardless of the foundation material or method employed to elevate the structure. These factors are: site conditions, durability and maintenance, insulation, utilities, and breakaway walls.

SITE CONDITIONS

A thorough site analysis is essential to the design of a proper elevated foundation and to determine the best building placement for minimizing the flood hazard. Building placement, building design, and the elevated foundation work together to determine how aesthetically and effectively a building is integrated with the site. The following five site conditions are among those that must be considered to achieve this integration:

1. *FLOOD ELEVATION*—The base flood datum level determines the height above grade at which the first habitable floor of a residence must be built. This height will influence the foundation design and help determine the landscaping measures appropriate for flood protection. In most cases, the finished surface of the first floor should be built to or above the Base Flood Elevation, however, in the coastal high hazard areas, the bottom of the lowest structural member should be at or above the Base Flood Level.

2. *DIRECTION OF FLOOD FLOW* – A residence should be oriented on its site in a way that will provide minimum resistance to the flow of flood waters. This requires that foundation walls extending above grade and solid infill walls at ground level be constructed parallel to the primary flow of flood waters. The surface area of such walls exposed to flowing flood waters and their number should be kept to a minimum.

   When column type foundations, such as piers, posts, or piles, are used an effort should be made to keep their number to a minimum and direction of maximum spacing perpendicular to the flow. This will help to limit debris build-up and excessive loads on the structure.

   If it is desired to enclose space at ground level and flowing flood waters are anticipated, the solid infill panels used to enclose the space should be of a breakaway variety. Breakaway fencing may also be used in velocity flow situations. If no debris build-up is anticipated, the fencing may be designed to include voids that will permit the water to flow through it (see Breakaway construction section, page 2-10).

3. *LANDSCAPING* – Landscaping of the site can provide useful protection against erosion, debris impact, and vandalism as well as enhance the design of the structure. Trees, plantings, fencing, earth berms, etc., can all provide this dual function of utility and aesthetics.

   Trees can be particularly useful as a natural barrier for deflecting debris from impacting on building foundations. Size, spacing, and placement of trees in relation to flood flow will determine their effectiveness.

   Trees, shrubs and other site vegetation also provide valuable aesthetic elements. They have the advantage of allowing water to flow freely and with proper placement will not cause dangerous debris build-ups. It should be noted that many small shrubs and trees may be lost in high velocity floods.

   Additional protection for an elevated structure can be achieved by altering site contours to channel water around and away from the structure. Earth mounds and berms may be used to shield a building from debris impacts that could severely damage the structure. [Refer to HUD manuals 4075.6, *Compacted Fills* and 4075.7, *Slope Protection*.]

4. *MEANS OF ACCESS AND EGRESS* – Buildings designed for flood hazard areas should provide some means of emergency egress and access during flooding. This consideration implies a concern for the safe evacuation of a residence if flood conditions make it necessary and for the community's continued ability to provide police, fire, and health services during a flood.

   The individual home owner can deal with this problem by assuring that some part of his home will be accessible by rescue boat and that this accessible portion will provide some means of exit and entry such as a door, deck, or window. Provision should also be made for safe access to a residence's roof from within the structure through some type of locking roof latch. Occupants could be forced to the roof by flood waters rising faster and higher than anticipated. The roof could also provide a good pickup point for helicopter rescue.

   Community strategies for confronting this access problem could include any or all of a wide variety of alternatives. Some of these alternatives are: raise roads and driveways in flood hazard areas; provide fire, police and health services with the proper emergency vehicles; develop early flood warning and evacuation plans; require homes in the flood areas to have emergency flood kits containing such things as first aid supplies, inflatible raft, fire extinguishers, emergency food and water, signalling devices, etc.; and lastly, develop good flood plain management regulations.

5. *DRAINAGE* – Good site drainage should allow flood waters to recede from a site without eroding it or leaving standing water that could cause structural deterioration or produce a health hazard.

DURABILITY AND MAINTENANCE

A building elevated above grade with the underside of its floor area exposed to climatic and flood conditions will require special maintenance to insure the useful life of the structure. The maintenance measures required largely depend upon the materials used for the foundation, floor framing and finishing, and the climatic conditions they are subjected to. These maintenance measures fall into four general categories: 1) treatment of foundation and floor framing materials, 2) care of the underside of floor deck, 3) care of exposed structural connections, and 4) care of ground area.

1. *TREATMENT OF FOUNDATION AND FLOOR FRAMING MATERIALS* – The durability of the primary foundation and framing materials, concrete, steel, and wood can be improved by chemical treatment and coatings. In the case of wood the individual wood members will be best preserved by pressure treatment with any one of a number of chemical preservatives. These preservatives make the wood resistant to fungi attack, insects, bacteria, rot and marine borers. Local conditions, requirements, and cost will determine the best treatment for each foundation. The American Wood Preservers Institute (AWPI), with offices at 1651 Old Meadow Road, McLean, Virginia 22101, can provide information for your specific needs.

   Steel framing and foundation members below the base flood can be protected by galvanization or by painting with rust retardant paints. The need for painting can be eliminated through the use of surface oxidizing steels (high strength low alloy). The American Iron and Steel Institute (AISI) can assist in answering particular questions on steel and its maintenance requirements. AISI's main offices are at 150 East 42nd Street, New York, N.Y. 10017.

   The durability of reinforced concrete and masonry block can be improved by the use of chemical additives mixed with the concrete and mortar and by special treatments and coatings. Additives are numerous and vary from those that will prevent spalling due to freezing to those that will improve strength. Surface treatments and coatings, such as silicone and epoxy paints, can be used to reduce water absorption and penetration, and to prevent damage by airborne pollutants. Corrosion of reinforcing steel in concrete that may be subject to salt air and salt water conditions can be minimized by using galvanized reinforcing. The conditions a particular foundation will be subject to will determine the methods that should be used to improve its durability and lower its maintenance requirements. Guidance in the use of concrete can be obtained from the Portland Cement Association, Old Orchard Road, Skokie, Illinois 60076. The National Concrete Masonry Association, 2009 14th Street North, Arlington, Virginia can answer questions on concrete masonry construction.

2. *CARE OF THE UNDERSIDE OF THE FLOOR DECK* – The climate and the desired appearance will determine whether or not the exposed underside of a floor should be sealed. Sealing exposed floors will protect subfloors and joists from the elements, improve insulation, and help conceal utilities.

   The material used to enclose floor spaces may be inundated by flood waters and thus should be resistant to water damage or inexpensive to replace if it is not resistant to such damage. Exterior grade plywood that is treated with preservatives is one water resistant material that would be satisfactory. Gypsum products should not be used unless an acceptable level of performance can be demonstrated.

   Regardless of the material used to seal the underside of a floor exposed to the elements, some provision must be made to allow water that may find its way into the floor sandwich during flooding to drain out and for the joist spaces to dry out.

3. *CARE OF EXPOSED STRUCTURAL CONNECTIONS* – The nature of elevated construction exposes many structural connections to the elements and possible inundation by flooding. This exposure will cause deterioration of vital structural links unless measures are taken to prevent it.

   Some effective measures to prevent the deterioration of connections are the use of galvanized bolts and connecting hardware. Connections can be improved further with protective flashing, by treating saw cuts and drill holes with preservative, and by painting the connections. Protection can also be provided by enclosing connections so they are no longer exposed to the weather. All exposed connections should be designed so that water will not collect on or in them.

4. *CARE OF GROUND AREA* – Ground space under an elevated structure that is not used for parking, storage, recreation, or other purposes should be maintained in a manner that will prevent fire or health hazards from developing (e.g., trash and/or garbage accumulation). Such ground areas should be surfaced with a material that will minimize erosion and water runoff. Crushed stone or vegetation appropriate to the area are two surfacing solutions. These comments apply equally to structures that are not elevated to a height where the ground space becomes usable.

INSULATION

Exposed floors of elevated residences have to be insulated against heat losses and heat gains just as the walls and roof of the structure do, except there are additional special factors that must be considered. First, elevating a building will expose plumbing to freezing temperatures. Such plumbing must be insulated against freezing. In extremely cold climates, heating cables may be necessary with the insulation. Second, insulated floor decks may be subject to inundation and should therefore use impermeable closed pore insulation able to withstand water submersion or insulation that can be economically replaced. Third, insulation should meet fire code requirements (see Figures 2-1, 2-2, and 2-3).

UTILITY AND MECHANICAL SYSTEMS

Residences are generally served by gas, plumbing, sewer, electrical, fuel, and telephone utility systems. These systems are most vulnerable to water and impact loading damage from the point they leave the ground to the point they

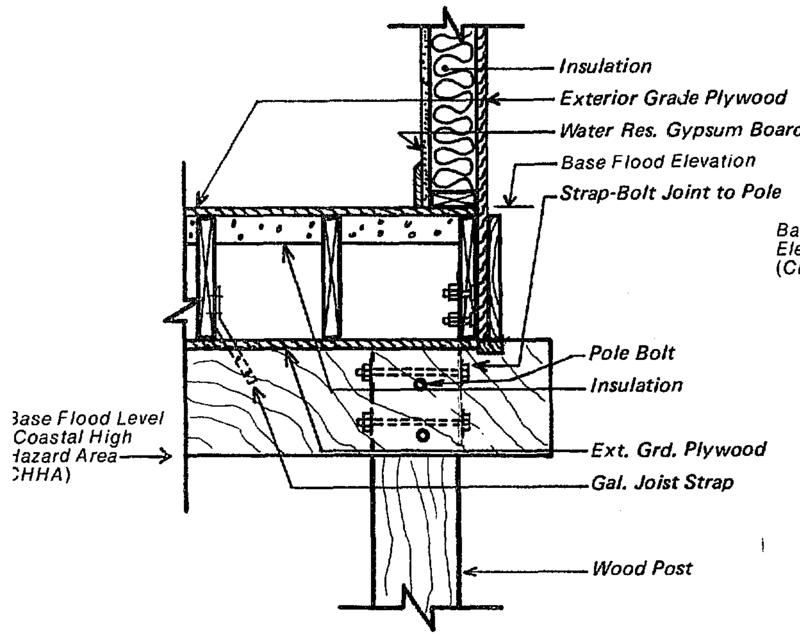


FIGURE 2-1
Insulated Floor Section on Wood Post Foundation

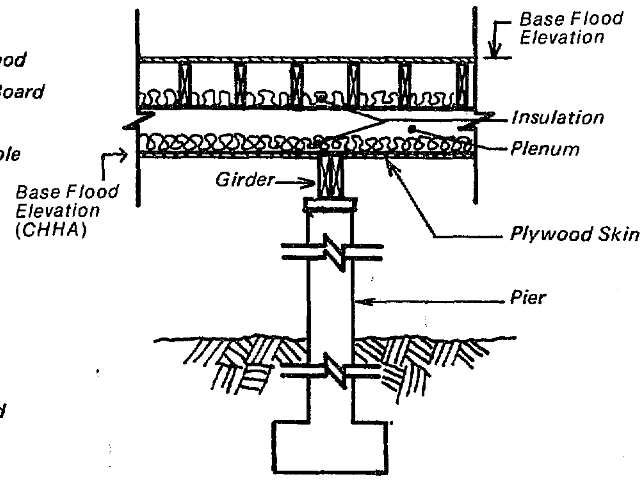


FIGURE 2-3
Double Insulated Floor Plenum Space Pier Foundation

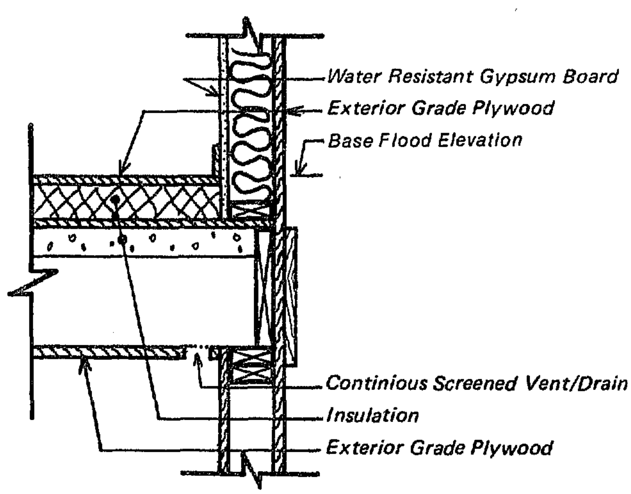


FIGURE 2-2
Insulated Floor Section Foundation Wall

enter the elevated residence. One means of achieving some measure of protection for these ground to house utility links is to bring all the utilities together in one linkup core that is itself designed to resist flood forces.

Chances for flood damage to utility distribution systems in the home can be reduced by limiting as much of these systems as possible to ceilings and walls. Electrical outlets, for instance, should be fed from the ceiling rather than the floor.

The heating, ventilating, and air conditioning equipment of a home should be elevated above the base flood level. An attic location, if available, would provide the equipment maximum safety. Low points of duct work should be fitted with drains to bleed off any flood water that gets into the system.

The following drawings demonstrate some of these concepts:

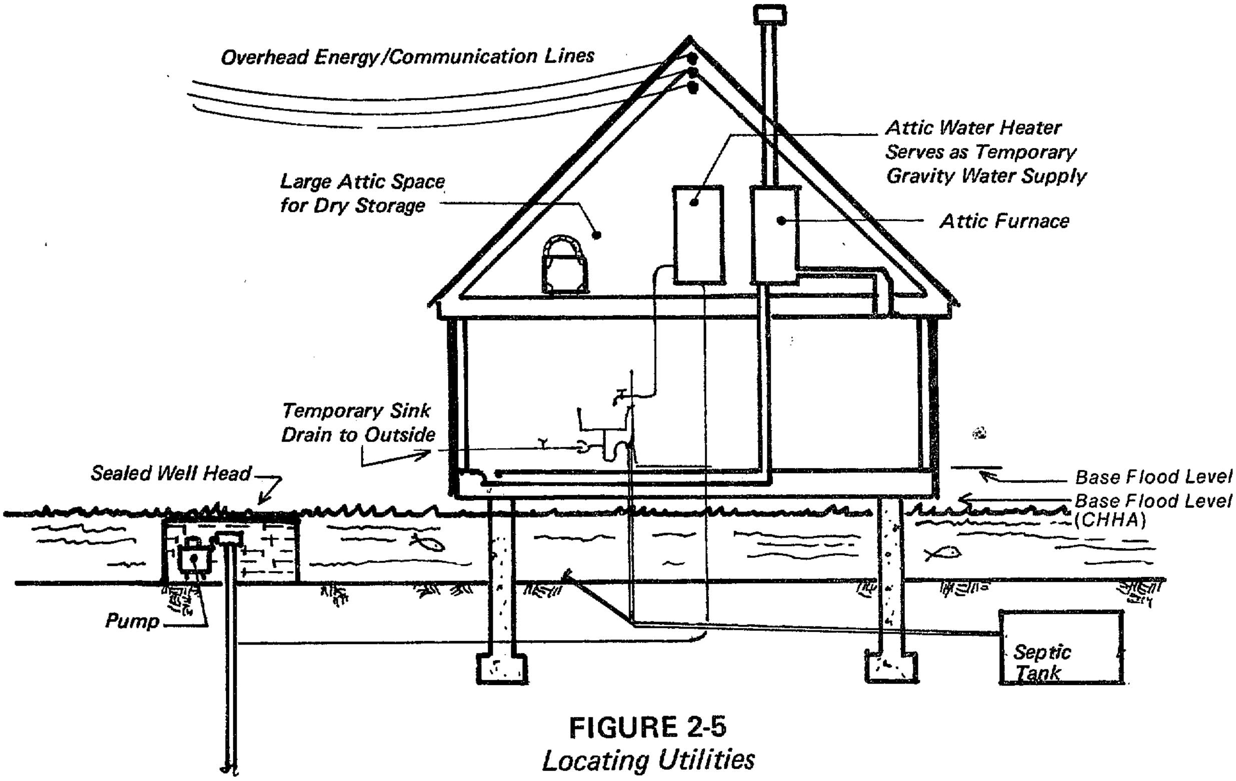


FIGURE 2-5
Locating Utilities

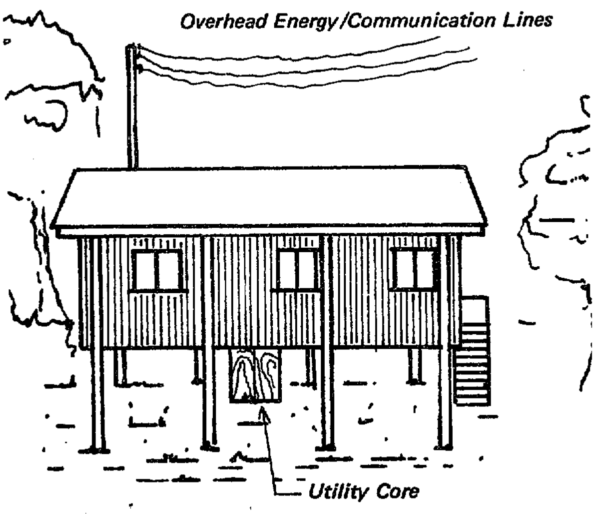


FIGURE 2-4
Utility Access Core

BREAKAWAY WALLS

In some instances it may become desirable for storage or recreation, or necessary because of climate to enclose part or all of the ground level under an elevated structure in Coastal High Hazard Areas (CHHA). The walls used to form the enclosed space must be designed so that they do not allow the pressure and velocity force of water and water-borne debris to load the structure excessively. Design techniques to avoid this problem include: walls that break away or fail under flood loads but remain attached to the house or are heavy enough to sink and not create a water-borne debris problem, walls that can be detached and stored before a flood, walls that hinge and can be swung out of the path of flood waters and debris, and where no debris flow is expected, louvered walls that will allow water to pass through them.

All ground level infill wall designs should:

1. Allow flood waters to rise and flow freely under the structure.
2. Not permit the infill walls themselves to become water-borne debris.
3. Not cause the accumulation of water-borne debris.

Figures 2-6 through 2-9 demonstrate some of the design approaches mentioned above.

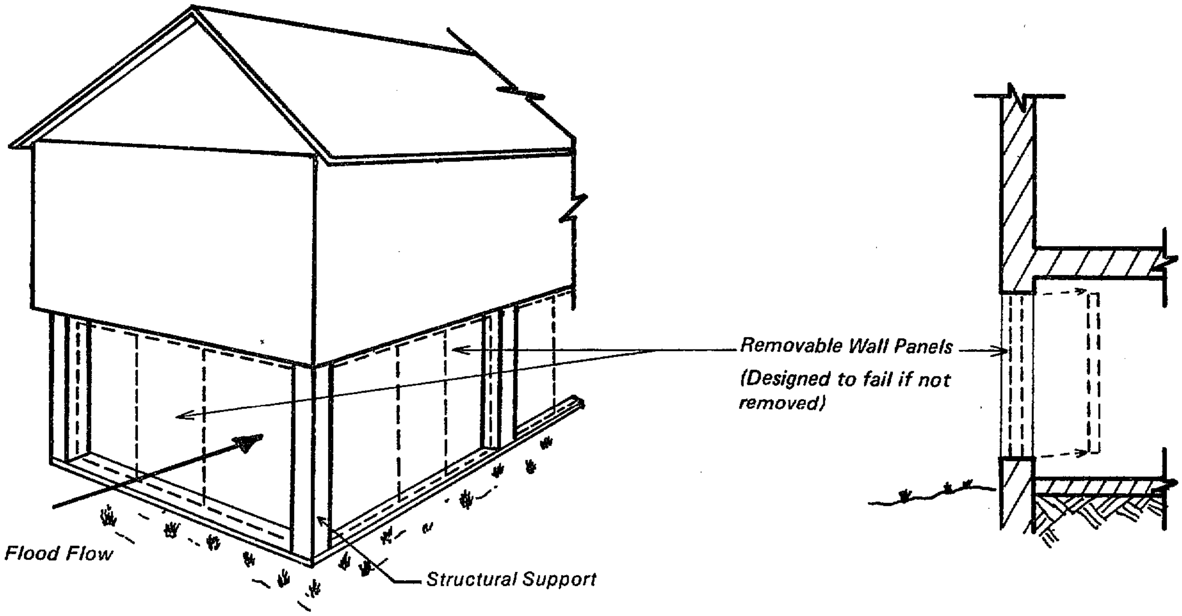


FIGURE 2-6
Removable Wall Panels

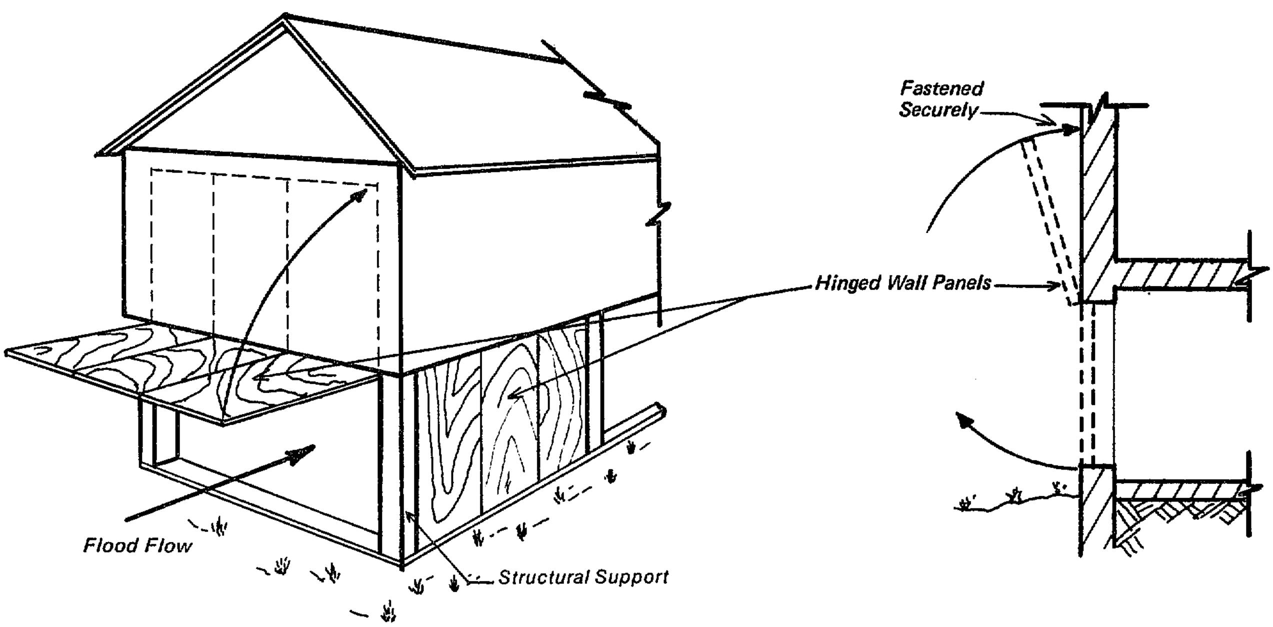


FIGURE 2-7
Hinged Wall Panels

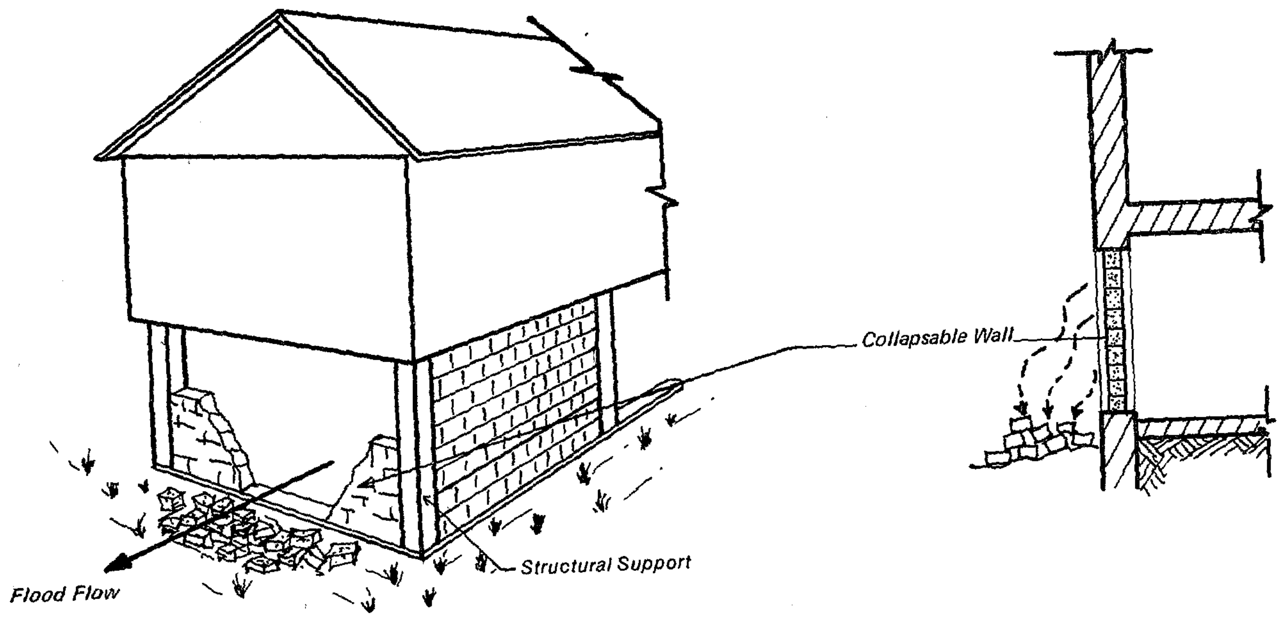


FIGURE 2-8
Collapsible Block Wall

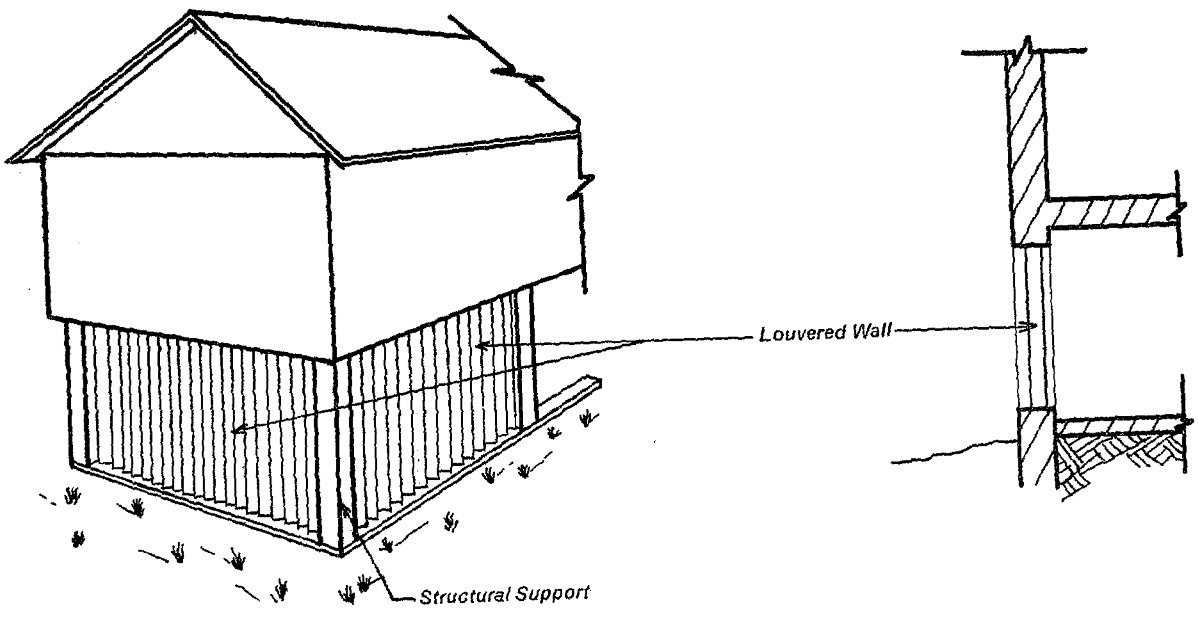


FIGURE 2-9
Louvered Wall

POST AND PILE FOUNDATIONS

The safety and satisfactory performance of post and pile foundation designs for flood hazard areas depend on the proper analysis of flood loads and soil conditions, as well as normal loads, stresses, and deflections. An architect or engineer should be consulted for this analysis and design.

The following guidelines for post and pile foundations are a collection of design and construction ideas intended to show those who plan to build post or pile foundations in flood hazard areas some of the techniques currently being used.

Wood, concrete, or steel can be used for posts or piles. The material that is selected should present no special difficulties since there are well known techniques for dealing with each.

POST FOUNDATION

This type of foundation utilizes long slender wood timbers or steel columns set in pre-dug holes or on concrete footings, piers, or pile caps. The timbers may be round, square, or rectangular in section--the square and rectangular sections being easiest to frame into. Steel columns can be found in all these sections plus wide flange sections and numerous others.

Post foundation holes are dug by machine or by hand. Bearing capacity and stability is improved by pouring a concrete bearing pad at the bottom of the hole and/or pouring a collar around the post after it has been partly backfilled.

Post foundations may be set by hand or machine. The longer and heavier the posts become the more necessary machinery will be. Sixteen foot wood posts are about the maximum men can handle safely without machine assistance.

The post type foundation must be adequately anchored and braced to resist both normal and flood loading conditions.

PILE FOUNDATION

This foundation type is constructed of long slender wood, steel, or reinforced concrete piles that are mechanically driven or jetted into the ground. Vertical loads can be carried by piles driven to a load bearing layer, such as rock (end-bearing piles) or by driving the piles deep enough into the earth to develop enough friction between the surface of the piles and the surrounding soil to carry the load (friction piles). Friction piles also have an end-bearing component.

Although post and pile foundations are similar, one important difference should be noted–piles are mechanically driven or jetted while posts are set in pre-dug holes. Both may use wood poles.

The availability of pile driving or jetting equipment and skilled operating crews in a particular area may influence the selection of the pile technique. The selection of piles or any other elevation technique, however, should not be based solely upon the local availability of men, equipment, or materials. Structural requirements and site conditions will also influence the selection. For example, if heavy scour is anticipated, piles should be used rather than posts.

EMBEDMENT

The depth posts or piles should be embedded is determined by local soil conditions, vertical loads, lateral loads (wind, impact, hydrodynamic, etc.), anticipated scour, uplift, and spacing and size of the posts or piles. The following comments and sketches explain some of the embedment techniques used in wood post and wood pile construction (steel and concrete would be similar) to provide adequate stability and bearing capacity.

WOOD POST FOUNDATIONS– Wood posts are generally embedded 4 to 8 feet. Hole excavations beyond 8 feet become uneconomical.

If design loads are small, and the allowable soil bearing capacity is adequate the post may be set on undisturbed earth at the bottom of the hole and then backfilled (see Figure 2-10).

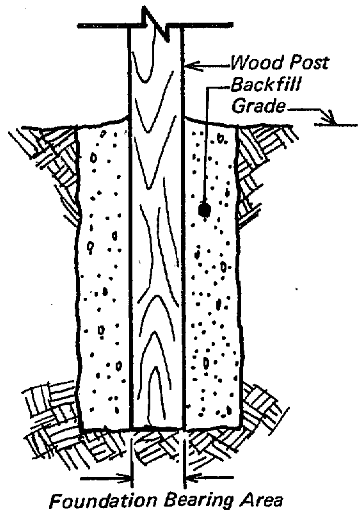


FIGURE 2-10
Earth Bearing

For larger loads and/or poorer soil conditions, a concrete pad should be poured into the bottom of the hole as Figure 2-11 shows. The pad should be approximately as thick as ½ its diameter with a minimum thickness of 8".

Backfilling the hole with concrete rather than gravel or sand, as shown in Figure 2-12, adds stability to the structure and increases the bearing area as in Figure 2-11. Shallower embedment is also permitted with this method. Figure 2-13 shows a variation on the total concrete backfilling method of Figure 2-12. Here the upper portion of the hole is backfilled with concrete to form a collar and the lower portion is backfilled with sand or gravel. This concrete collar has to be a minimum of two feet deep and reinforced with wire mesh to be effective in providing more rigidity to the structure and permitting shallower embedment.

If extremely poor soil conditions are encountered it may be necessary to drive a group of piles and cast a pile cap for each post to bear on. This is demonstrated in Figure 2-14.

Wood posts may also be raised entirely (see Figure 2-15) out of the ground on concrete piers. More thorough maintenance is possible with this approach but additional bracing may be required for lateral stability.

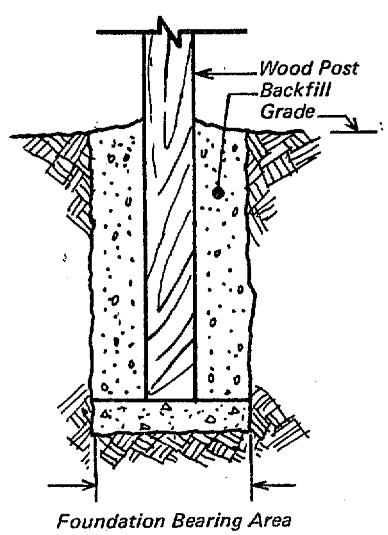


FIGURE 2-11
Post on Concrete Bearing Pad

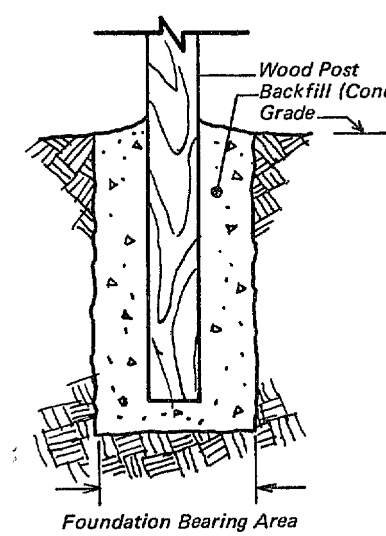


FIGURE 2-12
Concrete Backfill

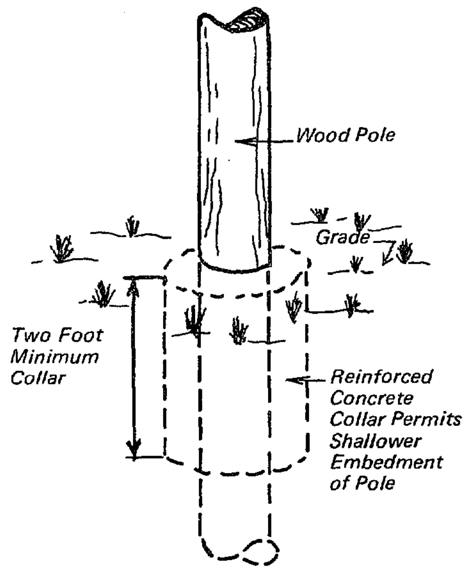


FIGURE 2-13
Concrete Collar

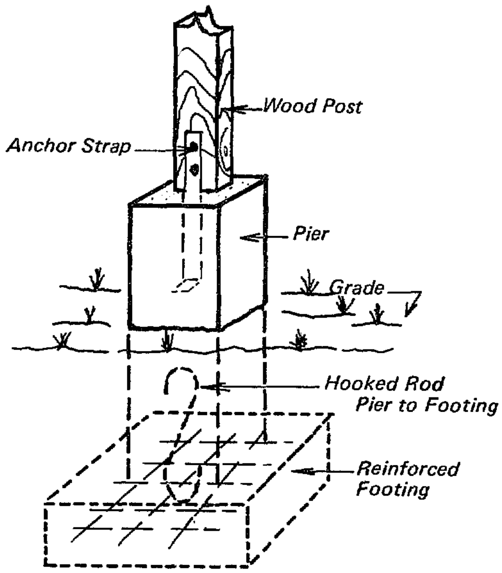


FIGURE 2-15
Post-Pier Foundation

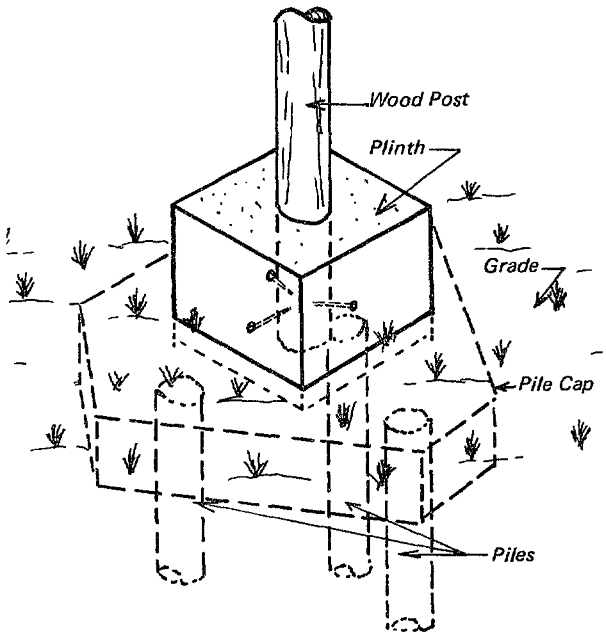


FIGURE 2-14
Pile/Pole Foundation -- Low-Load Capacity Soil

<u>HOLE SIZE</u> – In post construction the hole should be a minimum of 8" larger in diameter than the greatest dimension of a post section. This allows for alignment and backfilling.

<u>BACKFILLING</u> – A clean well consolidated backfill is necessary to assure a structure of good lateral stability and resistance against wind and water uplift. Some of the common backfill materials are: sand, gravel, crushed rock, pea gravel, soil cement, concrete, and earth.

Most backfill materials should be mechanically tamped to adequately consolidate and compact them. Wetting backfill materials such as earth or gravel will help their consolidation.

Soil cement is an economic alternative to concrete and attains strength nearly equal to it. Soil cement is made by mixing the earth removed from the dug hole with cement in the ratio of 5:1 (earth:cement). To achieve the best results all organic matter should be removed from the earth and it should be sifted to remove all particles larger than one inch.

Granular type fills that provide good drainage are generally considered the best. Drainage around the posts or piles at grade level should be positive to keep water from collecting and deteriorating the posts.

ANCHORAGE

Good anchorage of posts or piles to the ground is essential to preventing wind and flood forces from overturning or uplifting elevated structures.

<u>PILE ANCHORAGE</u> – In the case of piles, research and experience indicate that the friction force of earth against the sides of the pile will support the major portion of the vertical loads. The allowable frictional capacity, however, may vary from one code to another. Lateral loads will be discussed in the bracing section that follows.

<u>POST ANCHORAGE</u> - Two ways to anchor post foundations are to 1) embed them in concrete or 2) to fasten them to metal straps, angles, plates, etc., that are themselves anchored in concrete footings, piers or pile caps.

1. Figure 2-16 shows one method of anchoring wood posts in concrete. Large spikes or lag bolts (5/8" to 3/4" dia.) are driven into the post around its base prior to pouring the concrete footing. Once the concrete footing has been poured, the post is placed into the concrete and secured to bracing restraints to prevent penetration through the footing while the concrete sets.

2. The metal fastening method of anchorage can be used above or below ground. Figure 2-17 has a square wood post lag bolted to a metal shoe that is anchored in a pier. In Figure 2-18, heavy gauge galvanized steel straps are used to anchor the wood post to a concrete pad.

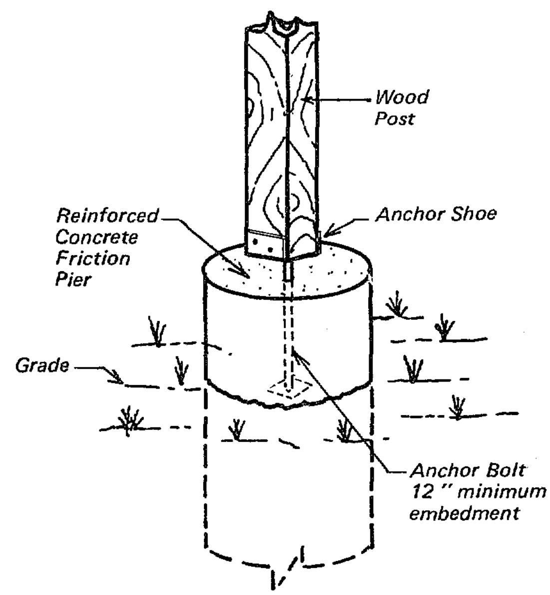


FIGURE 2-17
Metal Angle Anchorage Detail

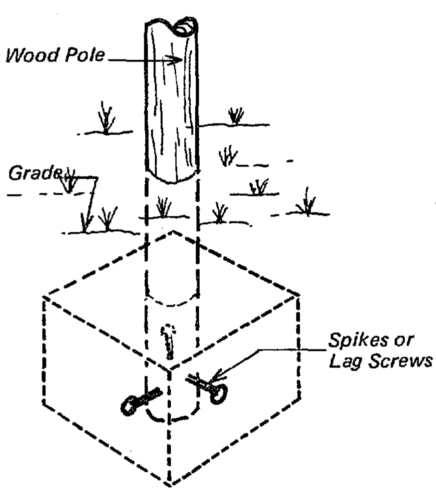


FIGURE 2-16
Spike Anchorage of Pole

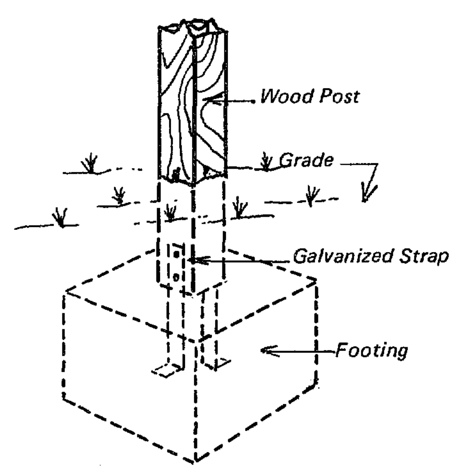


FIGURE 2-18
Galvanized Strap Anchorage Detail

BRACING

Post and pile foundations are braced when it is determined that their size, number, spacing,and embedment condition will not be sufficient to resist lateral forces. The most common methods for bracing post and pile construction are: wood knee and cross-bracing, threaded rods, guy wires, floor diaphragms, and shear walls.

If a post structure is laterally braced it will reduce the embedment to a depth that is necessary to prevent uplift, drift, and slippage. The minimum depth required for posts is 4' or solid rock if it is reached in digging.

WOOD KNEE AND CROSS BRACING – Knee bracing, shown in Figure 2-19, is usually 2" X 6" lumber nailed or bolted between the floor joist and post or pile. Cross-bracing is bolted or nailed at the base of one post or pile and fastened in a like manner to the adjacent post or pile just below the floor beams.

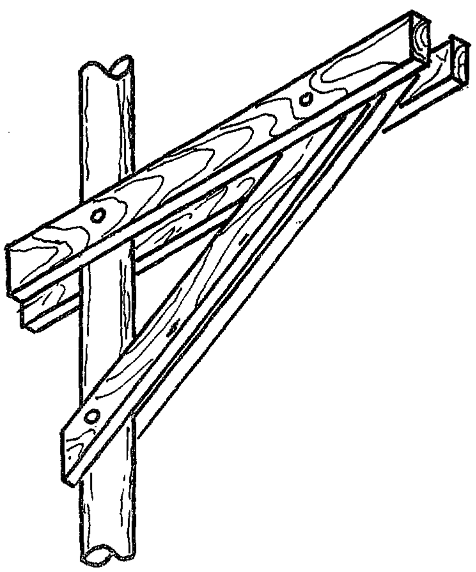


FIGURE 2-19
Knee Brace

THREADED RODS – Rod cross-bracing for wood posts or piles is accomplished by fitting the rods through drilled holes flooded with preservative and fastening the rods with nuts and cast beveled washers (see Figure 2-20). Welded connections or drill-holes could be provided in steel post or pile foundations for similar bracing schemes. The usual size of the rods is 5/8" to 3/4" diameter.

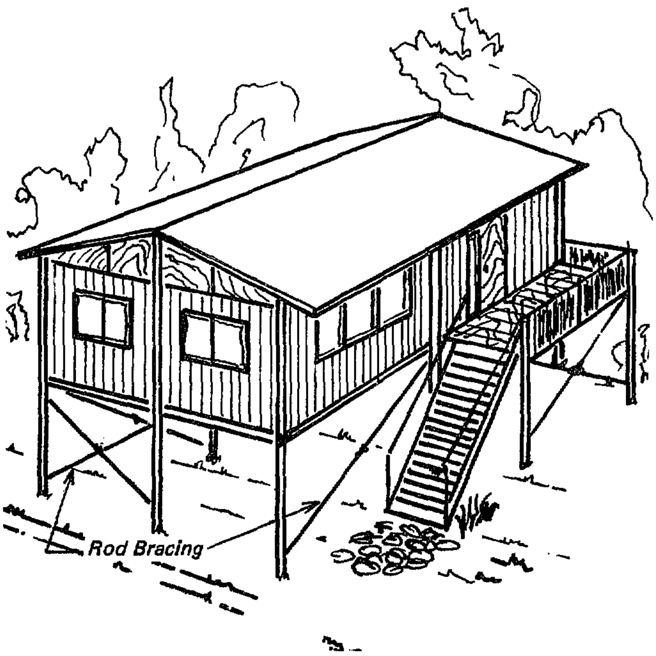


FIGURE 2-20
Rod Braced Post House

Rod bracing is particularly suited for use in areas where water, debris, and wind forces could be extremely large. This is because the rods provide adequate strength while presenting a relatively small surface area to water, wind, and debris.

GUY WIRES – The unsightly nature of this method as well as the inherent possibility of accidents (clotheslining of people and pets) suggests that it be used with caution and primarily where other methods of bracing are not possible.

SHEAR WALL BRACING – Shear walls can be used to brace post and pier foundations if they are carefully designed and installed. The shear walls must be rigid under the design loads and firmly attached to the posts or piles to prevent them from moving. The nails, plywood sizing, shear wall edges (chords), and tie downs are all factors in the proper use of this method of bracing. A shear wall storage room or stairwell is a possible use of this method of bracing (see Figure 2-21).

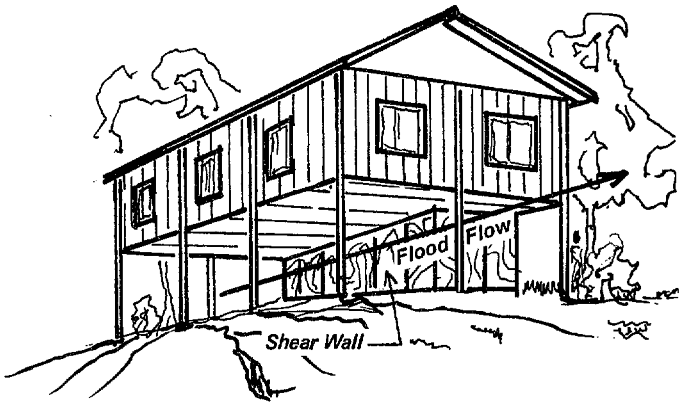


FIGURE 2-21
Shear Wall Braced Post House

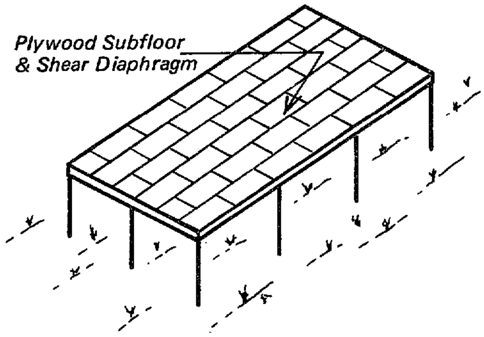


FIGURE 2-22
Floor Diaphragm Bracing

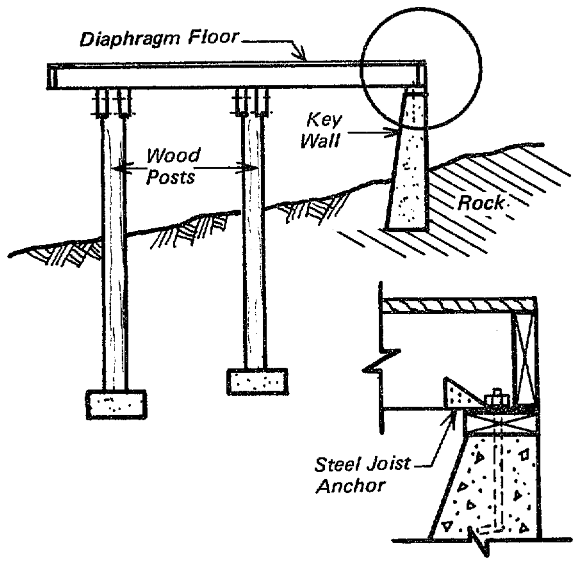


FIGURE 2-23
Key Wall Section

FLOOR DIAPHRAGM BRACING – Used in conjunction with a shear wall or a concrete key wall, a floor diaphragm can be used to transfer horizontal forces or reduce embedment when solid rock is reached when digging foundation holes. The floor diaphragm can be used with either pole frame or platform construction. Floor diaphragms usually call for the use of ½" to ¾" plywood. The application of the floor diaphragm with a concrete key wall is a practical solution for sloped, rocky sites. The downhill posts or piles can be embedded a minimum depth and the uphill line of the structure is fixed rigidly through the key wall (see Figures 2-22 and 2-23).

FRAMING AND CONNECTIONS

The connection of a post or pile foundation to the framing system of a structure is influenced by three factors: 1) the method of framing used, 2) the cross sectional shape of the post or pile, and 3) the post or pile material, i.e. wood, steel, concrete.

FRAMING METHODS – There are two different methods for framing into post or pile foundations that are in common use today. These are 1) platform construction and 2) pole frame construction.

1. Platform construction entails simply cutting posts or piles off at the desired elevation and framing them with beams to support floor joists and deck. The platform thus formed serves as the first habitable floor and construction platform for any type of anchored conventionally framed structure desired (see Figure 2-24).

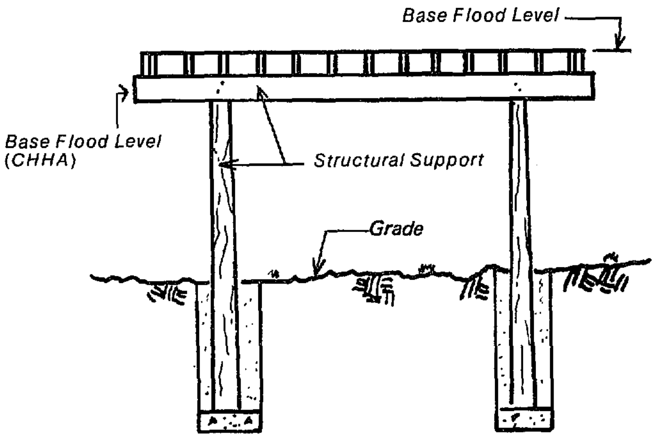


FIGURE 2-24
Platform Construction

A basic problem faced in both platform and pole frame construction is alignment of the structural supports. Posts can be easily plumbed and aligned before they are backfilled but piles must be jacked and pulled into position. Alignment is more critical and difficult for pole frame construction utilizing piles than for platform construction utilizing them.

This alignment problem of piles in pole frame construction and the varying diameter and round shape of wood piles dictates that they be located either on the exterior of the building or on the interior but not in the walls. It is difficult and expensive to make wall finishes meet the poles at close tolerances (See Figure 2-26).

2. Pole frame construction has the posts or piles extended up to or through the roof with beams framing around them as supports for floor joists (see Figure 2-25). This method securely ties the entire structure together and is excellent for high wind situations. Wood piles are generally driven butt first in this method because framing into the narrower part of the pole is easier.

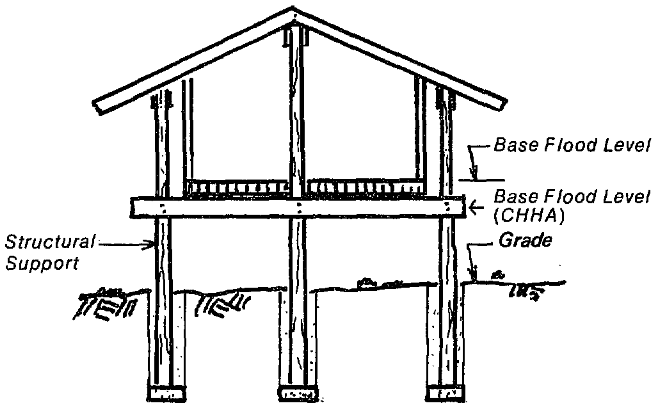


FIGURE 2-25
Pole Framing Construction

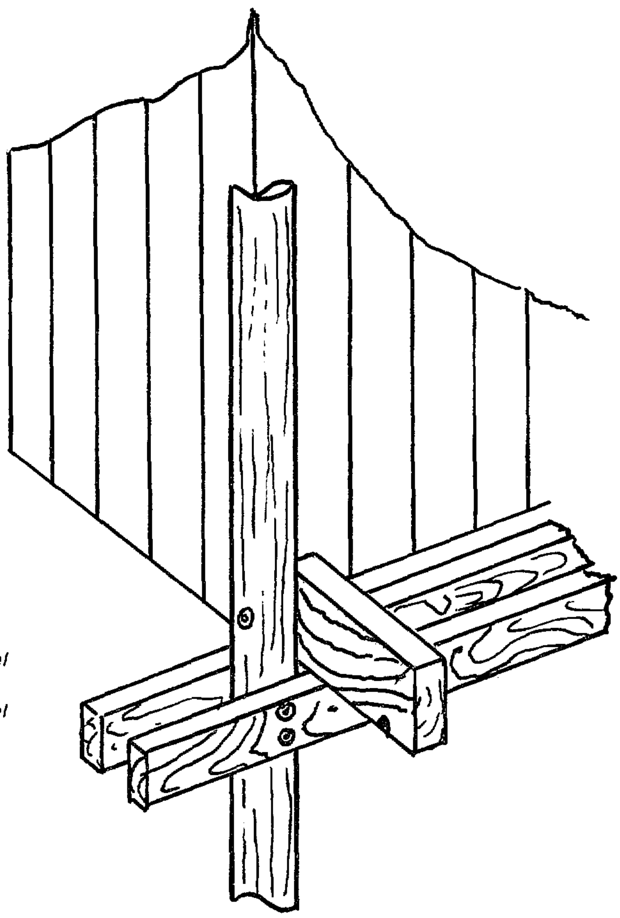


FIGURE 2-26
Exterior Pole Framing

CROSS SECTIONAL SHAPE– Rectangular and square post or pile sections usually require only conventional framing techniques similar to post and beam construction. Round sections, however, demand special concern for the connecting details. Connecting methods are reviewed in a succeeding section.

PLATFORM AND POLE CONSTRUCTION CONNECTIONS – Timber connections in platform and pole construction are similar and their design is similar to conventional framing methods thus allowing standard bolting and nailing values to be used. When round poles are used, the framing is somewhat complicated. With round wood poles it is generally best to frame the poles with a pair of beams, girders, or rafters--one on each side.

The roundness of wood poles is not considered when using bolted or spiked connections as shown in Figure 2-27. The design of framing is then the same as for any other timber member.

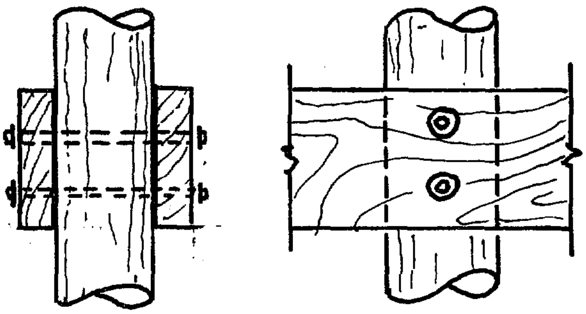


FIGURE 2-27
Bolted Connection to Round Pole

Another method of connection is to eliminate the curve of the pole by dapping and then connect with bolts, nails, gusset plates, or other connecting devices. As Figures 2-28 and 2-29 show, a dapped pole will form seats that assist the beams in carrying verticle loads. Poles that are small in section, however, should not be dapped.

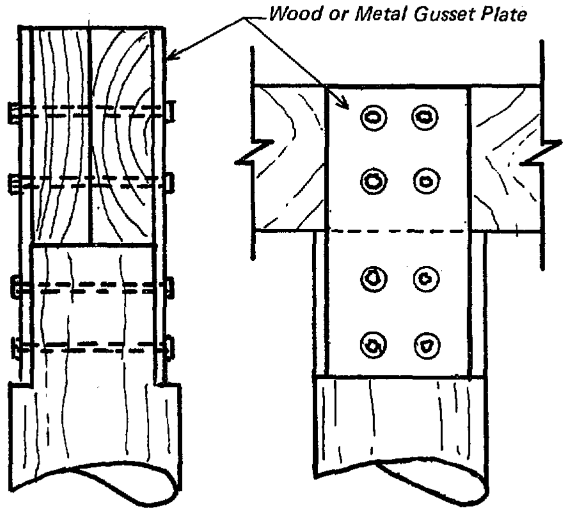


FIGURE 2-28
Dapped Gusset Plate Connection

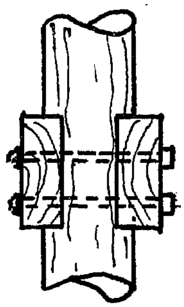


FIGURE 2-29
Dapped Pole Connection

Spike grid connections (see Figure 2-30), standard in bridge and warehouse construction, are less familiar to the home builder. A single curved grid inserted between the pole and the beam substantially increases the strength of the bolted connection. With the curved side of the grid against the pole and over predrilled holes, a high strength threaded rod is used to squeeze the two wood surfaces together forcing the tooth of the spike grid into the grain of both members. The high-strength rod is then replaced with a conventional bolt of the proper size. Each single curved spike grid with a ¾ inch bolt has a carrying capacity of 3800 lbs. in shear and with a one-inch bolt a capacity of 4100 lbs in shear. A flat spiked grid is used to connect two flat surfaces and double curved spiked grids connect two rounded surfaces.

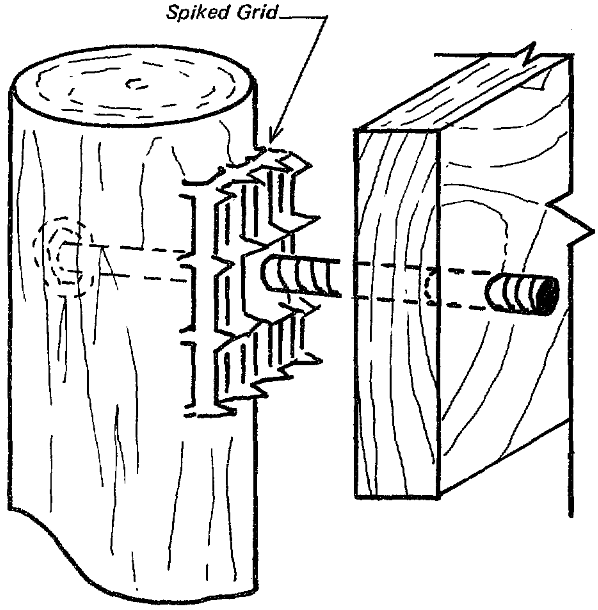


FIGURE 2-30
Spiked Grid

PIERS

Pier construction is another common technique for elevating structures in flood hazard areas. The special loading conditions associated with flooding make it essential that an architect or engineer be consulted for the design of pier foundations.

The guidelines which follow review some of the common types of piers and methods of pier construction. Specific site conditions, base flood level, soil characteristics, cost considerations, and material and labor availability will determine which type of pier, if any, is appropriate for a particular site. Additional guidance for the design of pier foundations can be obtained in section 601 of the 1973 edition of the *HUD Minimum Property Standards.*

TYPES OF PIER FOUNDATIONS

Pier foundations are classified here by their material—brick, reinforced concrete masonry, and poured in place concrete.

REINFORCED BRICK PIERS – Brick piers are an effective means of elevating residences. It is essential, however, that they be securely anchored to a properly sized concrete footing and be reinforced. A 12" x 12" pier should be the minimum size used for flood hazard construction (see Figure 2-31).

REINFORCED CONCRETE MASONRY – This type of pier is constructed of hollow concrete masonry units anchored to a concrete footing (see Figure 2-32). This hollow cells of these units should be filled with concrete and reinforced sufficiently to resist the anticipated loads. A minimum pier section for this type of construction should be considered 12" X 12".

POURED-IN-PLACE CONCRETE PIERS– Piers of this type are essentially reinforced concrete columns. They are cast in forms set in machine or hand dug holes. The holes may be widened or belled at the base to form a footing

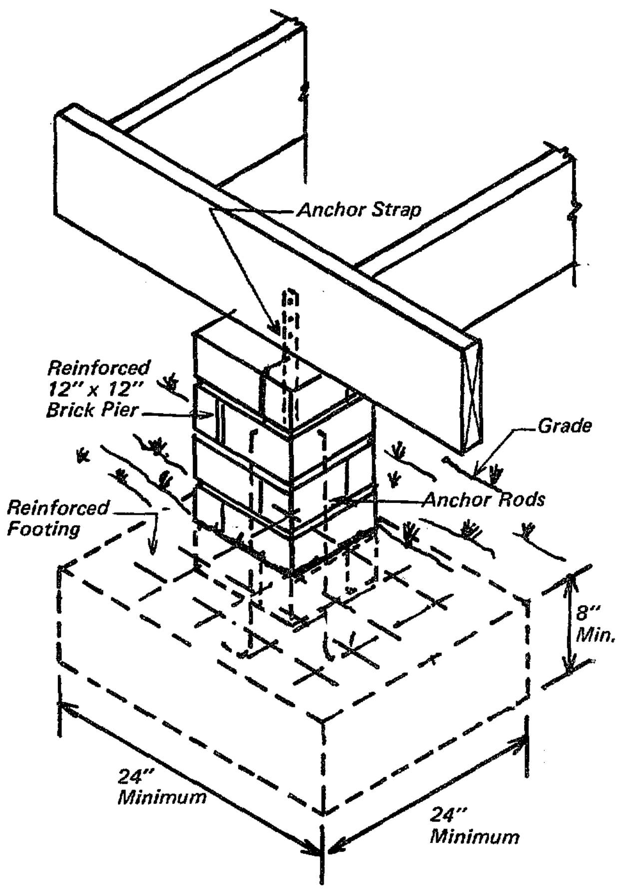


FIGURE 2-31
Brick Pier

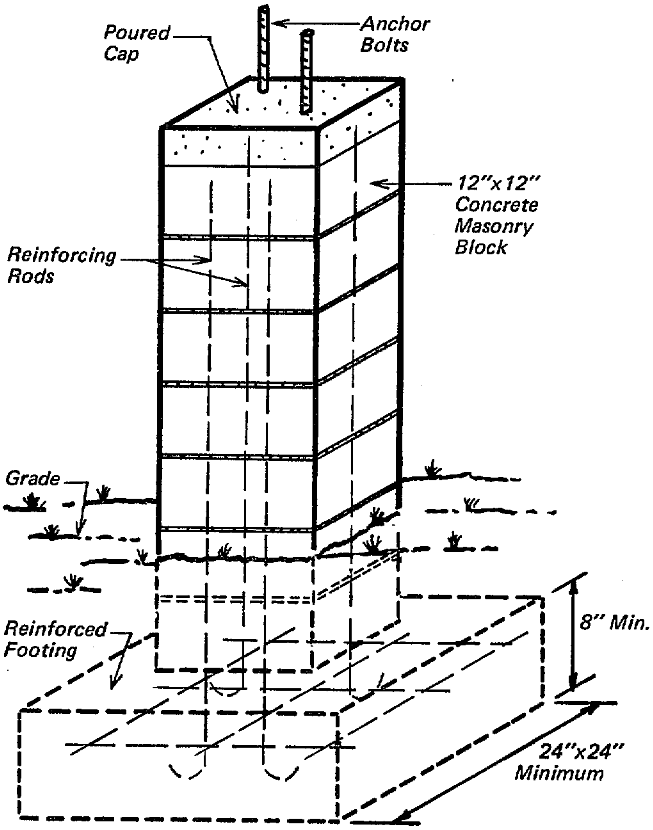


FIGURE 2-32
Reinforced Concrete Masonry Pier

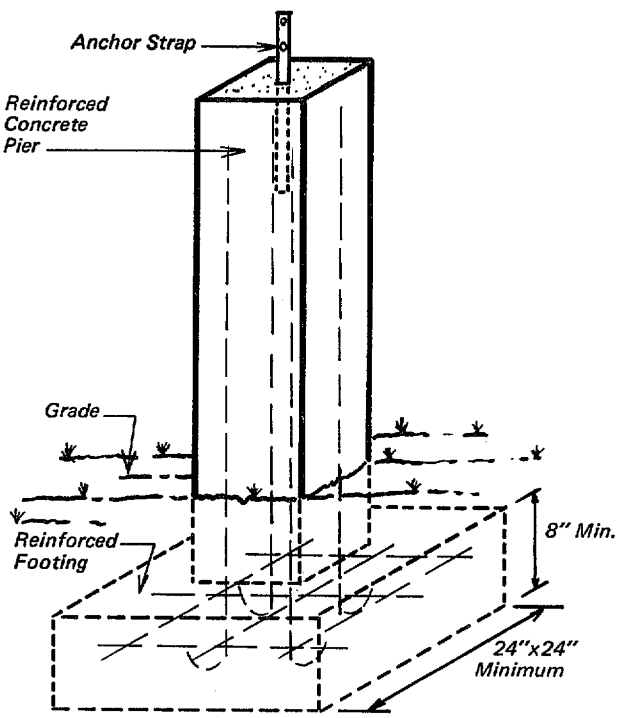


FIGURE 2-33
Reinforced Concrete Pier

integral with the pier, or a separate footing may be poured (see Figure 2-33) or if the soil conditions are right the footing may be eliminated all together and loads left to end bearing and friction between soil and pier.

PIER DESIGN AND CONSTRUCTION

Each pier of an elevated pier foundation should be designed and constructed to function as an independent structural element in supporting and transmitting building and environmental loads to the ground.

SIZE AND SPACING OF MASONRY PIERS – The height of reinforced concrete masonry piers should be limited to a maximum of ten times their least dimension. And if the piers are rectangular (square piers are preferred) the longer dimension should not exceed the shorter dimension by more than 50 percent.

According to the National Concrete Masonry Association, the allowable working stresses for concrete masonry piers are the same as those for the design of concrete masonry walls. The pier masonry should be laid with type M or S mortar. The association also recommends that the spacing between piers supporting floor joists should not exceed 8' in the direction perpendicular to the joists, nor 12' in the direction parallel to joists.

All of the minimum requirements listed above apply whether the pier is free standing or laterally supported.

In cases where exceptionally large loading conditions may exist, the pier cross-section will have to be increased and/or additional reinforcement added. A larger cross-section may be obtained by using pier walls. Reinforced masonry or poured-in-place concrete should be used to construct these pier walls, which are several feet or more in length. The long dimension should be placed parallel to the flood flow, as the example in Figure 2-34 shows.

SIZE AND SPACING OF POURED-IN-PLACE PIERS – Plain and reinforced concrete piers are designed as columns. The design should be guided by the American Concrete Institute's (ACI) standards and formulas with special concern for

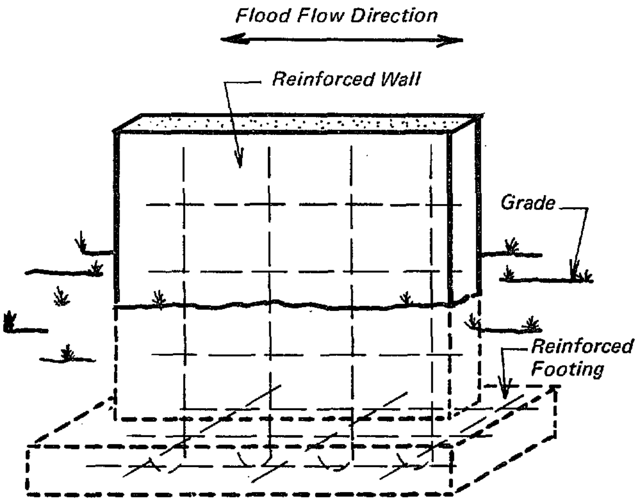


FIGURE 2-34
Wall Foundation

the flood loading conditions. For single family housing their size will range around 12" in diameter or 10" X 10" square.

Spacing of concrete piers is dependent on the type of framing used and on the building and environmental loads.

FOOTING SIZES – Pier footing sizes are a direct function of soil bearing capacity and loading and are easily computed. There are, however, certain minimums that should be observed and these are 24" X 24" X 8" minimum footing for masonry piers and 20" X 20" X 8" minimum footing for concrete piers.

DEPTH OF FOOTINGS – Four factors work to determine footing depth:

1. *FROST* – The bottom of all pier footings should be placed below the locally accepted extreme frost penetration level.

2. *FLOOD HAZARD LOADINGS* – In areas where flood loadings or wind loadings are expected to be high, deeper than normal footing may be required to resist the increased lateral and uplift forces (see Performance Criteria A-1, page 2-30).

3. *SCOUR* – In locales where scour may occur the pier footings must be located well below anticipated scour depths.

4. *HIGH VOLUME CHANGE SOILS* – Footings for pier foundations located in areas known (or determined) to contain soils of high volume change potential should be designed with the recommendations of a qualified soils engineer. This type of soil could create complex problems and should be dealt with cautiously.

FOOTING REINFORCEMENT– All pier foundation footings should be reinforced and tied into the piers. The reinforcing will either be welded-wire fabric for light loads or steel bar reinforcement for heavier loads. Piers and footings can be tied together by hooking reinforcing bars around the reinforcing in the footings and extending them into the piers (see Figures 2-32 and 2-33).

The following table (Table 2-1) summarizes some of the major requirements for pier construction that have been presented in this pier guidelines section.

TABLE 2-1
MINIMUM PIER REQUIREMENTS

Pier Material	Min. Pier Size	Min. Footing Size	Pier Spacing Right Angles to Joists	Pier Spacing Parallel to Joists	Useful Elevation Range
Brick	12" x 12"	24" x 24" x 8"	8' o.c.	12' o.c.	18" to 6'
Concrete Masonry	12" x 12"or 8" x 16"	24" x 24" x 8" 20" x 24" x 8"	8' o.c.	12' o.c.	18" to 8'
Poured-in-Place Concrete	Min. 12" dia., or 10" x 10"	20" x 20" x 8"			18" to 12'+

FRAMING AND CONNECTIONS

Pier foundations face essentially the same framing and connection problems as the other types of elevated foundations—they must be designed to resist normal loading and flood loading conditions. The two critical areas are the connections between floor beams and piers, and the connection between floor beams and floor joists.

PIER-FLOOR BEAM CONNECTION – Floor beams can be anchored to concrete and masonry piers with steel anchor bolts embedded in the pier and bolted through the beams with nuts and large diameter washers. The bolts should have a minimum ½" diameter and be embedded at least 12" in concrete piers and 18 inches in masonry piers. If floor beams butt on a pier, each beam must be anchored to that pier (see Figures 2-35 and 2-36).

FLOOR BEAM—FLOOR JOIST CONNECTION – Uplift and horizontal movement of joists can be avoided by securely anchoring the joists to the beams by any one or a combination of the following three methods: 1) metal framing plates and clips, 2) plywood sheathing or wood siding, and 3) metal strapping

1. *METAL FRAMING PLATES AND CLIPS*— Figure 2-37 shows how these connectors can be used to secure joists to beams. A

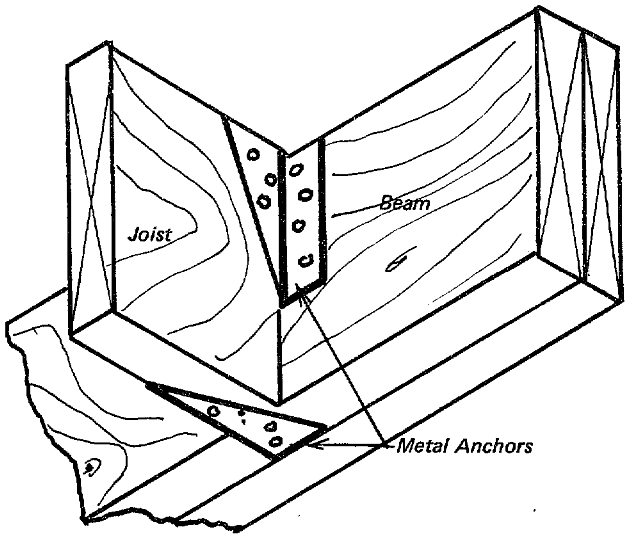


FIGURE 2-37
Metal Framing Anchors

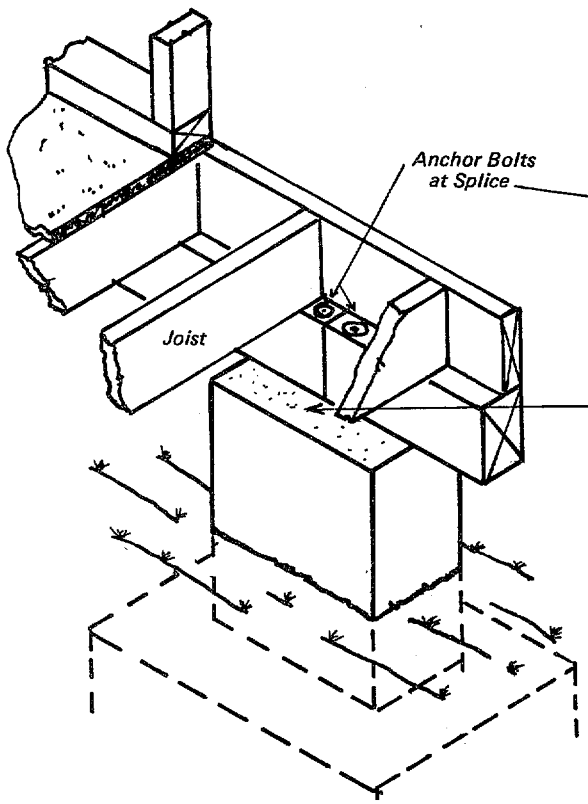


FIGURE 2-35
Beam Splice on Pier

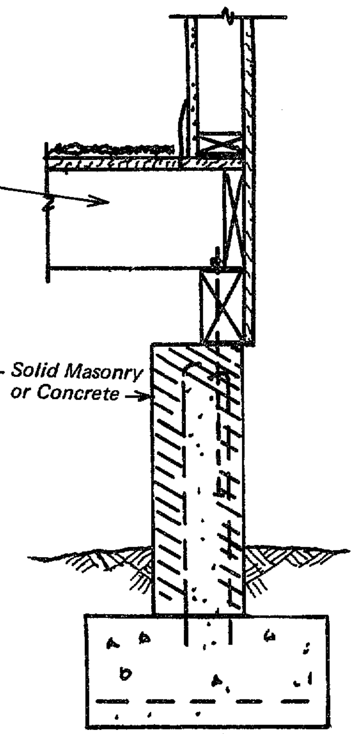
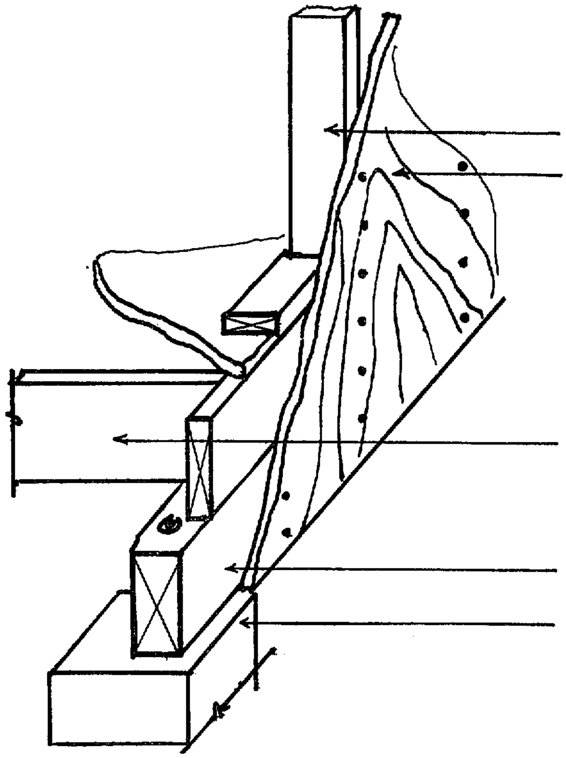


FIGURE 2-36
Pier -- Section

whole structure can be tied together with this type of framing hardware by extending their use to exterior studs and to rafters. This is recommended for structures in velocity flood and high wind areas.

2. *PLYWOOD SHEATHING OR WOOD SIDING* — Plywood sheathing or wood siding continuously nailed to the floor beam, header, sole plate, and wall studs provide adequate resistance against horizontal uplift forces (see Figure 2-38 and 2-39).

3. *METAL STRAPPING* — Where plywood or wood siding is not used as a sheathing material for stud wall construction, metal strapping provides an acceptable alternative for anchoring floor joists to the floor beam. The two most important requirements for the satisfactory usage of metal strapping are 1) use of sufficient number and 2) proper nailing. As a general guide, every other joist and wall stud should be anchored with a metal strap. Proper nailing requires not only a sufficient number of nails driven into the strap but also the nailing of the strap to the proper framing members. Figures 2-40 and 2-41 identify the most important strapping and nailing connections for floor framing.



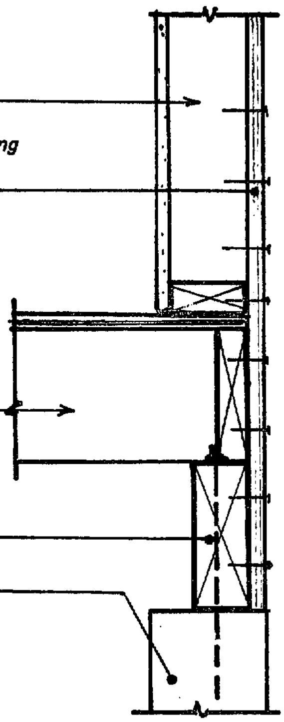


FIGURE 2-38
Plywood Anchorage -- Isometric

FIGURE 2-39
Plywood Anchorage -- Section

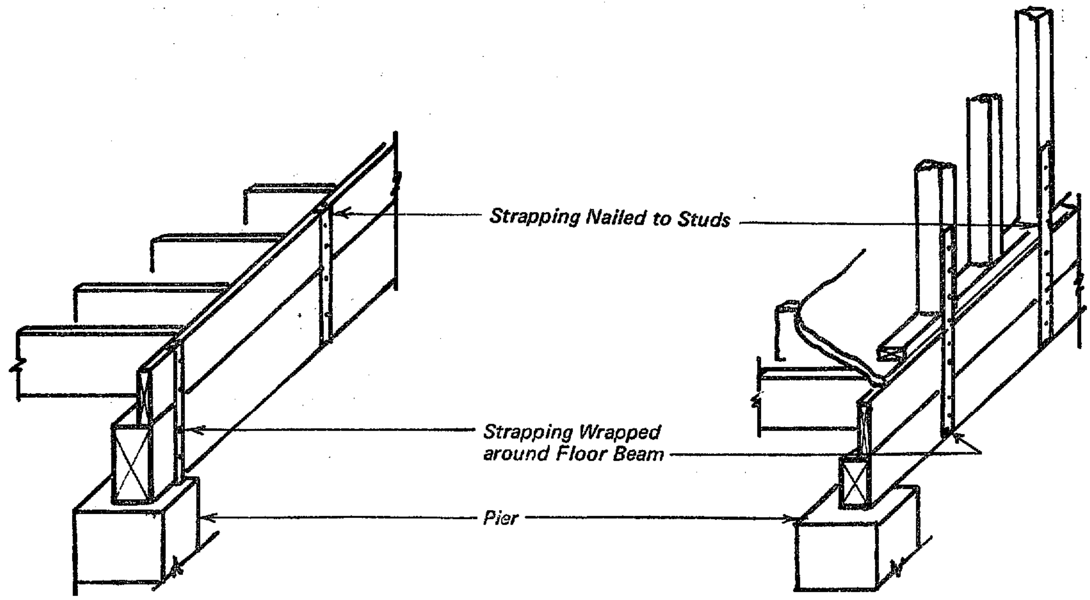


FIGURE 2-40
Metal Strapping of Framing

FIGURE 2-41
Metal Strapping of Wall Studs

PERFORMANCE REQUIREMENTS AND CRITERIA

The following performance requirements and criteria identify a range of considerations which should be addressed during the design of residential structures for flood hazard areas. The performance criteria do not represent the entire range of items applicable to each requirement. Instead, a selective number of criteria have been presented. During building design, it is these criteria which should be extensively addressed.

The performance requirements and criteria are applicable to all structural materials and all construction methods used in special flood hazard areas. Traditional or conventional construction solutions, as well as innovative techniques, are acceptable so long as the performance requirements and criteria are satisfied.

DEFINITIONS

Terms important to proper interpretation of the performance requirements and criteria are defined as follows:

Applicable Codes — The system of legal regulations adopted by a community 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.

Community — Any state or political subdivision thereof with authority to adopt and enforce flood plain management regulations for areas within its jurisdiction.

Design Flood (Base Flood)—The design flood is the base or 100-year flood (see base flood) as established by the Federal Insurance Administration for purposes of compliance with the National Flood Insurance Program regulations.
In the absence of an FIA designation of the base year flood datum level, the community is permitted to utilize the best available flood data.

Design Loads — The design load is the minimum loading condition which the building should be designed to resist. Some loading conditions most likely will be defined in the applicable codes while other load conditions (e.g., flood impact loads) will have to be determined. The following loads constitute the design load and should be considered as minimum loading conditions as defined in Criterion A.1:

1) *Dead Load (D)* — The weight of all permanent construction. The dead load includes: a) the weight of the structure itself, b) the weight of all materials of construction incorporated into the building that are to be permanently supported by the structure, including built-in partitions, c) the weight of permanent equipment, and d) forces due to 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 code. These include, where applicable, loads caused by soil and hydrostatic pressures.

3) *Wind Loads (W)* — Wind loads stipulated in the applicable code.

4) *Restraint Loads (R)* — Loads, forces, and effects due to contraction or expansion resulting from temperature changes, shrinkage, moisture changes, creep in component materials, movement due to differential settlement or combinations thereof.

5) *Flood Loads (F)* — Loads caused by the design flood which include:
   - Flood induced dimensional changes such such as swelling of wood or heave of expansive foundation soils,
   - Water loads as defined in Section 602.0 of the Corps of Engineers' publication, *Flood-Proofing Regulations,*
   - Soil loads as defined in Section 604.0 of the Corps of Engineers' publication, *Flood-Proofing Regulations.*

Sections 602.0 and 604.0 of Flood-Proofing Regulations are reproduced below:

SECTION 602.0 WATER LOADS

Sec. 602.1 Types: Water loads, as 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.

Sec. 602.2 Hydrostatic Loads: Hydrostatic loads are those caused by water either above or below the ground surface, free of confined, which is either stagnant or moves at very low velocities, or up to five (5) feet per second. 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 perpendicular to the surface on which they are applied. For the purpose of these Regulations, hydrostatic loads are subdivided into the following types:

Sec. 602.2.1 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.

Sec. 602.2.2 Lateral Loads: Lateral hydrostatic loads are those which act in a horizontal direction, against vertical 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.

Sec. 602.2.3 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. Hydrostatic loads acting on inclined, rounded or irregular surfaces may be resolved into vertical or uplift loads and lateral loads based on the geometry of the surfaces and the distribution of hydrostatic pressures.

Sec. 602.3 Hydrodynamic Loads: Hydrodynamic loads . . . are those induced on buildings or structures by the flow of flood water moving at moderate or high velocity around the buildings or structures or parts thereof, above ground level when openings or conduits exist which allow free flow of flood waters. 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 shall be computed or estimated by recognized and authoritative methods. Methods for evaluating water velocities and related dynamic effects are beyond the scope of these Regulations, but shall be subject to review and approval by the Building Official.

Sec. 602.3.1 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 RFD* by an amount dh, on the headwater side and above the ground level only, equal to:

$$dh = \frac{a V^2}{2g}, \text{ where}$$

V is the average velocity of the water in feet per second;

g is the acceleration of gravity, 32.2 feet per second;

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, shall be added to the depth measured between the design level and the RFD* 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 surfaces wetted by the tailwater shall be considered subject to hydrostatic pressures for depths to the RFD* only.

Sec. 602.4 Intensity of Loads:

Sec. 602.4.1 Vertical Loads: Full intensity of hydrostatic pressures caused by a depth of water between the design elevation(s) and the RFD* applied over all surfaces involved, both above and below ground

Sec. 602.4.2 Lateral Loads: Full intensity of hydrostatic pressures caused by a depth of water between the design elevation(s) and the RFD* applied overall surfaces involved, both above and below ground level, except that for surfaces exposed to free water, the design depth shall be increased by one foot.

Sec. 602.4.3 Uplift: Full intensity of hydrostatic pressures caused by a depth of water between the design level and the RFD* acting on all surfaces involved, unless provisions are made to reduce uplift intensities as permitted in 611.0.

Sec. 602.4.4 Hydrodynamic Loads: Hydrodynamic loads, regardless of method of evaluation, shall be applied at full intensity over all above ground surfaces between the ground level and the RFD*

Sec. 602.5 Applicability: . . . hydrostatic loads shall be used in the design of buildings and structures exposed to water loads from stagnant flood waters, for for conditions when water velocities do not exceed five (5) feet per second, and for buildings and structures or parts thereof not exposed or subject to flowing water. For buildings and structures, or parts thereof, which are exposed and subject to flowing water having velocities greater than five (5) feet per second, hydrostatic and hydrodynamic loads shall apply.

SECTION 604.0 SOIL LOADS

Sec. 604.1 Applicability: Full consideration shall 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 shall be computed in accordance with accepted engineering practice, giving full consideration to the effects that the presence of flood water, above or within the soil, has on loads and pressures. When expansive soils are present, the Building Official may require that special provisions be made in foundation and wall design and construction to safeguard against damage due to this expansiveness. He may require a special investigation and report to provide these design and construction criteria.

6) *Flood Impact Loads (FI)* — The loads caused by the design flood as defined in Section 603.0, "Impact Loads," and Section 605.0, "Hurricane and Tidal Wave Loads" of the

*Equivalent to the level of the base or design flood.

Corps of Engineers' publication *Flood-Proofing Regulations.* In the case of Section 605.0, where no specific guidance is provided, design loads shall be recommended by a professional engineer and subject to FIA review.

Sections 603.0 and 605.0 of Flood-Proofing Regulations are reproduced below:

SECTION 603.0 IMPACT LOADS

Sec. 603.1 Types:. . . Impact loads are those which result from floating debris, ice and any floatable object or mass carried by flood waters striking against buildings and structures or parts thereof. These loads are of three basic types: normal, special and extreme.

Sec. 603.1.1 Normal Impact Loads: Normal impact loads are those which relate to isolated occurrences of logs, ice blocks or floatable objects of normally encountered sizes striking buildings or parts thereof.

Sec. 603.1.2 Special Impact Loads: Special impact loads are those which relate to large conglomerates of floatable objects, such as broken up ice floats and accumulation of floating debris, either striking or resting against a building, structure, or parts thereof.

Sec. 603.1.3 Extreme Impact Loads: Extreme impact loads are those which relate to large floatable objects and masses such as runaway barges or collapsed buildings and structures, striking the building, structure or component under consideration.

Sec. 603.2 Applicability: Impact loads should be considered in the design of buildings, structures and parts thereof as stipulated below:

Sec. 603.2.1 Normal Impact Loads: A concentrated load acting horizontally at the RFD* or at any point below it, equal to the impact force, produced by a 1,000-pound mass traveling at the velocity of the flood water and acting on a one (1) square foot surface of the structure.

Sec. 603.2.2 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 and submitted for approval by the Building Official, the intensity of load shall be taken as 100 pounds per foot acting horizontally over a one-foot wide horizontal strip at the RFD* 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.

Sec. 603.2.3 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.

SECTION 605.0 HURRICANE AND TIDAL WAVE LOADS

Sec. 605.1 Applicability: Coverage of loads caused by flooding related to hurricanes, tidal waves and other similar natural events is beyond the scope of these Regulations and no specific or detailed treatment is provided. Concepts and requirements of these Regulations may be used as a guide in developing suitable provisions for flood-proofing of buildings exposed to flooding from these sources.

*Equivalent to the level of the base or design flood.

Flood or Flooding –

1. A general and temporary condition of partial or complete inundation of normally dry land areas from:
   a. The overflow of inland or tidal waters.
   b. The unusual and rapid accumulation or runoff of surface waters from any source.
   c. Mudslides (i.e., mudflows) which are proximately caused or precipitated by accumulations of water on or under the ground.

2. The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as a flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in 1(a) above.

Base Flood (Design or 100-Year Flood)—A flood that has a magnitude that may be equaled once every hundred years on the average. It has a one percent chance of annual occurence.

PERFORMANCE REQUIREMENTS AND CRITERIA FOR RESIDENTIAL STRUCTURES IN FLOOD HAZARD AREAS

PERFORMANCE REQUIREMENTS

The building, its contiguous structure(s), and its service systems shall be designed to withstand the Base or Design Flood without:

A. *Causing unacceptable risks to its occupants or to adjacent or downstream property owners;*

B. *Causing unacceptable health hazards to its occupants; and*

C. *Sustaining damage of unacceptable magnitude.*

PERFORMANCE REQUIREMENT – A

☐ *The building, its contiguous structure(s), and its service systems shall be designed to withstand the Design Flood without causing unacceptable risks to its occupants or to adjacent property owners.*

The building complies with Performance Requirement A if the following conditions are satisfied:

CRITERION A.1: STRENGTH

The building is designed to resist the following loads, acting simultaneously:

1.1 D, L, R, and F

1.2 D, L, R, F, and Fl

1.3 D, L, R, W, F, and Fl

1.4 0.9D, R, and F

1.5 0.9D, R, W, F, and Fl

Where the working stress method of design is used the following provisions apply:

2.1 In load combinations 1.1 through 1.5 all loads are applied as listed or as required by the applicable codes for the same load combinations with loads F and Fl.

2.2 Allowable (working) stresses cannot be exceeded for loading conditions 1.1 and 1.4. For all other loading conditions the allowable stresses can be increased by the amount permitted in applicable codes for design against load combinations including wind or earthquake load.

Where ultimate-load design is used (such as instances where ACI 318-71* is applicable) load factors are applied as recommended in the applicable standard, and F will be combined with L, or factored as if it were a live load for loading conditions 1.1 and 1.4. For all other loading conditions loads (F + Fl) will be combined with W, or considered to be equivalent to a wind load.

TEST

Structural analysis and/or physical simulation.

COMMENTARY

The criterion provides a suitable margin of safety against structural collapse when the building is subjected to the base flood. The intent of the criterion is that the margin of safety for these buildings, when subjected to the base flood, be no less than the margin required for other buildings not subjected to flooding. It is assumed that loads F may act on the building over a long period of time, while loads Fl are short-term loads. Thus the margin of safety against load combinations containing Fl need not exceed that provided against wind or seismic loads.

The combined load of earthquakes and floods is not considered here because of the low probability of a flood and an earthquake occurring simultaneously.

CRITERION A.2: STABILITY AND FLOTATION

There shall be a factor of safety of 1.5 against overturning, sliding, and flotation under the following load:

* American Concrete Institute, *Building Code Requirements for Reinforced Concrete (ACI 318-71)*, ACI, Detroit, 1971.

0.9D + W + R + F + FI

TEST

Stuctural analysis and/or physical simulation.

COMMENTARY

This criterion provides a suitable margin of safety against sliding and overturning. The most critical load combination is being considered. Tie-down devices can be used to achieve structural stability, provided it can be demonstrated that deterioration of these devices during the service life of the building, or by flood conditions will not cause the factor of safety to fall below its stipulated value.

CRITERION A.3: PROVISION AGAINST DEBRIS AND SCOUR

Unless it can be demonstrated that the flood waters will be stagnant, or that there will be no floating debris during the Design Flood, the following provisions apply:

1.1 Building on stilts shall comply with Section 612.2.3 of the Corps of Engineers' publication *Flood Proofing Regulations. This section is reproduced below.*

> *Sec. 612.2.3 Building on "Stilts":* The building may be constructed above the RFD* by supporting it on "stilts" or other columnar type members, such as columns, piers, and in certain cases, walls. *Clear spacing* of support members, measured perpendicular to the general direction of flood flow shall *not be less than eight (8) feet apart at the closest point.* The "stilts" shall, 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. "Stilts" shall be of a type that causes the least obstruction to the flow and the least potential for trapping floating debris. Foundation supports for the "stilts" may be of any approved type capable of resisting all applied loads, such as spread footings, mats, piles and similar types. In all cases, the effect of submergence of the soil and additional flood water related loads shall be recognized. The potential of *surface scour* around the stilts shall be recognized and protective measures provided, as required (for breakaway walls see pages 2-10 — 2-12).

*Equivalent to the level of the base or design flood.

1.2 For flow velocities in excess of 5 ft/sec. the hydrodynamic loads in F shall be assumed to act over the entire width of the building, perpendicular to the direction of flow, and reasonable vertical clearance shall be provided for the passage of debris. The depth of all foundation elements shall allow for the potential effect of scour.

TEST

Structural analysis and/or physical simulation. Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

COMMENTARY

Criterion A.3 is designed to prevent structural collapse caused by the accumulation of floating debris or the undermining of foundation elements as a result of scour. Part of the provision is designed to avoid debris accumulation. The other part provides adequate strength to resist the effects of the formation of a barrier over the entire width of the building. Buildings are exempt if it can be demonstrated that no debris will accumulate and no scour will occur.

CRITERION A.4: DISRUPTION OF SERVICE SYSTEMS

The service systems shall be designed to resist the loads stipulated in Criterion A.1 with safety margins as stipulated in A.1 against disruptions which may endanger human lives.

TEST

Engineering analysis and/or physical simulation. Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

COMMENTARY

This criterion only applies to disruption which may cause fatal accidents, such as rupture of gas lines. Lesser load levels are stipulated in B.1 for disruptions which constitute a health hazard.

CRITERION A.5: EXECUTION OF RESCUE OPERATIONS

The building is designed to permit the execution of rescue operations.

During the duration and at heights of the Design Flood the building shall:

1.1 Allow the safe evacuation of the occupants out of the building.

1.2 Allow the safe transfer of occupants from the building to rescue vehicles.

1.3 Provide means of access or adjacency for rescue vehicles.

TEST

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

COMMENTARY

Criterion A.5 is designed to prevent the entrapment of building occupants by rising water levels. Part of the provision is designed to provide means to evacuate the building (e.g., windows, roof trap door). The other parts provide for the accommodation and execution of rescue operations (e.g., by boat, helicopter).

PERFORMANCE REQUIREMENT – B

☐ *The building, its contiguous structure(s), and its service systems shall be designed to withstand the Design Flood without causing unacceptable health hazards to its occupants.*

The building complies with Performance Requirement B if the following conditions are satisfied:

CRITERION B.1: DISRUPTION OF UTILITY CONNECTIONS

Building utility connections shall be designed to resist the following loads:

At loading conditions:

1.1 D + L + R + W + F + FI

1.2 0.9D + W + R + F + FI

The building utility connections should not sustain:

2.1 Permanently disrupted and/or broken attachment with their fixtures and/or supporting structural element;

2.2 Leakage or escape of effluent which could contaminate drinking water;

2.3 Rupture of electrical service which could cause electrocution and/or fire.

TEST

Evaluation of data and documentation for design, tests, and installations; evaluation of plans and specifications. Inspection and/or testing of built elements when deemed essential. Determination of conformances to generally accepted codes, standards and engineering and trade practices, where applicable.

COMMENTARY

This criterion applies to all utility connections subject to the forces of the Design Flood. Utility connections which are designed to disconnect during the Design Flood without the release of deleterious substances are exempt from provisions 1.1, 1.2, and 1.3.

CRITERION B.2: PROVISION AGAINST DRINKING WATER CONTAMINATION

There will be no contamination of drinking water with sewer effluent or flood water.

Criterion B.2 and Performance Requirement B are deemed satisfied if the following provisions are met.

1.1 Approved backflow preventers or devices are installed on main water service lines, at water wells and/or at suitable building locations to protect the system from backflow or back siphonage of flood waters or other contaminants in the event of a line break or temporary disconnection.

Devices are installed at accessible locations and maintained in good working order.

1.2 Sanitary sewer and storm drainage system connections are provided with approved backflow preventers or devices installed at each discharge point.

1.3 No storm or flood waters are drained into systems designed for sewage only, and vice versa.

TEST

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

COMMENTARY

Criterion B.2 is designed to prevent contamination of drinking water with sewer effluent or flood waters. Also, the criterion is designed to prevent damage to fixtures and interior finishes (e.g., flooring, wall surfaces) from backflow or back siphonage of flood waters.

CRITERION B.3: PROVISION AGAINST CONTAMINATION OF POTABLE WATER WELLS

Private potable water wells shall not be contaminated by toxic substances or impurities caused by the Design Flood.

Criterion B.3 is deemed satisfied if the following provisions are satisfied.

1.1 Private potable well water is not supplied from a water table located less than 25 feet below grade, nor from any deeper supply which may be polluted by contamination entering fissure or crevice formations.

1.2 Each well is provided with a water tight casing to a distance of at least 25 feet below the ground surface and shall extend at least one foot above the well platform.

TEST

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Geological analysis of residential site.

COMMENTARY

Criterion B.3 is designed to prevent the contamination of water wells used as a source for potable water. Part of the provision provides against the contamination of the water supply source. The other part provides against the contamination of the water removal system. In any case, local health codes should be consulted.

PERFORMANCE REQUIREMENT – C

☐ *The building, its contiguous structure(s), and its service systems shall be designed to withstand the Design Flood without sustaining damage of unacceptable magnitude.*

The building complies with Performance Requirement C if the following conditions are satisfied:

CRITERION C.1: PROVISION AGAINST PERMANENT DAMAGE

Under loading conditions 1.1 through 1.3 the building as a whole, or any element thereof, shall not suffer permanent damage which would require replacement or major repair, or which would extensively impair its intended function.

1.1 D + L + R + W + F + Fl

1.2 0.9D + W + R + F + Fl

The criterion is deemed satisfied if deflection limits under loading conditions 1.1 and 1.2 do not exceed those stipulated in applicable codes, or if it can be demonstrated that deflections caused by load combinations 1.1 and 1.2 can be accommodated by suitable detail and adequate flexibility of elements.

TEST

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications. Inspection and/or testing of built elements when deemed essential. Determination of conformance to generally accepted standards and engineering and trade practices, where applicable.

COMMENTARY

This criterion assures that the Design Flood shall not cause excessive damage. Effects of swelling caused by increased moisture or inundation must be included in F.

CRITERION C. 2: PROVISION AGAINST UNNECESSARY DAMAGE

All living areas, major utilities, furnaces, and air conditioning units shall not be submerged by the Design Flood.

1.1 Living areas shall be considered habitable areas which provide for the essential needs of people: living, sleeping, dining, cooking and sanitation.

Recreation areas, libraries, and other speciality areas are to be considered habitable areas and therefore should not be submerged by the Design Flood.

1.2 The electrical system complies with Criterion C.2 if the following conditions are satisfied:

1.2.1 All portions of the electrical system installed below the Design Flood level are suitable for continuous submergence in water. Only submersible type splices are used and conduits located below the Design Flood level are self draining if subject to flooding.

1.2.2 Lighting panels, distribution panels, and all other stationary electrical equipment are located above the Design Flood.

1.3 The mechanical system complies with Criterion C.2 if the following conditions are satisfied.

1.3.1 Heating, air conditioning, and ventilating equipment are installed above the Design Flood.

1.3.2 All duct work for warm air heating systems which is located below the Design Flood level is provided with emergency openings for drainage of ducts after a flood condition.

1.4 The plumbing system complies with Criterion C.2 if the following conditions are satisfied:

1.4.1 Tanks, softeners and heaters are installed above the Design Flood.

1.4.2 Plumbing below the Design Flood level will not suffer loss of stability or loss of tightness that will permit leakage or physical damage to fixtures and joints and connections that will permanently impair functioning.

1.4.3 Utility connections designed to disconnect during the Design Flood are easily reconnected. (See Criterion B.1)

TEST

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

COMMENTARY

Criterion C.2 is designed to prevent unnecessary damage of living areas, major utilities, furnaces, and air conditioning units by the Design Flood. Part of the provision is designed to elevate living areas and equipment above the Design Flood. Other parts are designed to prevent the damage of utilities and mechanical/electrical connections below the Design Flood.

A Brief Survey of Design Improvements

INTRODUCTION

The following residential design concepts were developed to test the applicability and usefulness of the information presented in this manual. Four architectural firms and several architectural schools were asked to develop preliminary design concepts for various housing types (single-family, rowhouse, and multi-family), at varying heights above grade, and at a range of construction costs. The design concepts were to be responsive to the research findings and the performance criteria of the manual and also to present design ideas to alleviate the unaesthetic appearances often associated with elevated residential structures. Additionally, the designers were asked to reflect the flood hazard condition, material availability, construction capability, social acceptability, and aesthetic characteristics associated with their region.

The flood problems of four regions of the country--Northeast, South, Midwest and West--are represented. The types of floods for each area are described, followed by design ideas for particular cities within these areas.

The Atlantic coast regions of the U. S. are often subjected to flooding caused by the high winds and heavy rains of violent ocean storms and hurricanes. This flooding is characterized by fast moving rivers and heavy coastal surges.

BRIDGEPORT, CONNECTICUT

Design concepts were developed for both single-family and townhouse construction. A major consideration of both residential concepts is the relationship of the occupant and his automobile to the raised structure. The architects have provided ramps for both occupant entry and automobile parking to alleviate the inconvenience of elevated structures to children, the elderly, and the handicapped. Structurally, however, the residences are quite different. The single-family structure is supported by a wall foundation and the townhouse is supported by a pier foundation.

SINGLE-FAMILY RESIDENTIAL CONCEPT

Designing for a flood-hazard area with a four-foot elevation requirement and providing low-cost housing required a unique, responsive solution. Because of New England's adverse winter climate, the residence is supported on poured-in-place concrete walls (see Figure 3-1). The walls, reinforced and windowless, with a thick slab and waterbarrier at the slab/wall joint can be made waterproof. Windows could be included if reinforced and sealed watertight at floodline. The fill removed during excavation is used as an entrance ramp, flood diverter and parking area (see Figure 3-2). Use of excavated fill for the ramp material is generally satisfactory up to ramp heights of 6 feet. The water heater, furnace, ductwork and piping are required to be located above the base flood. Here, they are in the attic (see Figure 3-3).

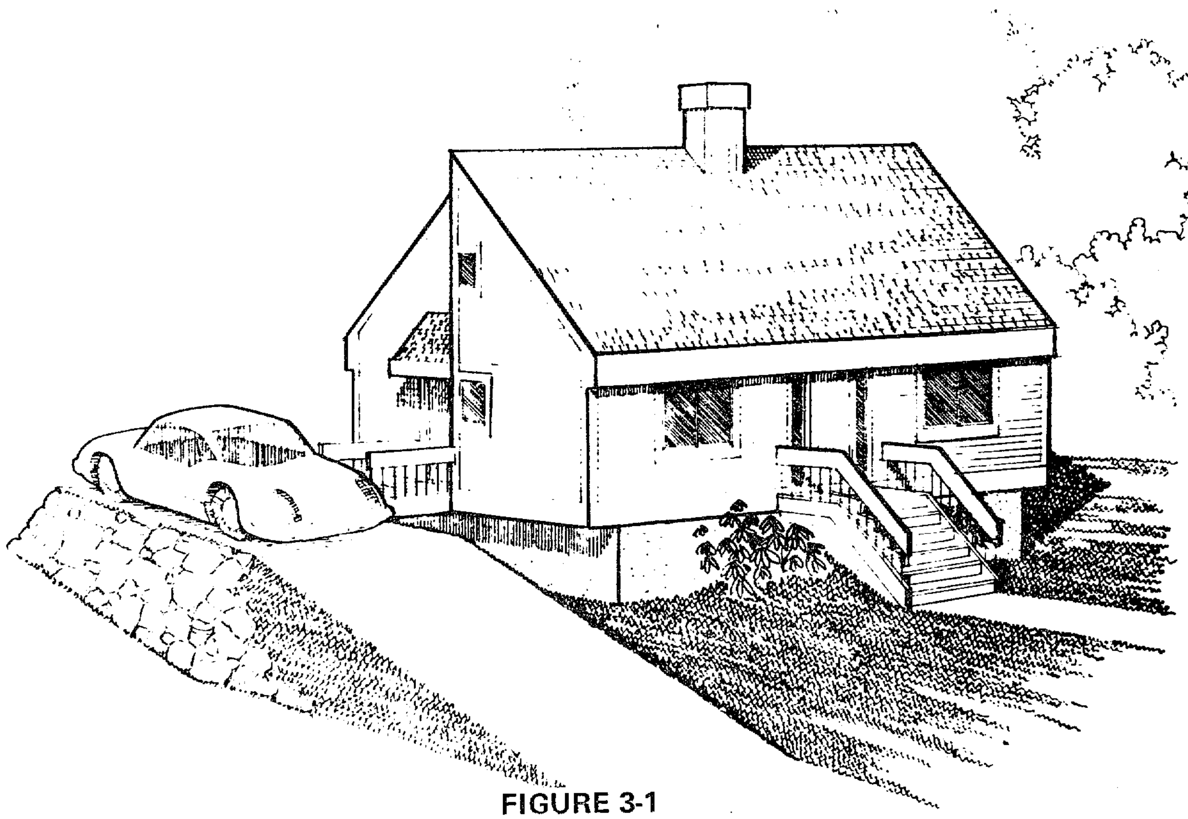


FIGURE 3-1

Single Family House

4' Elevation Above Grade

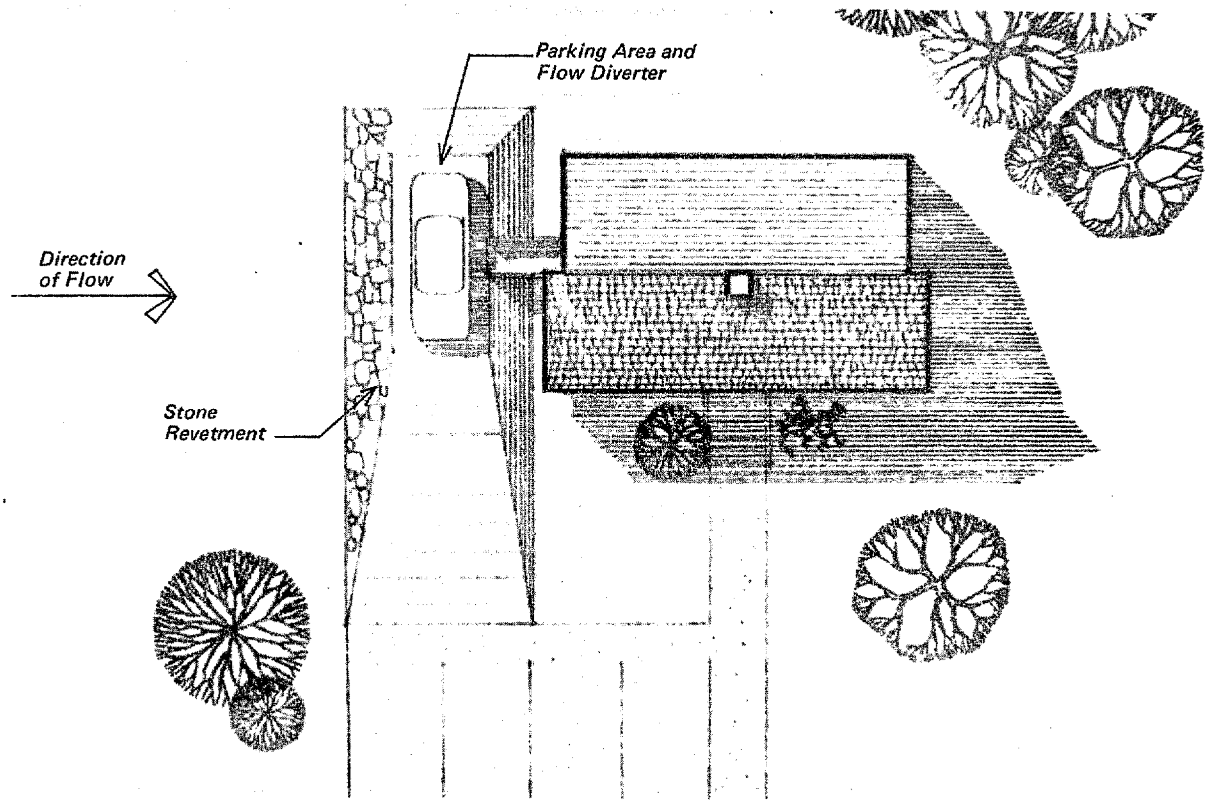


FIGURE 3-2
House Site Plan

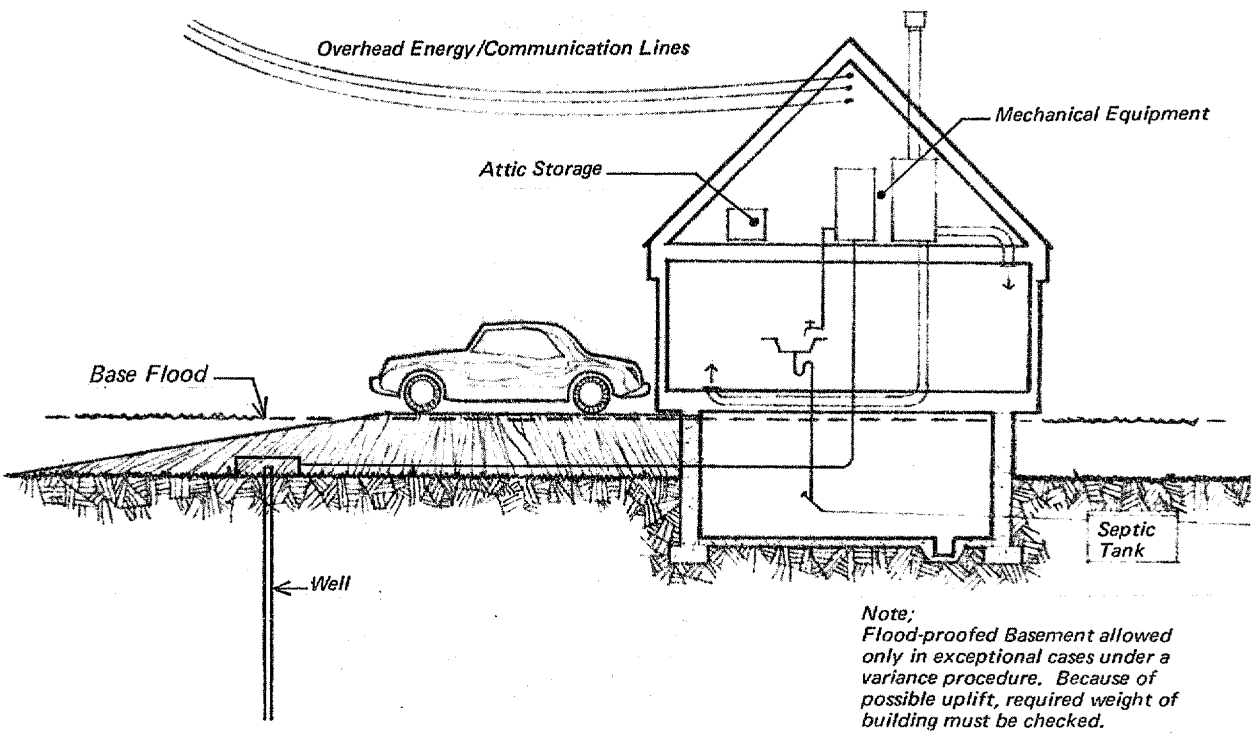


FIGURE 3-3
House Section

TOWNHOUSE RESIDENTIAL CONCEPT

With an elevation requirement of 10 feet above grade, the architects have designed these luxury townhouses around a central social deck (see Figures 3-4 and 3-5). Parking is located beneath the deck. Access to the deck and to the townhouses is provided by stairs and a timber ramp. The ramp provides access for children, the handicapped and the elderly. During times of flooding, the ramp can also be used for driving automobiles and rescue vehicles up to the deck level. Steel girders resting upon concrete piers support both the social deck and the townhouses (see Figure 3-6). The deck has double floors for added insulation and the protection of utility services.

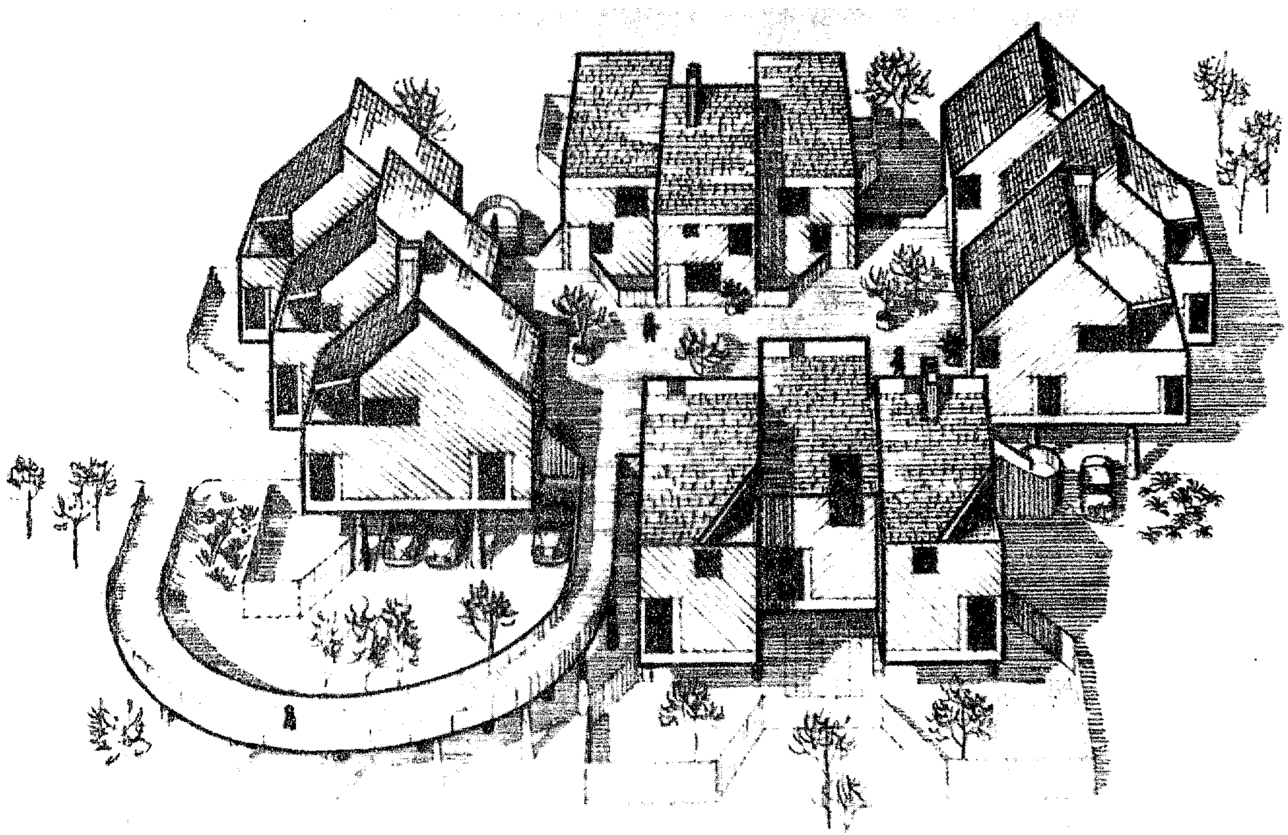


FIGURE 3-4
Town Houses Raised 10' Above Grade

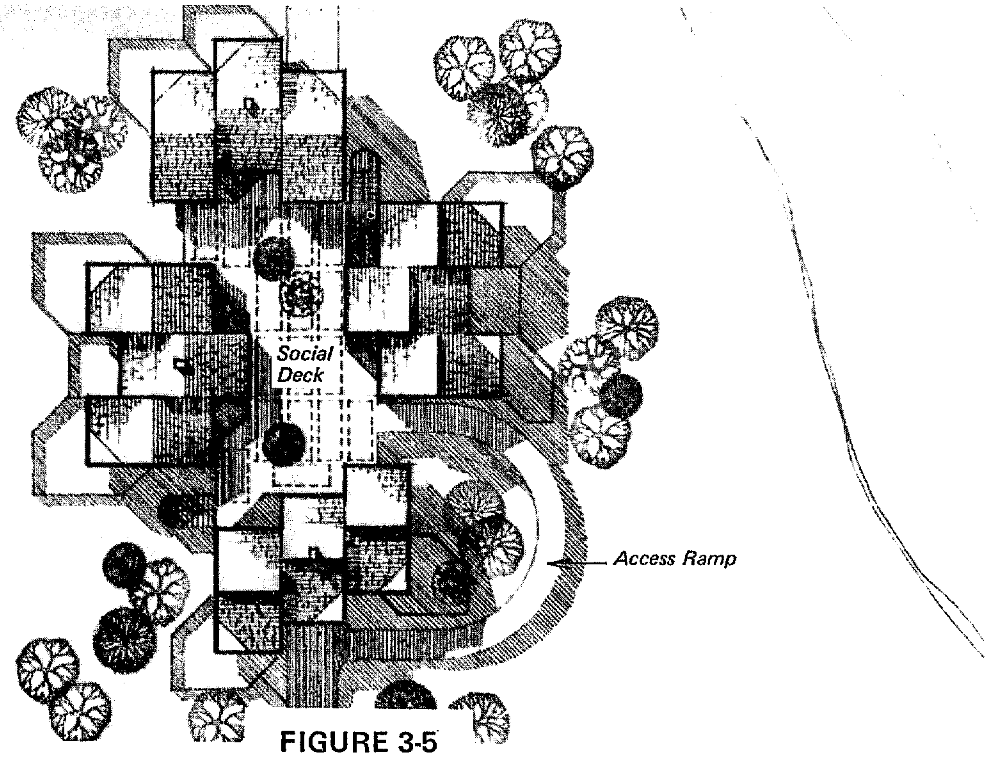


FIGURE 3-5
Town House Site Plan

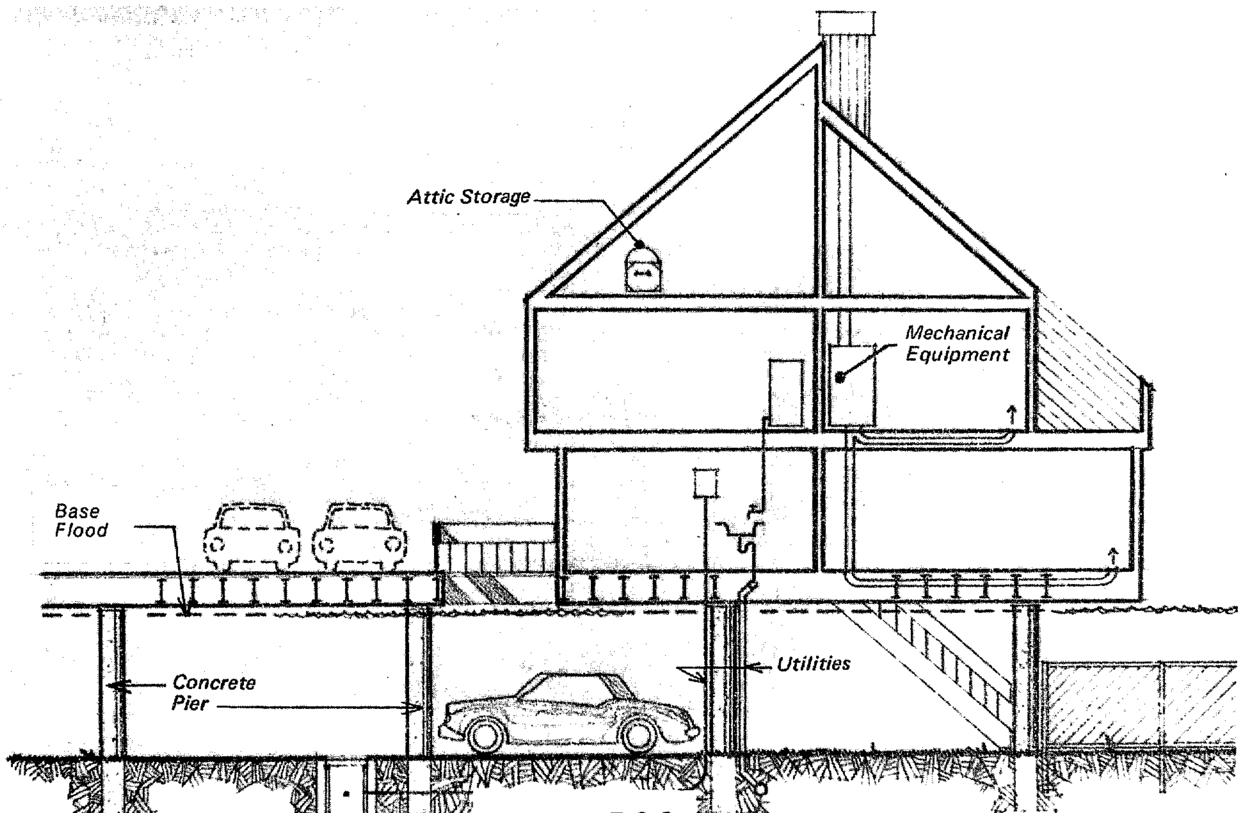


FIGURE 3-6
Town House Section

CHARLESTOWN AND NEWPORT, RHODE ISLAND

The architect has chosen two case study areas with distinctly different cultural and natural conditions that affect flood design considerations. The areas are Newport and Charlestown, Rhode Island. Newport is a compact commercial and recreation center which has many residences along the water's edge. The area studied in Newport is a protected harbor with access from Rhode Island Sound into Narragansett Bay. The portion of Charlestown that is the second study area is a beach front area with vacation house development. Most development is on the outwash plain that forms the beach or is directly facing the Atlantic Ocean on the barrier beach. Both study areas have high development pressures. Obvious environmental drawbacks have not restricted their intense use. Their location on the water's edge is scenically delightful, but has high risk factors. Until recently, these sites were actively developed with little or no concern for flood hazard.

In both areas there are historic, scenic and community values that should influence the design of elevated structures. In Newport the close proximity of the Historic District imposes height, bulk, material, and size considerations into any planned development.* Similarly in Charlestown, simply elevating structures within the open area of the barrier beach or outwash plain, without regard for the natural environment, could produce ungainly and visually distracting elements. It is necessary in flood area design to not only meet engineering requirements, but to also be cognizant of the visual effect such design will have on the prevailing character of the area in question.

CHARLESTOWN CASE STUDY

An inventory of critical natural factors was made to determine how and where development should take place in the Charlestown coastal flood plain. As a result, specific land area within the flood plain was deemed acceptable for residential development. The analysis then proceeded to the evaluation of methods of elevation appropriate to the development area.

For numerous functional and aesthetic reasons, berming with heavy stone revetment was chosen as the method for elevating residential structures in the coastal flood plain of Charlestown (see Figure 3-7). The homes were clustered to keep down the cost of fill and because the land available for safe building in the flood plain was limited (see Figure 3-8). A small scale single family scheme was chosen as desirable for visual continuity with earlier buildings (see Figure 3-9). On the common bermed area, all houses, a small amount of private space, and all utilities are located. Low intensity land uses such as parking, road and driveways, playgrounds, etc., are located on the lower surrounding areas. Ramps and steps are used to accommodate the height differences from parking to the finished first floor.

* In the case of historic structures in flood plains listed on the *National Register of Historic Places* or a state inventory of historic places, restoration may be accomplished without elevating the first floor through a variance procedure.

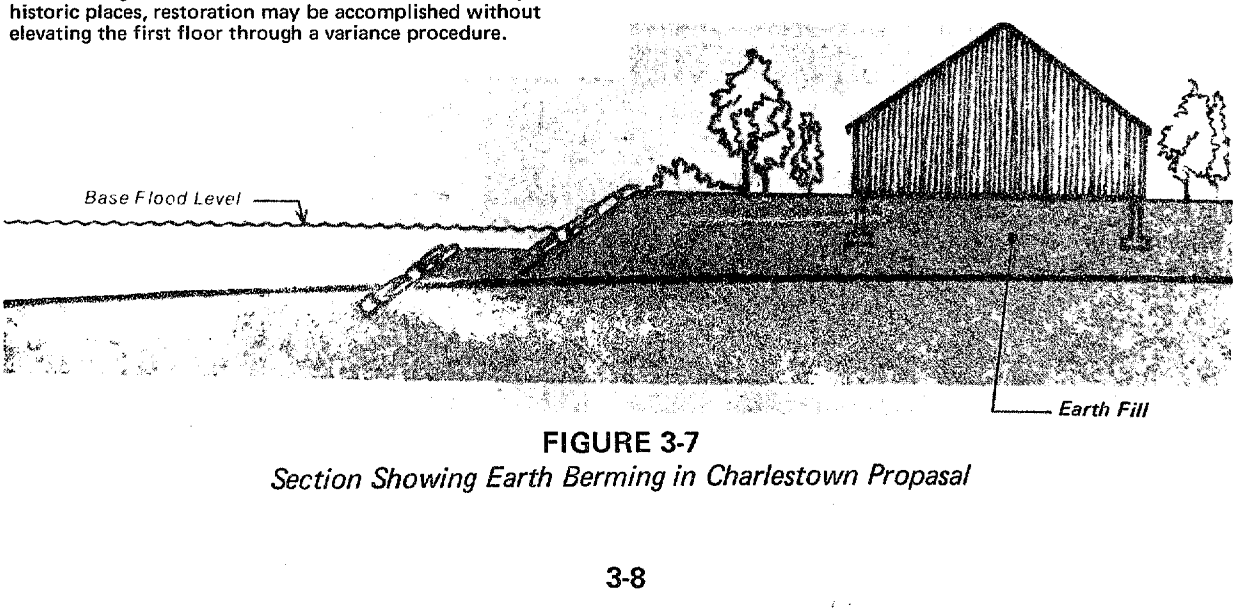


FIGURE 3-7
Section Showing Earth Berming in Charlestown Propasal

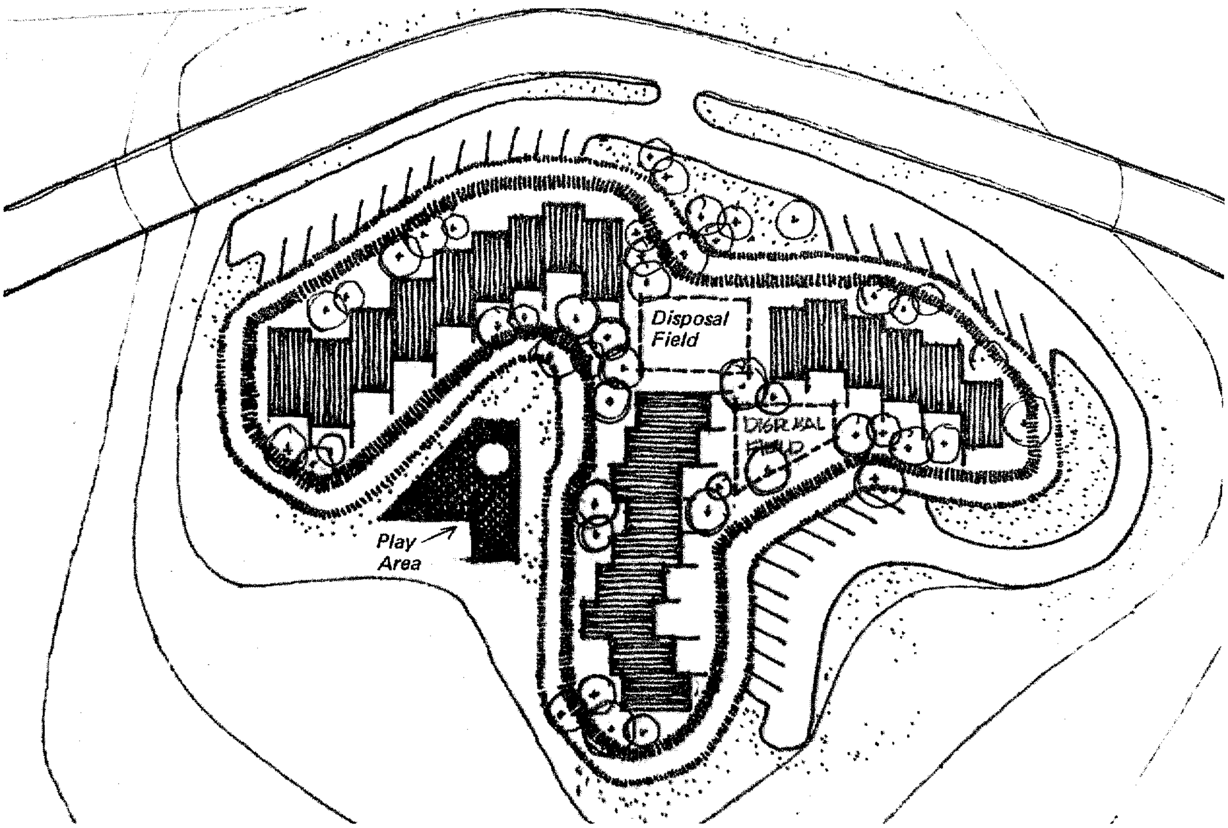


FIGURE 3-8
Charlestown Development Site Plan

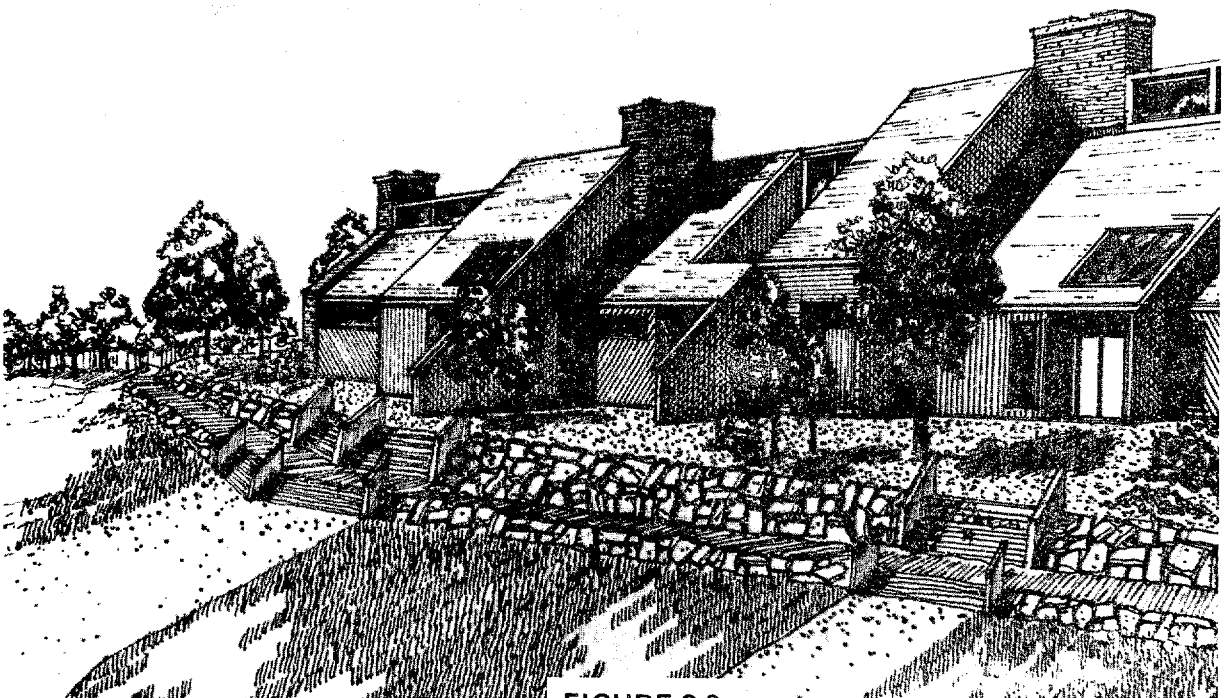


FIGURE 3-9
Perspective of Charlestown Development

NEWPORT, RHODE ISLAND CASE STUDY

Development in the wharf area in Newport is structured by a combination of natural and cultural conditions. It is in the special flood hazard zone, yet its water's edge location makes it visually attractive. It is separated from the older historic areas of Newport by a highway. Changes in the use of the wharf area and its new relationships with neighboring areas have resulted in an expansion of commercial and residential development. The low height above sea level means that new structures will have to be raised approximately to the level of the new highway to comply with Federal flood regulations. Vehicular and pedestrian access must be considered in the overall plan for the area, also making this an important prototypical example.

Analysis indicates that the optimal solution could be a combination of elevation techniques because different zones in the wharf area are suited to different elevation techniques.

In the area furthest from the water, berming offers flood protection and a gradual level change from that of the highway. A transitional middle section combines berming with raised structures. Level changes are integrated by linking extended decks with ramps and stairs. In the area closest to the water, raised structures which do not alter the water to land relationships or block views are used (see Figure 3-11). Commercial uses are most likely to locate in the bermed area, where first floor spaces are usable. Residential, restaurant, and small office uses are more suitable to the raised structures, where increased privacy and better views are found.

Spaces under and between the new buildings can be used for pedestrian malls, and thus reinforce the tourist and commercial uses of the area. Decks, balconies and trellises can connect different building levels. Utilities for the raised structures can be run beneath these raised decks and trellises and then tie into the berm, and thus be protected from flood damage. Manipulation of the spaces and level changes created by flood protection can be used to enhance the intricacy and human scale of the wharf (see Figure 3-12).

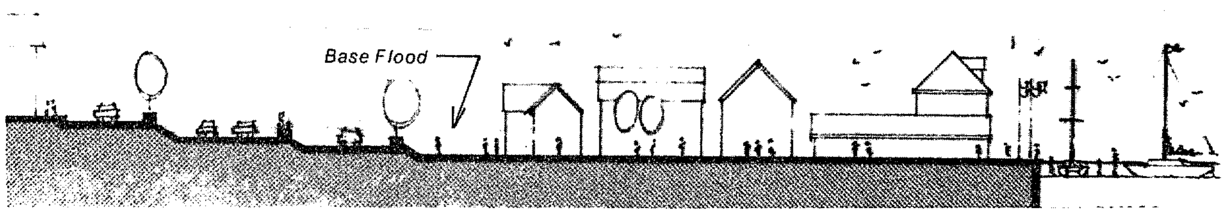


FIGURE 3-10
Existing Wharf Area in Newport

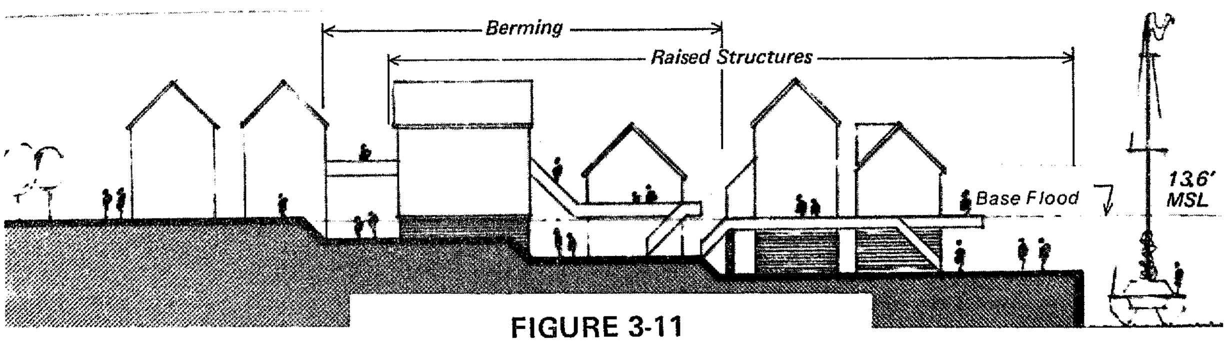


FIGURE 3-11
Proposed Wharf Area Development

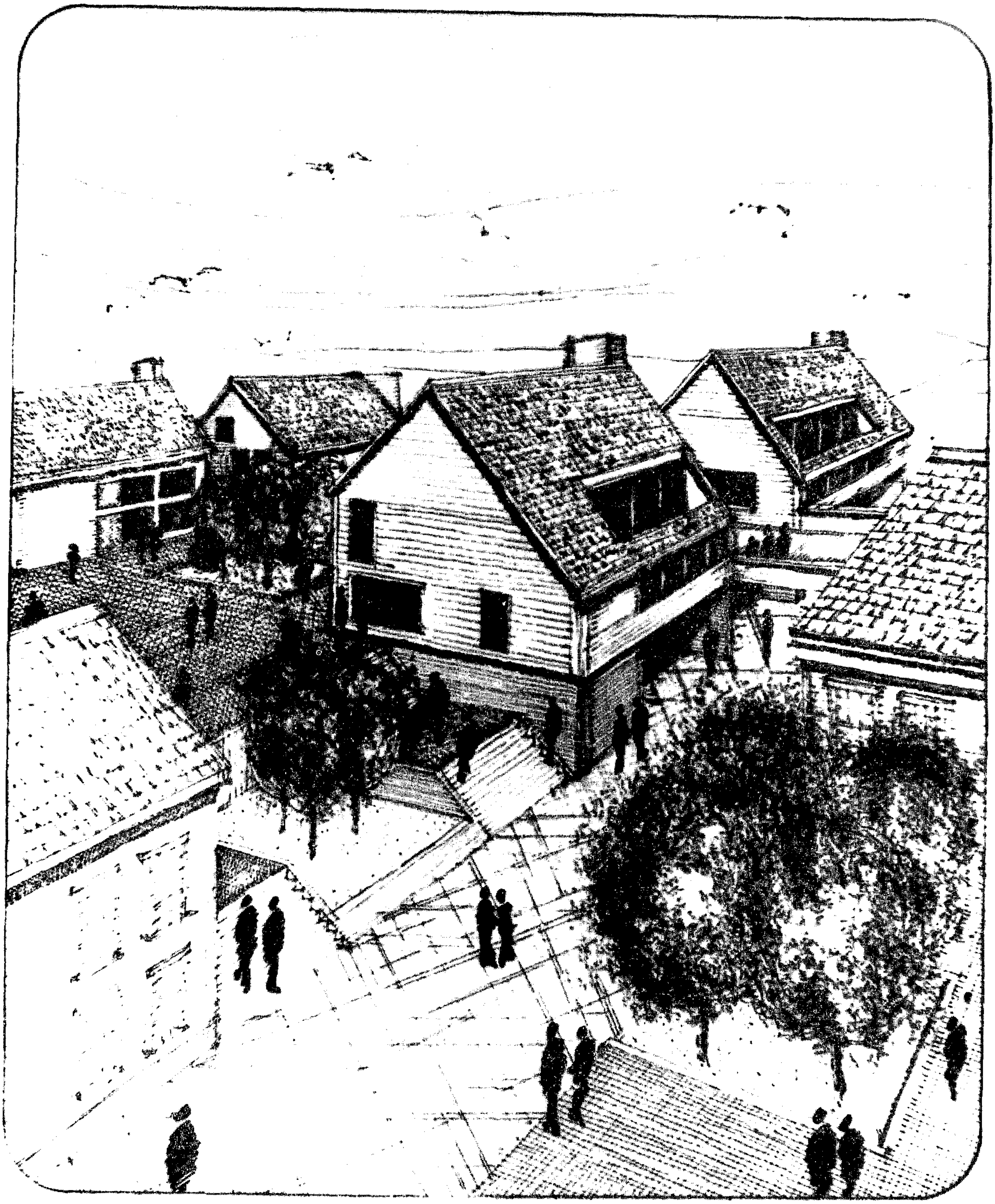


FIGURE 3-12
Perspective of Proposed Newport Development

SOUTHERN U.S.

A great portion of the Gulf coast and Mississippi River system is protected by a network of levees and emergency flood-control devices. The levees provide varying degrees of protection from Mississippi River flooding and hurricane-induced high water. However, where this protection is not totally sufficient to protect against the base flood, structures behind the levees may be required to be elevated, although possibly to a lower level. In addition, substantial unprotected areas in New Orleans and the Mississippi Delta area and along the Gulf coast are subject to riverine or coastal surge flooding.

NEW ORLEANS, LOUISIANA

A modular foundation concept was selected by the architects as the basis for their design of single-family and multi-family housing. It is the architect's belief that aesthetic design should incorporate the least number of supports above grade.

Consequently, the supporting foundation columns are placed on 14- to 16-foot centers resting on concrete-capped wood piles driven 20 to 30 feet into the ground. The column material(e.g., wood) is dependent on the loading, cost, and architectural considerations. In this instance, the architects have chosen a stressed skin (plywood) column. The utility services would be brought from underground into the residence inside a dummy column.

SINGLE FAMILY RESIDENTIAL CONCEPT

The stressed-skin columns visually organize and highlight this design for a single-family residence elevated 10 feet above grade. The plywood columns, resting on concrete-capped wood piles, are designed to resist all loads including flood and lateral loading without requiring unsightly cross-bracing.

Parking and storage is provided below the elevated living area. Second floor balonies assure a means of escape during high flooding as well as providing visual and spatial interest. The large windows provide for views and ventilation.

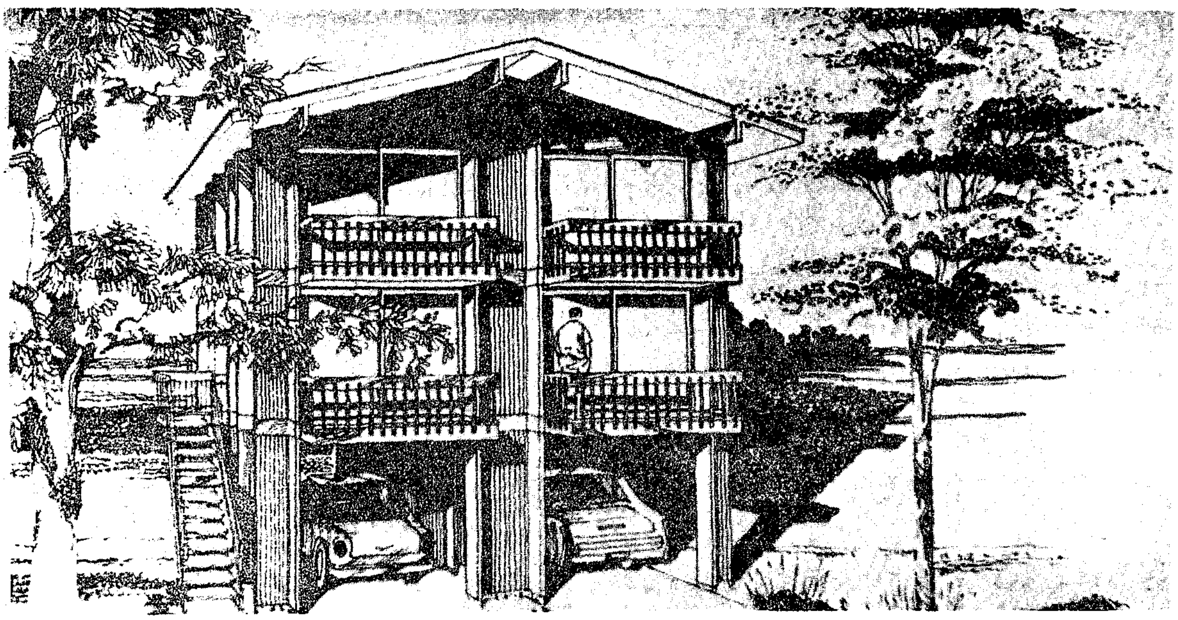


FIGURE 3-13
Elevated Single Family House
Elevated 10' Above Grade

MULTI-FAMILY RESIDENTIAL CONCEPT

Raised 4 feet above grade, this multi-family residence is both hurricane and flood resistant, as well as visually appealing. Stressed-skin columns of marine grade plywood again provide lateral and vertical support. Landscaping placed around the bottom of the structure minimizes the elevated appearance of the residence.

FIGURE 3-14
Elevated Multifamily Housing
Elevated 4' Above Grade

MIDWESTERN U.S.

Flooding in the midwest is of two types: riverine and lake flooding. The characteristics of both are usually slow rise and low velocity. However, flash flooding and lake shore scouring can and do occur. The Great Lakes area, more specifically, the Wisconsin, New York, Ohio, and Michigan lake shores have experienced growing problems of lake flooding and slow erosion caused by the increasing occurrence of high waters and high winds.

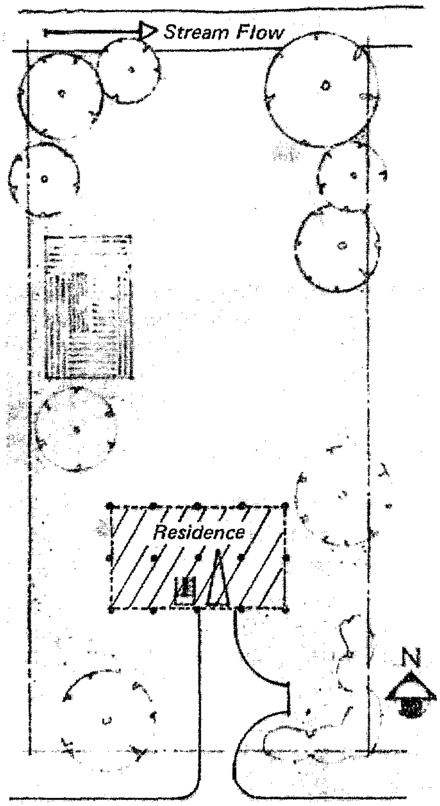


FIGURE 3-16
House Site Plan

CHICAGO, ILLINOIS

The architect has chosen two different foundation and structural systems for his design of a single-family residence and a garden apartment. The single-family residence is supported by a wood post foundation extended and anchored to the roof. The garden apartment, however, is supported by reinforced concrete block walls. Both residential concepts provide parking and entrances from under the building.

SINGLE-FAMILY RESIDENTIAL CONCEPT

Designed for an average income family in the Chicago area, the architects have conceived a

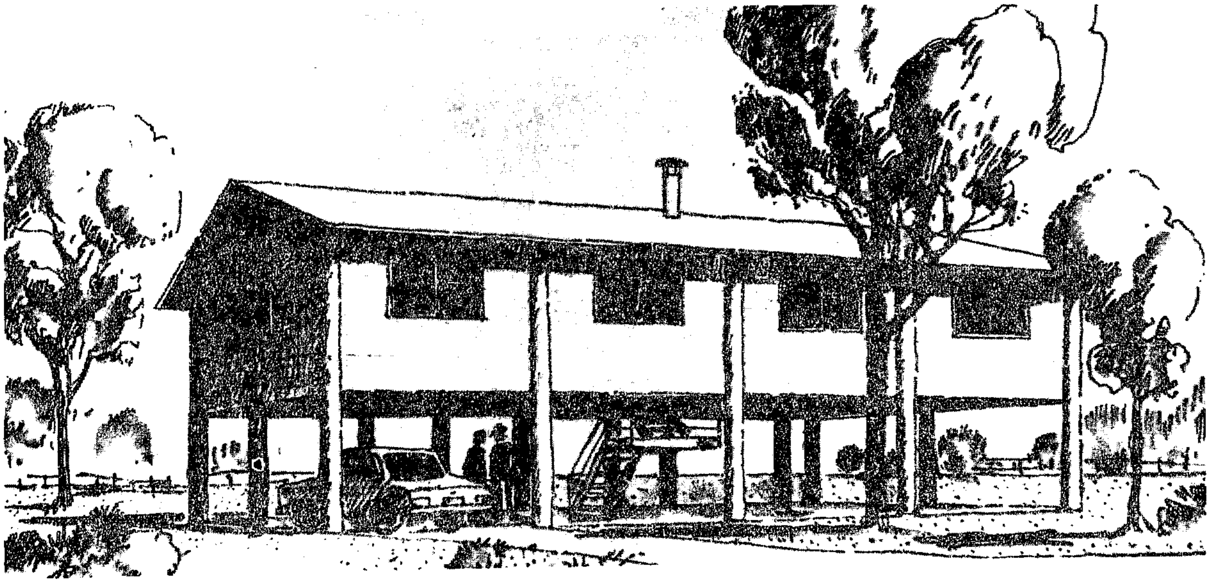


FIGURE 3-15
Single Family House
Elevated 8' Above Grade

well-proportioned residence (see Figure 3-15). Wood posts support the structure as well as organize the exterior appearance. To allow the passage of flood waters and floating debris, the area under the elevated structure has been left as open as possible. The entrance to the structure is provided by an open stair sheltered by the residence above. Automobile parking and sheltered relocateable storage is also provided under the structure.

GARDEN APARTMENT CONCEPT

Although elevated 8 feet and constructed of reinforced concrete block, this rowhouse does not appear to be designed for a potential flood condition. The covered parking and entrance level is handsomely integrated with the above living levels by reinforced concrete block walls which organize the entire structure. The walls are constructed parallel to the direction of possible water flow as shown in Figure 3-18. Although the entrance to the residence would be inundated by flood waters, the occupants would not be and they could evacuate by means of a second story balcony.

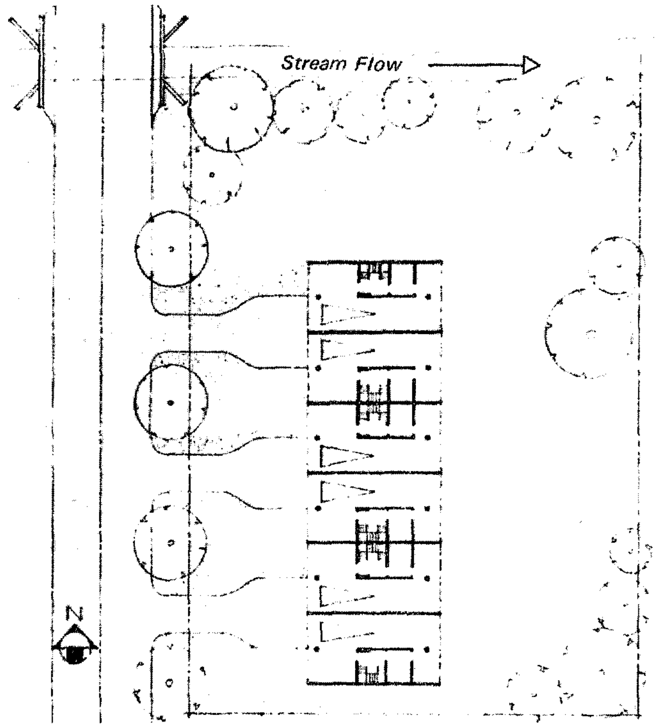


FIGURE 3-18
Housing Site Plan

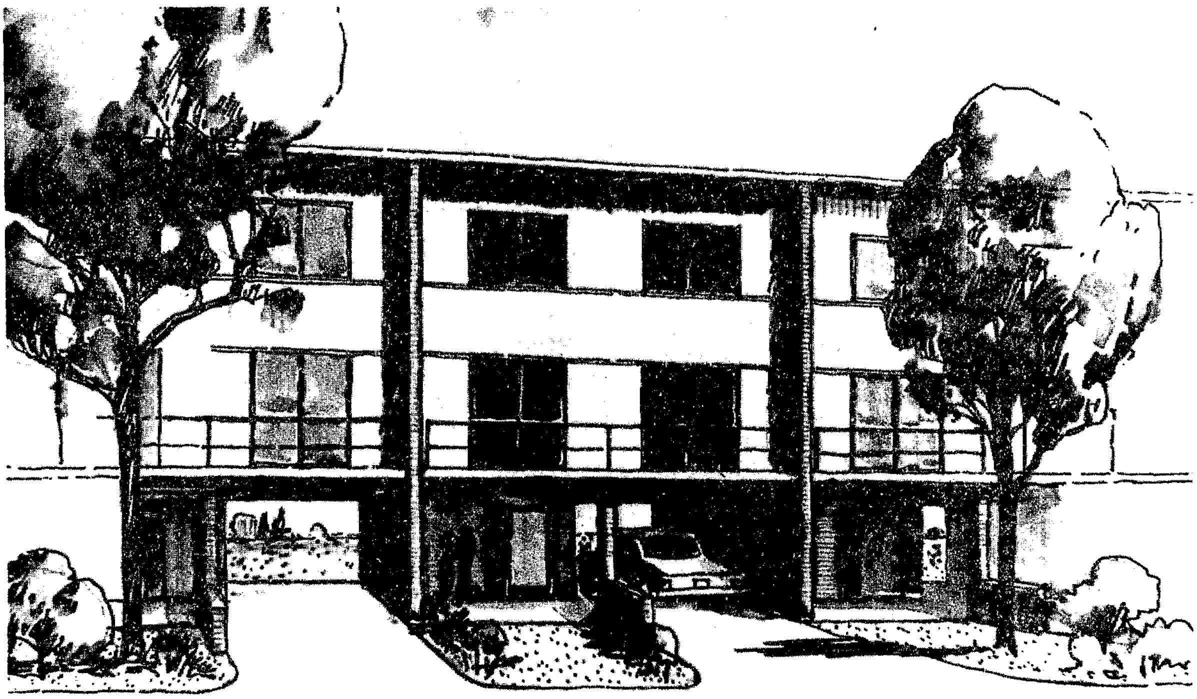


FIGURE 3-17
Garden Apartment
Elevated 8' Above Grade

Pacific coast flooding is generally associated with high seas and rains. Ocean storms accompanied by high winds have caused considerable erosion and damage to beach and coastal flood plain property. Inland rain storms, on the other hand, falling on the mountainous terrain cause major canyon and valley flooding. Both coastal and canyon flooding are dangerous high velocity situations. Slow-rising and lower velocity conditions occur on coastal marshes and low-lying riverbeds.

SAN FRANCISCO, CALIFORNIA

The architect has developed several very interesting and distinctive residential concepts for single- and multi-family housing. The use of landscaping, fences, and exterior decks minimizes the elevated appearance of the structures while providing functional visual highlights. Structurally the two concepts are quite different. Although both concepts utilize wood posts, the single-family residence uses a two-way structural grid supporting prefabricated housing units, while the multi-family structure is conventional wood frame construction built upon a wood post supported platform.

Parking for both residential concepts is under the structure.

SINGLE FAMILY RESIDENTIAL CONCEPT

A two way wood post structural grid supports the living units at levels above the base flood and serves to organize and unify the various units with a minimum impact on the ecology of the area. A seven foot clearance beneath the horizontal structural members allows for parking, storage, and sheltered recreation space separated from and below the living units (see Figure 3-19). The reduced land coverage of this design is in keeping with the architect's concern for efficient/effective land use. Shared facilities, clustering buildings, etc., further give these houses a unique identity and sense of community. Within the prescribed vernacular of poles, decks, railings, and fences, architectural variety with continuity is achieved. The fences are strapped together to prevent pieces from floating away if damaged during a flood. Water heater and furnace and air conditioning equipment are located 18 inches above base flood level with all ductwork in second floor or attic space (see Figure 3-20).

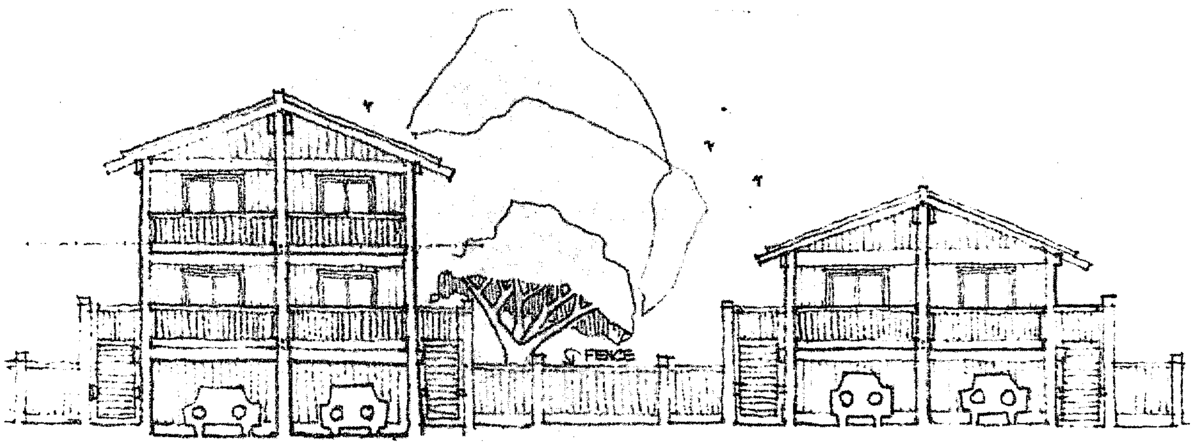


FIGURE 3-19
Single Family Detached One and Two Story Housing Elevated 7'-6" Above Grade

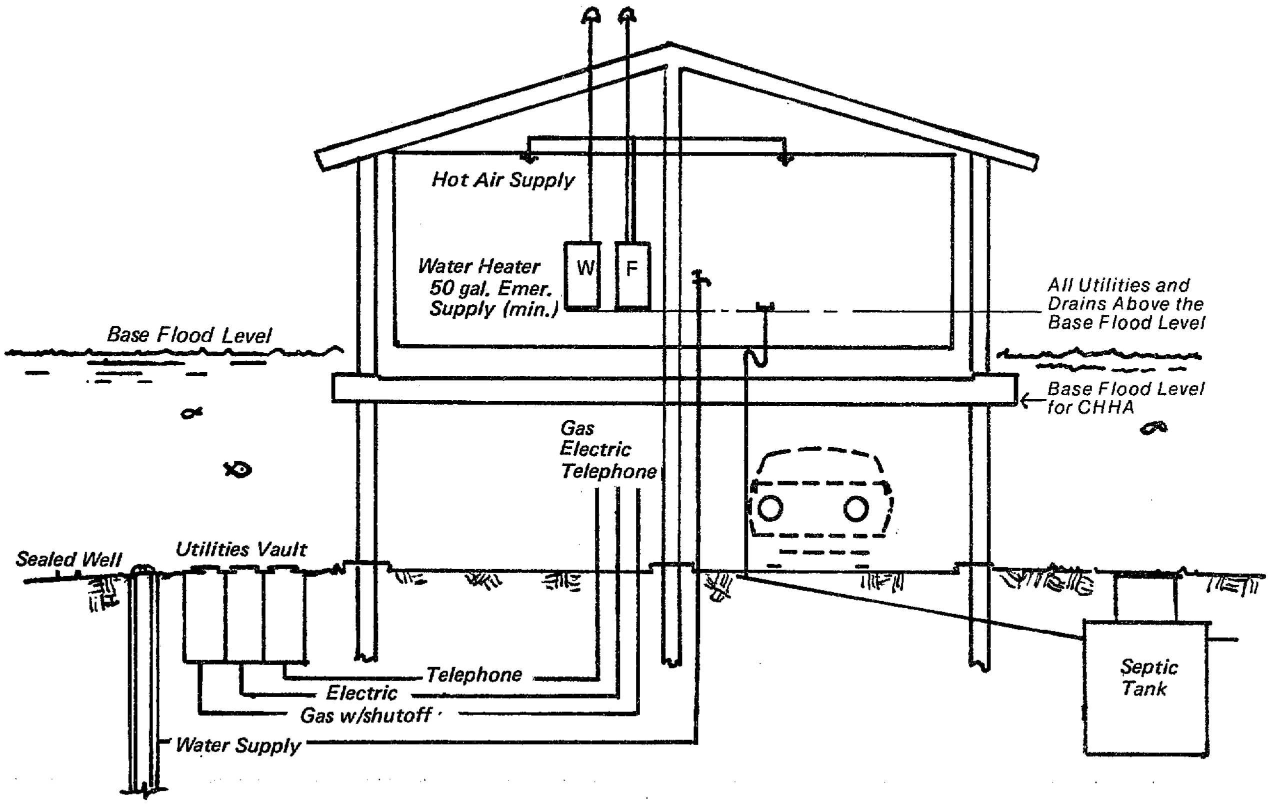


FIGURE 3-20
Mechanical Schematic of Single Family House

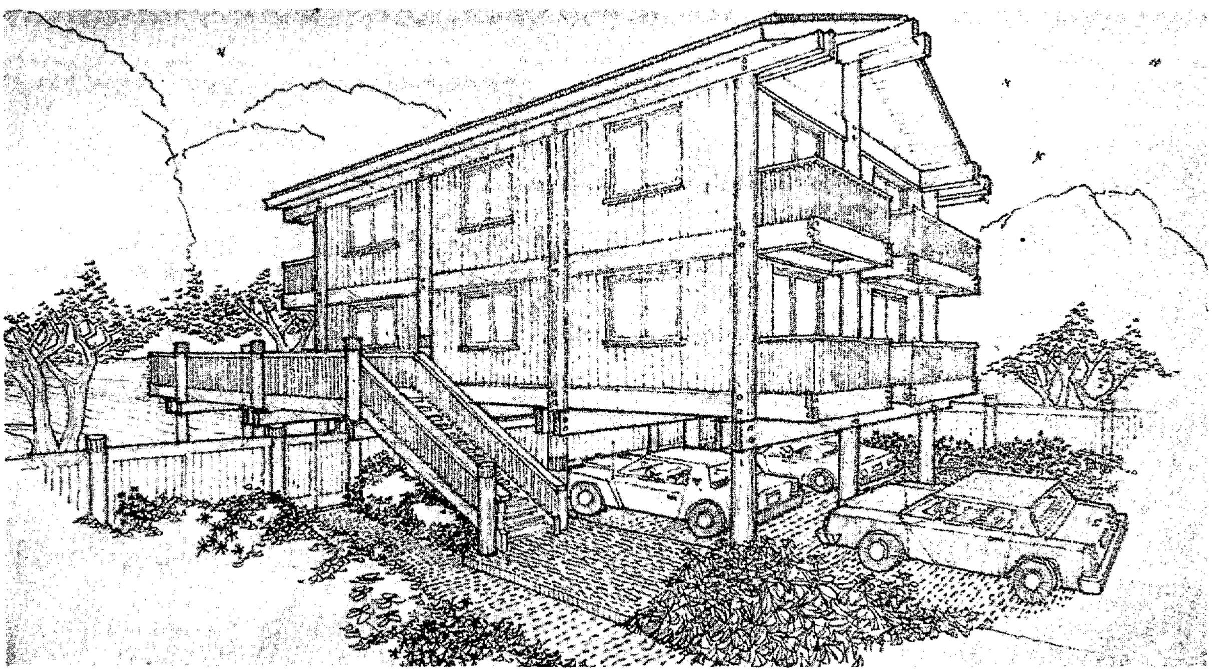


FIGURE 3-21
Perspective of Single Family House

MULTI-FAMILY RESIDENTIAL CONCEPT

To reduce costs, the architects have designed a conventional wood frame structure built upon a wood post platform. Raising the first floor to at least 8 feet above grade provides an opportunity to put parking under the building. This reduces the area of the site that has to be built upon and places cars closer to apartments. However, parking under the structure requires fire separation. Exposed entrance stairs and fencing minimize the elevated appearance of the structure while providing visual variety and privacy (see Figures 3-22 and 3-23).

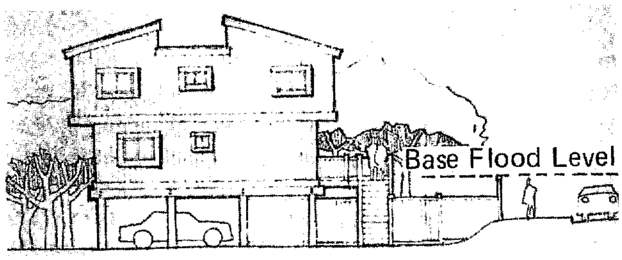


FIGURE 3-23
Elevation of Multifamily Housing

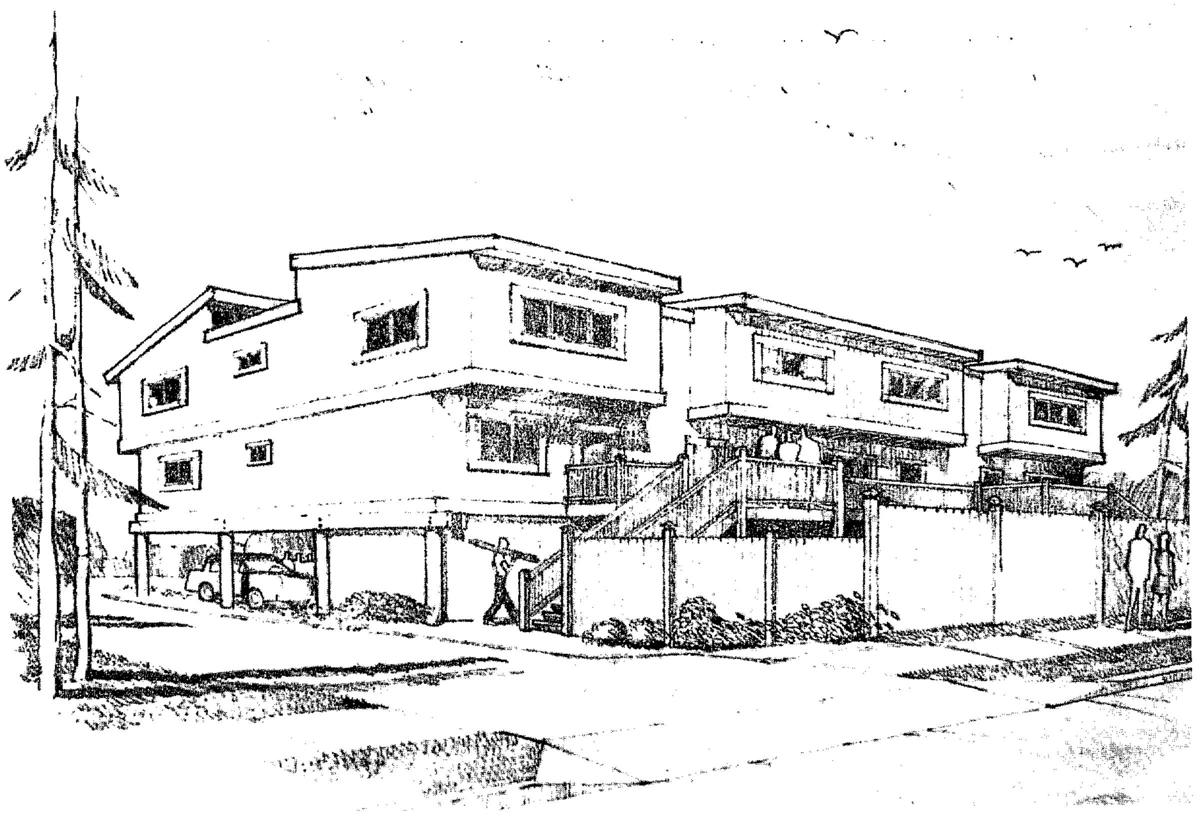


FIGURE 3-22
Perspective of Multifamily Housing Elevated 8' Above Grade

Cost Analysis of Elevated Foundations

COST ANALYSIS

Once a community decides that the economic risk and environmental impact of developing flood plain land for residential use is acceptable, the dollar cost of that development must be evaluated. Two factors bear significantly upon any such evaluation: first, how can you assess the net cost of construction in the flood plain which meets the requirements of the National Flood Insurance Program in light of the potential and unpredictable hazard of flooding and the losses which may ensue; secondly, what are the particular cost differentials between construction on elevated foundations, as required by the National Flood Insurance Program for new structures and substantial renovation in flood-hazard areas, and conventional building methods.

The conclusion is inescapable that the savings realized over the lifetime of a structure by building on a raised foundation, are considerable and dramatic when compared with the one-time increase in construction costs for an elevated foundation. This is especially valid considering the foundation costs are generally only eight percent of the total cost of a residential structure.

COST ANALYSIS APPROACH

In order to arrive at this conclusion as well as to compare the cost of elevated construction in the flood plain with the cost of building types most home builders are familiar with, the following steps were taken: (it is important to note that the average cost summaries for elevated foundations are without regard to the height of the structure.)

1. *Slab-on-grade, crawl space, and basement foundations* (see Figure 4-1) were selected as three of the most common types of residential foundations and detailed drawings of them were prepared. Detailed drawings were also prepared for the three most typical elevated foundation types. These are *post, pile, and pier foundations* (see Figure 4-2).

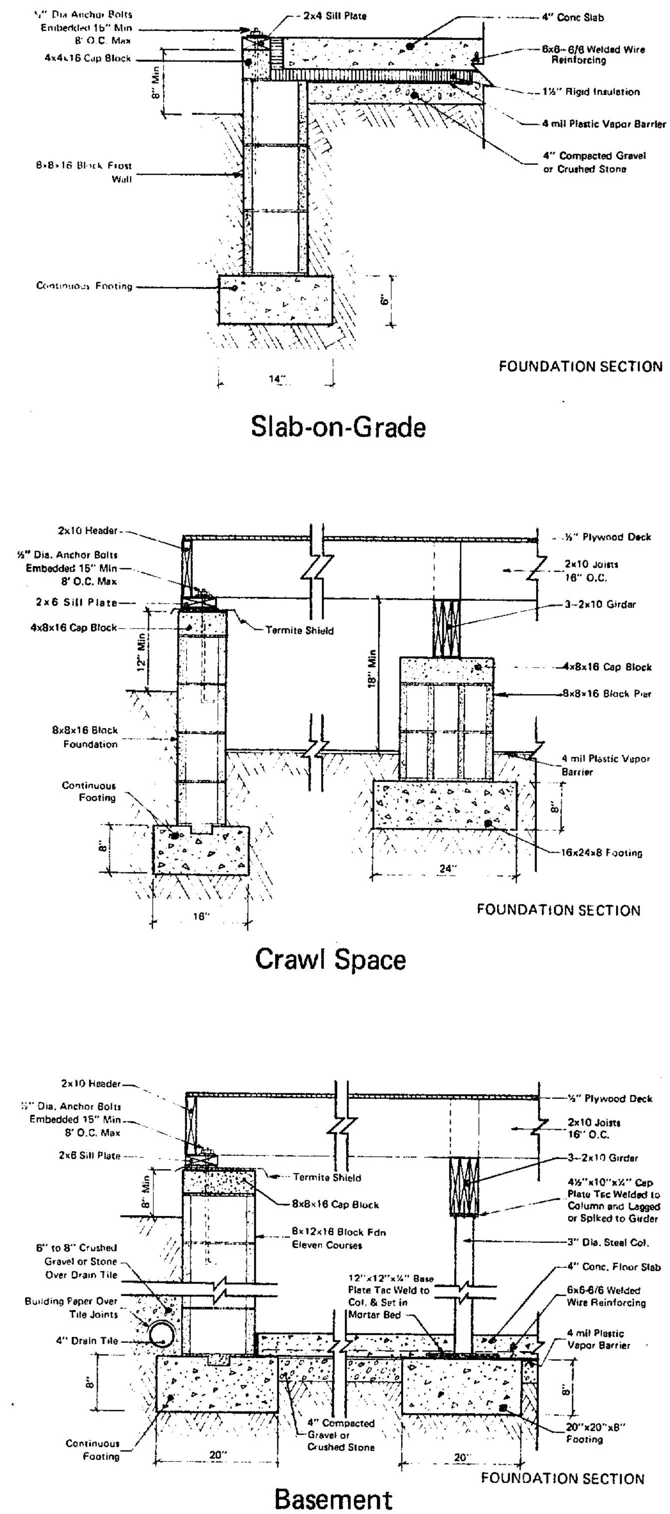


FIGURE 4-1
CONVENTIONAL FOUNDATIONS

2. These detailed drawings were distributed nationwide for cost estimates in early 1974. The estimates are summarized in Table 1. They are based on the foundation and deck of a 1500 square-foot house, 28' x 50' with a small offset (see example, page (4-9). The total cost of this house is in the $25,000 range excluding land. All estimates were based on construction practices acceptable under the FHA *Minimum Property Standards for One- and Two-Family Dwellings* and respond to the objectives of the performance requirements presented in the manual.

TABLE 4-1

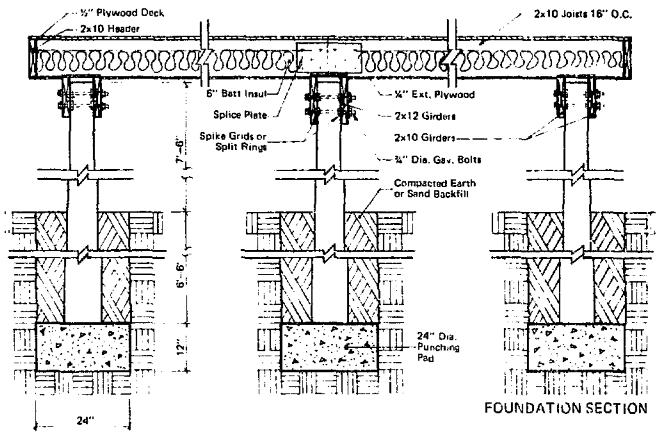
Foundation Cost Estimates
Average Cost Summary

CONVENTIONAL FOUNDATIONS		
SLAB-ON-GRADE	$1.27	per sq. ft.
CRAWL SPACE	$1.95	per sq. ft.
BASEMENT	$3.49	per sq. ft.
ELEVATED FOUNDATIONS		
WOOD POLE	$3.35	per sq. ft.
WOOD PILE	$3.05	per sq. ft.
CONCRETE PIER	$3.59	per sq. ft.

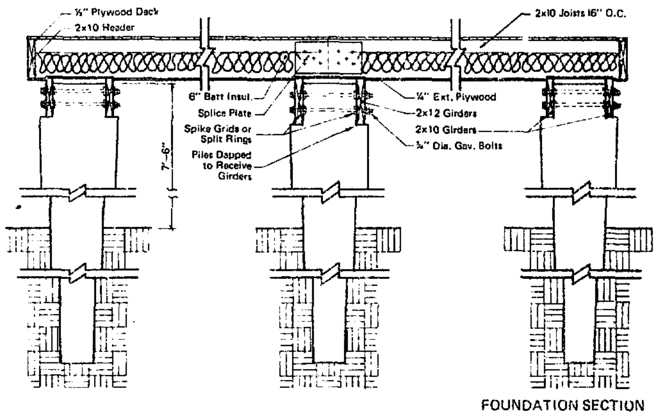
ESTIMATES—SPRING 1974

3. Using the data from this cost sampling, the average cost of each conventional foundation type was compared to the average cost of each elevated foundation type. This comparison was done in two ways: first, each elevated foundation was shown as a percentage of the cost of each conventional foundation (conventional foundations were established as base 100); and second, each foundation was shown as a percentage of the cost of the *entire* house. These cost comparisons are explained and graphed in the cost comparison section.

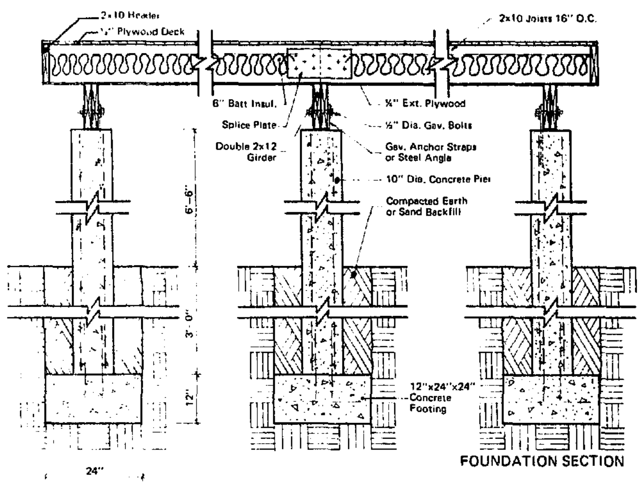
4. The height to which the first habitable floor of residences will have to be elevated will vary depending on base flood levels and topography. The effect increased elevation has on foundation costs was examined. The results are presented under *FOUNDATION COST COMPARISONS*.



Wood Posts



Wood Piles



Concrete Piers

FIGURE 4-2
ELEVATED FOUNDATIONS

5. The next step of the cost comparison analysis was to provide the user of this manual with some guidance for interpreting the effects future material cost variations will have on the cost of elevating residences. This is discussed in the *Future Factor* section.

6. Cost estimating sheets are included at the end of this part of the manual. They are provided to assist the user of this manual in making his own cost comparisons.

COST COMPARISON CONSIDERATIONS

FILL

Fill can be used to elevate conventional foundations such as slab-on-grade. The cost of this approach will depend on the availability, quality, and unit cost of fill as well as the height and compaction necessary. The environmental and engineering considerations involved in the use of fill are complex and directly related to local conditions. When elevating on fill is being considered as an option a soils engineer should be consulted for technical advice.

LOWER SPACE OPTIONS

The space created under a residence by raising it on piles, posts, piers or other such elevated foundation can be treated and used in several ways:

1. It can be left open and used for such things as parking and boat storage.
2. It can be enclosed with breakaway panels or knock-out walls that will collapse under hydrostatic pressure without disturbing the structural support of the building (see Figures 2-6 through 2-9). Recommended usage of this area would be temporary storage and garage space.
3. Basements are generally prohibited in residential structures that are located in flood hazard areas. Under extraordinary circumstances, where their omission would cause severe hardship and gross inequity, the Federal Insurance Administrator may grant an exception to permit basements. These basements must be completely flood-proofed, i.e., watertight and capable of resisting the action of the base flood.
4. Where a community has demonstrated a need for shelter against recorded occurrences of tornado or severe windstorm, the Administrator may grant permission for "storm cellars." Such storm cellars must be designed to insure the integrity of the main structure during the time of flooding and are limited to non-habitable uses. All electrical, heating and other utilities must be above the level of the base flood.

The decision on how to deal with this space below the elevated floor will affect the cost of construction and should be considered in the total cost picture.

EARTHQUAKES

Constructing elevated foundations in earthquake areas may require additional structural expenditures that should be noted in cost estimates. The local building code and a structural engineer should be consulted to evaluate local conditions.

ELEVATED FOUNDATION DEPTHS

The depths to which foundation footings have to be set or piles driven depend on local soil conditions, frost penetration levels, flood loads, and anticipated scour. These all affect the cost of construction, and can cause variation from the cost estimates presented here.

STAIRS AND UTILITIES

Elevating a residence may result in increased cost for stairs and for utilities that must be brought from grade. These costs were not considered in the estimates presented here since they may vary with height of elevation, cost assignment, i.e. who pays for installation, and elevation method.

THE REAL COST OF ELEVATING A RESIDENCE

The economic cost to the individual of building a home in the flood plain consists of both flood damages that will occur and the costs of whatever measures are taken to mitigate such damages. The cost of flood damages to the homeowner may be partially shifted to Federal, state and local government through low-interest loans and tax deductions for losses incurred. The Red Cross and other agencies also reduce the cost of flood losses to individuals through their disaster assistance programs. In communities participating in the National Flood Insurance Program, the owner of a new home may purchase flood insurance at actuarial rates which reflect the degree of risk. Essentially, flood insurance allows the homeowner to spread the flood risk to others facing the same hazards, and more importantly permits one to pay for expected flood losses which are unpredictable with respect to size and time of occurrence in predictable annual payments. These are more manageable than unexpected flood losses, especially if more than one large flood happens to occur in a very short time.

A prospective homebuyer could reduce his susceptibility to damage (and flood insurance premiums) by floodproofing. There are many forms of floodproofing; however, this discussion will deal only with elevation. Generally the least expensive means of obtaining 2 or 3 feet of elevation is with fill. For greater elevation, posts, piles, or piers would be the best choice. Figure 4-4 illustrates this relationship.

Tables 4-2 through 4-4 present the cost picture in terms of the 1500 square foot one-story house being used for estimating purposes in this section. The data presented in these three tables is for a particular flood plain in Louisiana and would likely be different on other flood plains.

Table 4-2 indicates the extent of damages that a $25,000 structure with $12,500 worth of contents would sufer from particular depths of flooding. The probability for each depth of flooding was used to refine the flood damage data in Table 4-2 into figures for the probable annual average flood damage that the owner of the example house could expect (see Table 4-3).

TABLE 4-2

Estimates of Flood Damage to a $25,000 1500 Square-Foot Home with No Basement With Contents Valued at $12,500

Depth of Water Above First Habitable Floor	Damage to Structure		Damage to Contents		Probable Total Value of Damage
0 Ft.	7%	$1,750	10%	$1,250	$ 3,000
+1 Ft.	10%	2,500	17%	$2,125	4,625
+2 Ft.	14%	3,500	23%	2,875	6,375
+3 Ft.	26%	6,500	29%	3,625	10,125
+4 Ft.	28%	7,000	35%	4,375	11,375
+5 Ft.	29%	7,250	40%	5,000	12,250
+6 Ft.	41%	10,250	45%	5,625	15,875

Table 4-4 illustrates the options which are available to an individual wishing to construct a new, $25,000 one-story home with no basement in Zone A-8 where the original ground is six feet below the base flood elevation. It should be noted that under FIA regulations a home could not be constructed with the first floor below the base flood level unless a variance has been granted by the community where the house is to be located; however, this example is useful to illustrate the economic advantage of elevating.

As shown in Table 4-3, at this location the house would receive $1,500 in average annual damages if constructed on a slab-on-grade, which is option A in Table 4-4. In this case the cost of flood insurance is approximately equal to the expected damages. Options B, C, and D are ways of reducing the net cost to the homeowner of occupying the flood plain. Option B is to elevate on fill, and options C and D are to elevate using columns. For purposes of comparison all costs in Table 4-4 were put on an annual basis, thus the initial cost of elevation which would normally be included in the mortgage is shown as the additional yearly cost which would result in the mortgage payments. This example also shows the relatively small impact of elevating on the monthly cost of the home, for example option D would result in a $22 per month increase in the mortgage payment.

These tables show that for this home it would be less expensive to elevate to or above the base flood level than to build below it and suffer loss.

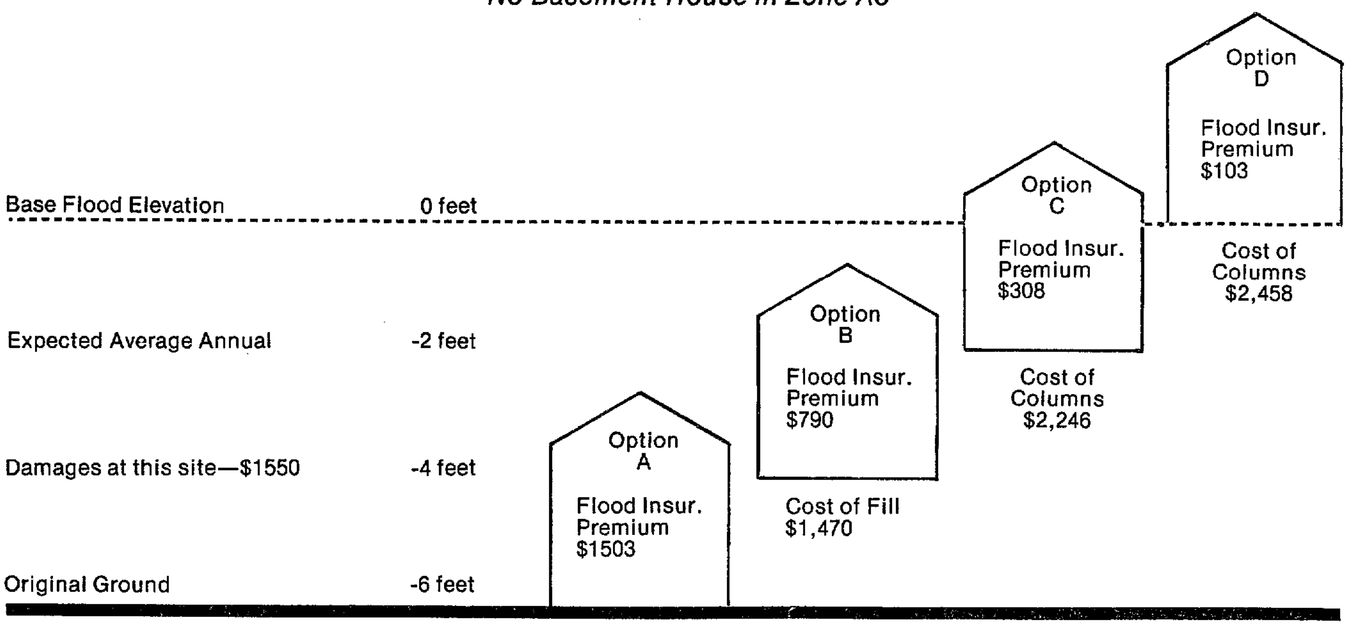
TABLE 4-3

Average Annual Damage

Floor Elevation Above Grade	Probable Average Annual Damage
0 Ft.	$1550
+2	625
+4	160
+6	50

TABLE 4-4

Economics of Elevation for a $25,000, One-Story, No Basement House in Zone A8



ANNUAL COSTS	A	B	C	D
Annual Flood Insurance Premium	$1503	$ 790	$ 308	$ 103
Additional Annual Cost of Elevation (30 yrs at 9%)		156	240	261
Total	$1503	$ 946	$ 548	$ 364
Average Annual Damages Expected	1550	1550	1550	1550
Net Annual Savings by Purchasing Insurance and	$ 47	$ 604	$1002	$1186

Clearly the probabilities indicate that the overall savings achieved by employing elevated foundations at least to the level of the base flood when constructing in the flood plain far out-distance increased foundation costs especially when considered in the perspective of the total cost of the structure.

ESTIMATING ELEVATED FOUNDATION COSTS

The costs of post, pile, and pier foundations are compared to each other and to the costs of conventional slab, crawl space, and basement foundations in this section of the manual. Cost data and estimating forms are provided for roughly estimating one's particular foundation costs.

The elevated foundation types reviewed here should not necessarily be construed as the best or most economical means of elevating residences: They are presented because they are currently the most common means.

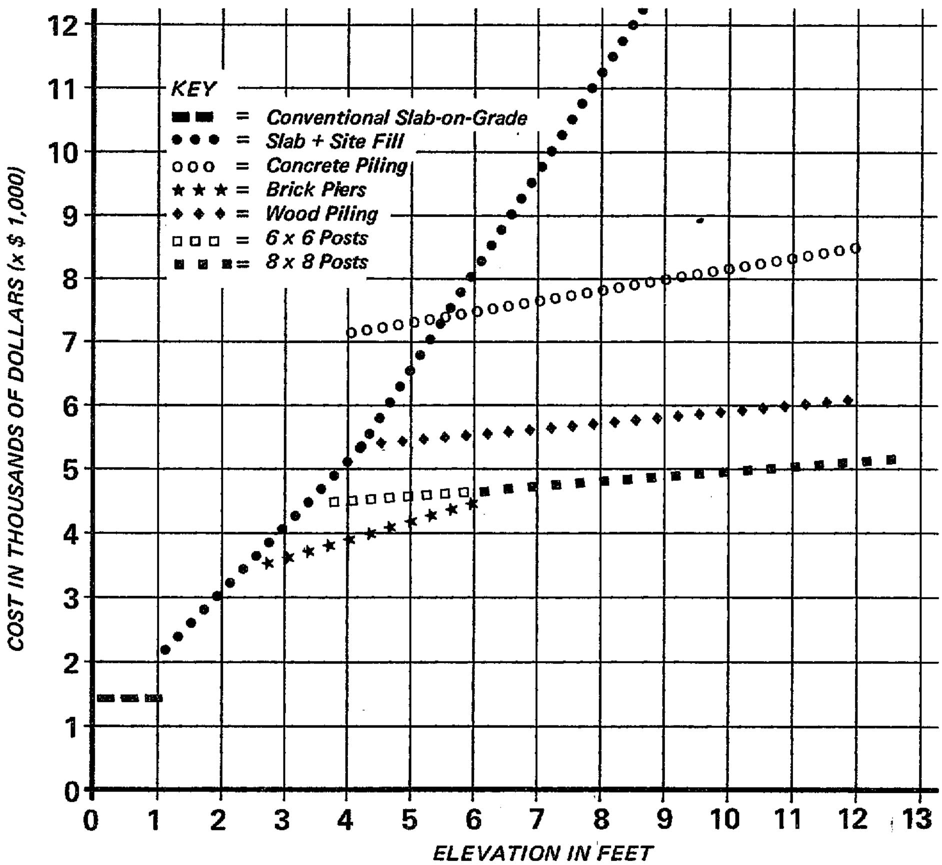
ELEVATION COST DIFFERENCES

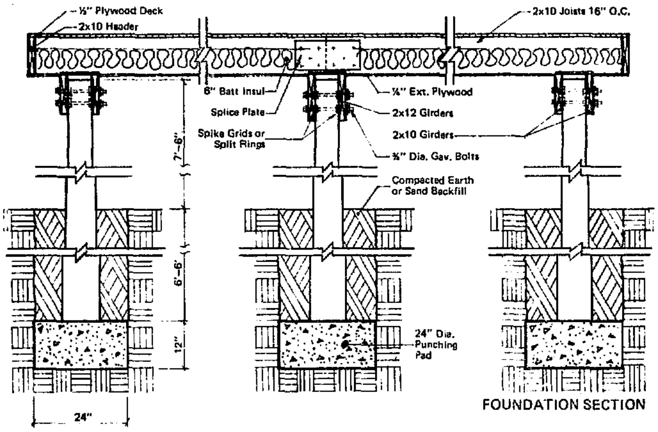
Table 4-5 graphically compares the cost of constructing seven types of foundations at various elevations. The foundation alternatives presented in the graph are for a 1624 square foot house on the Amite River in East Baton Rouge Parish, Louisiana. It is important to note, from this graph, the relative costs of foundation types and that increasing the floor elevation increases costs at a substantial rate only in the case of the fill option. The most economical type of foundation for elevating a residence will vary with the height of elevation. Table 4-5 relationships are specifically for Louisiana; however, the relationships should be similar throughout the nation.

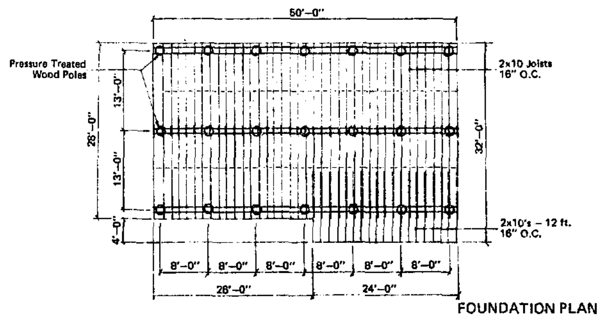
Cost is not the only determinant for selecting the material and method for elevating. Other considerations, including market acceptance (buyers and banks), architectural design integration, climatic conditions, site conditions, and anticipated flood hazards should also be considered.

TABLE 4-5

Cost Comparison of Foundation Types for a Specific House in Louisiana

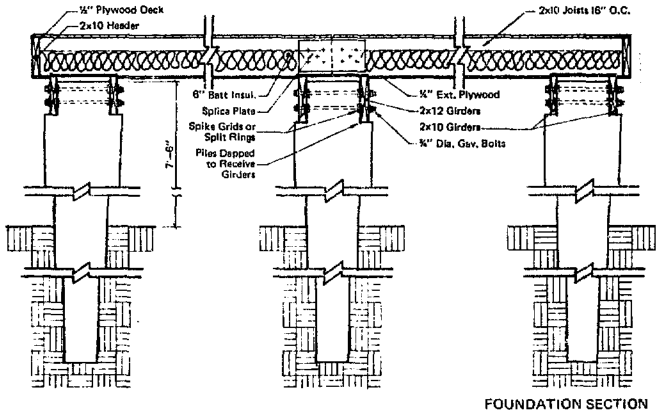


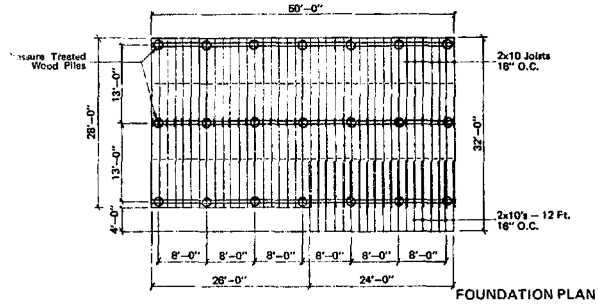




ELEVATED WOOD POST FOUNDATION

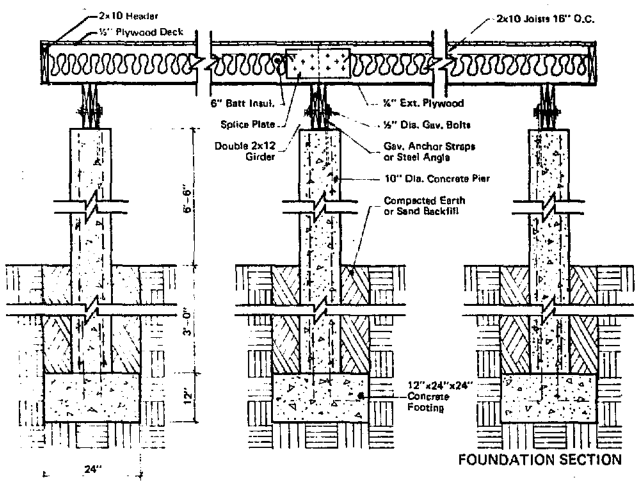
$ 3.35 per square foot

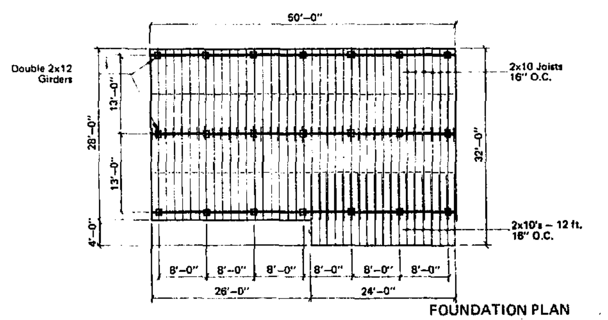




ELEVATED WOOD PILE FOUNDATION

$ 3.05 per square foot



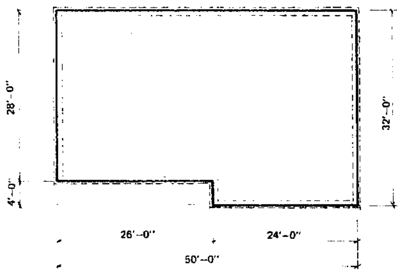


ELEVATED CONCRETE PIER FOUNDATION

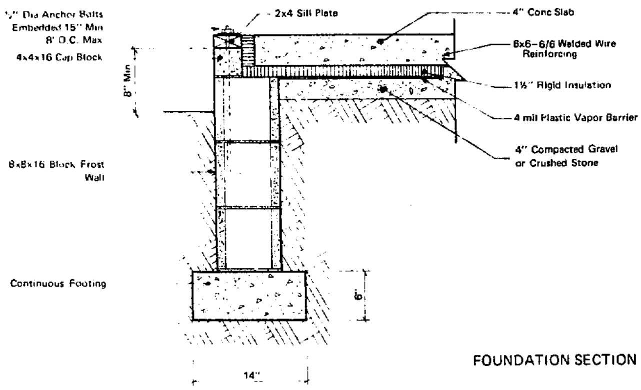
$ 3.59 per square foot

SLAB-ON-GRADE CONSTRUCTION vs. ELEVATED FOUNDATIONS

Use this page for cost estimating if the houses built in your area have foundation systems similar to the illustration at the right.



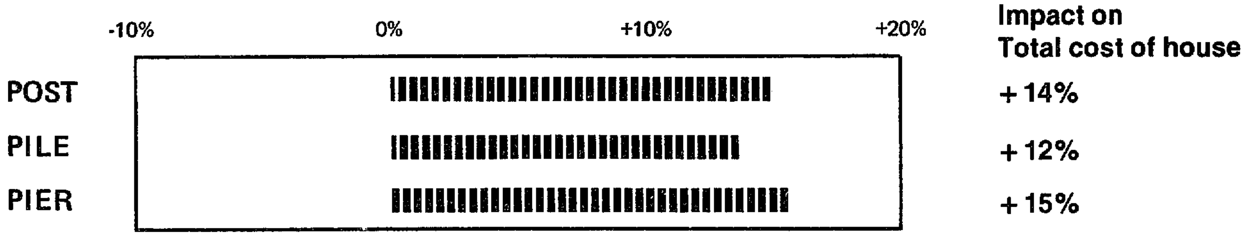
FOUNDATION PLAN



FOUNDATION SECTION

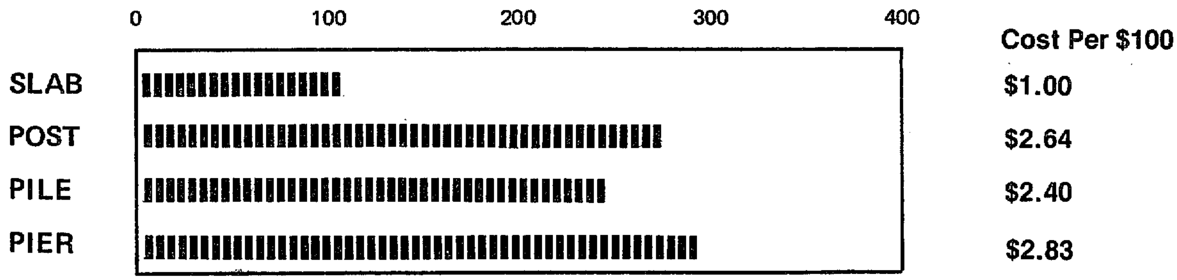
SLAB-ON-GRADE *$1.27 per square foot*

1. Since the foundation and floor slab of a conventional house represent about 8% of the total cost of that house (not including land), the effect of elevating by one of the three techniques shown in Figure 4-3 on the total price of the house is relatively modest.

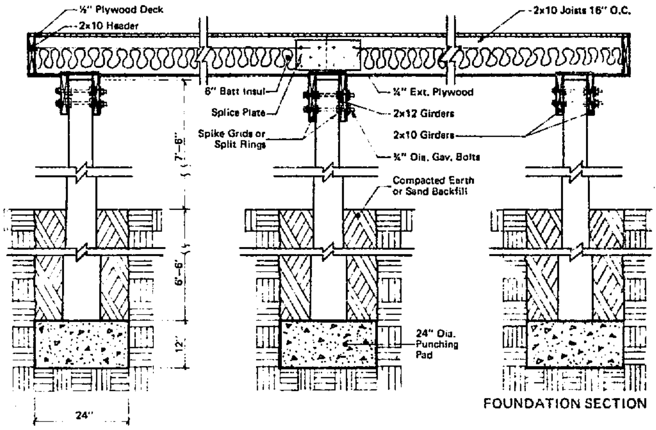


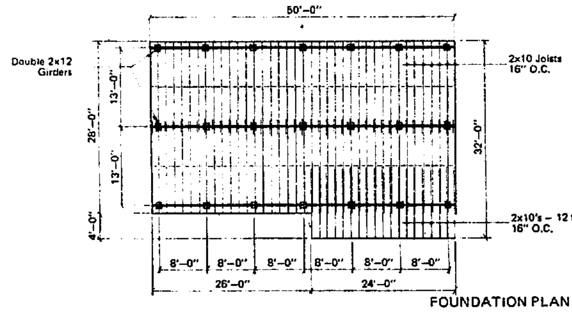
IMPACT OF COST ON WHOLE HOUSE

2. Figure 4-3 illustrates three practical methods of elevating house so that their first floors are above the base flood level. The relative cost of each per one hundred dollars as compared with the cost of conventional slab-on-grade construction is shown on the following bar graph. For example, the cost of a 1500 square foot slab-on-grade foundation would be $1905, based on a cost of $1.27 per square foot. A comparable wood post foundation would cost a total of $5029, with a pile foundation being less expensive and a pier foundation being more expensive.



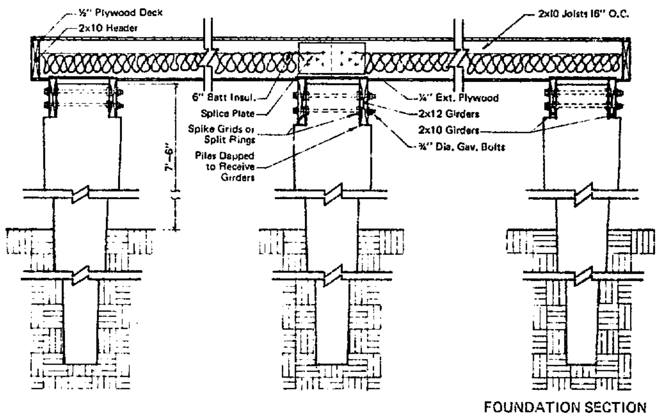
IMPACT OF COST ON FOUNDATION/DECK ONLY

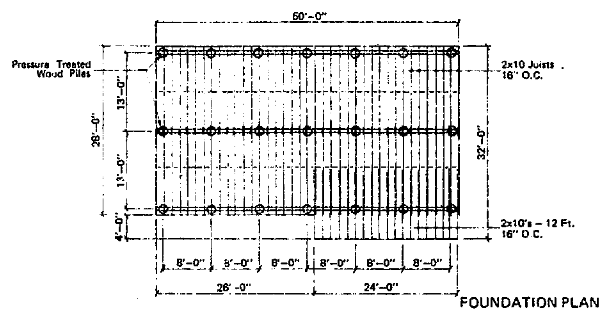




ELEVATED WOOD POST FOUNDATION

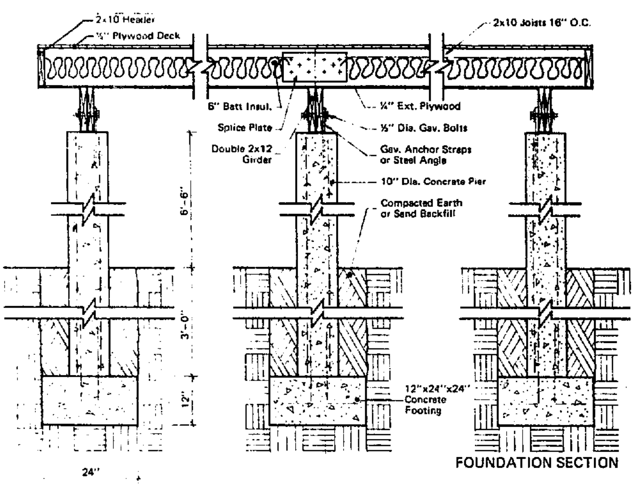
$ 3.35 per square foot

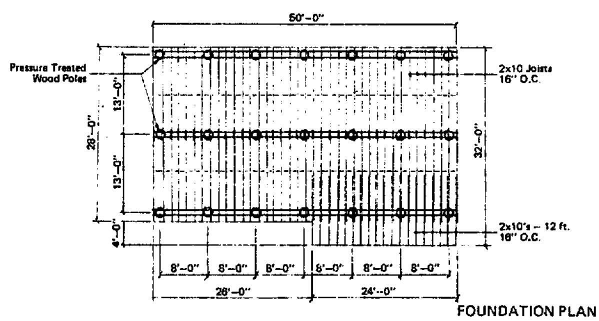




ELEVATED WOOD PILE FOUNDATION

$ 3.05 per square foot



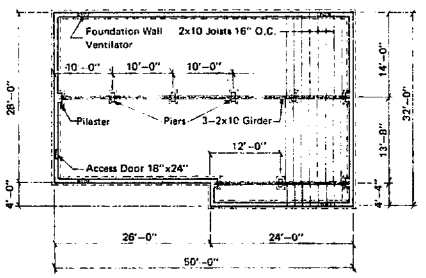


ELEVATED CONCRETE PIER FOUNDATION

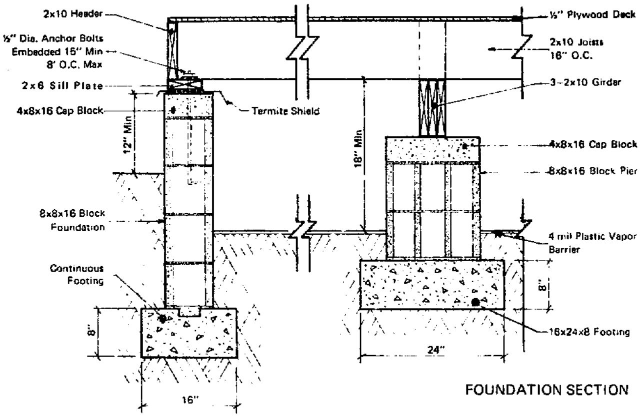
$ 3.59 per square foot

CRAWL SPACE CONSTRUCTION vs. ELEVATED FOUNDATIONS

Use this page for cost estimating if the houses built in your area have foundation systems similar to the illustration at the right.



FOUNDATION PLAN



FOUNDATION SECTION

CRAWL SPACE *$1.95 per square foot*

1. Since the foundation and deck of a conventional house represent about 12% of the total cost of that house (not including land), the effect of elevating by one of the three techniques shown in Figure 4-3 on the total price of the house is only:

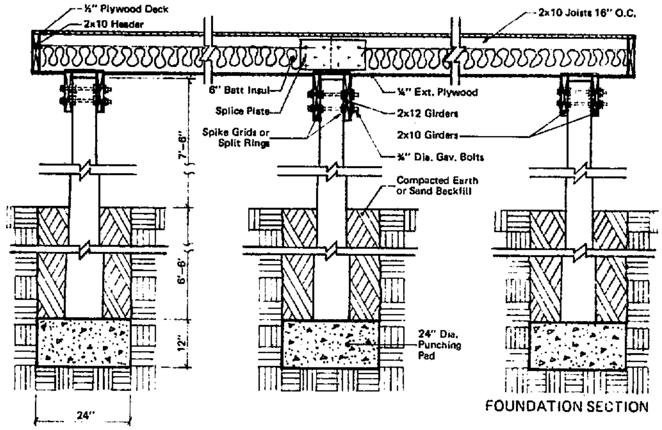
	(scale: -10% / 0% / +10% / +20%)	
POST	IIIIIIIIIIIIIIIIIIIIII	9%
PILE	IIIIIIIIIIIIIIIII	7%
PIER	IIIIIIIIIIIIIIIIIIIIIIIII	10%

IMPACT OF COST ON WHOLE HOUSE

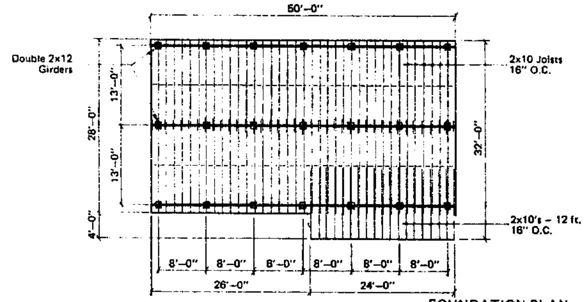
2. Figure 4-3 illustrates three practical methods of elevating houses so that their first floors are above the base flood level. The relative cost of each per one hundred dollars as compared with the cost of conventional crawl space construction is shown on the following bar graph. For example, the cost of a 1500 square foot crawl space foundation would be $2925, based on a cost of $1.95 per square foot. A comparable wood post foundation would cost a total of $5031, with a pile foundation being somewhat less expensive and a pier foundation slightly more expensive.

	(scale: 0 / 100 / 200 / 300 / 400)	Cost per $100
CRAWL	IIIIIIIIIIIIIIIIII	$1.00
POST	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	$1.72
PILE	IIIIIIIIIIIIIIIIIIIIIIIIIIII	$1.56
PIER	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	$1.84

IMPACT OF COST ON FOUNDATION/DECK ONLY



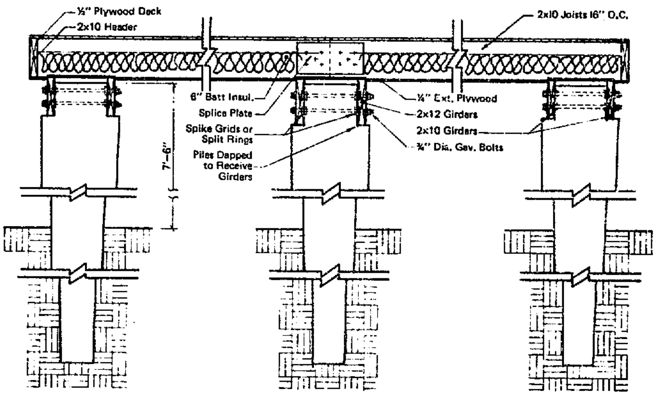
FOUNDATION SECTION



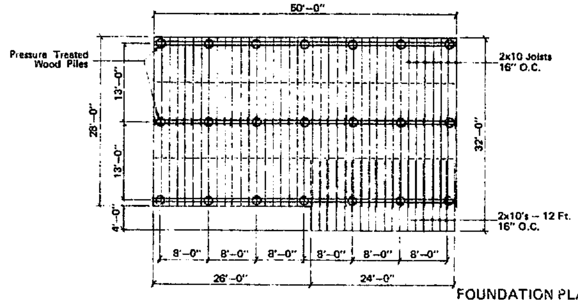
FOUNDATION PLAN

ELEVATED WOOD POST FOUNDATION

$ 3.35 per square foot



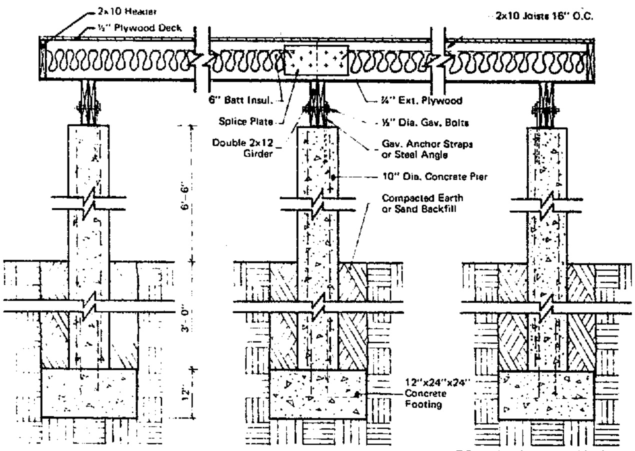
FOUNDATION SECTION



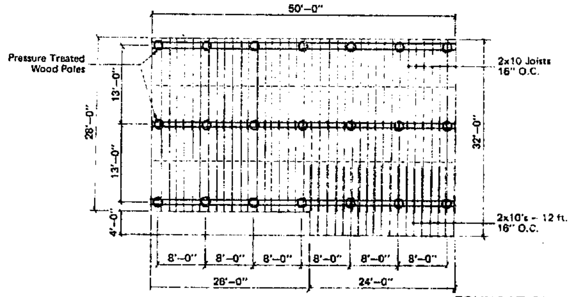
FOUNDATION PLAN

ELEVATED WOOD PILE FOUNDATION

$ 3.05 per square foot



FOUNDATION SECTION



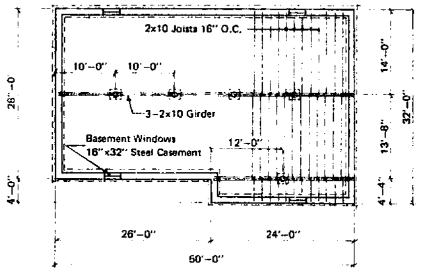
FOUNDATION PLAN

ELEVATED CONCRETE PIER FOUNDATION

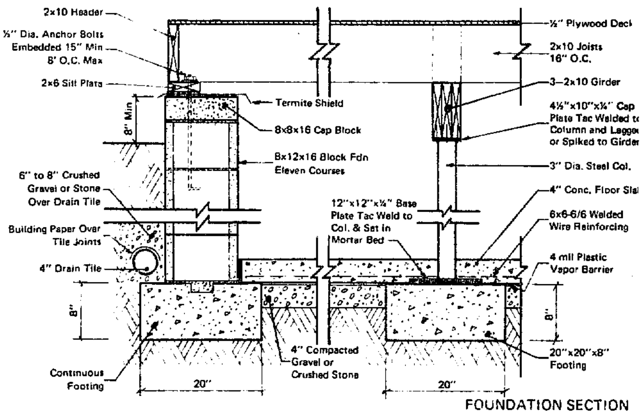
$ 3.59 per square foot

BASEMENT CONSTRUCTION vs. ELEVATED FOUNDATIONS

Use this page for cost estimating if the houses built in your area have foundation systems similar to the illustration at the right.



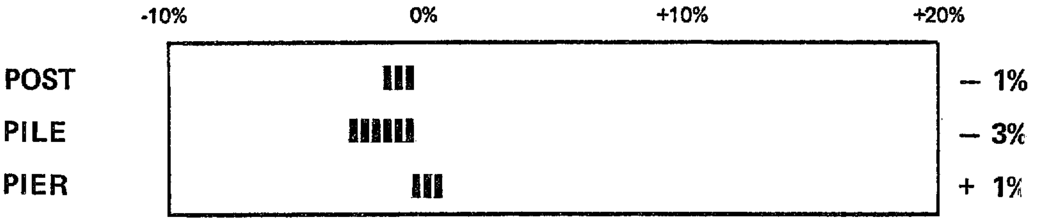
FOUNDATION PLAN



FOUNDATION SECTION

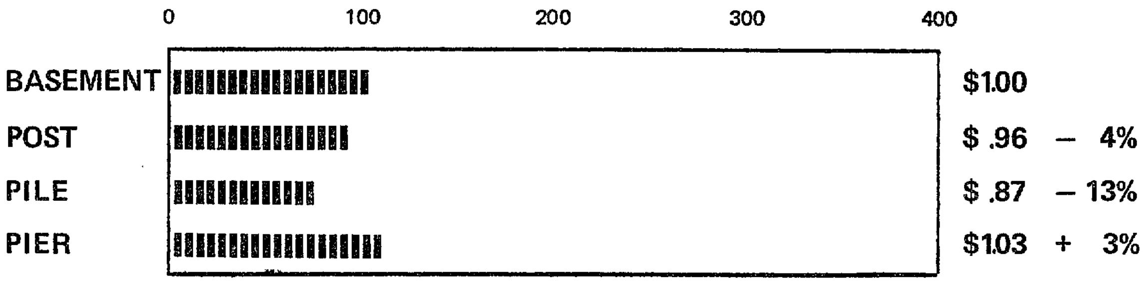
BASEMENT *$3.49 per square foot*

1. Since the basement foundation and deck of a conventional house represent about 20% of the total cost of that house (not including land), the effect of elevating by one of the three techniques shown in Figure 4-3 on the total price of the house is:



IMPACT OF COST ON WHOLE HOUSE

2. Figure 4-3 illustrates three practical methods of elevating houses so that their first floors are above the base flood level. The relative cost of each per one hundred dollars as compared with the cost of conventional basement construction is shown on the following bar graph. For example the cost of a 1500 square foot basement foundation would be $5235, based on a cost of $3.49 per square foot. A comparable wood post foundation would cost 4% less, or a total of $5025.



IMPACT OF COST ON FOUNDATION/DECK ONLY

NOTE: When comparing basements to elevated foundations the reader may want to allow for lost potential basement storage space. If this is the case, the reader may allow an added cost for the 300 to 900 cubic feet of storage space that is lost. Considering that basement storage is generally dead storage, the reader may add a square foot cost (appropriate to his area) for an additional 50 to 150 square feet of storage space.

FUTURE FACTOR

Building costs are difficult to get a long term handle on because of the tendency for the cost of basic construction commodities, lumber, concrete, and steel, to fluctuate and to vary relative to each other (see Figure 4-1). This section attempts to show the interested reader how to adjust the cost data presented in this manual for those cost variations. These adjustments will provide a rough current idea of how the cost of the various methods of elevating compare. Estimating sheets are provided at the end of this section for determining exact costs.

PERCENTAGE COST COMPARISONS[1]

The percentage cost comparisons made in the foundation cost comparison section should be valid whenever they are put to use *if the basic construction commodities are in approximately the same proportional relationship to each other as they were in the Spring of 1974.* At that time the **Wholesale Price Index** (WPI) for structural steel was 127.3; for ready mix concrete, 133.3; and for softwood lumber, 214.3.

The current Wholesale Price Index for each of the construction commodities can be obtained from the **Bureau of Labor Statistics** (BLS) of the Department of Labor in Washington, D.C. The following computational format shows one way to make the proportional comparison to see if current prices still have the Spring, 1974 relationships:

Date for BLSWPI: ____________________

Steel: (Steel)/(Steel) = 1

Concrete: (Concrete)/(Steel) = __________

Lumber: (Lumber)/(Steel) = __________

Proportional Relationship: 1: ____ : ____

Spring, 1974 computations:

Date for BLSWPI: Spring, 1974

Steel: 127.3/127.3 = 1

Concrete: 133.3/127.3 = 1.05

Lumber: 214.3/127.3 = 1.68

Proportional Relationship: 1:1.05:1.68

The following blank format is for computing the current relationship:

Date for BLSWPI: ____________________

Steel: (   )/(   ) = 1

Concrete: (   )/(   ) = __________

Lumber: (   )/(   ) = __________

Proportional Relationship: 1: ____ : ____

SQUARE FOOT COSTS[1]

The square foot costs stated in this manual can be adjusted, in approximate terms, for price variations by multiplying the square foot cost by an adjustment factor. This **Adjustment Factor** (AF) is determined by dividing the current WPI for the predominant foundation material by its 1974 WPI listed in this manual.

EXAMPLE: The year is 1976. You want to know the current square foot cost for an elevated wood pile foundation. The predominant material is wood with a 1974 WPI of 214.3 and a 1976 WPI of 244.5. The 1974 square foot cost is $3.05, therefore:

AF = (current WPI)/(1974 WPI)
= (244.5)/(214.3) = 1.14

Current Square Foot Cost = (AF) x (1974 cost)
= (1.14) x ($3.05) = $3.48

LOCAL ESTIMATING GUIDELINES

In order to confirm cost differences in your area cost worksheets are provided for the types of foundations shown in this analysis. These worksheets begin on the next page.

1. Material ordinarily comprises 60% of the cost of a dwelling. The Bureau of Labor Statistics Wholesale Price Index is for materials only. When making a rough estimate by ratio comparison using materials only a small error will develop since labor will be raised by the materials cost. This error is not too significant for rough estimating.

ESTIMATING FORMS

**ESTIMATING FORM
TO DETERMINE LOCAL COSTS**

Compute the following and enter:

________ *Square Footage of Floor Area*
________ *Lineal Footage of Perimeter*
________ *Square Footage of Foundation Wall*

Enter you costs (combine labor and material) and extend:

Layout house on lot				= $	________
Trench for footing	________	x ________	*LF*	= $	________
Place footings	________	x ________	*LF*	= $	________
Lay-up or form & pour foundation wall	________	x ________	*SF*	= $	________
Fill & grade for slab	________	x ________	*SF*	= $	________
Place vapor barrier, wire mesh & insulation	________	x ________	*SF*	= $	________
Place & finish slab	________	x ________	*SF*	= $	________
	Grand Total			$	________

CRAWL SPACE

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

_____________ *Square Footage of Floor Area*
_____________ *Lineal Footage of Perimeter*
_____________ *Square Footage of Foundation Wall*
_____________ *Number of Piers*

Enter your costs (combine labor and material) and extend:

Layout house on lot					= $ ________
Trench for footing	________	x	________	*LF*	= $ ________
Place footings	________	x	________	*LF*	= $ ________
Lay-up or form and pour foundation wall	________	x	________	*SF*	= $ ________
Place pier footings	________	x	________	*Ea.*	= $ ________
Lay-up or form and pour piers	________	x	________	*Ea.*	= $ ________
Backfill	________	x	________	*CY*	= $ ________
Floor Girder	________	x	________	*LF*	= $ ________
Floor Framing	________	x	________	*SF*	= $ ________
Insulation & sealer	________	x	________	*SF*	= $ ________
Subfloor	________	x	________	*SF*	= $ ________
Place floor slab	________	x	________	*SF*	= $ ________
	Grand Total				$ ________

BASEMENT

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

________ *Square Footage of Floor Area*
________ *Lineal Footage of Perimeter*
________ *Square Footage of Basement Wall Area*
________ *Number of Basement Support Columns*

Enter your costs (combine labor and materials) and extend:

Layout house on lot					= $ ________
Excavation & spoil removal	________	x	________	*SF*	= $ ________
Place footings	________	x	________	*LF*	= $ ________
Place pier footings	________	x	________	*Ea.*	= $ ________
Lay-up or form & pour foundation wall	________	x	________	*SF*	= $ ________
Parge wall	________	x	________	*SF*	= $ ________
Set drain tile	________	x	________	*LF*	= $ ________
Backfill	________	x	________	*CY*	= $ ________
Place vapor barrier and wire mesh	________	x	________	*SF*	= $ ________
Place and finish floor slab	________	x	________	*SF*	= $ ________
Place girder	________	x	________	*LF*	= $ ________
Frame Floor	________	x	________	*SF*	= $ ________
Place subfloor	________	x	________	*SF*	= S ________
	Grand Total				$ ________

WOOD POST

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

________ *Square Footage of Floor Area*
________ *Lineal Footage of Girders*
________ *Number of Posts*

Enter your costs (combine labor and material) and extend:

Layout house of lot				= $	________
Auger or dig post holes and remove spoil	________	x ____	*Qty*	= $	________
Place concrete punching pad	________	x ____	*Qty*	= $	________
Place poles	________	x ____	*Qty*	= $	________
Backfill poles and plumb	________	x ____	*Qty*	= $	________
Set girder	________	x ____	*LF*	= $	________
Frame floor	________	x ____	*SF*	= $	________
Place insulation & sealer	________	x ____	*SF*	= $	________
Place subfloor	________	x ____	*SF*	= $	________
	Grand Total			$	________

ESTIMATING FORM TO DETERMINE LOCAL COSTS

Compute the following and enter:

_______________ *Square Footage of Floor Area*
_______________ *Lineal Footage of Girders*
_______________ *Number of Piles*
_______________ *Total Lineal Footage of Piles*

Enter your costs (combine labor and material) and extend:

Layout house on lot					= $ _______________
Bring pile-driving equipment to site	_______________	x			= $ _______________
Furnish and drive piles	_______________	x	_______	LF	= $ _______________
Set girder	_______________	x	_______	LF	= $ _______________
Frame floor	_______________	x	_______	SF	= $ _______________
Place insulation and sealer	_______________	x	_______	SF	= $ _______________
Place subfloor	_______________	x	_______	SF	= $ _______________
	Grand Total				$ _______________

CONCRETE PIER

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

__________ *Square Footage of Floor Area*
__________ *Lineal Footage of Girder*
__________ *Number of Piers*

Enter you costs (combine labor and material) and extend:

Layout house on lot				= $ __________
Auger or dig pier holes and remove spoil	__________	x ______	*Qty*	= $ __________
Place concrete footing	__________	x ______	*Qty*	= $ __________
Form & pour piers	__________	x ______	*Qty*	= $ __________
Backfill	__________	x ______	*Qty*	= $ __________
Set girder	__________	x ______	*LF*	= $ __________
Frame floor	__________	x ______	*SF*	= $ __________
Place insulation and sealer	__________	x ______	*SF*	= $ __________
Place subfloor	__________	x ______	*SF*	= $ __________
	Grand Total			$ __________

Appendix

LOCAL SOURCES FOR FLOOD DATA

COMMUNITY INFORMATION SOURCES

To achieve useful results the general guidance provided in this manual must be combined with specific information relating to the local community. Those concerned with local flood conditions will want answers to such questions as, "Where is the flood plain boundary?" and "What is the base flood elevation above mean sea level?" (i.e., required elevation of the lowest floor) and "How do the local land elevations relate to the base flood level?" The answers to these and other similar questions are different for each community but should be answerable through one or more of the following sources:

LOCAL GOVERNMENT – Some or all of the following information on the community flood hazard areas should be available from the local building official:

1) Flood Hazard Boundary Map (FHBM),
2) Zoning Code,
3) Building Code (local, county or state),
4) Subdivision Regulations,
5) Flood Plain Ordinances and Resolutions (local or state).

FIA FLOOD INSURANCE RATE MAP (FIRM) – If it is not contained in the foregoing legal instruments the following information will be available on the FIA Flood Insurance Rate Map:

6) Elevation of the base flood,
7) Elevation reference marks and bench marks (on maps issued after July, 1975)
8) Identification of *velocity zones* and coastal high hazard areas.

Flood Insurance Rate Maps should be on file, together with the Flood Hazard Boundary Map, at the local building official's office once the maps have been received.

FEDERAL WATER RESOURCE AGENCIES – The following information is not usually found in local or state codes and regulations and is not found on rate maps but may be available from Federal agencies involved in water resources management

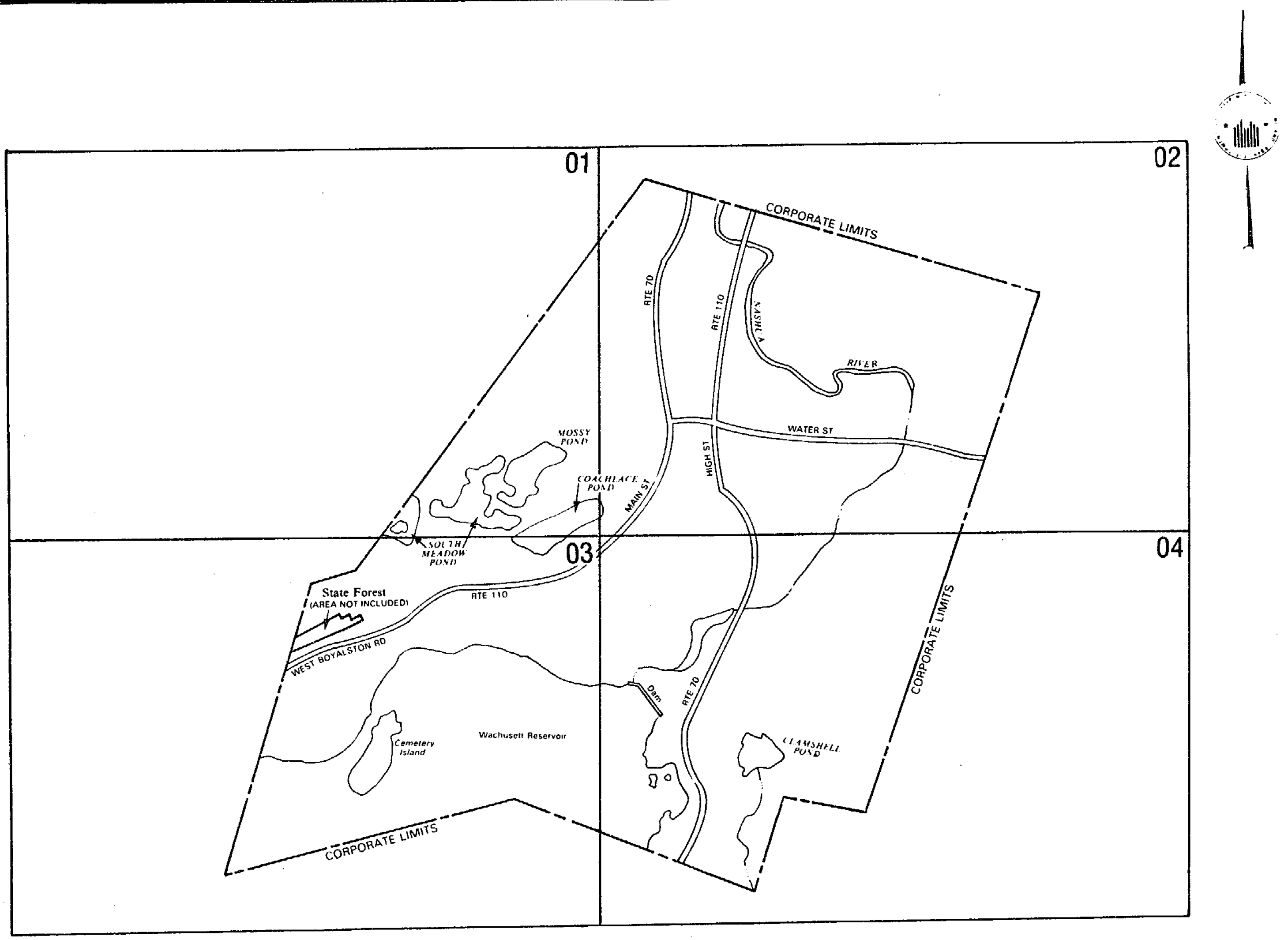
9) Riverine velocities and coastal surges.

STATE WATER RESOURCES AND FLOOD PLAIN MANAGEMENT AGENCIES – Most states have agencies under various titles that deal with water-related problems. They may provide valuable information for dealing with flood related problems.

EXPLANATORY NOTES – Some of the preceding information items deserve a word of further explanation.

1. Flood Hazard Boundary map (FHBM)—This map approximately identifies those areas within a community subject to inundation by the base flood and therefore subject to flood plain regulation. Owners requesting financial assistance from Federal or federally regulated or insured financial institutions for construction or substantial renovation of structures within a special flood hazard area are required to obtain flood insurance as a pre-requisite to such financial assistance. Similarly, in issuing building permits, communities must enforce flood plain regulations in these areas using the best information available with regard to the base flood elevation. The Flood Insurance Rate Map (FIRM) and the information it contains supersedes the FHBM when it becomes available, and in all cases, the latest information of additions to a FIRM should be consulted. (See examples of FHBMs and FIRMs on the following pages.)

2. Zoning—The flood plain management regulations a community adopts when it becomes a participant in the National Flood Insurance Program are frequently incorporated into the community's zoning code. Zoning restrictions generally specify how land may be developed, its carrying capacity, and what kinds of uses are acceptable. According to FIA's Flood Hazard Boundary Map a special flood hazard district or zone is created and the regulations controlling flood plain management specifically apply to this flood hazard zone.



LEGEND

SPECIAL FLOOD HAZARD AREA WITH DATE OF IDENTIFICATION	ZONE A DATE

Note These maps may not include all Special Flood Hazard Areas in the community After a more detailed study, the Special Flood Hazard Areas shown on these maps may be modified, and other areas added.

CONSULT NFIA SERVICING COMPANY OR LOCAL INSURANCE AGENT OR BROKER TO DETERMINE IF PROPERTIES IN THIS COMMUNITY ARE ELIGIBLE FOR FLOOD INSURANCE.

INITIAL IDENTIFICATION DATE:

AUGUST 9, 1974

REVISION DATES:

8 6 76 ; SHOW CURVILINEAR BOUNDARY, ADD SFHA, REDUCE SFHA.

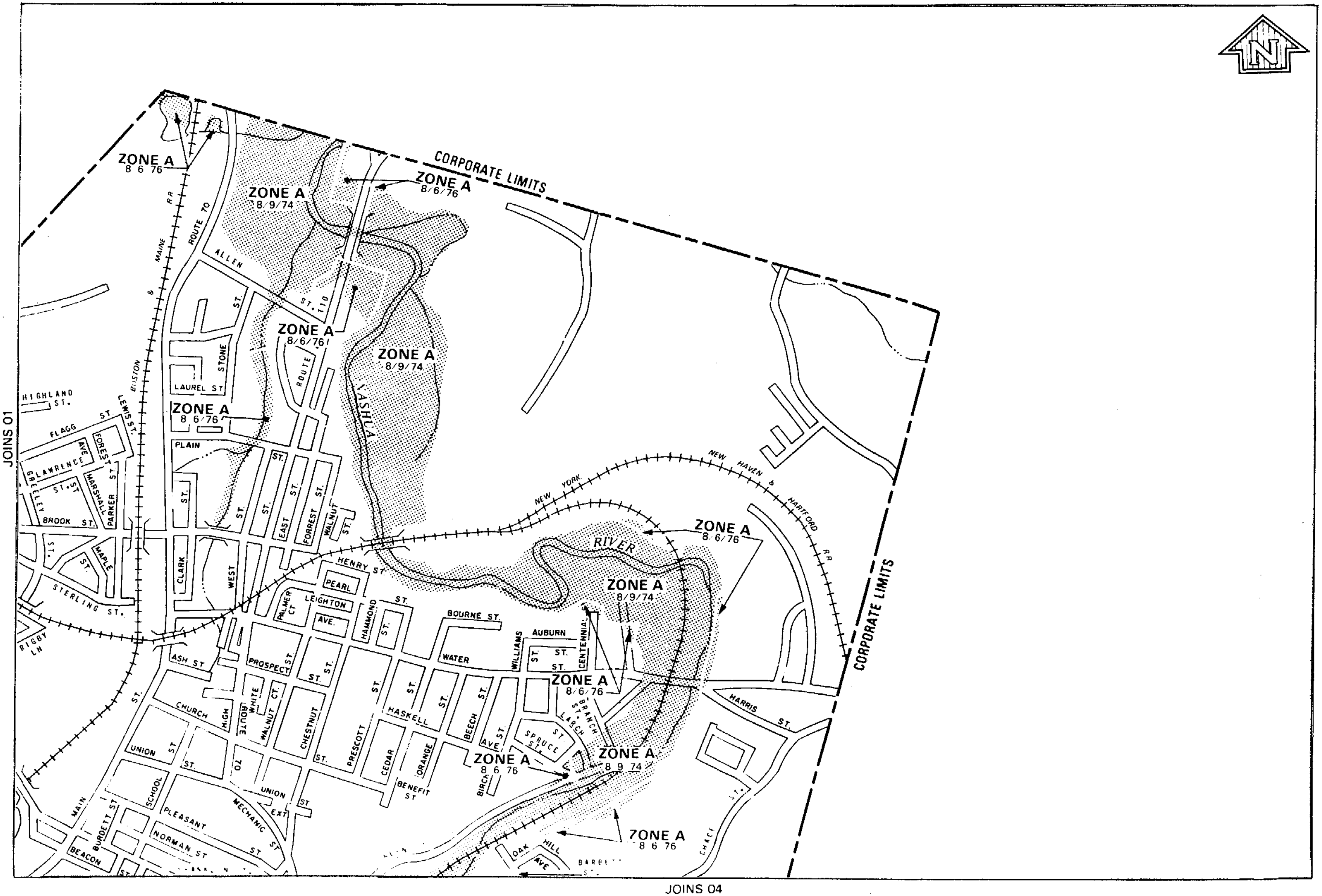
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Federal Insurance Administration

FLOOD HAZARD BOUNDARY MAP H - 01-04

NAME OF COMMUNITY

COMMUNITY NO 250300A



APPROXIMATE SCALE

1000 0 1000 2000 3000 FEET

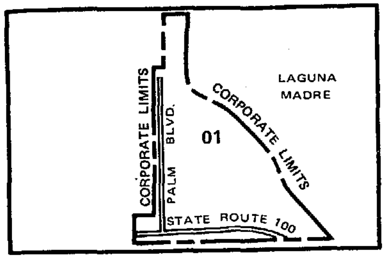
MAP REVISED 8/6/76

FLOOD HAZARD BOUNDARY MAP

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

NAME OF COMMUNITY

02



KEY TO SYMBOLS

ZONE DESIGNATIONS* WITH DATE OF IDENTIFICATION e., 12/2/74

ZONE B

ZONE B

Base Flood Elevation Line ~~~513~~~

Base Flood Elevation (513' MSL)

Elevation Reference Mark RM7×

River Mile • M1.5

*EXPLANATION OF ZONE DESIGNATIONS

A flood insurance map displays the zone designations for a community according to areas of designated flood hazards. The zone designations used by *FIA* are:

Zone Symbol	Category
A	Area of special flood hazards (SFH) and without base flood elevations determined.
A1 through A30	Area of special flood hazards (SFH) with base flood elevations. Zones are assigned according to flood hazard factors, and dates of SFH identification.
AO	Area of special flood hazards that have shallow *flood depths (less than two feet) and/or unpredictable* flow paths. Base flood elevations are not determined.
V	Area of special flood hazards, with velocity, that are inundated by tidal floods. Zones are assigned according to flood hazard factors and dates of SFH identification.
B	Area of moderate flood hazards.
C	Area of minimal flood hazards.
D	*Area of undetermined*, but possible, flood hazards.

CONSULT NFIA SERVICING COMPANY OR LOCAL INSURANCE AGENT OR BROKER TO DETERMINE IF PROPERTIES IN THIS COMMUNITY ARE ELIGIBLE FOR FLOOD INSURANCE.

INITIAL IDENTIFICATION DATE: JULY 21, 1972

INTERIM MAP REVISION EFFECTIVE JULY 1, 1974
TO CHANGE ZONE DESIGNATIONS

MAP REVISION EFFECTIVE JULY 11, 1975
TO REFLECT CURVILINEAR FLOOD BOUNDARY

ADDITIONAL MAP REVISION EFFECTIVE JUNE 11, 1976
TO CHANGE SUFFIX AND ADD SFHA

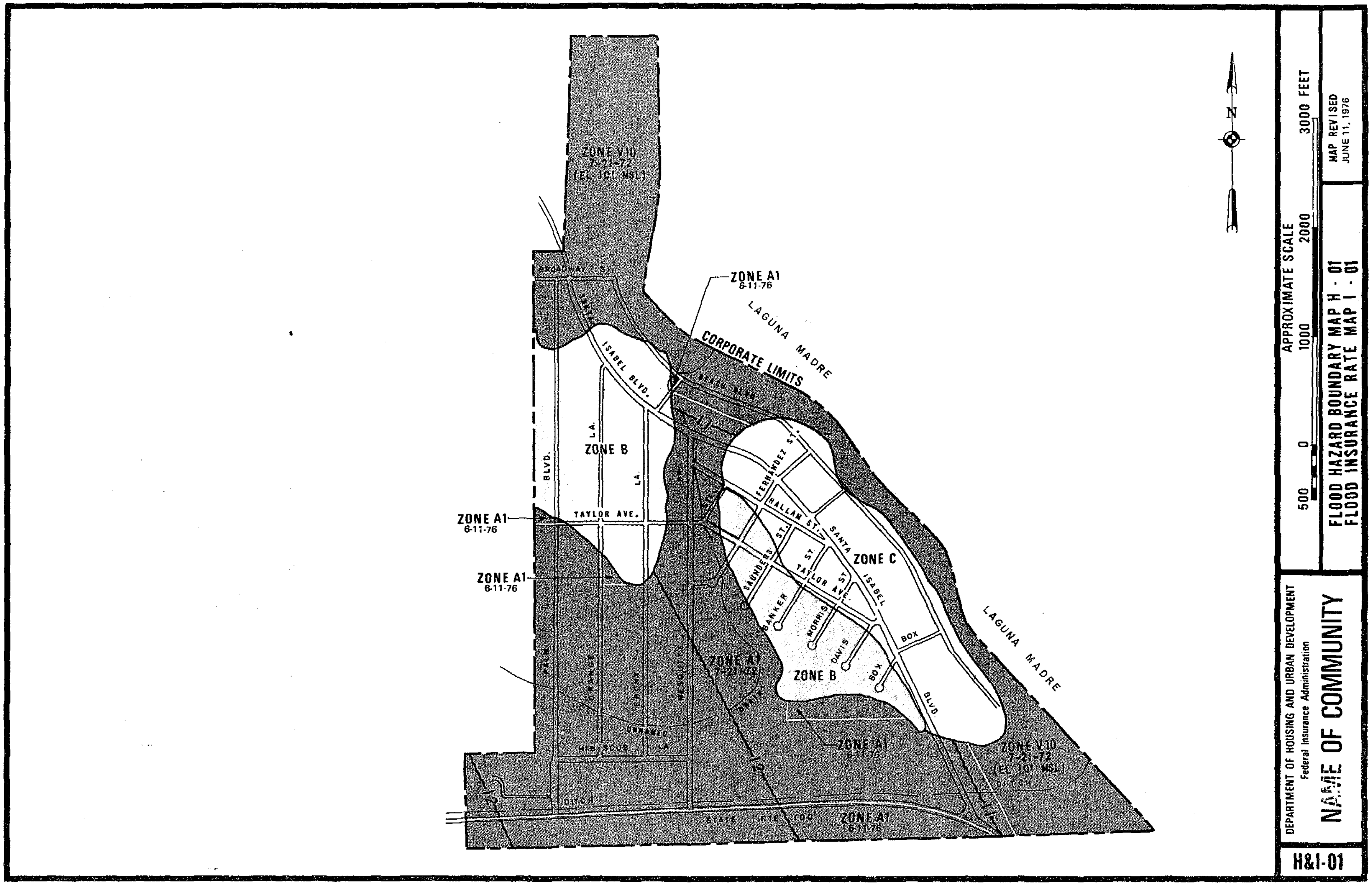
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

FLOOD HAZARD BOUNDARY MAP H - 01
FLOOD INSURANCE RATE MAP I - 01

MAP INDEX

NAME OF COMMUNITY

COMMUNITY NO. 485483C


ZONE V10
7-21-72
(EL 10' MSL)
BROADWAY ST.
ZONE A1
6-11-76
LAGUNA MADRE
CORPORATE LIMITS
ISABEL BLVD.
ZONE B
BLVD.
LA.
TAYLOR AVE.
ZONE A1
6-11-76
ZONE A1
6-11-76
FERNANDEZ ST.
HALLAM ST.
SANTA ISABEL
ZONE C
SAUNDERS ST.
TAYLOR AVE.
BANKER
MORRIS
DAVIS
BOX
BOX
BLVD.
LAGUNA MADRE
ZONE A1
7-21-72
ZONE B
PALM
ORANGE
UNNAMED
HIBISCUS
LA.
ZONE A1
6-11-76
ZONE V10
7-21-72
(EL 10' MSL)
DITCH
DITCH
STATE RTE 100
ZONE A1
6-11-76
N
APPROXIMATE SCALE
500 0 1000 2000 3000 FEET
MAP REVISED
JUNE 11, 1976
FLOOD HAZARD BOUNDARY MAP H - 01
FLOOD INSURANCE RATE MAP I - 01
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration
NAME OF COMMUNITY
H&I-01

3. Building Code (Local, County or State) —Sometimes those flood plain regulations that prescribe construction practices and floodproofing techniques are placed in the Building Code. In addition, the Building Code should be consulted for locally allowable soil bearing pressure required, safety factors, permit requirements, anchoring requirements, etc.

4. Subdivision Regulations – Sometimes special flood plain regulations, such as requirements for floodproofing of utilities, elevations of roads, grading and drainage requirements, lot sizes, etc., are found in Subdivision Regulations.

5. Flood Plain Ordinance and Resolutions (Local or State) – In some cases all requirements regarding land use and construction in the flood plain are brought together in a single flood plain ordinance.

6, 7, 8. Surface Elevations of the Base Flood, Elevation of Bench Marks, and Identification of Velocity Zones—The surface elevation of the base flood determines the level at which the finished floor of the of the lowest habitable floor of a building must be designed. The FIA Flood Insurance Rate Map divides the community into flood hazard zones and gives the base flood elevations for each zone. Zones are indicated as follows:

A1 through A30 – Special Flood Hazard areas inundated by the base flood with base flood elevations and zones assigned according to FHF (Flood Hazard Factor)

A0—Special Flood Hazard areas inundated by the base flood with *shallow flood depths and/or unpredictable flow paths.* Base flood elevations are not determined.

V1 through V30 – Special Flood Hazard areas inundated by the base flood with *additional hazards due to velocity with base flood elevations and and zones assigned* according to FHF (coastal areas).

B – Area between Zone A or V and the limits of the 500-year flood,

or

Area that is protected from a base flood by a dike, levee, or other completed water control structure.

C—Area subject to flooding by the greater than 500-year flood,

or

Area that is protected from the greater than 500-year flood by a dike, levee, or other water control structure.

Elevations indicated on FIRM may be determined in the field through elevation reference marks. Locations and descriptions of these bench marks or reference marks are generally included on the FIA Flood Insurance Rate Map. If not shown on the FIRM, bench marks or elevation reference marks must be obtained from the local building official or from the contractor or agency who prepared the FIRM.

9. Riverine Velocities and Coastal Surges – Estimated velocity data are generally available from local offices of Federal Agencies involved in water resources.

LEGISLATIVE DATA

As a condition of future federally-related financing, all communities in identified flood hazard areas are required to participate in the National Flood Insurance Program and to adopt adequate flood plain ordinances with effective enforcement provisions consistent with Federal standards to reduce or avoid future flood losses. The specific details and requirements for participation are spelled out in the National Flood Disaster Protection Act of 1973 (PL 93-234) and Title-24 from the Code of Federal Regulations. These are essential readings for those planning flood plain regulation or flood plain construction. They may be obtained by writing:

Federal Insurance Administration
Department of Housing and Urban Development
451 7th Street, S.W.
Washington, D.C. 20410

CONCLUDING COMMENTS

Investigation of the information sources reviewed above should provide designers, builders, bankers, community officials, and the general public with the appropriate information for prudent management, planning and construction in the flood plain.

Specific flood insurance questions should be addressed to the Flood Insurance Specialist in your HUD Regional Office (see listing below).

REGION I

Room 800
John F. Kennedy Building
Boston, Massachusetts 02203
(617) 223-2616

[Includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont]

REGION II

26 Federal Plaza
New York, New York 10007
(212) 264-4756

[Includes New Jersey, New York, Puerto Rico, Virgin Islands]

REGION III

Curtis Building
Sixth and Walnut Streets
Philadelphia, Pennsylvania 19106
(215) 597-9581

[Includes Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia]

REGION IV

1371 Peachtree Street, N.E.
Atlanta, Georgia 30309
(404) 526-2391

[Includes Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee]

REGION V

300 South Wacker Drive
Chicago, Illinois 60606
(312) 353-0757

[Includes Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin]

REGION VI

New Federal Building
1100 Commerce Street
Dallas, Texas 75242
(214) 749-7412

[Includes Arkansas, Louisiana, New Mexico, Oklahoma, Texas]

REGION VII

Federal Office Building
911 Walnut Street
Kansas City, Missouri 64106
(816) 374-2161

[Includes Iowa, Kansas, Missouri, Nebraska]

REGION VIII

Federal Building
1405 Curtis Street
Executive Tower, 27th Floor
Denver, Colorado 80202
(303) 837-2347

[Includes Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming]

REGION IX

450 Golden Gate Avenue
Post Office Box 36003
San Francisco, California 94102
(415) 556-3543

[Includes Arizona, California, Hawaii, Nevada]

REGION X

Room 3068 Arcade Plaza Building
1321 Second Avenue
Seattle, Washington 98101
(206) 442-1026

[Includes Alaska, Idaho, Oregon, Washington]

GLOSSARY

ACTUARIAL 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 applies.

BASE FLOOD—Sometimes referred to as 100 year flood, is a flood of the magnitude that has a 1% chance of occurring in any given year.

COMMUNITY—Any state or areas or political subdivision thereof, or any Indian tribe or authorized tribal organization, for which an application for participation in the National Flood Insurance Program is made, and which has the authority to adopt and enforce flood plain management regulations for the areas within its jurisdiction.

COASTAL HIGH HAZARD AREA (CHHA)—The portion of a coastal flood plain having special flood hazards that is subject to high velocity waters, including hurricane wave wash and tsunamis.

DEDUCTIBLE—The fixed amount of percentage of any loss not covered by insurance. The total loss must exceed this amount before any insurance claim may be paid.

EMERGENCY PROGRAM—The program which is initiated before the individual community ratemaking studies. It is intended as a program 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 flood plain management regulations.

EROSION—The collapse or subsidence of land along the shore of a lake or other body of water as a result of undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as a flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding. Therefore, the use of the word "erosion" shall mean flood-related erosion.

EXISTING CONSTRUCTION—For the purposes of determining rates, means those structures in existence or on which construction or substantial improvement was started on or before December 31, 1974, or the effective date of the Flood Insurance Rate Map (FIRM), whichever is later. For the purposes of flood plain management regulations requirements, existing construction means those structures in existence or on which construction or substantial improvement was started prior to the efective date of a flood plain management regulation adopted by a community. "Existing construction" may also be referred to as "existing structures."

FLOOD OR FLOODING—A general and temporary condition of partial or complete 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, or from mudslides, which are precipitated by accumulations of water on or under the ground, or from the collapse or subsidence of land along a shore of a body of water as a result of flood-related erosion.

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 river or other watercourse and the adjacent land areas required to carry and discharge the base flood without cumulatively increasing the water-surface elevation more than one foot at any point.

FLOOD ELEVATION STUDY OR FLOOD INSURANCE STUDY—A scientific examination, evaluation and determination of flood hazards and corresponding water surface elevations, or a scientific examination, evaluation and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards.

FLOOD HAZARD BOUNDARY MAP—An official map or plat of a community issued by the FIA on which the boundaries of the flood plain, mudslide and/or flood-related erosion areas having special hazards have been drawn.

FLOOD INSURANCE RATE MAP—An official map of a community on which the FIA has delineated the area in which flood insurance may be required under the Regular Flood Insurance Program and the actuarial rate zones applicable to such area. These maps also provide base flood elevations and, in coastal communities, the velocity zones.

FLOOD PLAIN OR FLOOD PRONE AREA—The land area adjoining a river, stream, watercourse, ocean, bay or lake which is likely to be flooded.

FLOOD PLAIN MANAGEMENT—The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works and flood plain management regulations such as zoning ordinances, building codes, health regulations, grading ordinances and erosion control ordinances.

FLOOD RELATED EROSION—The collapse or subsidence of land along the shore of a lake or other body of water as a result of undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm or by an abnormal tidal surge or by some similarly unusual and unforeseeable event which results in flooding.

HABITABLE FLOOR—Any floor used for living, which includes working, sleeping, eating, cooking or recreation, or combination thereof. A floor used only for storage purposes is not a Habitable Floor.

INUNDATION—A condition of flooding or a flow of mud characterized by: The overspreading with water or a wet softened mass of debris or plastic soils.

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.

MUDSLIDE (i.e. mudflow)—A condition where there is actually a river, flow or inundation of liquid mud down a hillside usually as a result of a dual condition of loss of brush and the subsequent accumulation of water on or under the ground (frequently caused by a period of heavy or sustained rain.) A mudslide may occur as a distinct phenomenon while a landslide is in progress and will be recognized as such by the FIA only if the mudflow, and not the landslide, is the proximate cause of the damage that occurs.

MUDSLIDE AREA OR MUDSLIDE PRONE AREA—An area characterized by unstable slopes and land surfaces, whose history, geology, soil and bedrock structure as well as climate indicate a potential for mudslides.

NEW CONSTRUCTION—For purposes of determining rates, means those structures the construction or substantial improvement of which is begun after December 31, 1974, or the effective date of the publication of the Flood Insurance Rate Map (FIRM), whichever is later. New construction, for the purposes of determining rates, also means those mobile homes within mobile home parks for which construction has started after December 31, 1974, or the effective date of the publication of the Flood Insurance Rate Map (FIRM), whichever is later and which are located within a new mobile home park, an expansion to an existing mobile home park, or within an existing mobile home park where the repair, reconstruction or improvement of streets, utilities, and pads equals or exceeds 50 percent of the value of the streets, utilities and pads before the repair, reconstruction or improvement has commenced. New construction, for the purposes of flood plain management regulations, means construction started after the effective date of a flood plain management regulation adopted by a community.

REGULAR PROGRAM—The Regular Flood Insurance Program under which buildings constructed on or before December 31, 1974, (or before the effective date of the Flood Insurance Rate Map, if later), as well as those structures located outside of the special flood hazard areas built after that time, remain eligible for the first layer of insurance coverage at either actuarial rates or subsidized rates, whichever are lower. All other buildings require actuarial rates on both layers of coverage. Regardless of date of construction, actuarial rates are always required for the second layer of coverage, which is made available upon the effective date of the Flood Insurance Rate Map. In return for such additional flood insurance coverage, a community is required to adopt additional Flood Plain Management Regulations in accordance with the specific flood hazard data provided on the Flood Insurance Rate Map.

SPECIAL FLOOD HAZARD AREA—The maximum area of the flood plain that, on the average, is likely to be flooded once every 100 years i.e. will be flooded during a base flood.

START OF CONSTRUCTION—The first placement of permanent construction of a structure on a site, such as the pouring of slabs or footings or any work beyond the stage of excavation. For a structure without a basement or poured footings, the start of construction includes the first permanent framing or assembly of the structure or any part thereof on its pilings or foundation for sites other than mobile home parks, or the affixing of any prefabricated structures to its permanent site. Permanent construction does not include land preparation such as clearing, grading, and filling; nor does it include the installation of streets and/or walkways; nor does it include excavation for basement, footings, piers, or foundations or the erection of temporary forms; nor does it include the existence on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not a part of the main structure. For mobile home parks which are equipped with concrete pads on which mobile homes are to be placed, "start of construction" means the time at which the pouring of the pads has begun. For mobile home parks which are not equipped with concrete pads, "start of construction" means the date on which the installation of utilities and final site grading are completed, and all park roads are completed and paved.

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.

STORM CELLAR—A room below grade, the total area of which is large enough only to accommodate the occupants of the structure as a means of temporary shelter against severe tornado and similar wind storm activity.

STRUCTURE OR BUILDING—A walled and roofed building other than 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. The term includes a building under construction or repair, but does not include building materials or supplies unless they are within an enclosed building on the premises.

SUBSIDIZED RATES—The rates which involve subsidizations by the Federal Government to encourage the purchase of the first layer limits of flood insurance on existing structures at reasonably affordable costs.

SUBSTANTIAL IMPROVEMENT—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 is started or (b) if the structure has been damaged, and is being restored, before the damage occurred. For the purposes of this definition, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure. The term does not, however, include either (1) any alteration to comply with existing state or local health, sanitary, building, or safety codes or regulations or (2) any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

WATER SURFACE ELEVATION—The heights in relation to Mean Sea Level expected to be reached by floods of various magnitudes and frequencies at pertinent points in the flood plain.

VARIANCE—A grant of relief by a community to a person from the terms of a flood plain management regulation permitting construction in a manner otherwise prohibited by the regulation and where specific enforcement would result in unnecessary hardship.

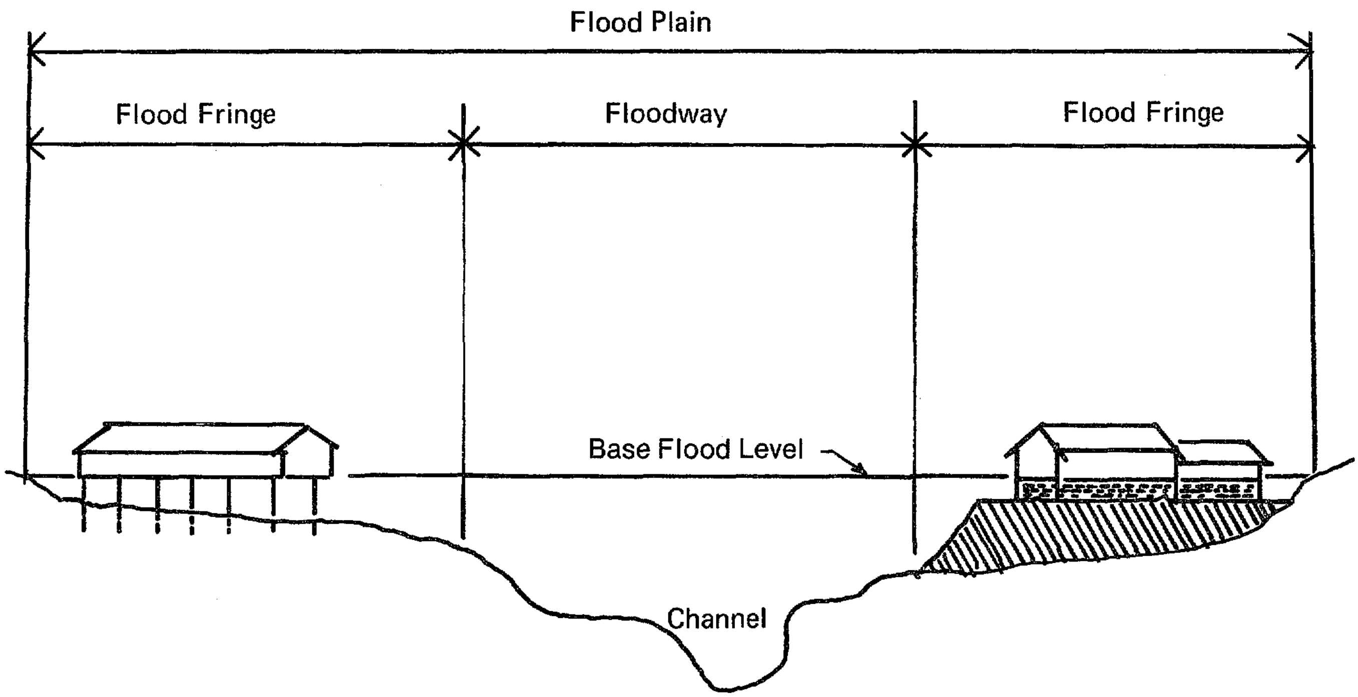


FIGURE 5-1
River Valley Cross Section

ANNOTATED BIBLIOGRAPHY

FLOOD LEGISLATION AND RELATED REPORTS

Department of Housing and Urban Development. *Insurance and Other Programs for Financial Assistance to Flood Victims.* Washington, D.C.: Government Printing Office, 1966.

This report was required by the Southeast Hurricane Disaster Relief Act of 1965 (Public Law 89 - 339). It provided the background data and analysis for the National Flood Insurance Act of 1968. The report viewed flood insurance as a means of helping the individual bear more easily the risks of flood damage to which his location often exposes him, and, equally, as a means of discouraging unwise occupancy of flood-prone areas.

____. *National Flood Insurance Act of 1968 As Amended.* Washington, D.C.: Government Printing Office, 1971.

This Act authorized a flood insurance program by means of which flood insurance, over a period of time, was made available on a nationwide basis through the cooperative efforts of the Federal Government and the private insurance industry. The title also encouraged state and local governments to minimize and restrict development in flood prone areas through appropriate land use adjustments. Damage and loss from mudslides was also recognized as part of the flood problem by this legislation.

____. *Title 24 - Revised As Of April 1, 1973.* Reprinted from Code of Federal Regulation.

This publication contains the guidelines, rules and regulations a community must follow to become eligible and remain eligible for the Flood Insurance Program. It has been amended to conform to the Flood Disaster Protection Act of 1973.

United States Senate, Committee on Banking, Housing and Urban Affairs. *Report on Flood Disaster Protection Act of 1973.* Report No. 93 - 583, 93rd Congress, 1st Session, 1973.

This report reviews a bill (H.R. 8449) to expand the national flood insurance program by increasing limits of coverage and total amount of insurance authorized to be outstanding and by requiring known flood prone communities to participate in the program. It is a good presentation of data and the issues involved.

United States Congress. *Flood Disaster Protection Act of 1973.* 93rd Congress, 1st Session, January 3, 1973.

The Act extends the emergency flood insurance program through December 31, 1975, and addresses three key areas: insurance, flood plain management, and local community consultation and appeals procedure.

Department of Housing and Urban Development. *Title 24, Chapter X, Subchapter 13, Amendments to Subchapter Necessitated by Legislation.* Washington, D.C.: H.U.D., January 1, 1974.

This is a list of amendments to the Title 24 regulations governing the national flood insurance program.

BOOKS AND SEPARATELY PUBLISHED MATERIAL

American Concrete Institute. *Building Code Requirements for Reinforced Concrete* (ACI 318-71). Detroit: American Concrete Institute, 1971.

American Creosote Works, Inc. Appendix I, *American Society Testing Materials Specifications for Round Timber Piles,* D25 - 58. pp. 30 - 34.

These specifications cover round timber piles to be used untreated or treated with standard preservatives. Most piles are manufactured and sold under these specifications.

American National Standards Institute, Inc. *American National Standard Specifications and Dimensions for Wood Poles,* ANSI 05.1 - 1972. New York: American National Standards Institute, August 1972.

This standard consists of specifications and dimensions for wood poles that are to be treated with preservatives.

American Wood Preservers Institute. *AWPI Technical Guidelines for Pressure-Treated Wood: Selection of Treated Timber Piling.* McLean, Virginia: American Wood Preservers Institute, 1971.

This eight-page publication thoroughly reviews ASTM standard D25 - 70, Round Timber Piles. It points out that use of D25 - 70 will greatly increase efficiency and economy in pile construction.

_____. *FHA Pole House Construction.* Washington, D.C.: American Wood Preservers Institute, 1971.

An excellent basic manual on the engineering and construction of pole houses. Useful tables and details are presented.

Anderson, L. O. and Smith, Walton R. *Houses Can Resist Hurricanes.* Madison, Wisconsin: U.S. Forest Products Laboratory, 1965.

A 48-page paper presenting construction methods, materials, and details to resist hurricane damage. Existing hurricane codes and factors to consider in new codes are reviewed. This is a good presentation with much of the data applicable to flood resistant construction.

Degenkolb, H. J. and Associates. *Design Notes and Criteria Pole Type Buildings.* San Mateo, California: J. H. Baxter Co., 1968.

A brief review of a structural design method for pole type buildings.

General Adjustment Bureau, Inc. *Floodwaters, Everybody's Problem.* New York: General Adjustment Bureau, 1973.

An insurance industry publication providing a very good overview of the scope of the nation's flood problem.

_____. *Nature's Destructive Forces.* New York: General Adjustment Bureau, 1973.

A review of the characteristics and forces associated with the various types of wind storms that occur in the U.S. and the forecasting and protection methods that are available.

The Hartford. *Flood-Proofing, A Technique of Avoiding Flood Damage.* n.p., n.d. Obtained from The Hartford Insurance Group, Hartford, Conn.

This 12-page manual is a presentation of some basic techniques for protecting property from flood damage if it is located in a flood hazard area.

Kusler, Jon A. and Lee, Thomas M. *Regulations for Flood Plains,* Richard Spicer, ed. Chicago: American Society of Planning Officials, 1972.

A comprehensive discussion of the necessity for, the problems of, and approaches to flood plain management.

National Flood Insurers Association. *National Flood Insurance Program - Flood Insurance Manual,* NFIA - ED 7/74. New York: National Flood Insurers Association, July 1974

All the basic information for obtaining and writing flood insurance is contained in this manual. The rules and requirements for flood insurance are reviewed and rate tables and sample forms are presented.

National Water Commission. *New Directions in U.S. Water Policy, Summary, Conclusions and Recommendations.* Washington, D.C.: Government Printing Office, 1973.

A thorough analysis of U.S. water problems and recommendations for water resource management.

Patterson, Donald. *Pole Building Design.* Washington, D.C.: American Wood Preservers Institute, 1972.

This 48-page manual covers the engineering and preservative treatment of wood poles and piles in a most complete manner. All the formulas, tables, and explanatory notes necessary for good design are presented.

Shaeffer, John R. *Introduction to Flood Proofing, An Outline of Principles and Methods.* Chicago: University of Chicago, 1967.

Sixty pages of flood proofing techniques for both residential and commercial properties.

Sumrall, Clinton L., Jr. *Prudent Construction in the Flood Plain.* Varna, Bulgaria: 8th Congress, International Commission on Irrigation and Drainage, May 1972.

This paper says that many areas within flood plains can be economically utilized for development if adequate consideration is given to flood problems and proper engineering techniques are applied. Examples of various "prudent" types of construction are reviewed.

Southern Forest Products Association, National Forest Products Association, and American Wood Preservers Institute. *How to Build Storm Resistant Structures.* n.p., n.d.

A short manual of construction details. Designed to increase safety and building resistance to storms and floods.

Tennessee Valley Authority. *Flood Damage Prevention: An Indexed Bibliography.* Knoxville, Tennessee: Tennessee Valley Authority, August 1973 (7th ed.)

A comprehensive bibliography of flood related publications listed by publication date. It covers the period from 1920 to 1973. 496 entries.

United States, Department of Commerce, Nation National Oceanic and Atmospheric Administration. *Floods, Flash Floods and Warnings.* Washington, D.C.: Government Printing Office, 1973.

This is a six-page flyer on the scope of flash flooding in the U.S. and a review of how people and communities can protect themselves from them.

____, Department of Housing and Urban Development. *Criteria for Compacted Fills.* Washington, D.C.: Government Printing Office, 1973. (4075.6).

A Comprehensive review of criteria for fills for single and multi-story residential properties.

____, ____, *Minimum Property Standards for One and Two Family Dwellings.* Washington, D.C.: Goverment Printing Office, 1973.

Revised Minimum Property Standards. They are oriented toward stating requirements in performance terms.

____, ____. *Slope Protection for Residential Developments.* Washington, D.C.: Government Printing Office, 1973. (4075.7).

Recommendations for improving slope stability and controlling slope erosion.

____, ____, *When You Return to a Storm Damaged Home.* Washington, D.C.: Government Printing Office, 1972.

This booklet thoroughly reviews the economic and safety steps the home owner should take to put his flood damaged home and its contents back in operating and living condition.

____, ____/Federal Housing Administration. *Minimum Property Standards For One and Two Living Units.* Washington, D.C.: Government Printing Office, 1966.

Minimum Standards for constructing safe, well planned and soundly built homes that will be eligible for mortgage insurance.

____, ____, Federal Insurance Administration. *Flood Insurance Study Guidelines,* HUD-1-58. Washington, D. C.: Government Printing Office, April 1974.

Presents a step-by-step procedure for defining the flood hazard conditions of an area. These guidelines must be followed by Agencies and/or Consultants performing Flood Insurance Studies for the Federal Insurance Administration.

____, Water Resources Council. *Regulation of Flood Hazard Areas to Reduce Flood Losses.* Vol. I, Parts I-IV. Washington, D.C.: Government Printing Office, 1970.

This volume explores selected issues in regulation of private and public land uses as a tool of flood plain management. It focuses primarily on basic regulatory issues and riverine flood problems.

____, ____. *Regulation of Flood Hazard Areas to Reduce Flood Losses.* Vol. II, Parts V-VI. Washington, D.C.: Government Printing Office, 1971.

This second volume is a more detailed investigation of techniques for regulating subdivisions of land in riverine and coastal flood hazard areas. It contains draft regulations for flood hazard areas.

____, ____. *The Nation's Water Resources.* Washington, D.C.: Government Printing Office, 1968.

A comprehensive assessment of the water and land related resources of the U.S. It has sections reviewing flooding and flood control. This is a good reference resource.

United States Army, Corps of Engineers, Albuquerque District. *Flood Plain Management Services.* Albuquerque, New Mexico: Department of the Army, June 1967.

This is a one-page flyer outlining the flood related services of the Army Corps of Engineers.

____, ____, Galveston District. *Appendix B. Criteria Relating to the Adoption of the 3-Foot Breaking Wave.* Galveston, Texas: Department of the Army, n.d.

A discussion of wave forces on standard wood frame construction.

____, ____, Vicksburg District. *Guidelines for Reducing Flood Damages.* Vicksburg, Miss Mississippi: Department of the Army, May 1967.

A ten-page manual reviewing three ways to prevent flood damages: control over the river, control over the land, and other measures.

____, Office of the Chief of Engineers. *Flood-Proofing Regulations.* Washington, D.C.: Government Printing Office, 1973.

This 77-page manual is one of the most comprehensive flood-proofing publications yet available. It is written in a code format that is adaptable for use in local building codes.

ARTICLES & PERIODICALS

Dorram, Peter B., "Flood Loss Reduction through through Planning and Regulating Flood Plain Development," *Federal Planning Information Report* (N.J.) 5, No. 3 (May 1970).

Mr. Dorram's paper reviews planning approaches and zoning and code regulations that can be applied to minimize flood losses. 75¢ from Executive Secretary, N.J. Federation of Planning Officials, 1308 Wood Valley Road, Road, Mountainside, N.J. 07092.

Haddon, William, Jr., "On the Escape of Tigers: An Ecologic Note," from *Technology Review* 72, No. 7 (May 1970).

This short paper proposes a systematic technique for identifying loss reduction strategies resulting from the transfer of energy.

Lin, T. Y. and Talbot, W. J., Jr., "Pretensioned Concrete Piles, Present Knowledge Summarized," *Civil Engineering* (May 1961).

A six-page review of the design, detailing, manufacture, driving, and applications of pretensioned concrete piles.

Phippen, George R., "A New Course to Ararat," *Water Spectrum* 3, No. 2 (Summer 1971): 9 - 15.

This is an excellent background article on flood plain management. It reviews the attitudes, consequences, approaches, economics, federal involvement and future of flood plain management.

UNPUBLISHED MATERIAL

Lee, Thomas M., "Factors in Floodway Selection." Paper presented at the August 18 - 20, 1971 ASCE, 19th Specialty Conference of the Hydraulics Division, Iowa City.

A 32-page paper intended to acquaint the engineer with the planning, social, and political aspects involved in floodway selection. The floodway being the river channel and adjacent flood plain needed to effectively convey flood flows.

Moore, John L., Middlebrooks, Burton, and Crawford, Beth. Battelle Columbus Laboratories. "Draft Final Report on Development of Criteria for Evaluating Alternative Flood Damage Prevention Measures with Limited Information: Case Study of Martins Ferry, Ohio." Prepared for State of Ohio, Department of Natural Resources, Flood Plain Management Section, December 12, 1973.

This 62-page report develops criteria for assessing flood damage prevention alternatives. The report attempts to specify the types of data needed, assess the availability of the data, and suggest methods for dealing with inadequate information.

Plaquemines Parish Commissioners. "Storm Resistive Construction for Plaquemines Parish, La." [1970?]

This manual was developed from a study of construction subjected to Hurricane Camille's (1969) destructive forces. It presents 28 pages of building details and methods for minimizing storm damage to residences.

Sutton, Walter G. "Planning for Optimum Economic Use of Flood Plains," ms. February 1963. Done at Atlanta, Georgia.

A short paper comparing the alternative costs of site development in and out of the flood plain.

Wall, Glenn R. *Administrative Law and the Use of Flood Plain Lands.* Lexington, University of Kentucky, Spring 1968 (Reproduced and distributed by Tennessee Valley Authority).

A good analysis of the legal background, concepts, and precedents of administering flood plain regulations.

_____. *Establishing an Engineering Basis for Flood Plain Regulations.* MA Thesis. University of Tennessee, December 3, 1969. (Reproduced and distributed by Tennessee Valley Authority).

This Master's thesis thoroughly tests the hypothesis that "the use of land use controls is a desirable and legal element in any plan for reducing flood damage when supported by an adequate engineering basis." After testing the hypothesis a process is proposed by which community officials can reach decisions concerning the flood problem. lem.

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