COST REPORT ON NON-STRUCTURAL FLOOD DAMAGE REDUCTION MEASURES FOR RESIDENTIAL BUILDINGS WITHIN THE BALTIMORE DISTRICT

A REPORT SUBMITTED TO:

U.S. ARMY ENGINEER INSTITUTE FOR WATER RESOURCES

KINGMAN BUILDING

FORT BELVOIR, VIRGINIA 22060

JULY 1977

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A Report Submitted to:

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The report provides information on design and costs for five non-structural measures including acquisition and demolition of house structures, relocation of house to alternative sites, relocation of household mechanical and electric equipment, house raising, and basement floodproofing. Cost estimates are for four locations within the Baltimore District. The report includes appendices on cost estimates, structural analyses, real estate policy guidelines and a bibliography.

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SYLLABUS

This report is intended to be utilized by planners, homeowners, local officials, and other segments of the public for the purpose of reduction and/or elimination of flood damages to residential structures by nonstructural alternatives. It should be emphasised that all material presented in this report is based on a cross section of residential structures within the Susquehanna River Basin and the Baltimore Metropolitan Area. Further use of this material for a particular structure or community should be reinforced with project specific design and cost criteria for each nonstructural measure(s) under consideration.

This report provides information on design and costs for five nonstructural measures. Specific components of this report include the main report, cost estimate appendix, structural analyses appendix, real estate appendix, and bibliography.

The main report is subdivided into four topics; introduction, methodology, presentation of results, and comparison of results. The introduction (Section I) outlines the purpose and scope of the design and cost analysis. The methodology used to analyze each nonstructural measure is then presented in Section II. This section also details various assumptions and considerations relating to evaluation of each nonstructural measure. Section III of the main report describes the results of the design and cost analyses for each nonstructural alternative and combination of alternatives. Included in this section are graphical and tabular representations of the cost associated with each of the alternatives. The final portion of the main report (Section IV) includes general information on the applicability of each nonstructural measure given a certain water surface elevation.

The cost estimate appendix (Appendix A) provides both general and specific estimates as developed for all houses which were inspected and evaluated for the purpose of this report. The structural analyses appendix (Appendix B) provides detailed design computations which were performed to develop the scope of each alternative for cost purposes. The real estate appendix (Appendix C) provides general information regarding PL 91-646 as it would affect the implementation of a federally funded non-structural project. The bibliography (Appendix D) provides a selected listing of references which were consulted most often during the course of this study.

The report is being published by IWR for distribution to Corps offices and the general public.

COST REPORT ON NON-STRUCTURAL FLOOD DAMAGE REDUCTION MEASURES FOR RESIDENTIAL BUILDINGS WITHIN THE BALTIMORE DISTRICT

I

INTRODUCTION

COST REPORT ON NON-STRUCTURAL
FLOOD DAMAGE REDUCTION MEASURES FOR RESIDENTIAL BUILDINGS
WITHIN THE BALTIMORE DISTRICT

I. INTRODUCTION

A. Purpose - This report will present various methods, costs, and limitations for using "non-structural flood control measures" as a means of providing needed flood protection for residential buildings located within the Baltimore District. However, it is stressed that the methods presented herein only serve to reduce or eliminate the amount of flood damage that an individual's house and contents may suffer. This report does not attempt to present alternatives for controlling flood levels.

B. General - It is essential that the context of the terms: "non-structural flood protection" and "floodproofing" as they are used throughout this report be clearly defined, since there have been numerous misinterpretations and seemingly contradictory definitions applied to those terms in the past.

The term "non-structural flood protection" is used to disassociate the measures discussed in this report from such traditional "structural" flood control measures as dams, levees, floodwalls, and channel improvements. This term is not intended to imply the exclusion of structures, as one may be led to believe. It will become evident that some of the "non-structural" alternatives presented actually involve various structural improvements which render a building less susceptible to flood damage.

The term "floodproofing" is misleading. Floodproofing is often thought of as preventing any ingress of floodwaters into a house, either by overland flow or groundwater seepage. For residential structures, it has been shown in numerous other reports that such "floodproofing" is impracticable. Instead, "floodproofing" has been used by technical writers as a label for various "...structural changes and/or adjustments incorporated in the design and/or construction and alteration of individual buildings, structures, or properties subject to flooding primarily for the reduction or elimination of flood damages." "Floodproofing" has also been used to describe the methods by which flood damages are mitigated through relocation of valuables and household utilities above the 100-year or greater flood level. In this report, the term "floodproofing" is defined as keeping a house totally free from infiltration by flood waters and section III-E has been devoted to a general analysis of the problems associated with this particular "non-structural" alternative.

"Non-Structural" flood damage reduction measures which have been considered for the purposes of this report consist of the following alternatives:

1. Acquisition and demolition of the existing flood prone structure.

2. Relocation of the flood prone structure outside the flood plain.

3. Relocation of household, mechanical, and electrical equipment to an area that is not subject to flooding.

4. Raising the first floor of a flood prone structure for heights in the range of one, three, five, and eight feet.

5. Floodproofing the basement against infiltration by overland flow and/or underground seepage.

6. Combinations of alternatives to achieve the maximum possible reduction in potential flood damages within the flood plain.

The "non-structural" measures considered in this report were applied to residential housing which is typical of flood prone communities within the Baltimore District area. Commercial and industrial establishments are outside the intended scope of this report. In addition, no specific flood elevation has been considered for the purpose of this report. All costs are presented in such a manner as to allow the planner to establish a reasonable cost estimate for a number of levels of "non-structural flood protection" when evaluating a particular community for a possible detailed project study. It is emphasized that the costs presented in this report have been generalized to allow their flexible application to any community in the District and should not be used as a basis for analyzing any specific project in detail.

Additional considerations and limitations for each non-structural alternative are presented in subsequent sections of this report.

It should be noted that there are several "non-structural" alternatives which are not addressed in this report but which also deserve careful consideration when examining the possibility of reducing flood damages within any flood prone community. Among these alternatives are:

1. Flood plain management (responsibility of local and state authorities).

2. Flood forecast and warning (coordinated by the National Weather Service).

3. Flood insurance (administered by the Federal Insurance Agency).

Some of the above alternatives may possibly be integrated with the measures analyzed in this report in developing the most effective plan for reducing flood damages in a particular locality.

II

METHODOLOGY

II. METHODOLOGY

A. General - To assure that a typical cross section of the various types of house construction found in the flood plain was obtained, four specific localities were identified for field surveys and inspections by District personnel. These four localities included Baltimore, Maryland; Sidney, New York; Lock Haven, Pennsylvania; and Alexandria, Pennsylvania. The houses that were inspected and/or observed in these areas had a wide range of age, but generally fell into one of the twelve categories of home construction listed in Table II-1.

Table II-1
Categories of Home Construction

House Type	Type of Construction	Foundation/ Construction
Split Level	Brick	Block
Split Level	Frame	Block
Slab on Grade	Brick	N/A
Slab on Grade	Frame	N/A
One Story w/Basement	Brick	Block
One Story w/Basement	Brick	Stone
One Story w/Basement	Frame	Block
One Story w/Basement	Frame	Stone
Two Story w/Basement	Brick	Block
Two Story w/Basement	Brick	Stone
Two Story w/Basement	Frame	Block
Two Story w/Basement	Frame	Stone

These twelve house types will be considered for the purposes of this report. Differing types of basement flooring, i.e., dirt, brick, and poured concrete, were also encountered during field inspections; however, the analysis showed that these conditions had little or no effect on the cost of the non-structural measures being considered.

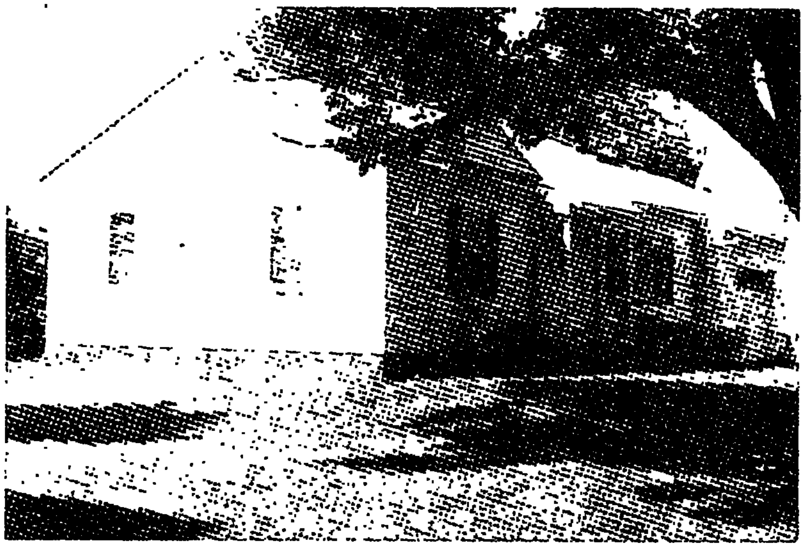
B. Residences Considered -

1. General - It was noted during field inspection that most of the houses exceeded 25 years in age and had suffered repeated flooding of varying degrees over the years, leaving the basic structure weakened as evidenced by sagging joists, cracks in foundation walls and floors, and deteriorating subflooring. Past surveys performed by Corps personnel have supported the fact that such deteriorating houses are typical for flood plains. These conditions are not conducive to "non-structural" measures, other than demolition, unless a significant amount of shoring and/or replacement of structural members is effected. Figures II-A through II-F present pictures of the typical housing inspected.

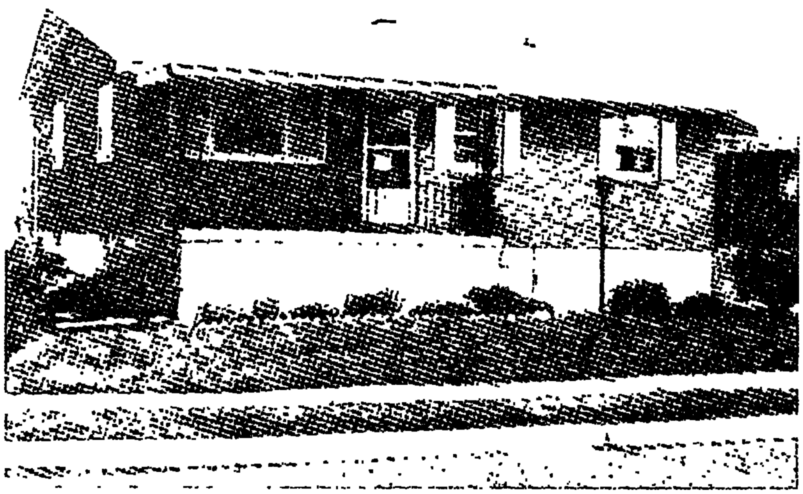
Slab-On-Grade: 1700 Sunny Court Drive
Baltimore, MD

Split Level: 333 Essex Road
Baltimore, MD

FIGURE II-A



One Story: Delmar and Maple Sts.
Alexandria, PA



One Story: 318 Essex Rd.
Baltimore, MD

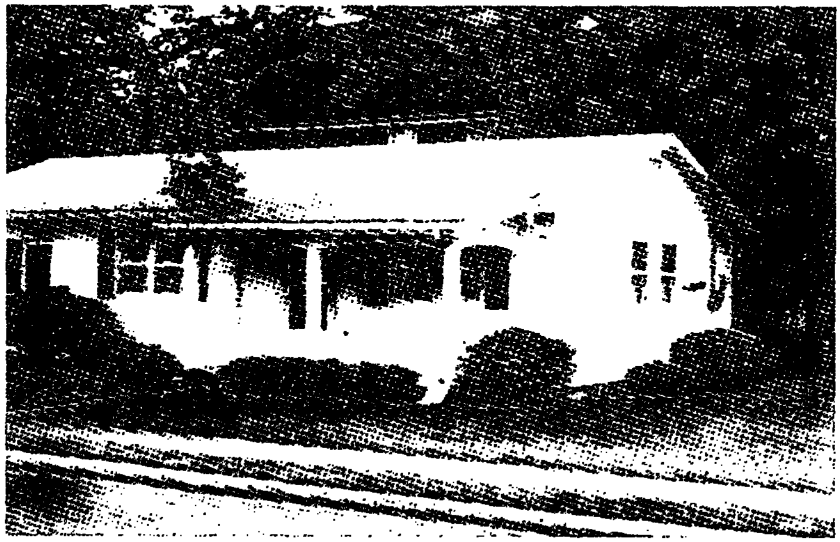
FIGURE II-B

Two Story: Weir and Maple Sts.
Sidney, NY

Two Story: Main Street
Alexandria, PA

Two Story: Typical Group
Lock Haven, PA

FIGURE II-C



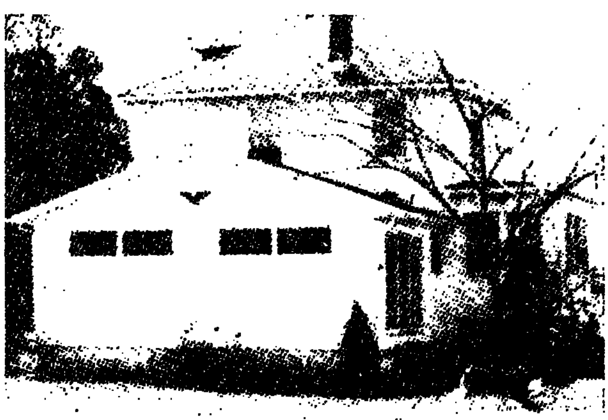
One Story: Liberty St.
Loch Haven, PA

Typical Two Story Group: Commerce St.
Loch Haven, PA

FIGURE II-D

One Story: Church St.
Loch Haven, PA

Two Story: Sidney, NY



Two Story: Sunnyside Lane
Baltimore, MD

FIGURE II-E

Two Story: Sidney, NY

Two Story: East Church St.
Alexandria, PA

One Story: Gwynndale Ave.
Baltimore, MD

FIGURE III-F

2. Types of houses - The four types of houses considered to be typical for the purposes of this report are: slab-on-grade, split level, one-story with basement, and two-story with basement.

3. Structural composition - Originally, four types of structural composition were considered, i.e., brick, block and stone masonry, and frame. Since it was observed that frame and brick houses represent the vast majority of flood plain houses, stone and block masonry houses were eliminated from specific consideration and are to be evaluated as being brick for the costing purposes of this report.

4. Foundation construction - Prior to the field inspection of the typical flood plain communities, three types of foundation walls (poured concrete, block, and stone) were identified for consideration. Since no poured concrete walls were observed during the field inspections of some 30-40 typical houses, they were eliminated. Because of the uncertainty of the physical properties of brick foundation walls and the limited number encountered, they are being treated in the same manner as field stone foundations with no specific differentiation made. As mentioned previously, differing types of foundation flooring were also observed but were determined to have no measurable effect on the design and costs of the various "non-structural" methods being evaluated.

C. <u>Alternatives for Flood Damage Reduction</u>:

1. Acquisition and demolition of structures - This alternative includes relocation of the homeowner, the purchase of a particular structure at a fair and reasonable price, demolition of that structure, and restoration of the entire housing site by filling, grading, and seeding where required. Restoration of the housing site does not include the razing of public streets or sidewalks. It should be noted that the estimates developed for this alternative include an allowance for costs associated with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646). Conformance with this law is required if a Federally funded non-structural project is to be considered for a particular community. A discussion of the benefits available to individual homeowners as a result of that act is presented in the Real Estate Appendix of this report.

A difficulty arises when generalizing this alternative through the assignment of land and property values. The market value of all properties which were inspected and/or observed during field investigations have been estimated. Attempting to extrapolate these values so that they may be applied throughout the District can lead to a distortion of cost unless considerable care is exercised. This report will present a group of values for each locality inspected which can be used as typical of each, subject to certain qualifications to be discussed later.

Another potential problem with this alternative is created by the resulting influx of numerous residents into the real estate market. A shortage of comparable decent, safe, and sanitary housing may be realized. In addition, the law of supply and demand will tend to inflate the costs of available housing. The supplementary costs which may be incurred because of this economic repercussion are beyond the intended scope of this report.

Before any project involving the relocation of homeowners can begin, the District would have to study the housing market in order to determine if adequate replacement housing will be available. When a project is authorized, the acquisition of residential properties should be accomplished in a manner that would not have a negative impact on the local housing market.

2. Relocation of a house to a non-flood plain site - This "non-structural" plan includes the cost of physically moving the structure a reasonable distance to a prepared site of comparable value. The costs of house relocation have been developed on the premise that the Corps of Engineers will administer all the necessary contracts for house relocation (i.e., moving, razing of abandoned site, preparation of new site, and modifying house to place it in decent, safe and sanitary condition). There are some ramifications to this alternative which must be considered if a Federal project is authorized. Section 302(a) of Public Law 91-646 states: "Not withstanding any other provision of law, if the head of a Federal agency acquires any interest in real property in any state, he shall acquire at least an equal interest in all buildings, structures, or other improvements located upon the real property so acquired and which he requires to be removed from such real property..." This section is subject to interpretation; however, it seems to imply that the Corps cannot acquire a homeowner's land without also acquiring his house and improvements. The St. Paul District's (Corps of Engineers) Draft Phase I GDM (General Design Memorandum) for their authorized "non-structural" project at Prairie Du Chien, Wisconsin, recommends house relocation. However, their preliminary plan is to purchase both the land and the house, sell the house back to the owner at salvage value, and leave the actual house relocation and all associated expenses to him, with the Corps providing technical advice and assistance. This is basically the same procedure that is used by the Corps when acquiring properties to accommodate reservoir projects. The homeowner then is eligible to receive the benefits of Public Law 91-646, should his cost for reacquiring and relocating his house exceed the amount paid for the house by the Corps.

3. Relocation of household mechanical and electrical equipment - Two specific methods were studied:

a. Construction of a new utility room on the first floor of the house to accommodate any equipment presently subject to flood damage in the basement.

b. Construction of a watertight 8' x 8' utility cell in the basement to protect the furnace, electric switchbox, gas and electric meters, and hot water heater.

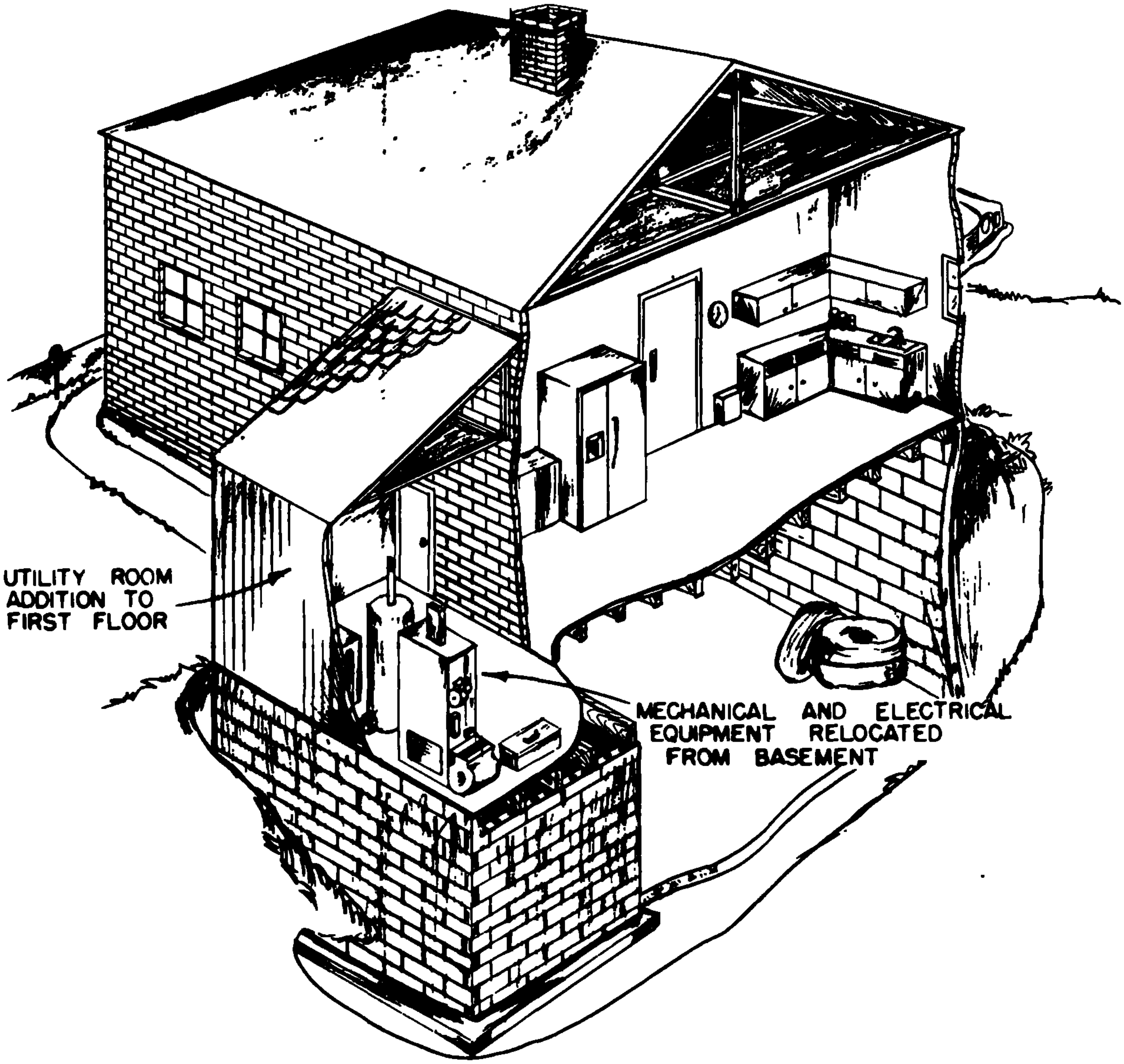
This alternative is especially adaptable to a situation where the design flood level is below the first floor elevation and the predominant damages occur in the basement.

Pictorial conceptions of methods (a) and (b) are presented in Figures II-G and II-H.

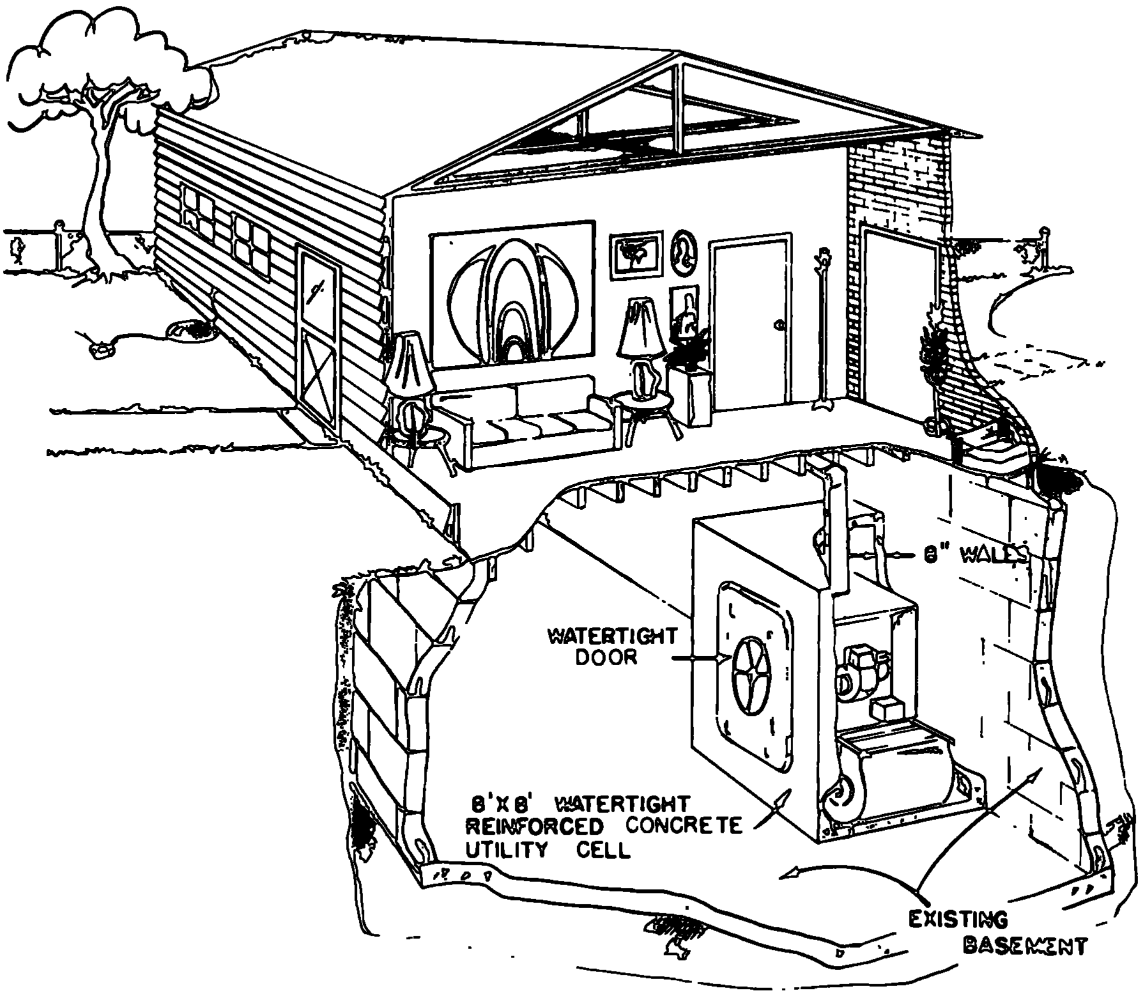
4. House raising - Raising a house to four different levels was considered. Raising of the superstructures was tailored so that an even number of courses of eight-inch concrete block could be used, i.e., heights of 1'-4", 3'-4", 5'-4", and 8'-0". For each height increment, it was assumed that nothing would be done to prevent basement flooding. Only the family dwelling is to be considered for raising. Garages and other appurtenant out-buildings are to remain at their existing elevations.

When reviewing this alternative as part of a "non-structural" plan, consideration should be given to the development of an evacuation plan. Raised houses may leave the occupants stranded for the duration of the flooding condition. Although flood waters frequently have only a short duration throughout most of the Baltimore District, the possibility exists of a flood exceeding the raised first floor elevation necessitating evacuation when the water level reaches some predetermined "critical" point.

5. Basement floodproofing - As previously mentioned, the discussion of "floodproofing" in this report is defined as preventing infiltration of a structure by floodwaters through either overland or groundwater flows. This alternative is the most difficult to evaluate in light of the numerous factors involved in determining whether it is even practicable to floodproof a particular structure. In the majority of reports written on the subject of floodproofing, the conclusion has been that it is only feasible for a sound structure and even then only to a very minimal elevation or flood height. In most cases, for the type of housing observed, the substructures have been damaged and weakened considerably, through repeated flood loadings. In the Pawtuxet River Study prepared by the New England Division of the Corps of Engineers, floodproofing a sound structure was found to be feasible to a 2-3 foot level provided the structure could withstand the hydrostatic pressure. It was concluded that floodproofing was infeasible without significant supplementary structural measures to strengthen the substructure. The considerable age of the homes encountered by New England Division was also a major factor in evaluating floodproofing feasibility. Significant age was also encountered in most of the houses inspected in the Baltimore District. Numerous old fieldstone foundations were observed for which floodproofing is impracticable.



RELOCATION OF HOUSEHOLD MECHANICAL
AND ELECTRICAL EQUIPMENT TO FIRST FLOOR
FIGURE II-G



8'X8' REINFORCED UTILITY CELL
FIGURE II- H

Two levels of floodproofing were evaluated for the purpose of this report:

a. Basement to be fully floodproofed by itself.

b. Maximum level of floodproofing possible, including basement and portion of structure's first story, if practicable.

Various shields and closure structures were investigated for preventing flood waters access into windows and doorways; however, the most reasonable approach to floodproofing such openings in residential structures is to seal them off permanently. At a recent Corps conference at Fort Belvoir, Virginia, on "non-structural flood protection" measures, it was concluded that flood shields and closure structures are not practical for floodproofing residential structures as part of a Federal project. The possibility of incurring flood damage in the event a closure is neglected or fails to function as intended due to improper placement is one of the primary reasons for this recommended policy.

A more detailed description of the structural analyses performed for the structures considered is presented in Section III-E. A figure depicting the relative forces acting on a floodproofed structure is also included.

6. Combinations of alternatives - This option deals with those combinations of household equipment relocation, house-raising, and basement floodproofing alternatives which may be feasible from both an economic and structural standpoint. It can be readily seen that a study of these combinations will determine the maximum degree of flood damage reduction that can be achieved for any particular structure without abandonment. This alternative, as well as the house relocation, raising, and floodproofing alternatives discussed previously, should be considered only if the existing structure is determined to be reasonably sound.

D. Utilities - The following are utility costs considered for each of the alternatives:

1. Acquisition and demolition of structures - Nominal cost to disconnect and cap all existing utilities prior to demolition.

2. House relocation - All costs associated with disconnecting utilities at the existing site and connecting similar utilities at the new site. Also, the cost for providing alternative utility service should the same services not be available at the new site as existed at the abandoned site, i.e., septic tank in lieu of public sewerage. The cost for disconnecting traffic lights and overhead utility lines during the moving is presented on a lump sum per disconnect/service interruption basis.

3. Relocation of household mechanical and electrical equipment - The cost of disconnecting utilities at their existing location and then relocating them in the space provided. Also included is the cost for providing check valves in sanitary lines to prevent sewage and stormwater back-up. (See Figure II-I)

4. House raising - Whenever the basement floor is being raised, the cost of extending utilities the additional height of such raising is included in the cost estimates. The cost of providing the check valves mentioned in the previous paragraph is also included.

5. Floodproofing - The utility costs associated with this alternative are the provision of check valves on sanitary lines as noted under prior headings and the temporary removal and replacement of household mechanical and electrical equipment.

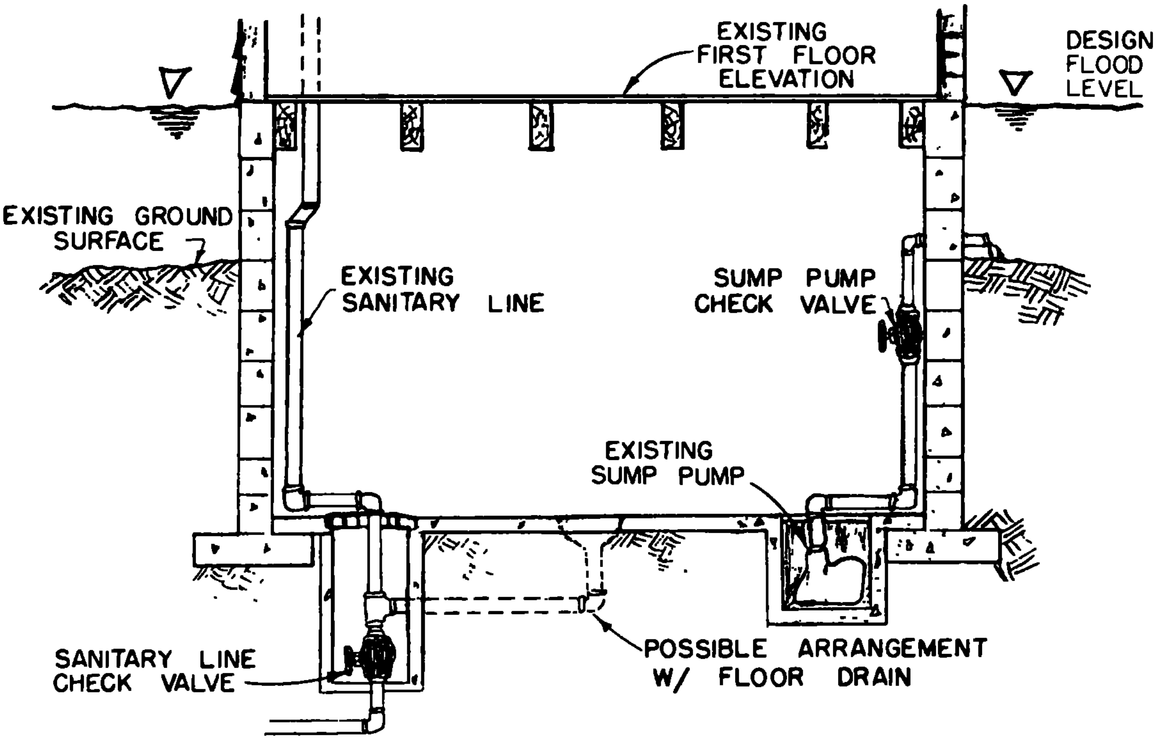
6. Combination of alternatives - Utility costs for combination will be dependent on the combinations to be considered and will be addressed later.

E. Cost Estimates - The cost estimates which have been developed for this report are based on information supplied by house moving, demolition, and raising contractors. These estimates reflect the reasonable cost which may be expected in effecting any of the non-structural alternatives discussed in this report. Each house inspected during the field investigations was costed for each alternative. Where appropriate, the results are presented graphically for ease in interpolation. In some cases, house types and sizes had to be "assumed" to fill in gaps where a specific type of construction was not encountered during the field survey.

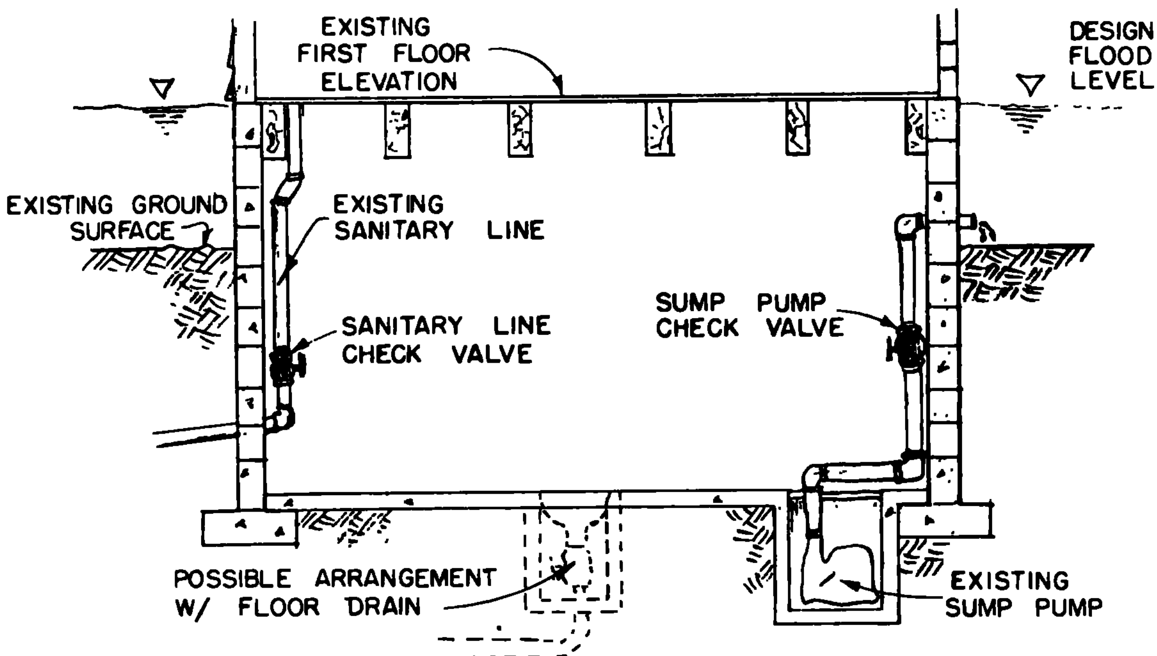
Emphasis is placed on the fact that the costs presented for each alternative have been generalized to allow their application throughout the District and reflect wage rates that are currently in accordance with the Davis-Bacon Act. Local wage rates and/or material costs could have an effect on costs when a specific location is considered.

For both house moving and raising, a percentage of the total costs may be saved when a number of homes in the same locale are to be raised or moved under the same contract. This factor will be discussed in Section III. Due to the preliminary nature of the data which the cost estimates are based upon, it is recommended that a 20 percent contingency factor be appended to the total project costs derived.

The costs presented are at September 1976 price levels. Future use of these figures is subject to revision by implementing the Engineering News Record cost index which accounts for changes due to economic factors.



A. WITH SANITARY LINE THROUGH BASEMENT FLOOR



B. WITH SANITARY LINE THROUGH BASEMENT WALLS

CHECK VALVE PLACEMENT

FIGURE II-I

III

PRESENTATION OF RESULTS

III. PRESENTATION OF RESULTS

A. Acquisition and Demolition of Structures -

1. General - Developing and presenting generalized costs, which can be readily applied during field surveys, proves to be impractical for this alternative without the assistance of knowledgeable real estate personnel.

Based on comparable sales and market values, a real estate appraiser has compiled a range of average home values for the communities visited. These values are shown in Tables III-1 and III-2 and include price ranges for the various types of homes. An estimated land value for property within the flood plain is given in Table III-3, as is the price per square foot of land outside the flood plain. Realistically, these prices are unique to the indicated communities and should not be applied to other locales. Rather than attempt to extrapolate similar price ranges for communities exhibiting parallel economic and social characteristics, to one of the listed areas, an appraiser should be employed to develop ranges for each specific community. Once this has been established, the procedure presented in the following section may be used to calculate a reasonable market value of individual houses. The market value to be computed will be a function of the size, age, location, quality of construction, and condition of the house.

Table III-1
Home Price Ranges
Sidney, NY; Alexandria, PA; and Lock Haven, PA
Flood Plain Area

Type of Home	Structural Composition	Foundation Construction	Dwelling Only ($)
Split Level	Brick	Block	20,000-35,000
Split Level	Frame	Block	19,000-33,000
Slab on Grade	Brick	N/A	20,000-35,000
Slab on Grade	Frame	N/A	19,000-33,000
One or Two Story w/Basement	Brick	Block or Stone	12,000-35,000
One or Two Story w/Basement	Frame	Block or Stone	11,000-33,000

Table III-2
Home Price Ranges
Baltimore, MD
Flood Plain Area

Type of Home	Structural Composition	Foundation Construction	Dwelling Only ($)
Split Level	Brick	Block	20,000-40,000
Split Level	Frame	Block	19,000-38,000
Slab on Grade	Brick	N/A	20,000-35,000
Slab on Grade	Frame	N/A	19,000-33,000
One or Two Story w/Basement	Brick	Block or Stone	16,000-40,000
One or Two Story w/Basement	Frame	Block or Stone	15,000-38,000

Table III-3
Land Values Per Square Foot
(Without Improvements)

Location	Within Flood Plain	Outside Flood Plain
Baltimore, MD	$.40	$.60
Lock Haven, PA	.40	.50
Alexandria, PA	.10	.15
Sidney, NY	.20	.30

The house size is categorized into: small, small to medium, medium to large, and large. The square foot area associated with each category is given under "Determination of Costs."

The age of the house will be a decisive factor in arriving at the final weighted market value. Two major distinctions are made in the age: (1) A relatively new house, less than 25-years old, or an older house which has been completely remodeled, and (2) An older house, over 25 years of age, which has not been completely remodeled. In addition to these two distinctions, each will be broken into four different age classifications. (See Tables III-4 and III-5)

The remaining three items which determine the market value of the house (location, quality of construction, and condition), are to be evaluated as: poor, fair, good, or excellent. A few questions which should be considered in judging these aspects are:

a. Location - Is the house near convenient shopping, schools, major employers, parks, recreational areas, maintained roads, and public utilities?

b. Condition of the house - Is the building in need of painting? Are there signs of wood rotting, shingles missing, damaged siding, and deteriorating brick work?

c. Quality of construction - Does the house construction demonstrate poor workmanship? Are the construction materials of low or high grade composition? Is the dwelling well insulated?

The price ranges quoted in the tables have taken all the preceeding factors into account. The lower price reflects a small old house, which has not been remodeled, showing evidence of being poorly constructed, in poor condition and in an undesirable location. The higher value indicates a new large home, well constructed and maintained, in an excellent location.

The cost of structural demolition and site reclamation includes cost for disconnecting and capping all utilities, removal of material unsuitable for use as landfill, and the material required to backfill the foundation. This cost does not include the razing of public streets or walks.

2. Determination of cost - The total cost for this alternative is composed of the purchase value of the land, market value of the house, structural demolition and site reclamation, resettlement fees, and acquisition expenses.

A sample acquisition work sheet (Figure III-A) is provided to simplify the computations required to obtain the land and market values. This work sheet utilizes the numerical values given to the ratings of each of the influential factors previously discussed (see Tables III-4 and III-5). To calculate the market value, it must first be determined whether Table III-4 or Table III-5 is to be used. This decision is based on the age of the dwelling and whether or not the house has been completely remodeled. After choosing the table required, the five adjustment items are evaluated and their numerical ratings added. This total, the initial rating figure, is then either added to or subtracted from 1.0, depending on the rating table used, yielding a final numerical rating. Once again, depending on the table utilized in evaluating the adjustment factors, the final numerical rating is multiplied by the lowest or highest figure of the price range quoted for the type of house being marketed; resulting in the market value of the house. The land value is obtained by multiplying the appropriate cost per square foot from Table III-3 by the lot size in square feet.

Table III-4
Numerical Rating Value
Houses Over 25-Years Old
Not Remodeled
Flood Plain Area

	Rating			
Adjustment Factors	Poor	Fair	Good	Excellent
Location	0.00	0.033	0.067	0.10
Quality of Construction	0.00	0.033	0.067	0.10
Condition of House	0.00	0.033	0.067	0.10
	Square Foot Area			
	Small 800 to 999	Sm/Md 1,000 to 1,199	Mdm/Lge 1,200 to 1,399	Large 1,400 to 1,600+
Size	0-0.06	0.06-0.12	0.12-0.18	0.18-0.24
	Years			
	100+	75-100	50-75	25-50
Age	0.00	0.033	0.067	0.10

Table III-5
Numerical Rating Values
Houses Less Than 25-Years Old
Or Completely Remodeled Old House
Flood Plain Area

	Rating			
Adjustment Factors	Poor	Fair	Good	Excellent
Location	0.10	0.067	0.033	0.00
Quality of Construction	0.10	0.067	0.033	0.00
Condition of House	0.10	0.067	0.033	0.00
	Square Foot Area			
	Small 800 to 999	Sm/Mdm 1,000-to 1,199	Mdm/Lge 1,200 to 1,399	Large 1,400 to 1,600+
Size	0.24-0.18	0.18-0.12	0.12-0.16	0.16-0.00
	Years			
	75-100+	50-75	25-50	New-25
Age	0.10	0.067	0.033	0.00

Acquisition Work Sheet

Address: Weir and Maple Streets, Sidney, NY (See Page 6)

Type of Construction: Two-story frame w/stone foundation

Age of House: 75 years ±

Size of House: 1,500 sq. ft

Size of Lot: 20,000 sq. ft.

Price Range: Table III-1 - $11,000-33,000

Table for Ratings: Table III-4

Adjustment to Price Range to Obtain Market Value:

Item	Rating
Location	0.033
Quality of construction	0.067
Condition of house	0.067
Size	0.22
Age	0.033
Initial Rating Figure	0.420

Final Numerical Rating :

For Rating Table III-4
1.0+ Initial Rating Figure

1.0 + 0.42 = 1.42

For Rating Table III-5
1.0- Initial Rating Figure

____

Initial Base Figure:

For Rating Table III-4
Use Lowest Figure in Price Range

$11,000

For Rating Table III-5
Use Highest Figure in Price Range

____

Market Value of House

Initial Base Figure X Final Numerical Rating

$11,000 X 1.42 = $15,620

Land Value:

Size of Lot X Value/Sq. Ft.

20,000 sq. ft. X $0.20/sq. ft. = $4,000

Figure III-A

The cost of demolition and site reclamation will vary with the size of the house and the type of house construction. For simplicity, the costs are divided into frame and brick construction with each separated into four categories comparable to the four ranges of size used in determining the market value (i.e., small, small-medium, medium-large, and large). An estimated cost is assigned each of these as shown in Table III-6.

Table III-6
Structural Demolition And
Site Reclamation Costs
(Square Feet)

House Construction	Small 800-999	Sm/Mdm 1,000-1,199	Mdm/Lge 1,200-1,399	Large 1,400-1,600+
Frame	$700	$850	$1,000	$1,150
Brick	800	950	1,100	1,250

The resettlement fee is the cost difference which will be realized between the market value of the present house and the value of comparable housing outside the flood plain. The resettlement fee is limited by law to $15,000. Although this cost is considered part of the total cost for this alternative, only those costs not associated with providing decent, safe, and sanitary housing affect a project's benefit-cost ratio. Because of this and the complexities associated with Public Law 91-646, resettlement costs cannot be estimated unless a detailed study is made for a specific location. It has been the Baltimore District's experience for reservoir projects that a reasonable average cost for resettlement falls between $8,000 and $9,000.

Appendix C provides an insight into the benefits which will be available (under Public Law 91-646) to homeowners should a "non-structural" project be authorized for their community.

The acquisition expenses are the project costs associated with obtaining the properties, such as land survey, property title search, and legal fees. The average cost for the acquisition expense is $3,000. See figure IV-A for an example of the total cost for this alternative.

B. Relocation of House to a Non-Flood Plain Site -

1. General - Relocation of a house that is subject to frequent flooding involves the physical raising and moving of the superstructure to a new site beyond the limits of the flood plain. This entails disconnecting and capping all utilities at the present site, removal of obstructions enroute to the new location, construction of a new foundation/basement at the relocation site, backfilling the existing basement, and landscaping both lots.

The cost for these items is evaluated on the relatively ideal premises that:

a. The house can be relocated within a 10-mile radius.

b. A new housing site is available along an existing public road with utility services.

c. The existing electrical and mechanical fixtures, in the house to be relocated, comply with local building codes.

The largest portion of the total cost for house relocation is the raising and moving of the superstructure. This cost increases significantly for a two-story house over a one-story dwelling, because of the additional problems encountered when moving a taller structure.

2. Cost estimates - Figure III-B gives the estimated cost for a typical house relocation, based on the previous assumptions, in proportion to the square foot area of the first floor. This cost does not include the expenses which may be incurred during relocation (such as, temporary disconnection of traffic signals and overhead powerlines and removal of trees). The curves are a result of the cost estimates compiled for the various houses visited and hypothetical houses. Because many of the houses in the areas inspected were of similar size, hypothetical homes had to be assumed to give the variation in floor area required for the curves. Such hypothetical homes are typical of those structures which were observed in the communities that were visited, although specific examples were not noted. The estimates can be found in Appendix "A."

The costs for temporary disconnection of overhead transmission lines and traffic signals, along with the cost for the necessary tree removals, will be dependent upon the route to be traversed when moving the house. The costs for disconnections and removals are estimated as:

a. $1,500 per service interruption of overhead transmission lines.

b. $250 per intersection for service interruption of overhead traffic signals.

c. $400 per large tree removal.

In the event that public utilities are not available at the proposed new site, an additional $2,700 is to be added to the figure obtained from the appropriate curve. This amount includes a 1,000 gallon septic tank at $500, drilling a 100-foot well at $800, and a 250-770 GPH well pump at $1,400.

All the costs which have been presented are based on the supposition that the relocation will be contracted for by the Corps, without purchasing the house. If it becomes mandatory that the Corps purchase a landowner's house, and other improvements located on his property, the costs to

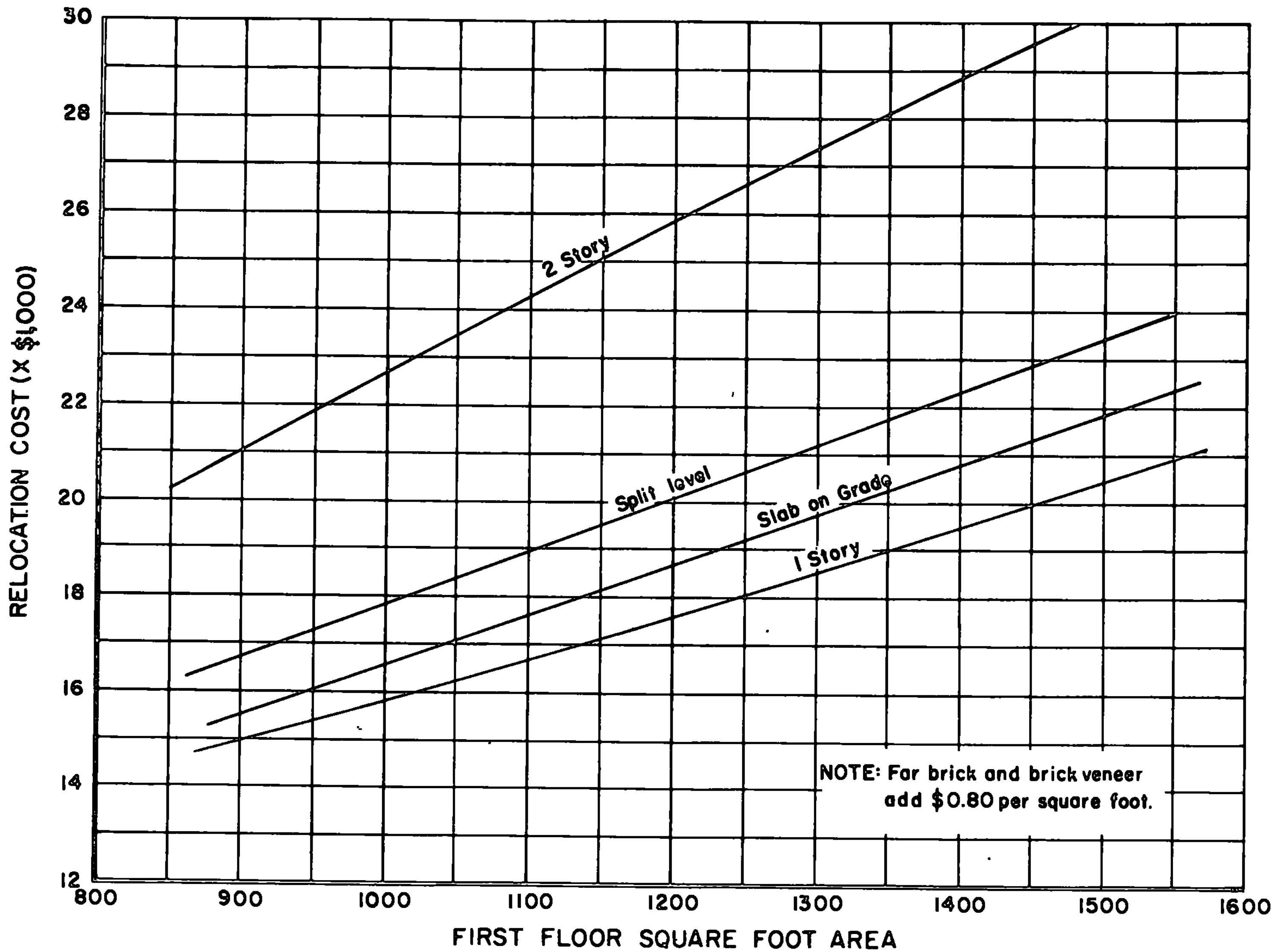


FIGURE III - B HOUSE RELOCATION

move the house will be incurred by the landowner who will then be eligible for the relocation (resettlement) benefits described in Section II-C, paragraph 2 and Appendix C of this report.

When several homes in the same locale are to be relocated under one contract, 10% may be deducted from their total relocation cost as a savings realized by reduced mobilization costs.

C. Relocation of Household Mechanical and Electrical Equipment - Based on the premise that an eight-foot by eight-foot area provides ample space for the normal household mechanical and electrical equipment, two cost estimates were compiled

Table III-7 gives the prices of various items considered for the construction of a new utility room added onto the existing house at the first floor level. This addition should only be considered when the first floor is above the design flood elevation.

As an option to relocating the mechanical and electrical equipment to a higher elevation, the concept of providing a waterproof cell in the basement was investigated. An eight-foot square reinforced concrete cell, with a watertight door, was designed based on eight feet of water encompassing it. (See Appendix "B" for design calculations.) Table III-8 demonstrates that the watertight door is the predominant expense under this consideration. The $5,000 cost figure for a watertight door is a quoted installed price obtained from a manufacturer of such doors. This door provides a quick and effective closure. A cheaper unproven closure method was investigated. This method involves the use of a steel door with a rubber gasket around the perimeter and a series of bolts to secure it in place. However, it should be noted that attaining an effective closure will be a time consuming operation. For this reason, this alternative closure is considered to be generally impracticable. The cost of this door is $1,500.

This option is nearly double the cost for relocation of domestic utilities to a higher elevation (first floor level). Nonetheless, modifications of this option may have merit where the expected water level is less than four feet in the basement. A floodwall surrounding the utilities, with a removable flood shield, may be provided to keep the basement equipment dry. Potential variations should be addressed thoroughly in a detailed report.

The two cost estimates given are based on the assumption that the mechanical and electrical equipment are susceptive to relocation. In some instances, it may be necessary to permit the inundation of that equipment which cannot be relocated. Replacement of such equipment with furnishings compatible to the existing fixtures may be feasible. However, such costs are not included in this report.

Table III-7
Cost Estimate
Utility Room Addition
At First Floor Level

Item	Cost
Excavation and Backfill	$ 200
Foundation	1,000
Superstructure Framing, Siding & Roofing	1,500
Doors, Windows, Gutters & Painting	1,100
Electrical Work	300
Relocation of Equipment	1,000
Check Valve	700
Total	$5,800

Table III-8
Cost Estimate
8'x8' Reinforced Utility Cell

Item	Cost
Concrete	$ 1,800
Reinforcing	500
Waterstops	200
Watertight Door	5,000
Electrical Work	300
Relocation of Equipment	1,500
Check Valve	700
Total	$10,000

D. House Raising -

1. General - As previously indicated, raising of a house would be accomplished in accordance with an even number of eight-inch concrete block layers. Height increments of 1'-4", 3'-4", 5'-4", and 8'-0" were evaluated. Under this alternative, it is assumed that raising the house will place the first floor living area above the design flood elevation. Basement flooding would remain unchanged. Figures III-C through III-D show typical house raisings with respect to the structure and existing ground conditions. The renderings are based on an existing foundation capable of supporting the indicated raisings.

In order to estimate the cost of raising typical houses, a structural analysis of the existing block foundations was performed. New substructures were designed for stone and brick foundations. Producing the analyses and cost estimates required numerous assumptions. These included general suppositions and specific premises that apply to the individual types of homes listed in paragraph II.A. The general suppositions were:

a. All basement interiors flood with the rising flood waters.

b. Houses with concrete block foundations can adequately support the additional layers of block required for the raisings.

c. Houses with stone, brick, or combination stone-concrete foundations were considered incapable of supporting the additional layers of block required for the raisings.

d. New footings have a 28-day compressive strength of 2,500 pounds per square inch.

e. All basements are unfinished.

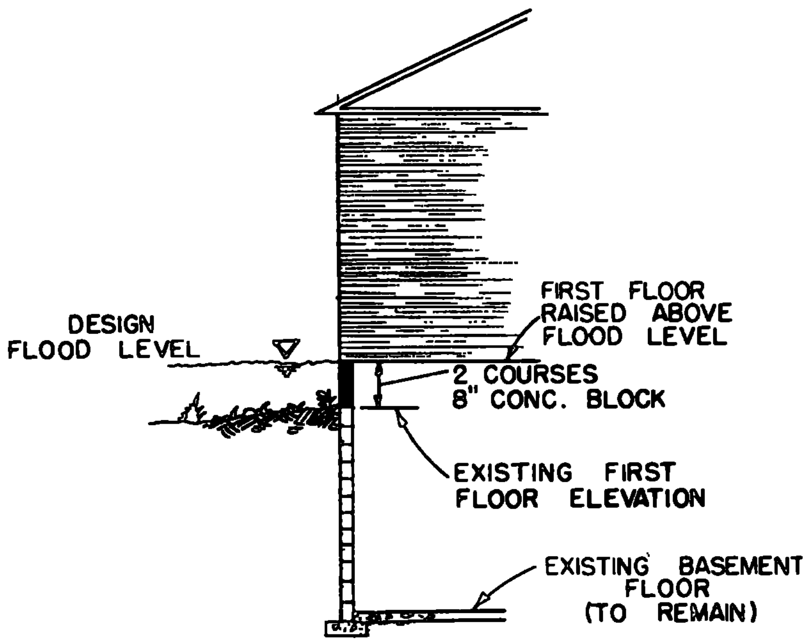
f. Houses shall be raised by using steel beams and jacks.

g. Design velocity for the flood waters is 6 feet per second which is an average overbank velocity.

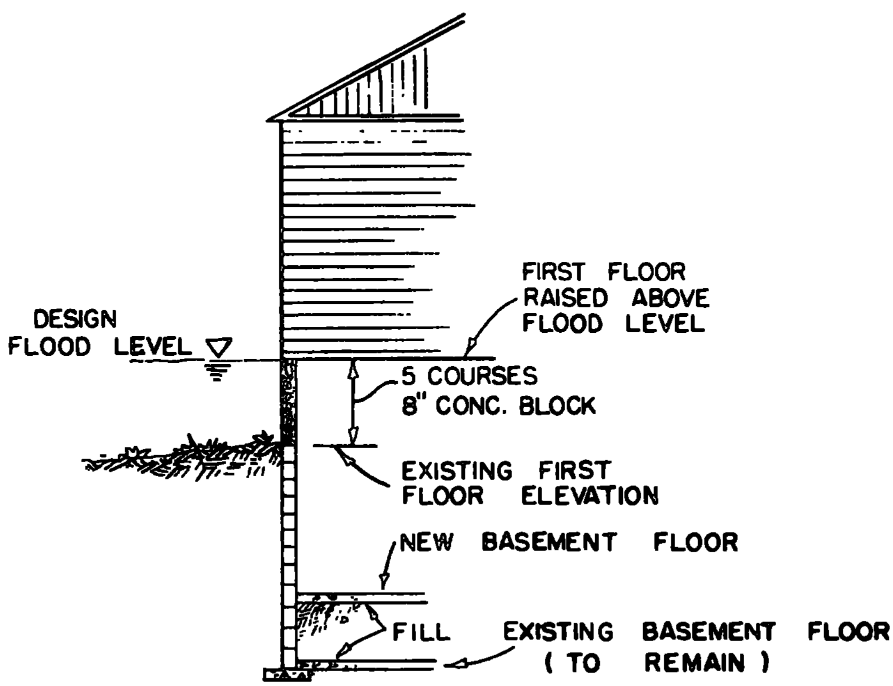
h. The flood plain in which the houses are located is of sufficient capacity that the addition of exterior fill around the perimeter of the homes will not significantly affect the design flood water profile.

i. If temporary housing is required during the raising or moving of a house, an average allowance of $400 per family should be used.

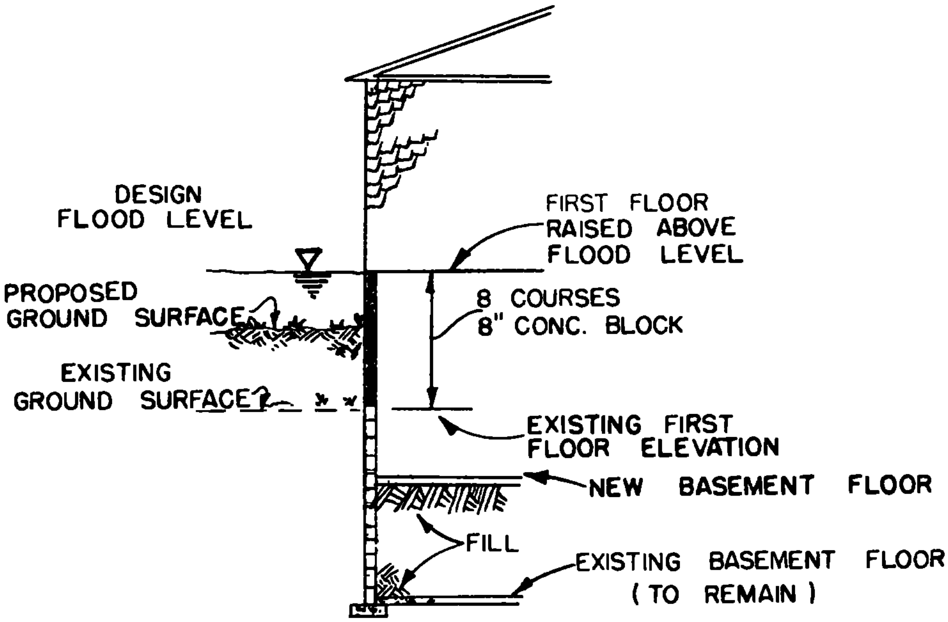
Specific premises will be discussed further with each type of house.



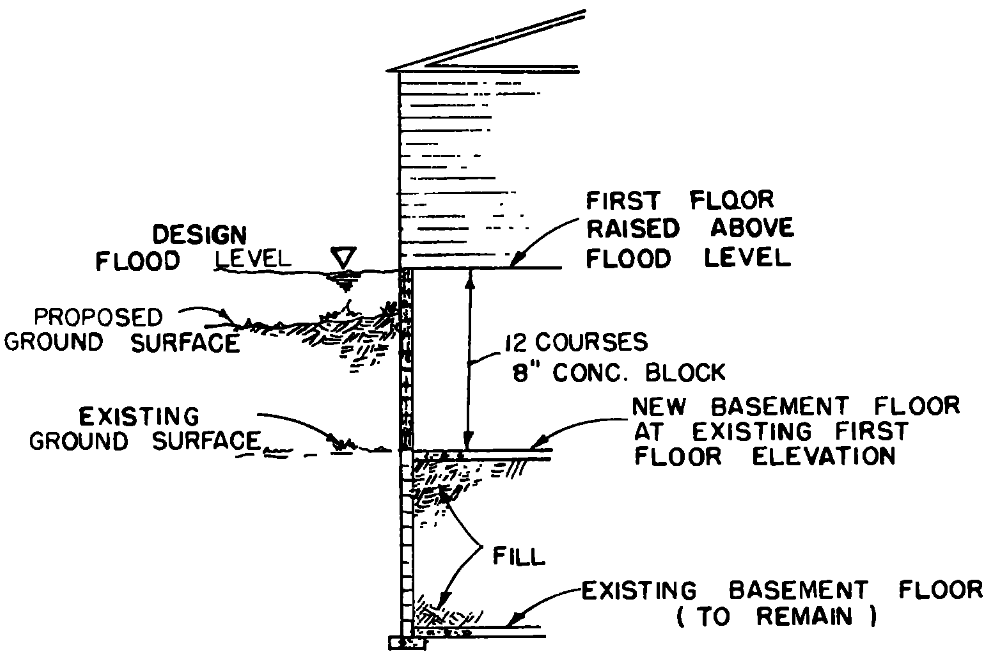
RAISING FIRST FLOOR 1'-4"



RAISING FIRST FLOOR 3'-4"
(FIGURE III - C)



RAISING FIRST FLOOR 5'-4"



RAISING FIRST FLOOR 8'-0"
(FIGURE III - D)

The structural analyses for the houses examined during site visits are presented in Appendix B. The loadings considered in the analyses include the weight of the structure and permanent mechanical equipment, commonly known as the dead load, the average weight of the furnishings and occupants (live loads), the forces exerted against the basement walls by the surrounding soil, and the hydrodynamic load associated with the velocity of the floodwaters. Since the basement is being considered inundated, the hydrostatic pressures will be equalized. Figure III-E gives a schematic representation of the forces and the general location of impact. The floor composition is immaterial, in the case of raising, since the basement will be flooded and all forces acting on the basement floor will be in balance.

2. Cost estimates - The cost estimates for raising houses inspected during site visits can be found in Appendix A. These estimates were employed in the derivation of the cost curves in Figures III-F through III-K.

In some instances, hypothetical houses had to be conjectured in order to obtain a sufficient number of points along the cost curves. The curves represent the total cost of raising frame structures the indicated heights, based on the square foot area of the first floor living space. The total cost includes all utility extensions and the placement of a check valve in the sewerline. The cost for raising a brick or brick veneer home may be obtained by adding $0.80 per square foot of first floor area to the total obtained from the appropriate curve for a frame house.

A 10 percent cost savings may be gained when several house raisings in the same vicinity can be accomplished under one contract.

a. Slab-on-grade - The cost curve in Figure III-F shows the total cost associated with raising a frame slab-on-grade house. In raising a house of this type, the concrete slab is severed from the superstructure and removed. A new foundation footing is constructed to support the block walls, used in the raising, and a wooden flooring system is provided in place of the concrete slab. This method will create a crawl space under the house. The costs for the 5'-4" and 8'-0" raisings are based on the assumption that the inhabited area where the dwelling is located is not densely populated, allowing exterior fill to be placed around the house for access and aesthetic purposes.

b. Split level - All of the split level homes noted during field inspections had one level constructed as a slab-on-grade and the second level built with a crawl space underneath. Based on this information, the raising of a split level home becomes similar to that of a slab-on-grade in that the concrete slab is removed and replaced with a wooden flooring system.

As in the previous case, it was assumed that exterior fill would be placed around the perimeter of the dwelling for the five-foot to eight-foot raisings. In addition, it was also presumed that the portion of the building with the existing crawl space has footings capable of supporting the additional raisings.

The cost curve in Figure III-G presents the cost of raising a frame split level house the prescribed increments.

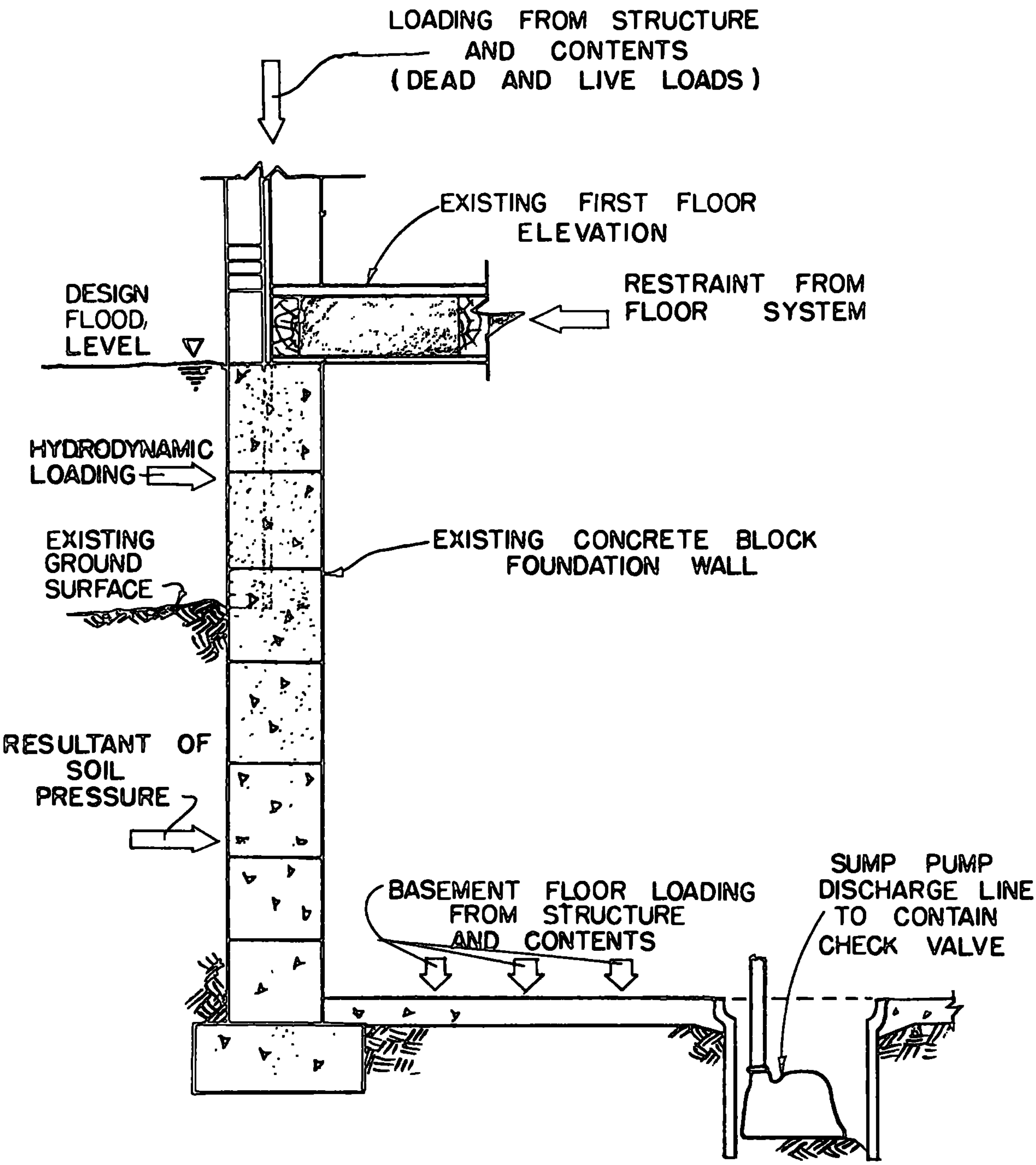
c. One and two-story houses with basements - Because of the similarities between the one and two-story houses, they are being presented together.

Although the number of stories has an effect on the cost of raising a structure, the type of basement construction is the most significant factor. As seen in Table II-1, eight different possibilities exist in the typical one and two story categories. However, there are only two possible alternatives for foundation construction. Each of these is to be considered separately:

1. Block foundation - The cost curves in Figures III-H and III-I represent the costs affiliated with raising one and two story houses with block foundations. The cost estimates were derived from the general supposition that the existing block foundation is capable of supporting the additional load provided by the increase in foundation walls. The existing basement floor is to remain in place. Interior fill will be placed in the basement to the desired elevation and a new basement floor constructed. This format is followed for the raisings in the three to eight-foot range. When considering the 1'-4" raising, the existing basement floor is utilized at its present elevation.

2. Stone foundations - Substructures composed of brick, or combinations of brick, stone, and mortar, will be considered as stone foundations. Because of the uncertainty of the physical properties of these foundations, they are assumed to be inadequate for raisings. Although some of the stone foundations may prove to be of sufficient strength to support the lower increments of raising, it would be virtually meaningless to structurally analyze their adequacy without proper testing of the foundation materials. Consequently, the removal of all stone substructures is taken into account and new foundations are provided. The costs for raising one and two-story houses with stone foundations can be obtained from the cost curves in Figures III-J and III-K.

E. <u>Basement Floodproofing</u> - As a solution for reducing damage caused by flood waters within a dwelling, a structural analysis was performed which endeavored to provide the maximum level of basement floodproofing that could be expected from a concrete block foundation without



LOADINGS CONSIDERED FOR HOUSE RAISING
FIGURE III E

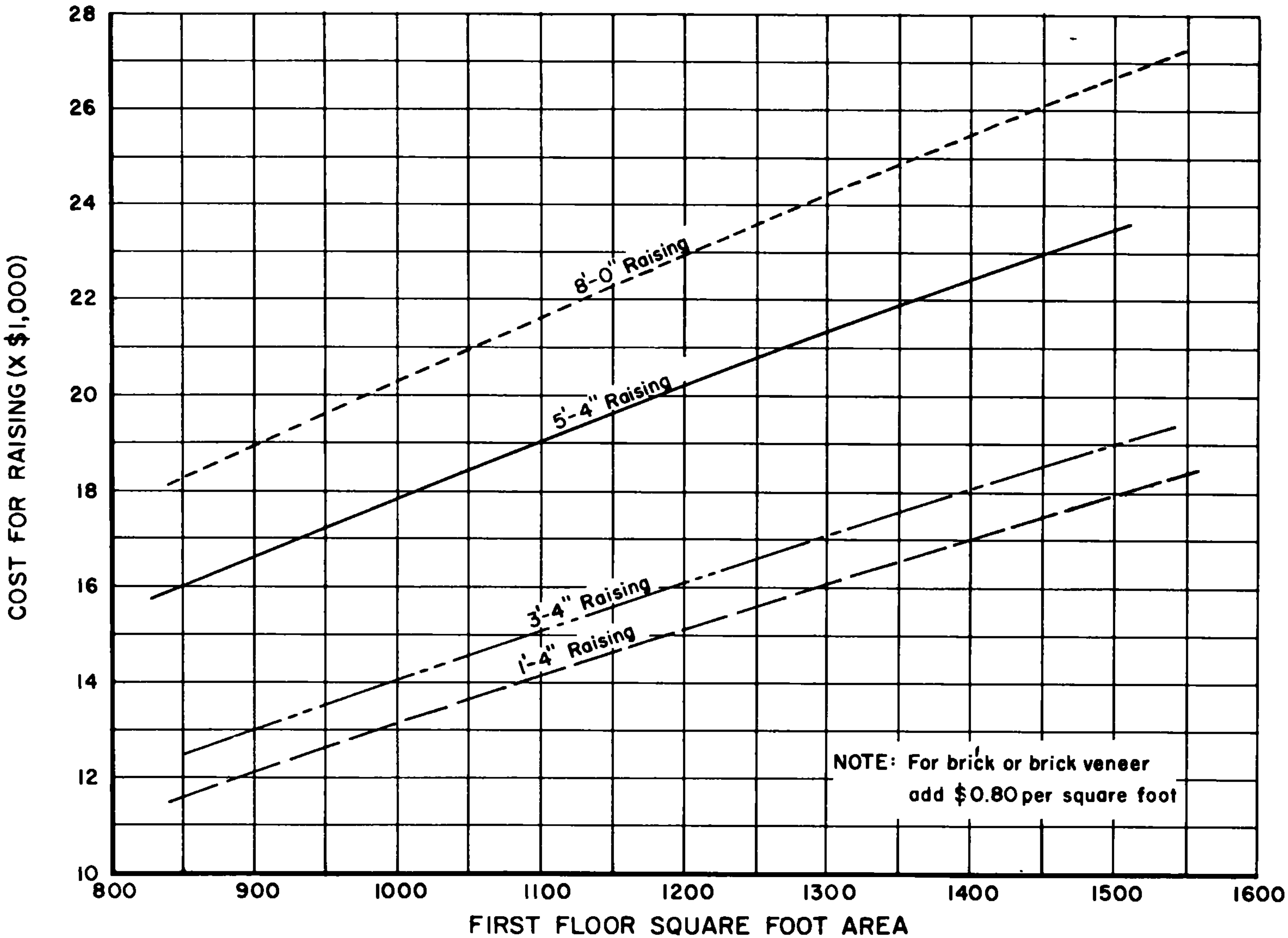


FIGURE III - F HOUSE RAISING SLAB ON GRADE

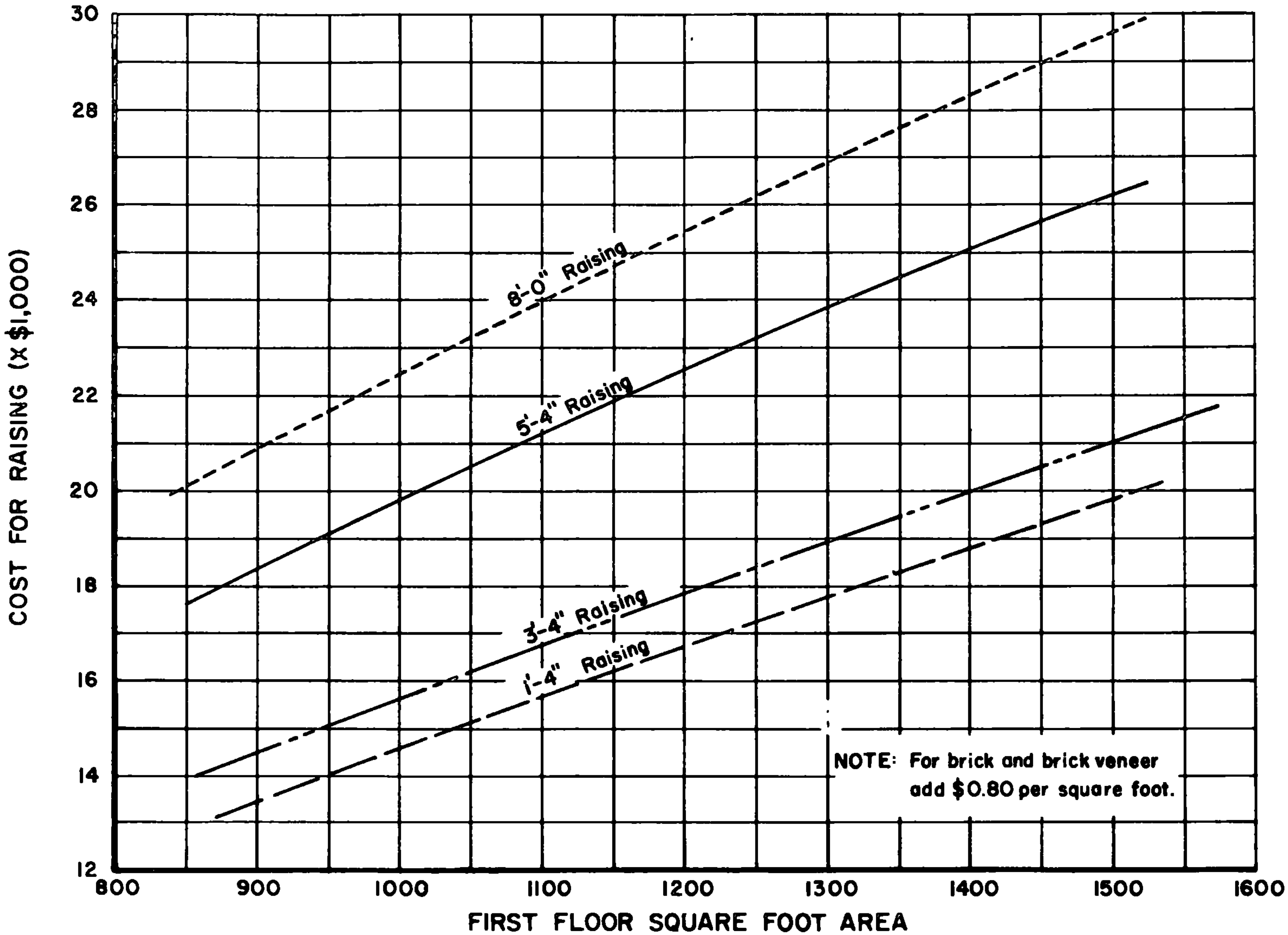


FIGURE III-G HOUSE RAISING SPLIT LEVEL

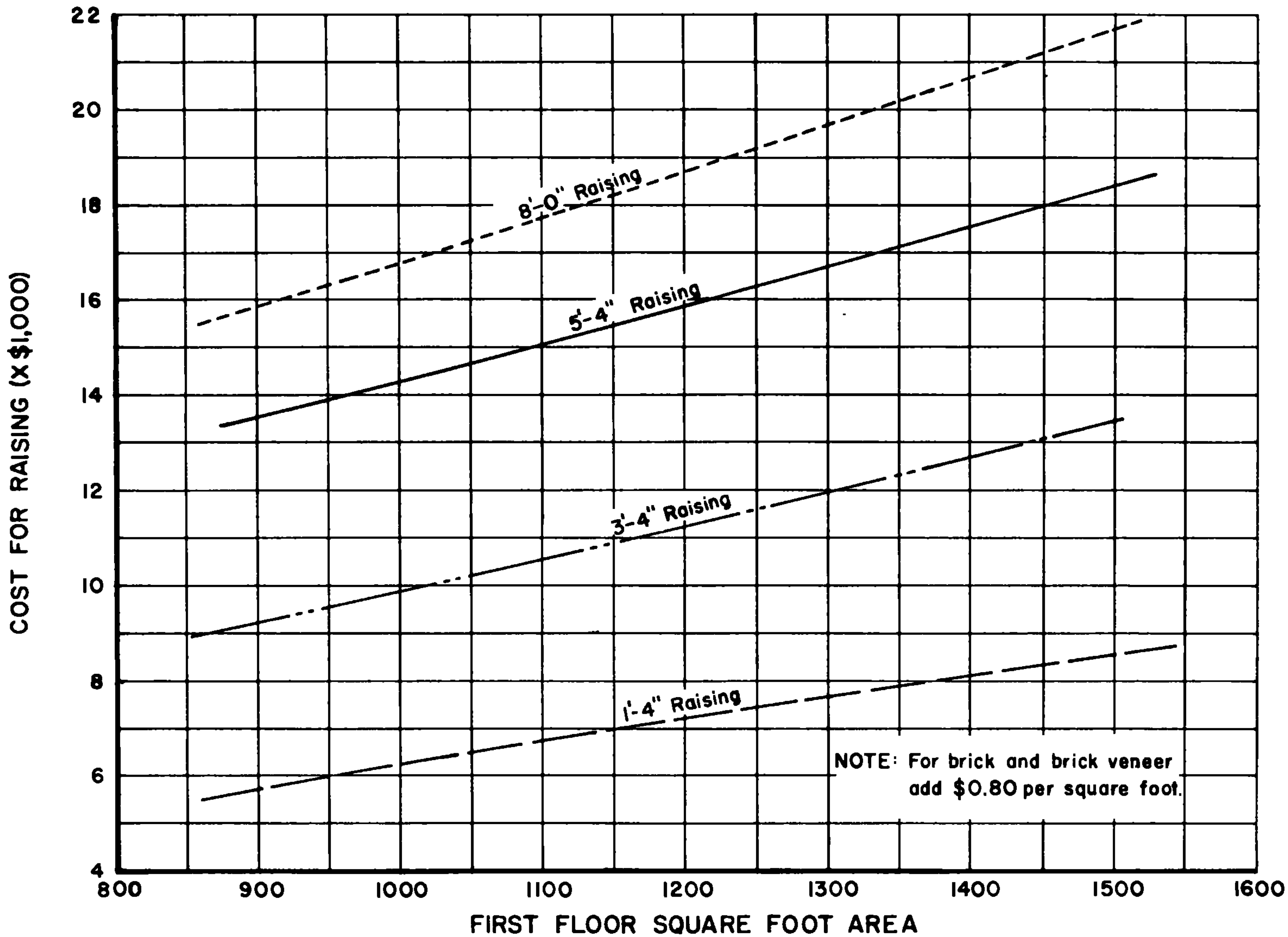


FIGURE III - H HOUSE RAISING ONE STORY W/BLOCK FOUNDATION

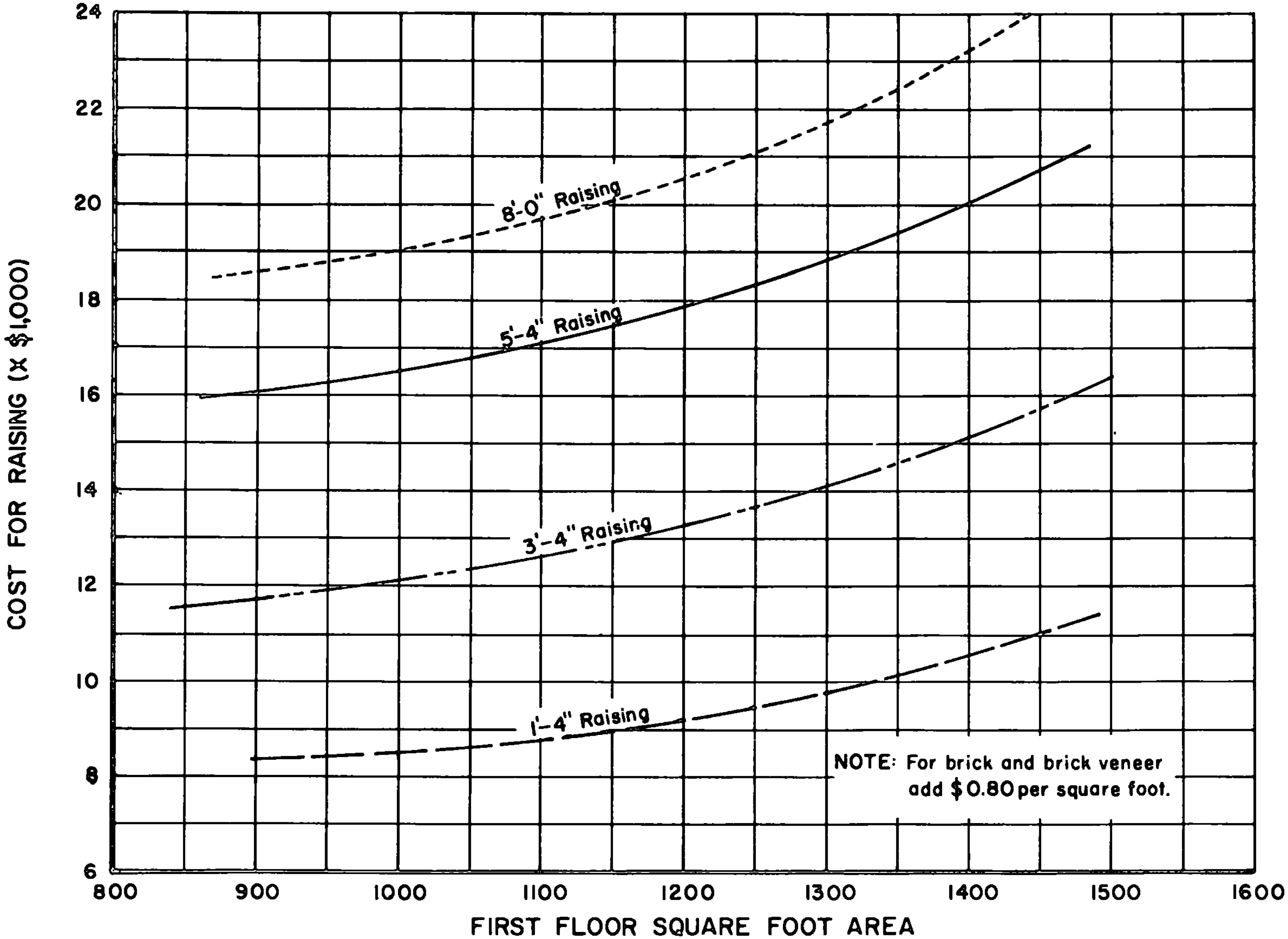


FIGURE III - I HOUSE RAISING TWO STORY W/BLOCK FOUNDATION

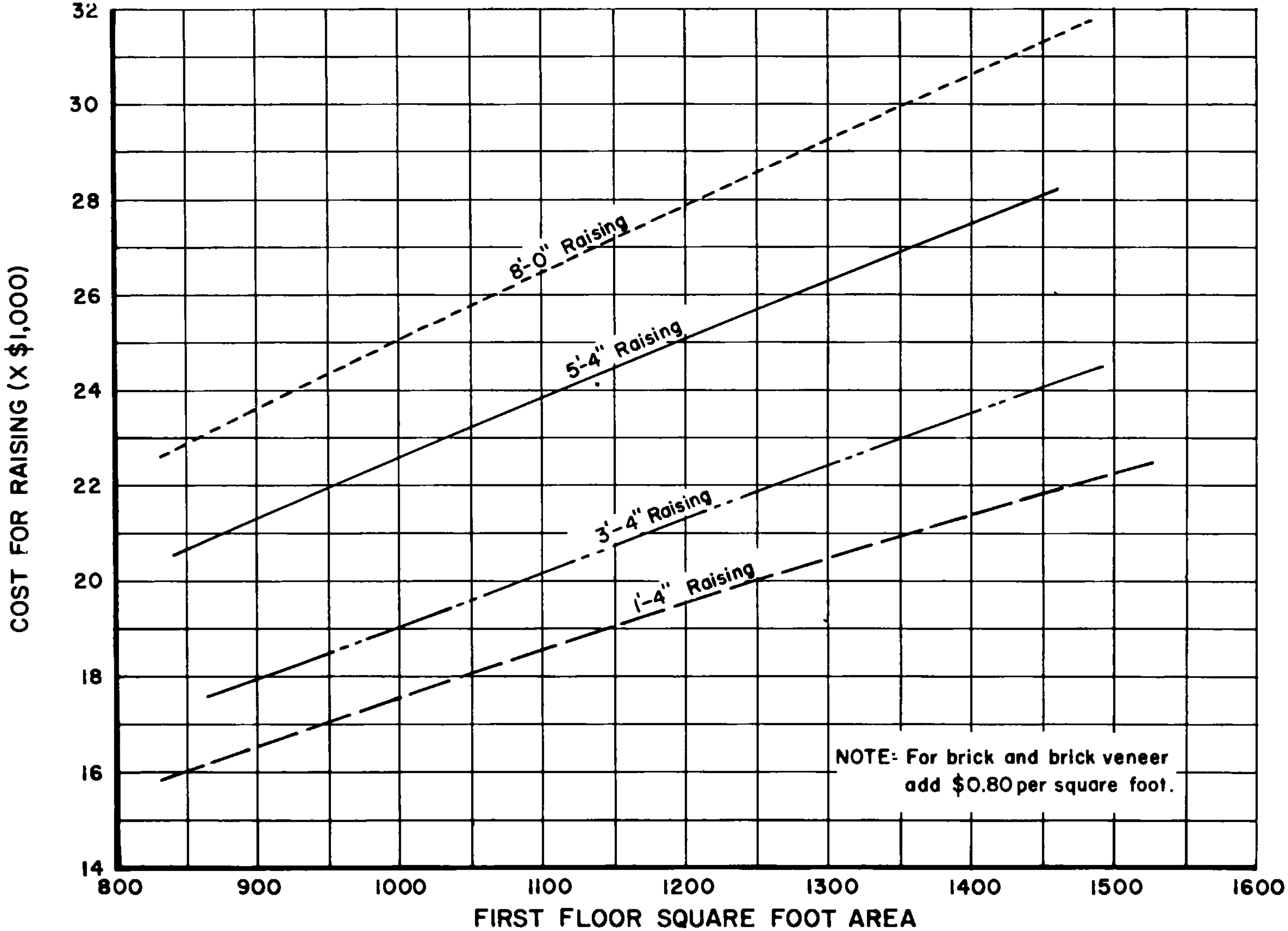


FIGURE III - J HOUSE RAISING ONE STORY W/STONE FOUNDATION

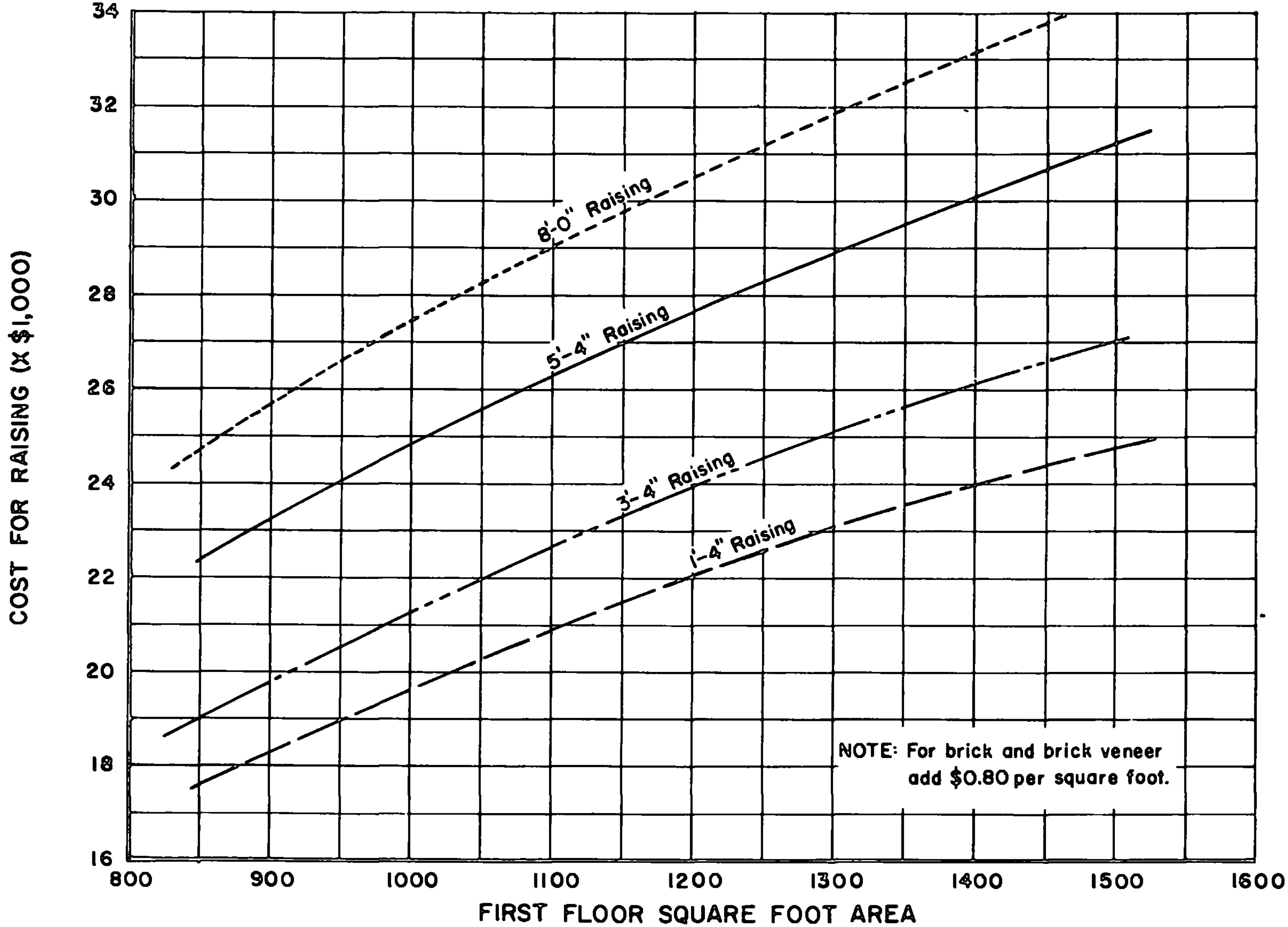


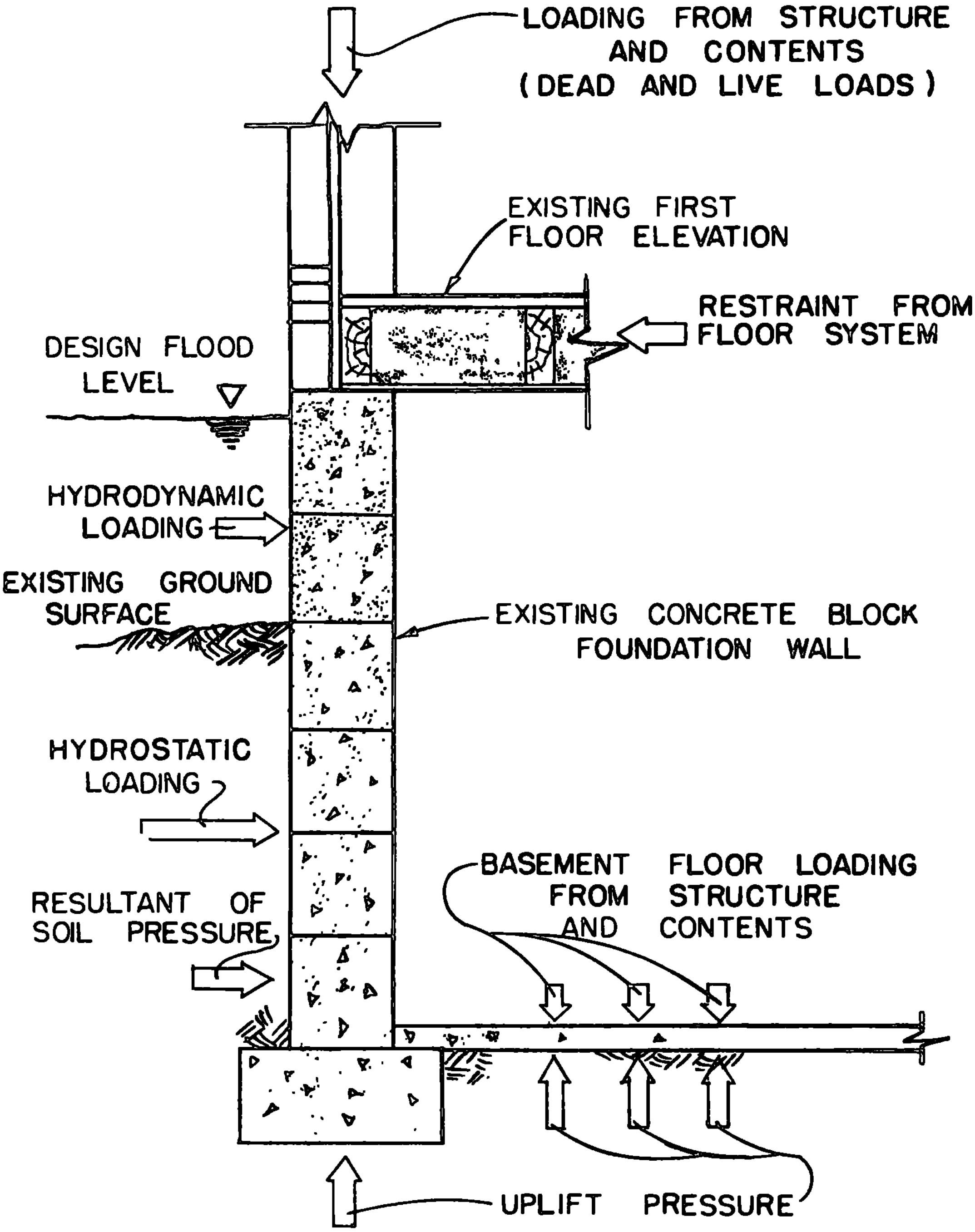
FIGURE III-K HOUSE RAISING TWO STORY W/STONE FOUNDATION replacement of foundation walls or slab. The premises were formed that the existing floor was a four-inch concrete slab with reinforcing, and the existing walls could be waterproofed with an asphaltic mixture.

Prior to analyzing the basement, it was established that the use of foundation subdrains for the perimeter of the basements would be meaningless in a flood condition. The drains would be completely inundated, resulting in a full pipe for the duration of the flooding, thereby negating the effect of the drains.

The forces acting on the foundation which were considered in the analysis are depicted in Figure III-L. These forces differ from those analyzed in house raising in that additional forces created by the imbalance of water pressure known as the hydrostatic and uplift pressure are present. This asymmetry of water pressure proves to be the influential factor in the design analysis. The uplift pressure causes the basement floor to heave and develop cracks. Because of the pressures exerted by the water, a minute crack will soon deteriorate causing basement flooding.

It was concluded that an existing concrete block foundation can only be waterproofed for depths of one to two feet, whether it is exposed or unexposed. This has been verified by previous studies on the topic of floodproofing as mentioned earlier. Based on this finding, a cost estimate was compiled for replacing an existing substructure with a watertight reinforced concrete foundation. The new foundation was designed with waterstops in all construction joints to prevent seepage, temporary flood shields over basement windows and doors, and check valves in sewage lines. It is assumed that the design flood level is below the first floor elevation. If the flood level is above the first floor, this alternative alone will not suffice. Table III-9 lists the costs related to floodproofing a basement for a structure which is typical of a group of houses found in Lock Haven, Pennsylvania. The figures shown will be utilized in Section IV, Comparison of Alternatives, to portray the relationship between the alternatives and their expenses.

Additional estimates and the structural analysis of the substructure, referred to previously, can be found in Appendices A and B respectively. Appendix B also contains the design analysis on which the estimate of Table III-9 was based.



LOADINGS CONSIDERED FOR BASEMENT FLOODPROOFING
(FIGURE III-L)

Table III-9
Basement Floodproofing
Lock Haven, Pennsylvania
(1,000 Sq. Ft., Two-Story Frame W/Stone Foundation)

Items	Costs
House Raising (to allow construction of new foundation)	$ 6,000
Foundation Removal	4,700
New Reinforced Concrete Foundation	16,900
Landscaping	1,000
Total	$28,600

F. Combinations of Alternatives -

1. General - Providing the maximum possible degree of flood damage reduction for any structure within the flood plain requires a combination of the alternatives already presented. Only three possible combinations exist. They are:

a. House raising and relocation of utilities to a watertight 8' X 8' concrete cell in the basement, allowing the rest of the basement to flood.

b. House raising and relocation of utilities to a new addition at the first floor level, allowing basement flooding.

c. Raising the house and floodproofing the basement. Requires no permanent relocation of utilities.

All of these combinations involve elevating the first floor above the design flood water level and protecting the household mechanical and electrical equipment.

Since the means of protecting the equipment is the only variable in the three combinations, it will be the decisive factor in comparing these possibilities.

The costs of providing and 8' x 8' watertight utility cell and a utility room addition to the first floor were presented under "Relocation of Household Mechanical and Electrical Equipment." The estimated cost which should be attributed to floodproofing, when being considered in combination with raising, must be computed.

The cost of floodproofing will be the difference in cost for providing a new watertight foundation and that of the foundation work required in raising the structure. This cost will vary but will be at its minimum when the raising requires a completely new substructure (as in the case of a stone basement).

As a typical example using the house in Lock Haven, Pennsylvania, for which a floodproofing estimate is given in Table III-9, the cost of a new reinforced concrete basement is $16,900. The same group of houses was also estimated for raising, and Appendix A (Cost Estimates) gives the cost of providing a new concrete block basement for the various raisings increments. Neglecting the additional foundation work required under each raising, the cost of providing a new basement is $7,500. The difference between the two foundations is $9,400. This cost will increase significantly when considering a home with existing block foundation which does not require a new substructure.

Comparing these three alternatives and their costs yields:

Floodproofing	8'X8' Utility Cell	Utility Room Additions
$9,400+	$10,000	$5,800

It is obvious from the comparison that the combination of house raising and relocation of household mechanical and electrical equipment to the first floor elevation is the most economically feasible combination.

2. Cost estimates - Cost for the combination of house raising and relocation of utilities are given in the cost curves in Figure III-M through III-Q. The curves are only for the most economical combination. Note that the costs obtained from these curves are not a direct addition of the cost of house raising and the additional utility room. The cost of the addition will vary with the increment of raising and the cost of raising decreases slightly because of the elimination of duplicated items (i.e., removing and replacing the equipment).

The assumptions which were previously made for each of the two alternatives are still valid for their combination. A pictorial sketch of the combination house-raising and utility relocation is presented in Figure III-R.

No cost curve is provided for the slab-on-grade home since the existing utilities are found at the first floor elevation.

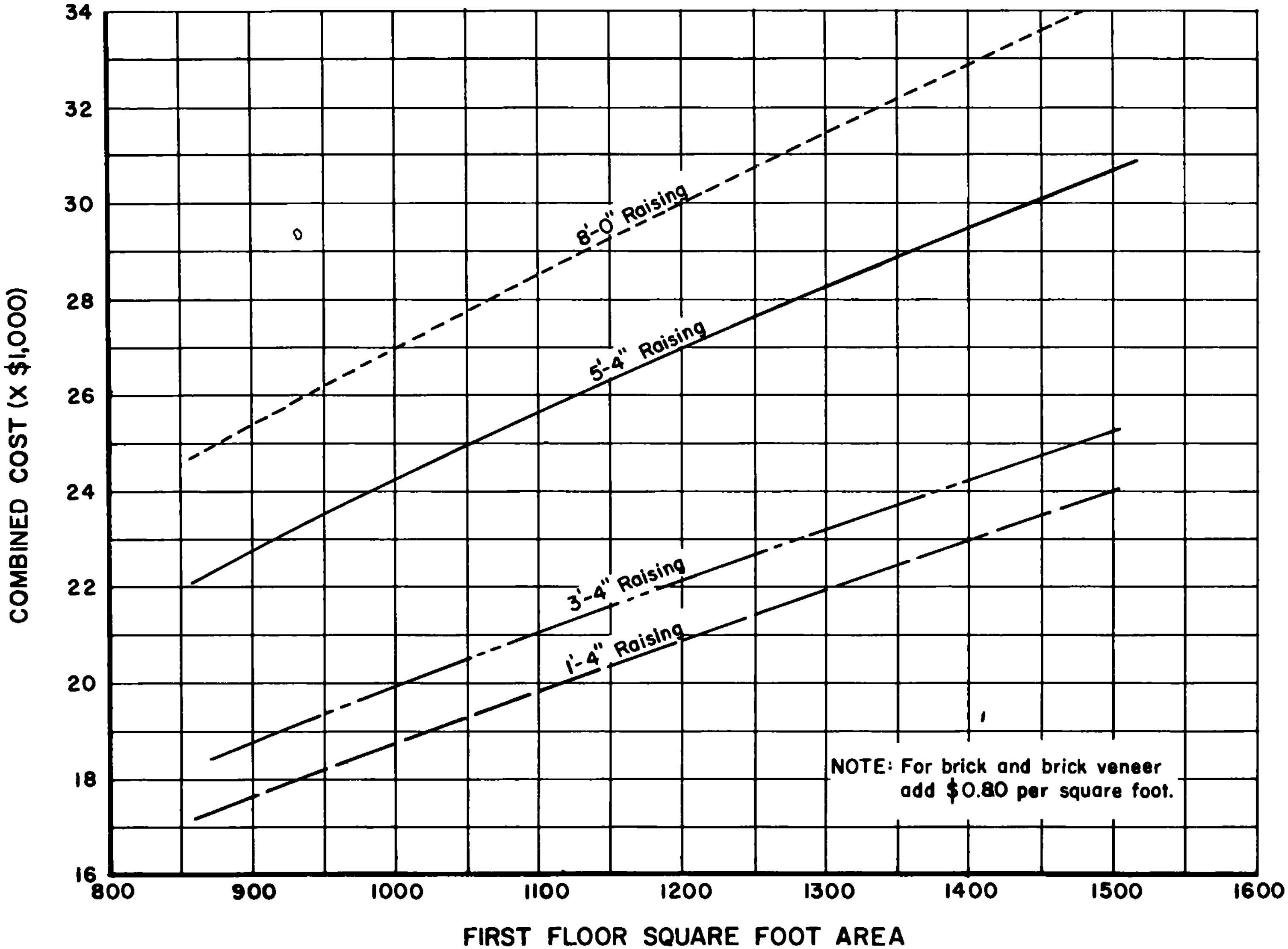


FIGURE III-M COMBINATION-SPLIT LEVEL

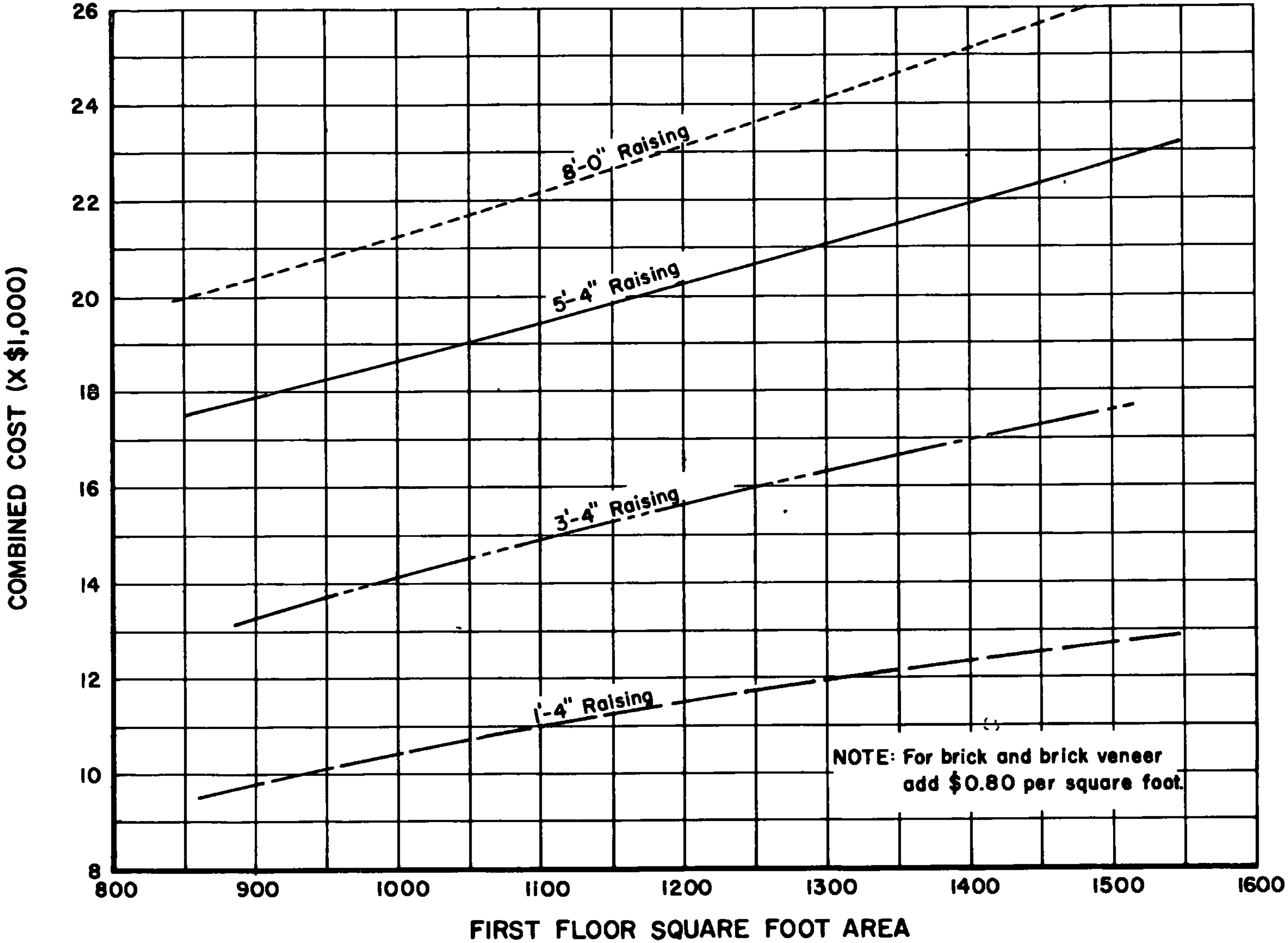


FIGURE III-N COMBINATION–ONE STORY W/BLOCK FOUNDATION

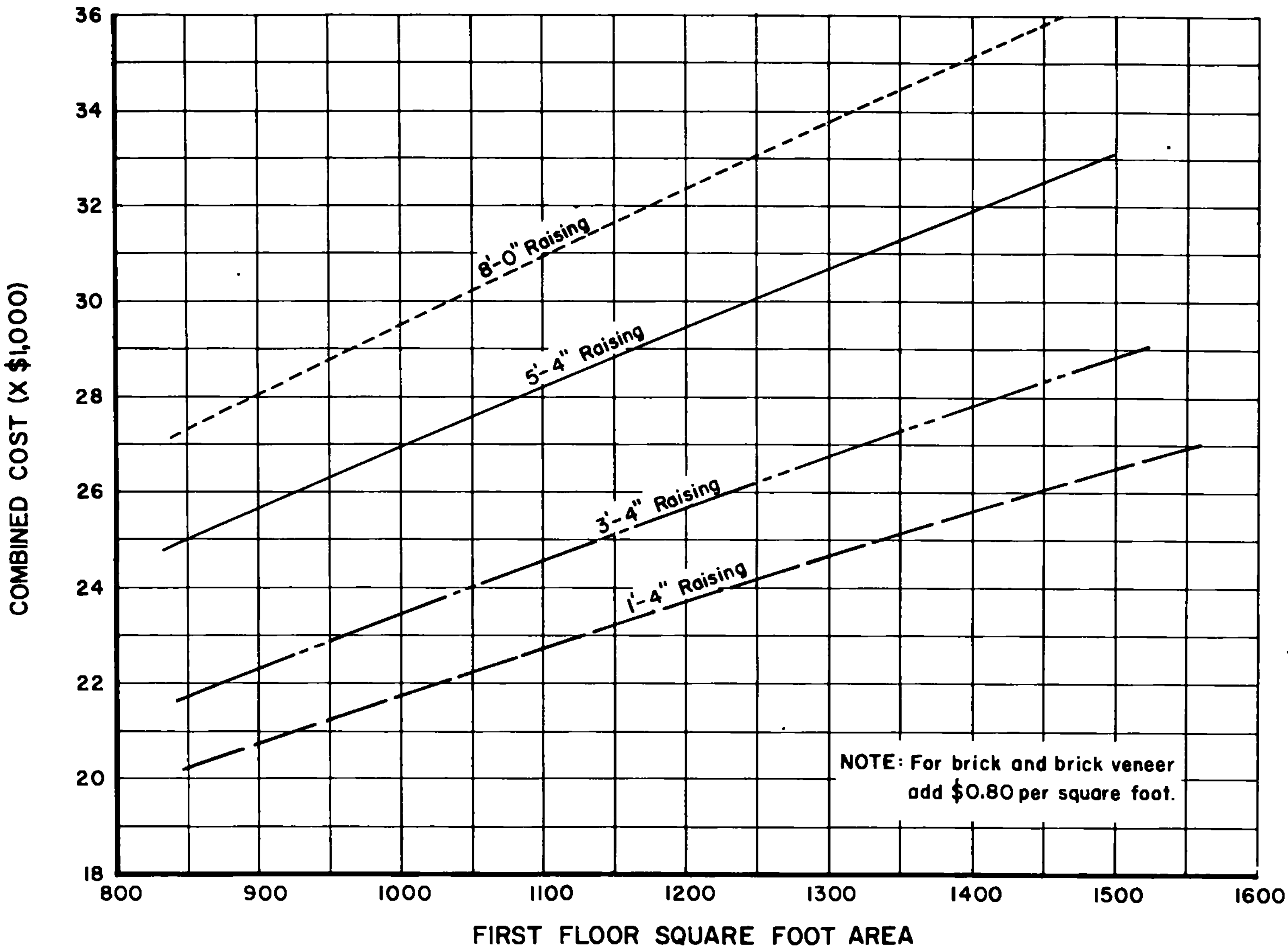


FIGURE III-O COMBINATION-ONE STORY W/STONE FOUNDATION

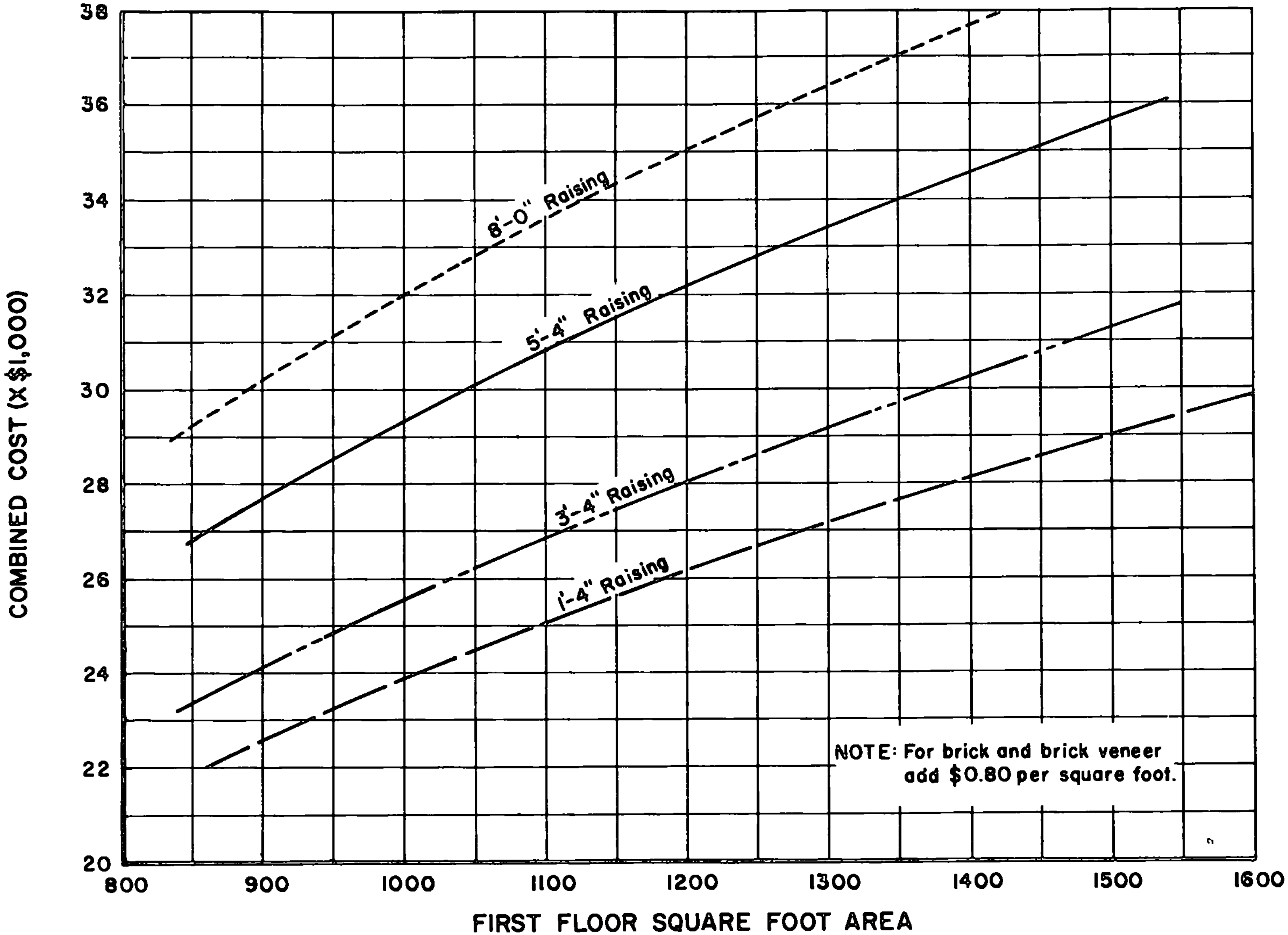


FIGURE III - P COMBINATION-TWO STORY W/STONE FOUNDATION

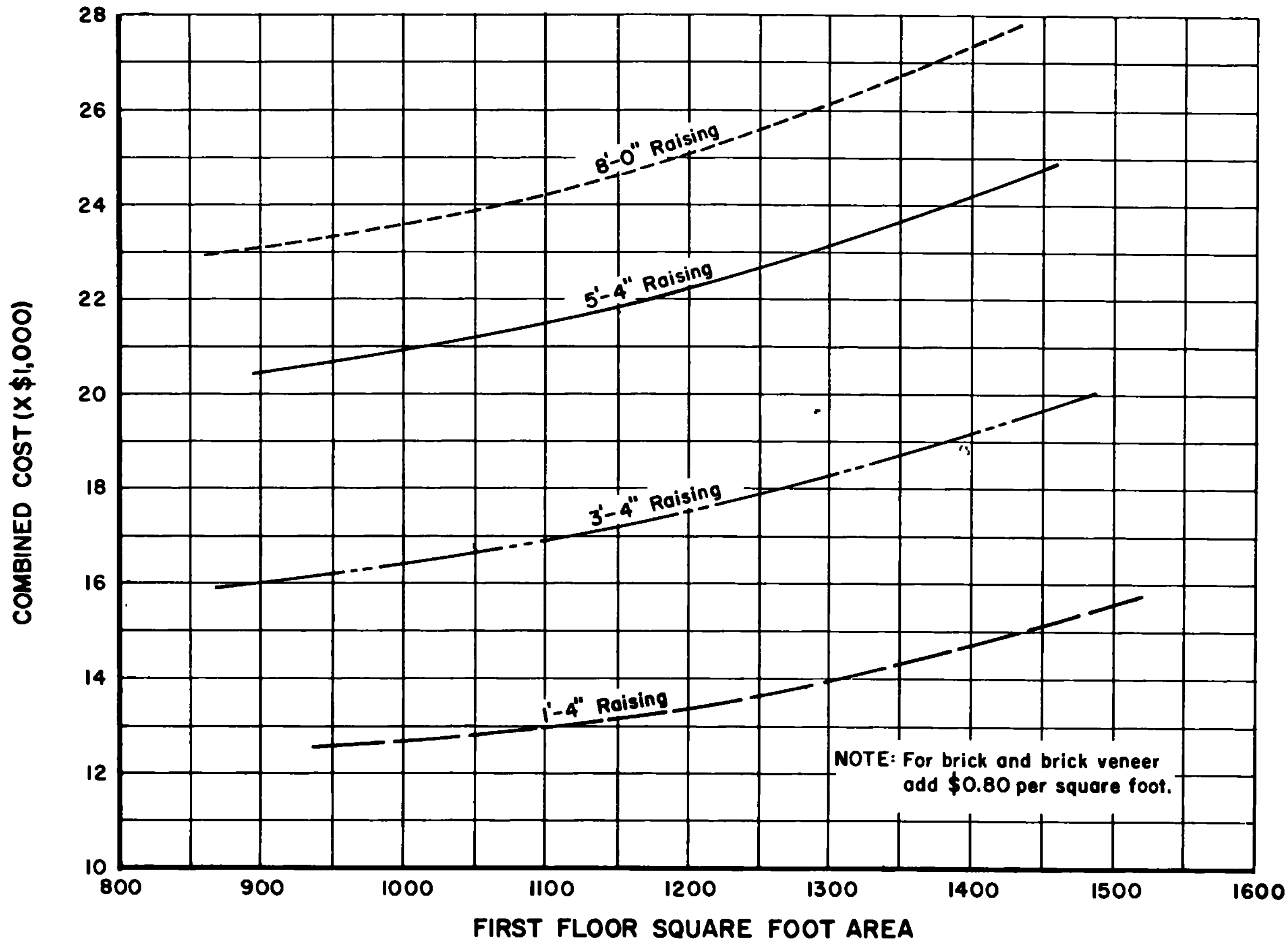
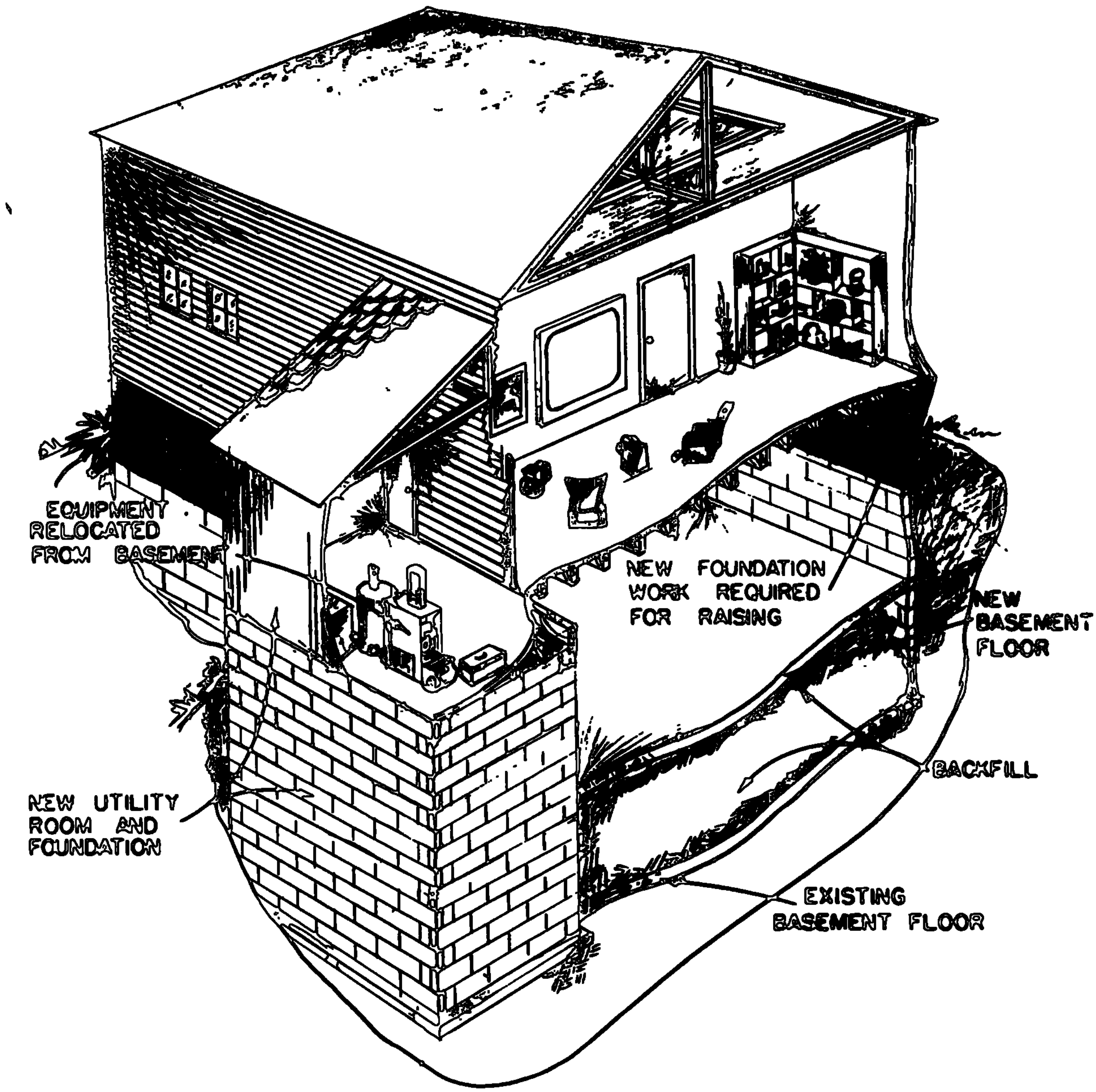


FIGURE III-Q COMBINATION-TWO STORY W/BLOCK FOUNDATION



COMBINATION HOUSE RAISING AND RELOCATION OF HOUSEHOLD MECHANICAL AND ELECTRICAL EQUIPMENT TO FIRST FLOOR UTILITY ROOM ADDITION
(FIGURE III - R)

IV

COMPARISON OF ALTERNATIVES

IV. COMPARISON OF ALTERNATIVES

Because of the varying degrees of inundation which can be found in a flood prone community, no single alternative will be the most economical means of flood damage reduction for the entire locale. Individual structures within the flood plain will have to be evaluated for each of the practicable alternatives.

In many of the houses observed in the Baltimore District area, the mechanical and electrical equipment represented virtually all of the significant damage that would occur should the basement sustain flooding. Consequently, as shown under Combination of Alternatives, relocation of the equipment to a level above the design flood water surface in conjunction with raising is the most economical means of protecting this equipment when design flood water is above the first floor. If the design flood elevation is lower than the first floor, complete protection of the basement utilities may be obtained by either relocating the equipment to the first floor or implementing the utility cell option, whichever is more economical.

A comparison of the cost estimates shows that the above in-place measures can be accomplished more economically than floodproofing. Consequently, floodproofing is considered an uneconomical means of flood damage reduction, leaving five options to be evaluated. The comparison of these alternatives will be dependent on the design flood level that is established for the house being considered.

For flood elevations above the first floor, no alternatives or combination thereof can be singled out as being the most cost effective. Costs for each practicable alternative or combination of alternatives should be computed and compared to determine which is the most economical.

Figure IV-A provides an example for evaluating and comparing each alternative for a specific house.

Figures IV-B and IV-C present photographs of a few homes observed during field investigations which had incorporated some of the flood damage reduction measures discussed in this report.

Sample Cost Comparison
One Story Frame - Brick Veneer W/Block Foundation
318 Essex Road, Baltimore, MD

Acquisition and Demolition

Purchase Value of Land (from worksheet) (20,000 sq.ft.)		$ 8,000	
Purchase Value of House (from worksheet)		31,000	
Acquisition Expense		3,000	
Demolition and Site Reclamation (from Table III-6)		1,100	
Resettlement		8,500	
Total Acquisition and Demolition			$51,600

Relocation

Relocation Cost (from graph)		$17,600	
Adjustment for Brick or Brick Veneer $0.80 x 1,200 (sq. ft. area) =		960	
Land Value at Existing Site	$ 8,000		
Land Value at Relocation Site	12,000		
Larger of the Land Values		12,000	
Value of Site Improvements		2,000	
Overhead Traffic Signals No. 3 x $250/disconnect =		750	
Overhead electric lines No. - x $1,500/disconnect =		-	
Tree Removal No. 1 x $400/removal =		400	
Septic Tank and Well System (if required)		-	
Supplemental Housing		-	
Total for Relocation			$33,710

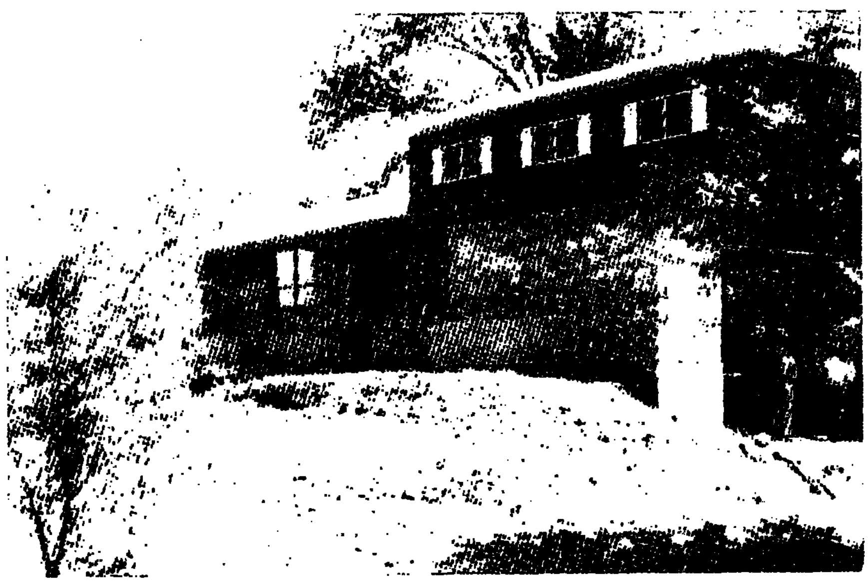
House Raising - 5'-4"

Cost of Raising (from graph)	$15,800	
Adjustment for Brick or Brick Veneer $0.80 x 1,200 (sq. ft. area) =	960	
Supplemental Housing	400	
Total Cost of House Raising		$17,160

Combination House Raising and Utility Relocation

Cost of Combination (from graph)	$20,200	
Adjustment for Brick or Brick Veneer $0.80 x 1,200 (sq. ft. area) =	960	
Supplemental Housing	400	
Total For Combination		$21,560

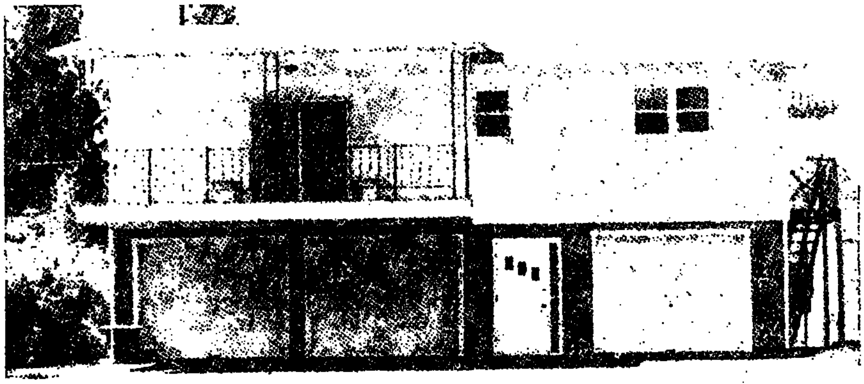
Figure IV-A



House Raising With New Block Foundation
Harrisburg, PA

For Flood Damage Reduction

FIGURE IV-B



House Raising - Converting Basement Into Garage
Alexandria, PA

House Raising - Leaving Basement Area Open
Lock Haven, PA

House Raising For Flood Damage Reduction

FIGURE IV-C

ACKNOWLEDGEMENTS

This report was prepared by the Baltimore District, Corps of Engineers, under the general supervision of Colonel G. K. Withers, USA, the District Engineer. Specifically, this report was prepared by the Engineering and Real Estate Divisions for use by the Planning Division under the direct supervision of William E. Trieschman, Chief, Planning Division.

Original conception concerning the nature and scope of material presented in this report, in addition to report review, were the responsibility of Mr. Ronald Mazcko, Project Investigation Branch; Mr. David Ladd, Chief, Project Investigation Branch; and Mr. Harold Nelson, Assistant Chief, Planning Division.

The report was prepared and written by Mr. William Augustine, Design Branch, and Mr. Edward Hecker, Project Planning Branch, Engineering Division. The following personnel provided assistance in developing the technical aspects of the report:

Mr. Jack Lapouraille - Estimating
Mr. David Lee, Mr. John Davidson, and Mr. Peter Rossbach - Structural Analyses
Mr. Donato Floriza - Concept Sketches
Mr. Carl Keller and Mr. James Eutsler - Drafting
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In addition, Mr. Paul Sandacz and Mr. Dominic Lijoi of the District's Real Estate Division were instrumental in the preparation of those portions of the report which deal with property acquisition and the application of Public Law 91-646.

APPENDIX A

COST ESTIMATES

APPENDIX A - COST ESTIMATES

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APPENDIX A
COST ESTIMATES

I. House Relocation

A. General - The cost estimates presented for relocating a superstructure are subdivided into three major categories: house raising and moving, preparation of new foundation, and reclamation of the old site. New foundation work includes: excavation, backfill, concrete footings, CMU walls, damp-proofing, painting, gravel drain fill, concrete slab, windows, stairs, doors, and utility connections. The particular items associated with the foundation work are dependent on the type of house being estimated. Reclamation of old site includes the same items that were considered in the Acquisition and Demolition Alternative.

B. Estimates -

1. Slab-On-Grade

Dwelling No. 1
Address: 1700 Sunny Court Drive, Baltimore, MD
Construction: Slab-on-grade
Floor Area: 1,250 sq. ft.
Estimate:

Item	Cost
Raise and move house	$10,500
New foundation	7,600
Reclamation of old site	1,100
Total	$19,200

Dwelling No. 2
Address: Hypothetical house
Construction: Slab-on-grade
Floor Area: 900 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 8,300
New foundation	6,200
Reclamation of old site	1,000
Total	$15,500

Dwelling No. 3
Address: Hypothetical house
Construction: Slab-on-grade
Floor Area: 1,440 sq. ft.
Estimate:

Item	Cost
Raise and move house	$11,700
New foundation	8,300
Reclamation of old site	1,200
Total	$21,200

2. Split Level Homes

Dwelling No. 1
Address: 333 Essex road, Baltimore, MD
Construction: Brick - split level
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost
Raise and move house	$12,600
New foundation	7,300
Reclamation of old site	1,100
Total	$21,000

Dwelling No. 2
Address: Hypothetical house
Construction: Frame - split level
Floor Area: 1,496 sq. ft.
Estimate:

Item	Cost
Raise and move house	$13,800
New foundation	8,300
Reclamation of old site	1,200
Total	$23,300

Dwelling No. 3
Address: Hypothetical house
Construction: Frame - split level
Floor Area: 900 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 9,500
New foundation	6,200
Reclamation of old site	1,000
Total	$16,700

3. One-Story Homes

Dwelling No. 1
Address: 7109 Queen Anne Road, Baltimore, MD
Construction: One-story frame - veneer w/block basement
Floor Area: 1,500 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 8,800
New foundation	11,500
Reclamation of old site	1,200
Total	$21,500

Dwelling No. 2
Address: Delmar and Maple Streets, Sindey, NY
Construction: One-story frame w/block foundation
Foor Area: 1,000 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 5,500
New foundation	9,300
Reclamation of old site	1,000
Total	$15,800

Dwelling No. 3
Address: 318 Essex Road, Baltimore, MD
Construction: One-story frame - veneer w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 7,400
New foundation	10,000
Reclamation old site	1,100
Total	$18,500

Dwelling No. 4
Address: Rishel Residence - Main Street, Alexandria, PA
Construction: One-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

Item	Cost
Raise and move house	$ 4,500
New foundation	8,000
Reclamation of old site	900
Total	$13,400

4. Two-Story Homes

Dwelling No. 1
Address: Weir and Maple Streets, Sidney, NY
Construction: Two-story frame w/stone foundation
Floor Area: 1,500 sq. ft.
Estimate:

Item	Cost
Raise and move house	$17,600
New foundation	11,500
Reclamation of old site	1,200
Total	$30,300

Dwelling No. 2
Address: 1810 Sunny Side Lane, Baltimore, MD
Construction: Two-story frame w/block foundation
Floor Area: 1,360 sq. ft.
Estimate:

Item	Cost
Raise and move house	$16,000
New foundation	11,300
Reclamation of old site	1,200
Total	$28,500

Dwelling No. 3
Address: Hypothetical house
Construction: Two-story frame w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost
Raise and move house	$14,400
New foundation	10,000
Reclamation of old site	1,100
Total	$25,500

Dwelling No. 4
Address: Typical group, Lock Haven, PA
Construction: Two-story frame w/stone foundation
Floor Area: 1,000 sq. ft.
Estimate:

Item	Cost
Raise and move house	$12,000
New foundation	9,700
Reclamation of old site	1,000
Total	$22,700

C. Detailed Estimate -

Sample estimate broken down to establish the above point on the cost curve for house relocation.

Cost Curve - House Relocation (See Figure III-B)
Two-Story Frame - 1,000 Sq. Ft. (Dwelling No. 4)
Lock Haven, PA

Raise and move house		$12,000
New foundation		
Excavation	$1,019	
Backfill	519	
Concrete footing	595	
CMU Wall	3,640	
Damp-proof wall	672	

Painting	504	
Gravel drainage fill	150	
Concrete slab	800	
Windows & lintels	160	
Stairs & doors	450	
Utility connections	1,200	
	$9,709	9,709
Old site reclamation		1,000
Total Estimated Cost		$22,709

II. Raising

A. General - The cost estimates presented for raising a structure at its existing location are broken into four major categories: house raising, removal of existing foundation, new foundation work, and landscaping. New foundation work includes: concrete footings, CMU walls, new flooring, painting, windows and doors, check valves, and the removal and replacement of equipment. The particular items associated with the foundation work are dependent on the type of house being estimated.

B. Estimates -

1. Slab-On-Grade Homes

Dwelling No. 1
Address: 1700 Sunny Court Drive, Baltimore, MD
Construction: Slab-on-grade
Floor Area: 1,250 sq. ft.
Estimate:

	Cost Height of Raising			
Item	1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 7,800	$ 7,900	$ 8,000	$ 8,100
New foundation	6,800	7,700	10,800	13,500
Landscaping	1,000	1,000	2,000	2,000
Total	$15,600	$16,600	$20,800	$23,600

Dwelling No. 2
Address: Hypothetical house
Construction: Slab-on-grade
Floor Area: 900 sq. ft.
Estimate:

	Cost Height of Raising			
Item	1'-4"	3'-4"	5'-4"	8'-0"
House Raising	$ 5,600	$ 5,700	$ 5,800	$ 5,900
New foundation	5,500	6,300	8,000	11,000
Landscaping	1,000	1,000	2,000	2,000
Total	$12,100	$13,000	$15,800	$18,900

Dwelling No. 3
Address: Hypothetical house
Construction: Slab-on-grade
Floor Area: 1,440 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 9,000	$ 9,100	$ 9,200	$ 9,300
New foundation	7,400	8,300	11,700	14,600
Landscaping	1,000	1,000	2,000	2,000
Total	$17,400	$18,400	$22,900	$25,900

2. Split Level Homes

Dwelling No. 1
Address: 333 Essex Road, Baltimore, MD
Construction: Brick-split level
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 9,500	$ 9,600	$ 9,700	$ 9,800
New foundation	7,100	8,200	11,700	14,600
Landscaping	1,000	1,000	2,000	2,000
Total	$17,600	$18,800	$23,400	$26,400

Dwelling No. 2
Address: Hypothetical house
Construction: Frame-split level
Floor Area: 1,496 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$10,600	$10,700	$10,800	$10,900
New foundation	8,100	9,200	13,300	16,600
Landscaping	1,000	1,000	2,000	2,000
Total	$19,700	$20,900	$26,100	$29,500

Dwelling No. 3
Address: Hypothetical house
Construction: Frame-split level
Floor Area: 900 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 6,400	$ 6,500	$ 6,600	$ 6,700
New foundation	6,300	6,900	9,700	12,100
Landscaping	1,000	1,000	2,000	2,000
Total	$13,700	$14,400	$18,300	$20,800

3. One-Story Homes

Dwelling No. 1
Address: 7109 Queen Anne Road, Baltimore, MD
Construction: One-story frame - veener w/block basement
Floor Area: 1,500 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 7,500	$ 7,600	$ 7,700	$ 7,800
New foundation	2,100	6,800	9,800	13,000
Landscaping	100	100	2,000	2,000
Total	$ 9,700	$14,500	$19,500	$22,800

Dwelling No. 2
Address: 318 Essex Road, Baltimore, MD
Construction: One-story frame - veneer w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 6,000	$ 6,100	$ 6,200	$ 6,300
New foundation	2,100	6,000	8,600	11,200
Landscaping	100	100	2,000	2,000
Total	$ 8,200	$12,200	$16,800	$19,500

Dwelling No. 3
Address: Weir and Maple Streets, Sidney, NY
Construction: Two-story frame w/stone foundation
Floor Area: 1,500 sq. ft.
Estimate:

	Costs Height of Raising			
Item	1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 8,700	$ 8,800	$ 8,900	$ 9,000
Foundation removal	5,600	5,600	5,600	5,600
New foundation	9,500	11,600	14,700	17,700
Landscaping	1,000	1,000	2,000	2,000
Total	$24,800	$27,000	$31,200	$34,300

Dwelling No. 4
Address: 1810 Sunny Side Lane, Baltimore, MD
Construction: Two-story frame w/block foundation
Floor Area: 1,360 sq. ft.
Estimate:

	Costs Height of Raising			
Item	1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 7,900	$ 8,000	$ 8,100	$ 8,200
New foundation	2,100	6,400	9,200	12,100
Landscaping	100	100	2,000	2,000
Total	$10,100	$14,500	$19,300	$22,300

Dwelling No. 5
Address: Hypothetical house
Construction: Two-story frame w/block foundation
Floor Area: 1,000 sq. ft.
Estimate:

	Costs Height of Raising			
Item	1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 6,500	$ 6,600	$ 6,700	$ 6,800
New foundation	1,900	5,400	7,800	10,200
Landscaping	100	100	2,000	2,000
Total	$ 8,500	$12,100	$16,500	$19,000

Dwelling No. 6
Address: Hypothetical house
Construction: One-story frame w/stone foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Costs Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 5,100	$ 5,200	$ 5,300	$ 5,400
Foundation removal	4,900	4,900	4,900	4,900
New foundation	8,400	10,900	12,700	15,400
Landscaping	1,000	1,000	2,000	2,000
Total	$19,400	$22,000	$24,900	$27,700

4. Two-Story Homes

Dwelling No 1
Address: Hypothetical house
Construction: Two-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

Item	Costs Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 4,400	$ 4,500	$ 4,600	$ 4,700
Foundation removal	4,000	4,000	4,000	4,000
New foundation	6,800	8,000	9,900	11,900
Landscaping	1,000	1,000	2,000	2,000
Total	$16,200	$17,500	$20,500	$22,600

Dwelling No. 2
Address: Typical Group - Lock Haven, PA
Construction: Two-story frame w/stone foundation
Floor Area: 1,000 sq. ft.
Estimate:

Item	Costs Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 5,800	$ 5,900	$ 6,000	$ 6,100
Foundation removal	4,700	4,700	4,700	4,700
New foundation	8,200	9,700	12,200	14,700
Landscaping	1,000	1,000	2,000	2,000
Total	$19,700	$21,300	$24,900	$27,500

Dwelling No. 3
Address: Delmar and Maple Streets, Sidney, NY
Construction: One-story frame w/block foundation
Floor Area: 1,000 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 4,200	$ 4,300	$ 4,400	$ 4,500
New foundation	1,900	5,400	7,800	10,200
Landscaping	100	100	2,000	2,000
Total	$ 6,200	$ 9,800	$14,200	$16,700

Dwelling No. 4
Address: Rishel Residence - Main Street - Alexandria, PA
Construction: One-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 3,200	$ 3,300	$ 3,400	$ 3,500
Foundation removal	4,000	4,000	4,000	4,000
New foundation	6,800	8,000	9,900	11,800
Landscaping	1,000	1,000	2,000	2,000
Total	$15,000	$16,300	$19,300	$21,300

Dwelling No. 5
Address: Hypothetical house
Construction: One-story frame w/stone foundation
Floor Area: 1,440 sq. ft.
Estimate:

Item	Cost Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 6,100	$ 6,200	$ 6,300	$ 6,400
Foundation removal	5,400	5,400	5,400	5,400
New foundation	9,200	11,300	14,200	17,300
Landscaping	1,000	1,000	2,000	2,000
Total	$21,700	$23,900	$27,900	$31,100

Dwelling No. 6
Address: Hypothetical house
Construction: Two-story frame w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Costs Height of Raising 1'-4"	3'-4"	5'-4"	8'-0"
House raising	$ 7,000	$ 7,100	$ 7,200	$ 7,300
New foundation	2,000	6,000	8,600	11,200
Landscaping	100	100	2,000	2,000
Total	$ 9,100	$13,200	$17,800	$20,500

C. Detailed Estimates - House Raising

1. Sample estimate broken down to establish the point of cost curve for raising a one-story dwelling 5'-4".

One-Story W/Block Foundation (See Figure III-H)
1,200 Sq. Ft. - Brick Veneer (Dwelling No. 2)
Essex, MD

Raise house		$ 6,200
Foundation work		
CMU wall	$1,965	
Window & lintels	160	
Gravel drain fill	180	
Interior fill	1,920	
Concrete slab	960	
Painting	505	
Exterior fill	1,165	
Remove & replace equipment	1,000	
Backwater check valve	700	
	$8,555	8,600
Landscaping, seeding, walks, etc.		2,000
		$16,800
Less brick veneer - 1,200 s.f. x $0.80		960
Total Estimated Cost		$15,840

2. Sample estimate broken down to establish the point on cost curve for raising a two-story dwelling 3'-4".

Two-Story W/Stone Foundation (See Figure III-K)
1,000 Sq. Ft. - Frame (Dwelling No. 2)
Lock, Haven, PA

Raise house		$ 5,900
Remove old foundation		
Remove	$2,700	
Excavation	1,095	
Backfill	910	
	$4,705	4,700
New foundation		
Concrete footing	$ 595	
Gravel drain fill	150	
Concrete slab	800	
Interior fill	1,010	
CMU walls	4,150	
Damp-proof walls	670	
Windows & lintels	160	
Painting	505	
Remove & replace utilities	1,000	
Backwater check valve	700	
	$9,740	9,700
Landscaping		1,000
Total Estimated Cost		$21,300

III. Floodproofing

A. General - The cost estimates for floodproofing are composed of raising the house, removing the existing foundation, constructing a new reinforced concrete substructure with waterstops, a check valve in the storm and sanitary lines, and landscaping.

B. Estimates -

1. One-Story Homes

Dwelling No. 1
Address: 7109 Queen Anne Road, Baltimore, MD
Construction: One-story frame - veneer w/block basement
Floor Area: 1,500 sq. ft.
Estimate:

Item	Cost
House raising	$ 7,700
Foundation removal	5,000
New foundation	20,400
Landscaping	1,000
Total	$34,100

Dwelling No. 2
Address: 318 Essex Road, Baltimore, MD
Construction: One-story frame - veneer w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

Item	Cost
House raising	$ 6,200
Foundation removal	4,800
New foundation	17,900
Landscaping	1,000
Total	$29,900

Dwelling No. 3
Address: Delmar and Maple Streets, Sidney, NY
Construction: One-story frame w/block foundation
Floor Area: 1,000 sq. ft.
Estimate:

Item	Cost
House raising	$ 4,400
Foundation removal	4,700
New foundation	16,700
Landscaping	1,000
Total	$26,800

Dwelling No. 4
Address: Rishel Residence - Main Street, Alexandria, VA
Construction: One-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

Item	Cost
House raising	$ 3,400
Foundation removal	4,000
New foundation	14,500
Landscaping	1,000
Total	$22,900

2. Two-Story Homes

Dwelling No. 1
Address: Typical Group - Lock Haven, PA
Construction: Two-story frame w/stone foundation
Floor Area: 1,000 sq. ft.
Estimate:

Item	Cost
House raising	$ 6,600
Foundation removal	4,700
New foundation	16,900
Landscaping	1,000
Total	$29,200

Dwelling No. 2
Address: Weir and Maple Streets, Sidney, NY
Construction: Two-story frame w/stone foundation
Floor Area: 1,500 sq. ft.
Estimate

Item	Cost
House raising	$ 8,900
Foundation removal	5,600
New foundation	20,400
Landscaping	1,000
Total	$35,900

Dwelling No. 3
Address: 1810 Sunny Side Lane, Baltimore, MD
Construction: Two-story frame w/block foundation
Floor Area: 1,360 sq. ft.
Estimate:

Item	Cost
House raising	$ 8,100
Foundation removal	4,900
New foundation	18,700
Landscaping	1,000
Total	$32,700

IV. Combinations

A. Split Level Homes -

Dwelling No. 1
Address: 333 Essex Road, Baltimore, MD
Construction: Brick-split level
Floor Area: 1,200 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost of raising	$16,600	$17,800	$22,400	$25,400
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$21,800	$23,100	$27,800	$30,900

Dwelling No. 2
Address: Hypothetical house
Construction: Frame-split level
Floor Area: 1,496 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$18,700	$19,800	$25,100	$28,500
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$23,900	$25,100	$30,500	$34,000

Dwelling No. 3
Address: Hypothetical house
Construction: Frame-split level
Floor Area: 900 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$12,400	$13,400	$17,300	$18,800
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$17,600	$18,700	$22,700	$24,300

B. One-Story Homes -

Dwelling No. 1
Address: 7109 Queen Anne Road, Baltimore, MD
Construction: One-story frame - veneer w/block basement
Floor Area: 1,500 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 8,700	$13,500	$18,500	$21,800
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$13,900	$18,800	$23,900	$27,300

Dwelling No. 2
Address: 318 Essex Road, Baltimore, MD
Construction: One-story frame - veneer w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 7,200	$11,200	$15,800	$18,500
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$12,400	$16,500	$21,200	$24,000

Dwelling No. 3
Address: Delmar and Maple Streets, Sidney, NY
Construction: One-story frame w/block foundation
Floor Area: 1,000 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 5,200	$ 8,800	$13,200	$15,700
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$10,400	$14,100	$18,600	$21,200

Dwelling No. 4
Address: Rishel Residence - Main Street- Alexandria, PA
Construction: One-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$14,000	$15,300	$18,300	$20,300
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$19,200	$20,600	$23,700	$25,800

Dwelling No. 5
Address: Hypothetical house
Construction: One-story frame w/stone foundation
Floor Area: 1,440 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost of raising	$20,700	$22,900	$26,900	$30,100
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$25,900	$28,200	$32,300	$35,600

Dwelling No. 6
Address: Hypothetical house
Construction: One-story frame w/stone foundation
Floor Area: 1,200 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$18,400	$20,200	$23,900	$26,700
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$23,600	$25,500	$29,300	$32,200

C. Two-Story Homes -

Dwelling No. 1
Address: Hypothetical house
Construction: Two-story frame w/stone foundation
Floor Area: 750 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$15,200	$16,500	$19,500	$21,600
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$20,400	$21,800	$24,900	$27,100

Dwelling No. 2
Address: Typical Group Lock Haven, PA
Construction: Two-story frame w/stone foundation
Floor Area: 1,000 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$18,700	$20,300	$23,900	$26,500
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$23,900	$25,600	$29,300	$32,000

Dwelling No. 3
Address: Weir and Maple Streets, Sidney, PA
Construction: Two-story frame w/stone foundation
Floor Area: 1,500 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost of raising	$23,800	$26,000	$30,200	$33,300
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$29,000	$31,300	$35,600	$38,800

Dwelling No. 4
Address: 1810 Sunny Side Lane, Baltimore, MD
Construction: Two-story frame w/block foundation
Floor Area: 1,360 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 9,200	$13,500	$18,300	$21,300
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$14,400	$18,800	$23,700	$26,800

Dwelling No. 5
Address: Hypothetical house
Construction: Two-story frame w/block foundation
Floor Area: 1,000 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 7,500	$11,100	$15,500	$18,000
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$12,700	$16,400	$20,900	$23,500

Dwelling No. 6
Address: Hypothetical house
Construction: Two-story frame w/block foundation
Floor Area: 1,200 sq. ft.
Estimate:

	Height of Raising			
	1'-4"	3'-4"	5'-4"	8'-0"
Total cost for raising	$ 8,100	$12,200	$16,800	$19,500
Cost of addition	5,200	5,300	5,400	5,500
Total Combined Cost	$13,300	$17,500	$22,200	$25,000

APPENDIX B

STRUCTURAL ANALYSES

APPENDIX B

STRUCTURAL ANALYSES

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I

INVESTIGATION OF AN 8'x8' WATERTIGHT CHAMBER

APPENDIX B

STRUCTURAL ANALYSES

I INVESTIGATION OF AN 8'x8' WATERTIGHT CHAMBER

A. Assumptions - It is assumed that an 8'x8' area is sufficient to house the required utilities. The chamber will be 7' high and designed to withstand 7 feet of water pressure.

B. Design Calculations - Using an 8" wall thickness with a 22" slab the dead loads are computed as:

DEAD LOADS:

WALLS = Volume of concrete x Unit wt. of conc.
= (8/12)(0.150)(7) (4x8 + 4x8/12)
= 24.27 Kips

BOTTOM SLAB = Volume of concrete x Unit wt. of conc.
= $(22/12)(0.15)(8+2x8/12)^2$
= 23.96 Kips

TOTAL DEAD LOADS = 48.93 Kips

The uplift force is to be compared to the dead load.

UPLIFT FORCE = Unit Wt. of water x depth of water x floor area
= $(0.0625)(7+22/12)(8+2x8/12)^2$
= 48.02 Kips $<$ 48.93 Kips O.K.

WALL DESIGN - Using the ratio of the width of wall (b) to the height of wall (a)

b/a = 9.33/7 = 1.33 use b/a = 1.5

From table II of "Rectangular Concrete Tanks" for b/a = 1.5

Maximum $+M_x$ = 0.027 Wa^3
Maximum $-M_x$ = 0.013 Wa^3
Maximum $+M_y$ = 0.028 Wa^3
Maximum $-M_y$ = 0.063 Wa^3

Where $Wa^3 = (0.0624)(7^3) = 21.4$

$+M_x$ = 0.027(21.4) = 0.578 Kip-Ft.
$-M_x$ = 0.013(21.4) = 0.278 Kip-Ft.
$+M_y$ = 0.028(21.4) = 0.599 Kip-Ft.
$-M_y$ = 0.063(21.4) = 1.348 Kip-Ft.

Set d = 8"-2" = 6" (d = distance from face of wall to reinforcing). From the Reinforced Concrete Design Handbook the d required for the Maximum moment (1.348 Kip-Ft.) is:

$$d = \sqrt{\frac{1000\ M}{K}}$$

$$= \sqrt{\frac{1000\ (1.348)}{324}} = 2.04'' < 6'' \quad O.K.$$

CHECK SHEAR:

From the "Rectangular Concrete Tanks" the coefficient is

$(-0.440-0.583)/2 = -0.5115$

The maximum shear (V) is

$V = -0.5115\ Wa^2$

$= -0.5115\ (0.0624)(7)^2$

$= -1.534$ Kips

The allowable shear stress given by the ACI Building Code is defined as:

$$v = 1.1\sqrt{f'_c}$$

$$= 1.1\sqrt{4000}$$

$$= 0.0696$$

The actual shear stress is given by:

$v = V/(bd)$

Consider a unit section (b = 1') and solving for d yields

$d = 12''(0.0696)/1.534$

$= 0.53'' < 6''$ O.K.

REINFORCING REQUIRED:

Vertical

$A_s = M/(ad)$

Using the maximum M_x moment previously determined

$A_s = (0.578)/(1.44(6))$

$= 0.067\ in^2$

The minimum vertical steel as given by ACI

$= 0.0015(8)(12) = 0.14\ in^2 > 0.067\ in^2$

therefore, use the minimum requirement #4 bars @ 12"

Horizontal

Using the maximum M_y moment previously determined

$A_s = 1.348/(1.44(6))$

$= 0.16\ in^2$

The minimum horizontal steel required

$= 0.0025\ (8)(12)$

$= 0.24\ in^2 > 0.16\ in^2$

therefore, use the minimum requirements #4 @ 10"

BOTTOM SLAB DESIGN

Top Steel

Since the bottom slab is square the ratio of b/a = 1, which indicates that the maximum $M_x = M_y$ thus:

$$M = 0.044\ Wa^2$$

where

W = the net load on the slab (Uplift - dead load of conc.)
= 0.276 Kip/ft

$$M = 0.044(0.276)(8)^2$$
$$= 0.777 \text{ Kip-Ft.}$$

d for the bottom slab is 22"-3" = 19". The d required for the computed moment is

$$d = \sqrt{\frac{1000(0.777)}{324}}$$

$$= 1.5 \text{ in} < 19" \qquad \text{O.K.}$$

The area of the reinforcing steel required is

$$A_s = 0.777/(1.44(19))$$
$$= 0.03 \text{ in}^2$$

Bottom Steel

For the bottom steel W is taken to be the dead load of the concrete .

W = 0.15 (22/12) = 0.275 Kip/Ft.

So that $M = 0.044\ (0.275)(8)^2$
$= 0.774$ Kip-Ft.

Resulting in a required area of steel of

$$A_s = 0.774/(1.44(19))$$
$$= 0.03 \text{ in}$$

The required minimum reinforcing is

$$= 0.002\ (12)(22)/2$$
$$= 0.27 \text{ in}^2 > 0.03 \text{ in}^2$$

Use the minimum requirements #5 bars @ 12"

II

HOUSE RAISING

II. HOUSE RAISING

A. Assumptions - In order to determine the structural adequacy of an existing foundation to support the additional loading on the walls and footers the following assumptions were developed:

1. The basement interior floods at nearly the same rate as the exterior.

2. The existing footings are adequate to support the additional loading when the existing walls are considered adequate.

3. New concrete footings have a 28 day compressive strength (fc') of 2,500 pounds per square inch.

4. The average weight of saturated soil (γ sat.) was set at 110-120 pounds per cubic foot.

5. The friction angle of the soil (ϕ) is 30^{o}.

6. The soil bearing strength is 2,000 pounds per square foot.

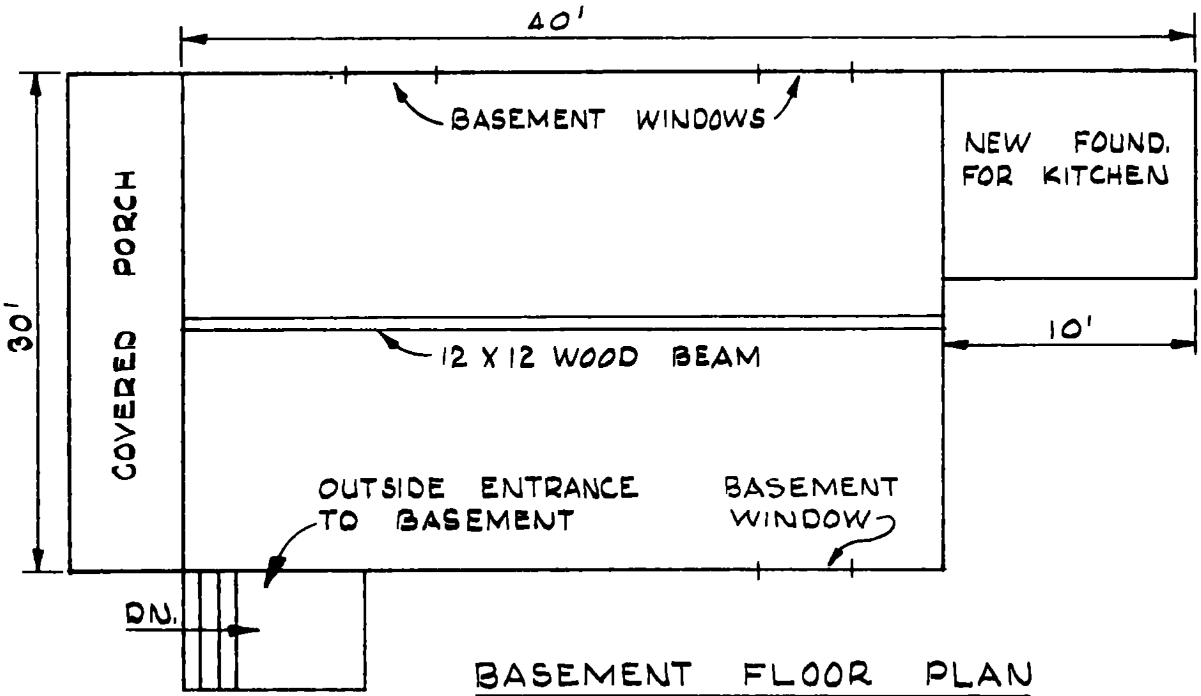
7. The existing and new CMU walls have type "N" mortar as defined by TM-5-809-3.

8. The average velocity of overland flow is 6 feet per second.

B. Calculations -

BUILDING #1

ADDRESS: 5007 Gwynndale Ave. Balto., Md.
CONSTRUCTION: 1½ story-frame, concrete block foundation.
GENERAL NOTES: Foundation approximately 3 feet below grade.
First floor is paneled, assume plaster construction.



BASEMENT FLOOR PLAN

LIVE LOADS:

Roof	=	20 psf
1st Floor	=	50 psf
2nd Floor	=	50 psf
TOTAL	=	120 psf

Live load to walls = 120 psf (30 ft./2) = 1,800#/ft.

DEAD LOADS:

Roof	=	15 psf
1st Floor	=	10 psf
2nd Floor	=	10 psf
TOTAL	=	35 psf

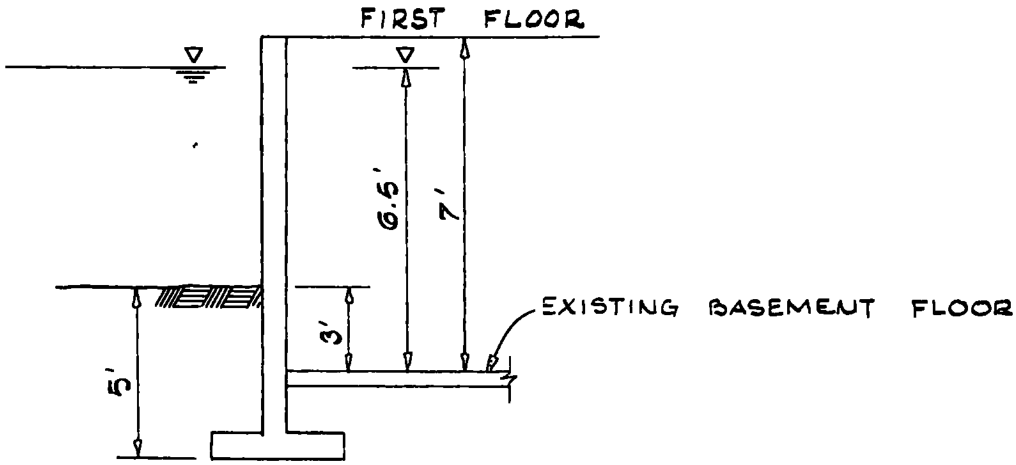
Load to walls = 35 psf (30 ft./2) = 525#/ft.

Walls above foundation walls:

2x4's @ 16" on center	=	2 psf
Plaster	=	10 psf
Exterior Sheathing	=	3 psf
Siding and Miscellaneous	=	5 psf
TOTAL	=	20 psf

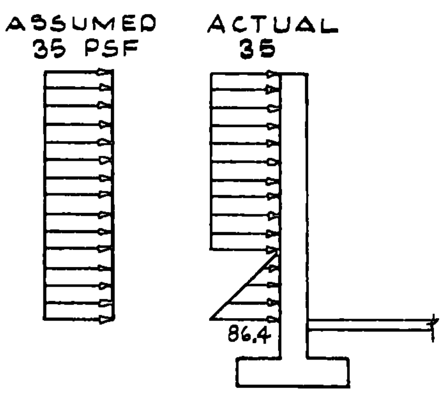
Load to foundation walls = 20 psf (15') = 300#/ft.

Total dead load above foundation walls = 825#/ft.



The highest flood water level attained in this building was approximately to the bottom of the joist for the first floor. The only damages suffered were in the basement. Because of the floor plan of the building, there would not appear to be any hydrostatic pressure from the water. During flooding, the water would enter through the exterior stairwell and eventually through the basement windows. The pressure on the walls would be caused by the soil and dynamic water force.

Flood condition loading at present state:



PRESSURE FROM SOIL: ASSUMING $\phi=30^{o}$

$P = \gamma HK = (120-62.4)\#/ft.^3 (3\ ft.)(0.5)$

$= 86.4\#/ft.^2$

where K = coefficient of lateral stress at rest

H = height of the soil

γ = unit weight of the soil

DYNAMIC WATER FORCE: ASSUME VELOCITY = 6 fps

$P = (W/2g)\ V^2$

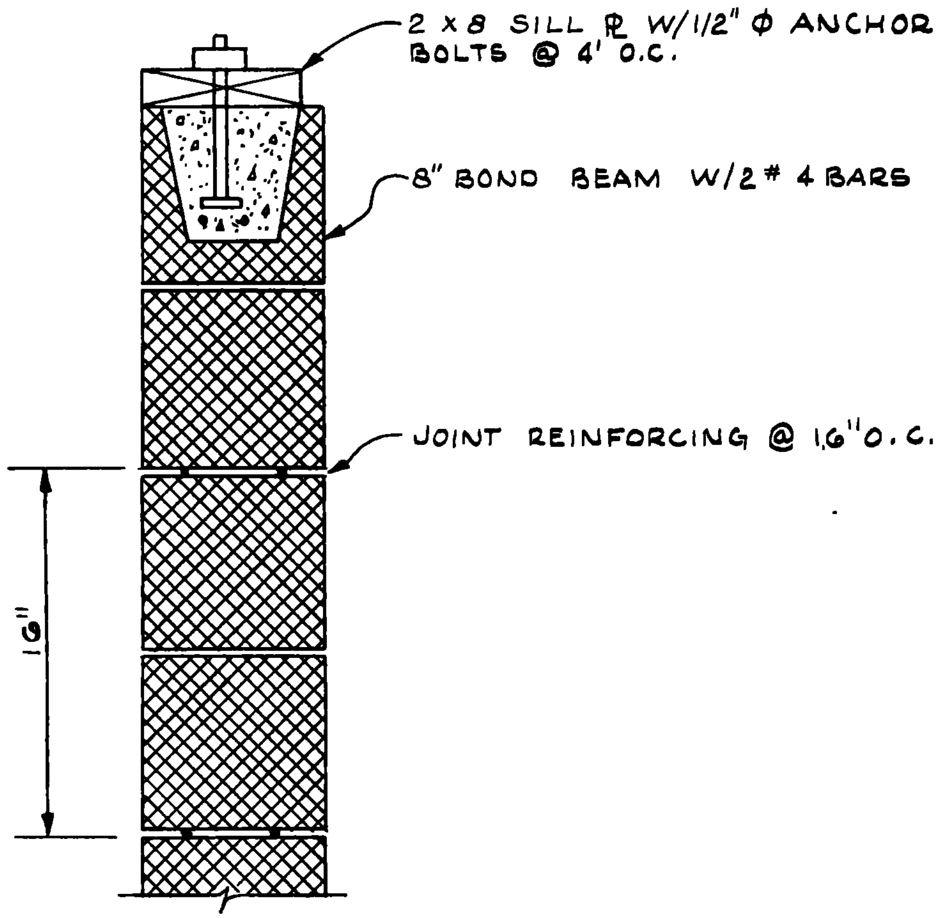
$= (62.4\#/ft.^3/2x32.2\ ft./sec.^2)(6\ ft./sec.)^2$

$= 34.88\ lb./ft.^2$ (Say 35)

ASSUME 8" CMU wall with type "N" mortar

From TM 5-809-3, Plate 4-22N, 8" wall is adequate for purposes of raising. It is assumed that the existing footings will be sufficient.

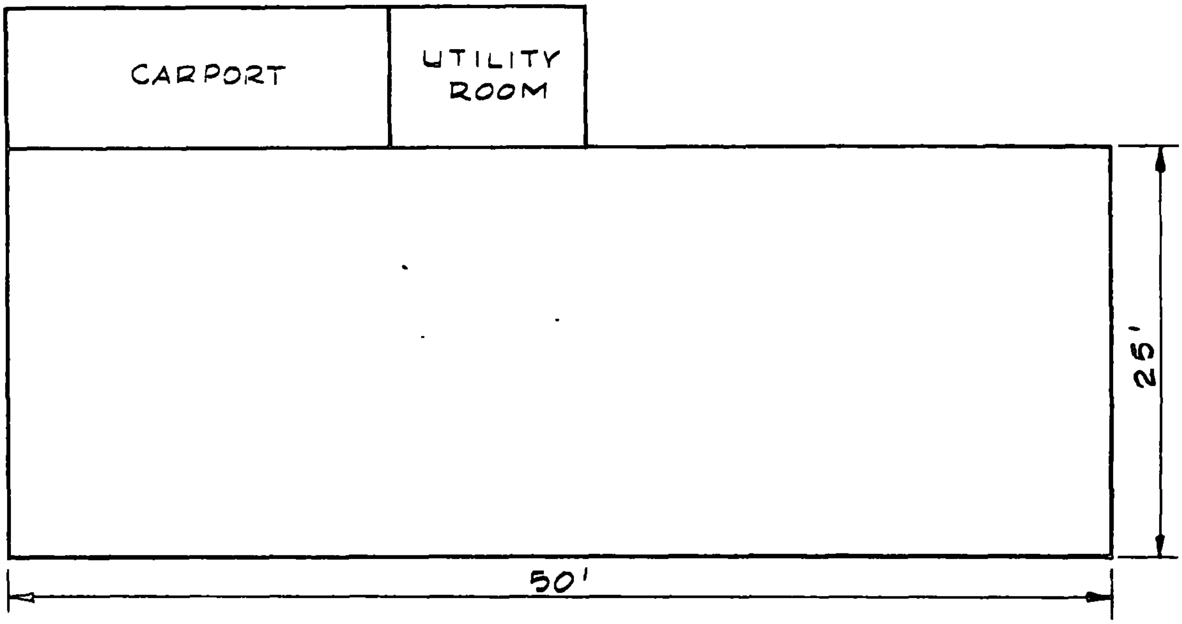
BUILDING #1 SUMMARY: In raising this building the prescribed increments, the building will be raised and the existing sill plate removed. New 8" concrete block, without reinforcing, will be placed on the existing block and type "N" mortar used. A bond beam will be utilized on the top course of block. A 2"x8" sill plate with ½" diameter anchor bolts at 4' on center will be anchored to the bond beam. The basement floor will be raised with each raising above the 1'-4" level. When the basement floor is to be raised above the existing exterior ground surface, fill should be placed against the foundation. The new concrete floor will be 4" thick with 6x6-W2.1xW2.1 WWF. Horizontal wall joint reinforcing shall be 16" on center vertically.



BUILDING #2

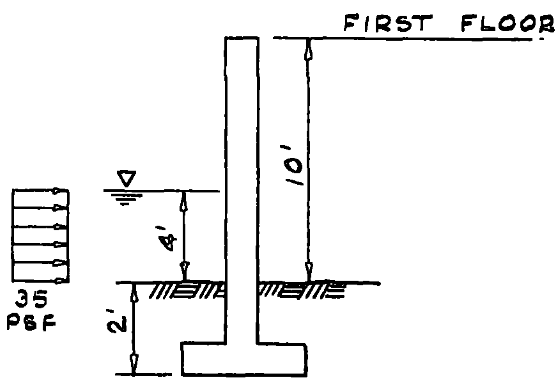
ADDRESS: 1700 Sunny Court Dr. Balto., Md.
CONSTRUCTION: 1 story slab-on-grade, frame w/brick veneer.
GENERAL NOTES: Typical for 4 houses in the same area.

Approximately 4' of flood water in house during maximum flood.



BASEMENT FLOOR. PLAN

Consider raising the structure and not filling inside and outside.



Assume the maximum moment occurs at the footing. Based on the maximum flood level to date:

M = 35 lb./ft.x4'x12"/ft.x4'
= 6,720 in.-lbs.

LIVE LOADS:

Roof	=	20 psf
1st Floor	=	50 psf
TOTAL	=	70 psf

Live load to walls = 70 psf (25 ft./2) = 875#/ft.

DEAD LOADS:

Roof	=	15 psf
1st Floor	=	10 psf
TOTAL	=	25 psf

Load to walls = 25 psf (25 ft./2) = 312.5#/ft.

Walls above foundation walls:

2x4's @ 16" on center	=	2 psf
Gypsum	=	4 psf
Siding and Miscellaneous	=	4 psf
TOTAL	=	10 psf

Load to foundation walls = 10 psf (10') = 100#/ft.

Total dead load above foundation walls = 412.5#/ft.

BEARING CAPACITY OF WALL (Assuming 8" CMU)

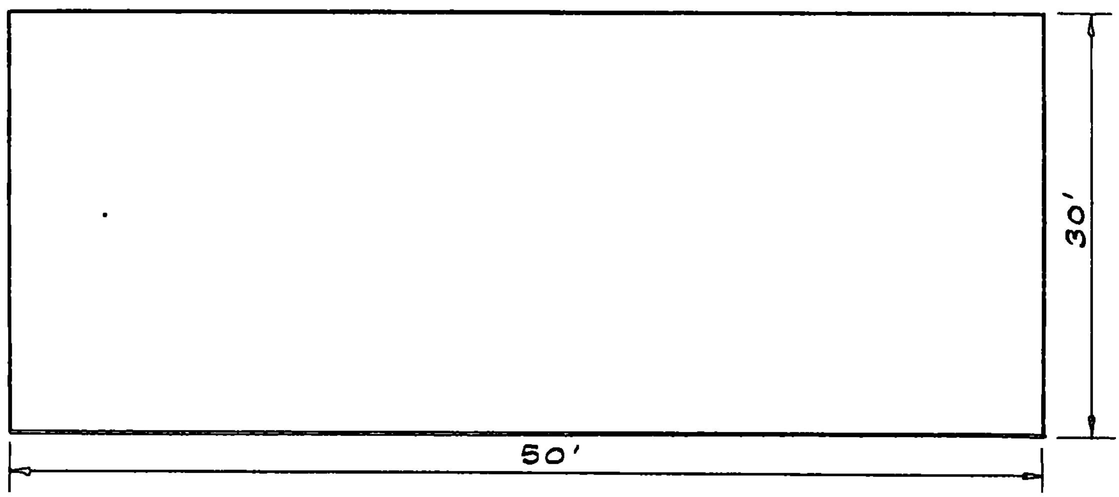
The axial load (N) is computed as

$$N = 1.5\ (wh^2\ A/S) - w'h/2 - F_t\ A$$
$$= 1.5\ (35\#/ft.^2 (8\ ft.)^2 \times 30\ in.^2/81\ in.^3) - 54\#/ft.^2 (8\ ft.)/2 - 16\#/in.^2 (30\ in.^2)$$
$$= 548\#$$

where

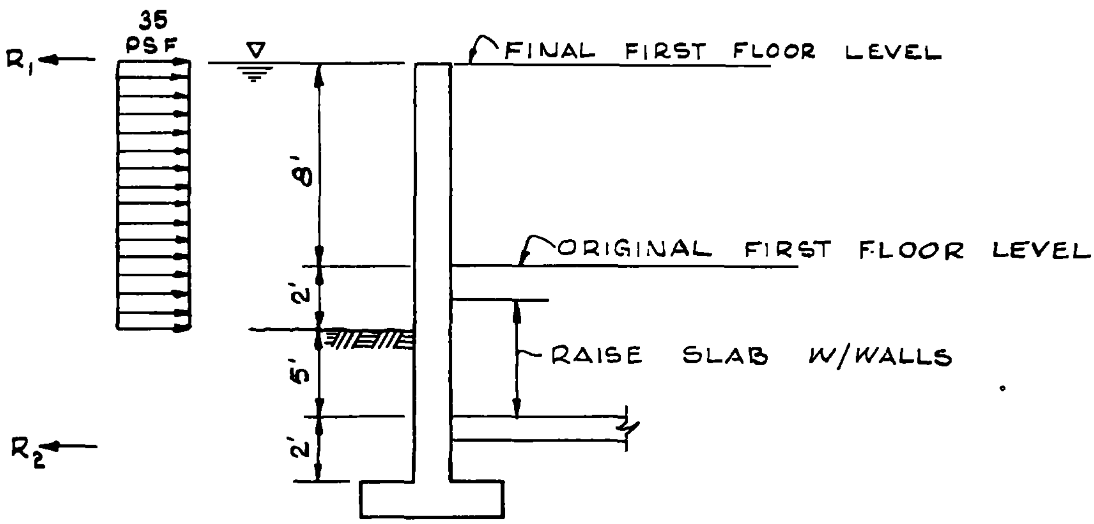
w = pressure being exerted on the wall
h = the height of the wall
A = area of the CMU block
S = section modulus of the block
w' = weight of the block
F_t = allowable tensile stress of CMU

BUILDING #2 SUMMARY: From TM 5-809-3, 8" non-reinforced CMU walls are adequate for building #2. The inside and outside grade may be raised equally but do not necessarily have to be raised. If no fill is to be used, screened holes should be provided at the bottom of each wall to allow for the entrance of flood waters so that the pressure may be equalized. A bond beam and sill plate with anchor bolts should be provided on the top course (See Building #1) along with horizontal reinforcing at 16" on centers vertically. If a basement is to be incorporated with the 8 foot raising the concrete floor slab will be identical to building #1. It is assumed that the existing footers are capable of supporting the additional loading.



BUILDING #3

ADDRESS: 7109 Queen Anne Rd. Balto., Md.
CONSTRUCTION: 1 story frame, concrete block foundation.
GENERAL NOTES: Basement floor is approximately 5' below grade.
Maximum flood waters were 12' above grade.
Assume basement interior floods equally with outside.
Oil storage tank in basement.



Based on the dynamic water force the maximum moment
$= 35(8)^2/8 = 280$ ft.-lbs.
$= 3360$ in.-lbs.

DEAD LOADS:

Roof	=	15 psf
1st Floor	=	10 psf
TOTAL	=	25 psf

Load to walls = 25 psf (30'/2) = 375 lb./ft.

Walls above foundations walls:

2x4's @ 16" on center	=	2 psf
Gypsum Board	=	4 psf
Siding and Miscellaneous	=	4 psf
TOTAL	=	10 psf

Subtotal load to foundation walls = 10 psf (12') = 120 lb./ft.

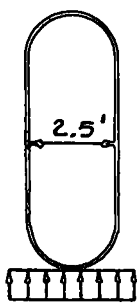
Brick Veneer = 40 psf
Load to foundation walls   40 psf (6') = 240 lb./ft.

Total dead load above foundation walls = 735 lb./ft.

Assuming 8" block check the bearing capacity

$N = 1.5(wh^2\ A/S) - w'h/2 - F_tA$
$= 1.5(35(8)^2 x30/81) - 54(8)/2 - 16(30)$
$= 548$ lb./ft.

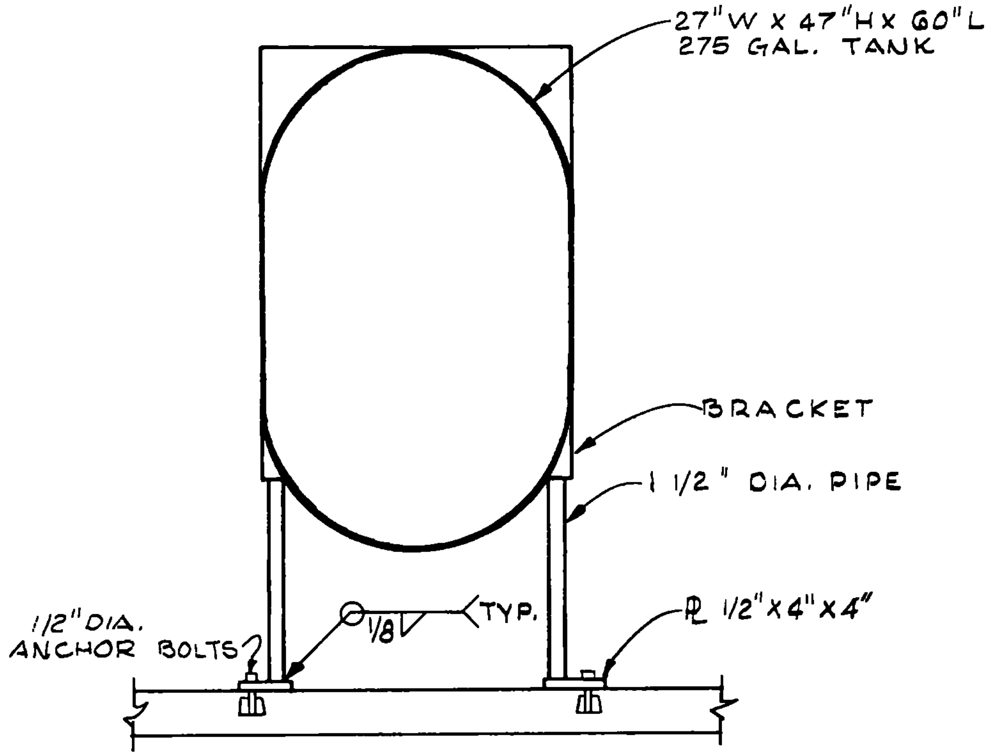
ANCHORING THE OIL TANK



Pressure from 8' of water = p
$p = \gamma H = 62.4(8)$
= 500 lb./ft.
Total uplift force = pA
= 500 (2.5)5 = 6,250 lb.
Use 4 bolts to anchor the tank
Force on each bolt = 6,250/4 $\approx$ 1,600 lb./bolt
Use 3/8" diameter anchor bolts

Strap the tank with 2 straps
Allowable stress = 0.6(36,000) = 21,600 psi
Strap area = 1600/21600 = 0.07 $in.^2$

Try 3/16"x1" strap with 3/16" fillet weld
Allowable stress = 0.3(60,000) = 18,000 psi
or 0.4(36,000) = 14,400 psi
Capacity of the 3/16" fillet weld = 3/16(0.707)14,400 = 1909#/in.
Total Capacity = 1"(1909#/in.) = 1909# > 1600# O.K.

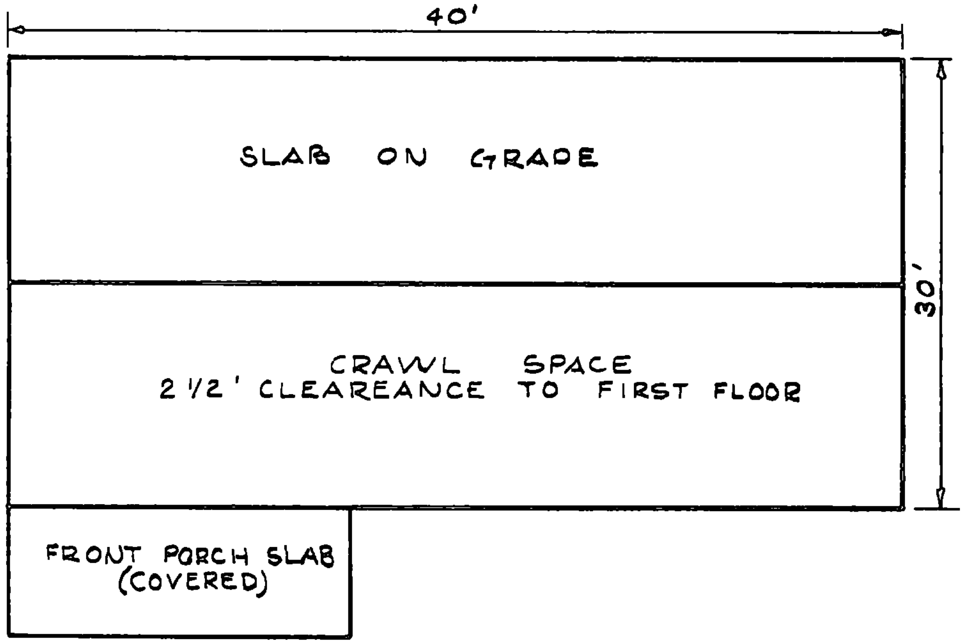


TYPICAL INTERIOR TANK

BUILDING #3 SUMMARY: This building can be raised using 8" CMU with the typical bond beam sill plate and joint reinforcing as shown on building #1. The basement floor will be raised at the same rate as the first floor until the basement floor reaches the existing exterior ground surface. At this point fill is to be placed against the foundation walls on both the interior and exterior. The basement slab is to be similar to that of building #1.

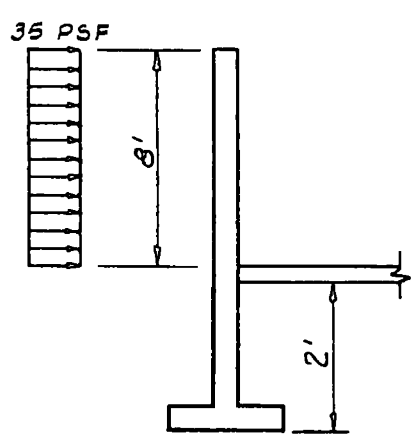
BUILDING #4

ADDRESS: 333 Essex Rd. Balto., Md.
CONSTRUCTION: 1½ story frame - ½ brick veneer
GENERAL NOTES: Maximum flood level experienced - 2' of water in lower level.



DEAD LOADS:

Roof	=	15 psf
2nd Floor	=	10 psf
TOTAL	=	25 psf



Load to walls = 25 psf (30'/2) = 375#/ft.

Walls above foundation walls:

2x4's @ 16" on center	=	2 psf
Gypsum Board	=	4 psf
Siding and Miscellaneous	=	4 psf
TOTAL	=	10 psf

Load to foundation walls = 10 psf (12') = 120 lb./ft.

Load from Brick Veneer = 40 psf (4') = 160 lb./ft.

TOTAL LOAD ABOVE FOUNDATION WALLS = 655#/ft.

Assuming 8" CMU with type "N" mortar - check the bearing capacity of the wall.

$$N = 1.5(wh^2 A/S) - w'h/2 - F_t A$$
$$= 1.5(35(8)^2 x 30/81) - 54(8)/2 - 16(30)$$
$$= 548\#$$

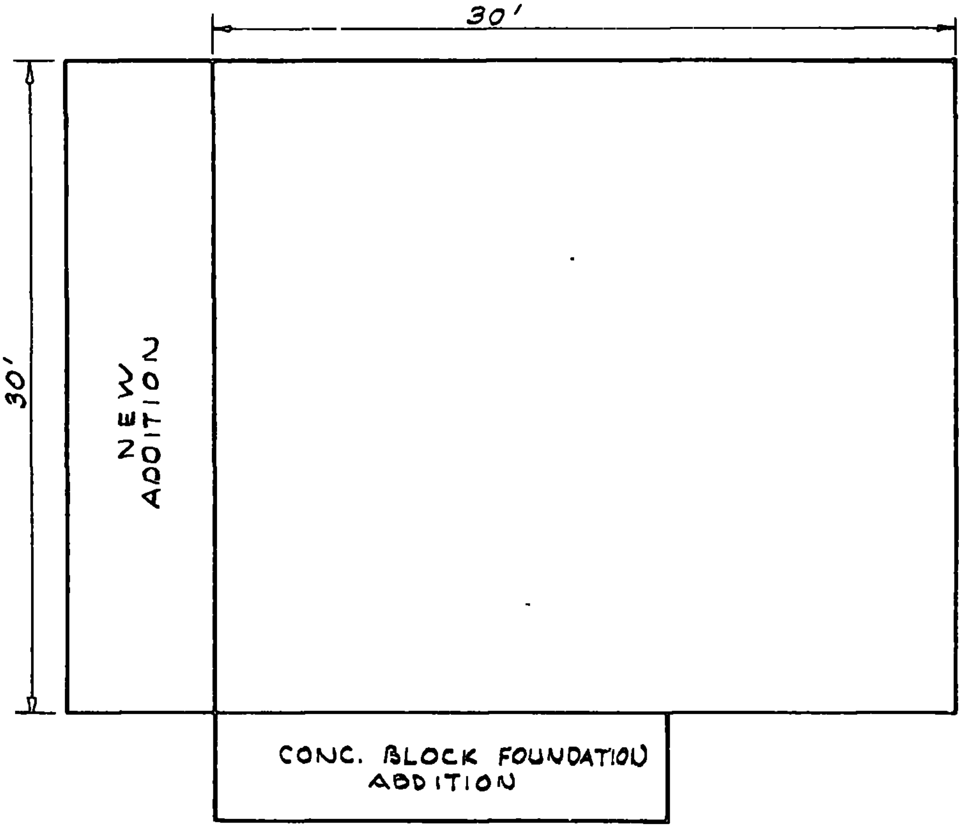
BUILDING #4 SUMMARY: Conclusions identical to that of building #1.

BUILDING #5

ADDRESS: 318 Essex Rd. Balto., Md.
CONSTRUCTION: 1 story frame - brick veneer
full block foundation
GENERAL NOTES: This building is similar to building #3 and should be raised in a similar manner.

BUILDING #6

ADDRESS: 1810 Sunny Side Lane Balto., Md.
CONSTRUCTION: 2 story frame with concrete block foundation
GENERAL NOTES: Maximum flood level experience = 6' in basement.
Exterior oil storage tank.



DEAD LOADS:

Roof	=	15 psf
1st Floor	=	10 psf
2nd Floor	=	10 psf
TOTAL	=	35 psf

Load to walls = 35 psf (30'/2) = 525#/ft.

Walls above foundation walls:

2x4's @ 16" on centers	=	2 psf
Plaster	=	10 psf
Exterior Sheathing	=	3 psf
Siding and Miscellaneous	=	5 psf
TOTAL	=	20 psf

Load to foundation walls = 20 psf (20') = 400#/ft.

TOTAL DEAD LOAD = 925#/ft.

Assuming 8" CMU with type "N" mortar

$$N = 1.5(wh^2\ A/S) - F_tA$$
$$= 1.5(35(8)^2 x30/81) - 54(8)/2 - 16(30)$$
$$= 548\ lb./ft.$$

For an exterior oil storage tank assuming 8' of water the uplift force is approximately 6400# as computed for building #3.

Try using an anchor pad with a 4'-3"x6'-0"x1'-0" footer and 4 stems 2'-0" high by 1 foot square.

Total Wt = (4.25x6x1)150+4(1x1x2)150
+ 2(0.5x2x6x110) + (1.25x2x6)110
= 7995# > 6400# O.K.
(See page 18 for detail)

BUILDING #7

ADDRESS: Lock Haven, Pa. Typical Group
CONSTRUCTION: All houses two story frame with stone foundation. All houses have very old foundations. It is recommended they be replaced.
The average size of this group of homes is 22'x40' with 6' basements.

COMPUTE EXISTING LOADS

DEAD LOADS

Roof	=	15 psf
2nd Floor	=	15 psf
1st Floor	=	15 psf
TOTAL	=	45 psf

Load to walls = 45 psf(22'/2) = 495 lb./ft.

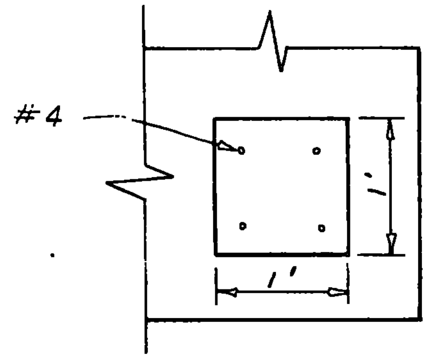
Walls above foundations walls:

2x4's @ 16"	=	2 psf
Plaster	=	10 psf
Sheathing	=	3 psf
Siding and Miscellaneous	=	5 psf
TOTAL	=	20 psf

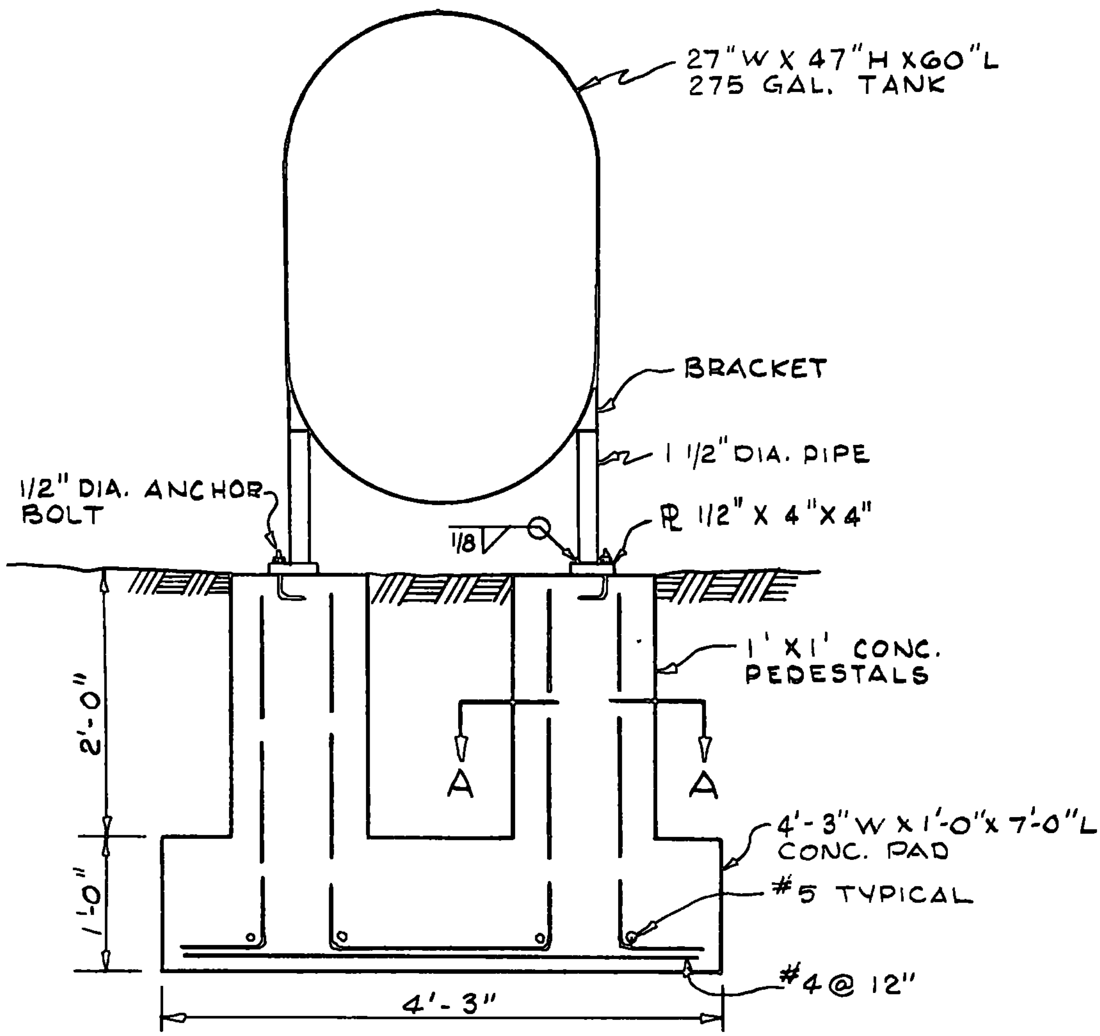
Load to foundation walls = 20 psf x 25' = 500 lb./ft.

TOTAL DEAD LOAD NON-BEARING WALL = 500 lb./ft.

TOTAL DEAD LOAD BEARING WALL = 995 lb./ft.



SECTION A-A



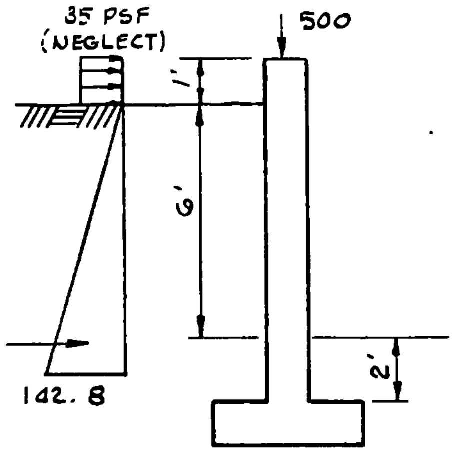
TYPICAL EXTERIOR TANK

LIVE LOADS

Roof	=	20 psf
2nd Floor	=	50 psf
1st Floor	=	50 psf
TOTAL	=	120 psf

Total live load to bearing wall = 120 psf(22'/2) = 1320 lb./ft.

Consider the non-load bearing wall raised one foot.



Neglecting the dynamic load the hydrostatic pressure is

$p = \gamma HK$
$= (110-62.4)(6)(0.5)$
$= 142.8$ lb./ft.^{2}

Assuming the basement floods and water pressure is equal on the inside and outside, the moment is equal to

$M = 0.1283\ wl$

where $w = \frac{1}{2}(p)H$
$= \frac{1}{2}(142.8)(6)$
$= 428.4$ lbs.

resulting in

$M = 0.1283(428.4)(6)$
$= 329.8$ ft.-lbs.

Assuming 8" CMU
$A = 30$ in.^{2}; $S = 81$ in.^{3}; $t = 7.625$ in. and $w' = 54$ psf

The computed axial compression stress for the non-load bearing wall is: f_a = Max N/A
$= (500+9(54))/30$
$= 32.9$ lb. in.^{2}

The flexural compressive stress
$f_m = M/S$
$= 329.8$ ft.-lbs. (12 in./ft.)/81 in.^{3}
$= 48.86$ lb./in.^{2}

The allowable axial and flexural compressive stresses are defined as $F_a = 0.2f_m'R$ and
$F_m = 0.3f_m'$
where $f_m' = 1000$ for type "N" mortar
and $R = 1-[(12h)/(40t)]^3$
Thus:
$F_a = 0.2(1000)(1-[12(9)/(40\text{x}7.625)]^3)$
$= 192$ lb./in.^{2}
and
$F_m = 0.3(1000)$
$= 300$ lb./in.^{2}

Check the interaction expression

$f_a/F_a + f_m/F_m < 1$

$32.9/192 + 48.86/300 = 0.33 < 1$ O.K.

For the load bearing wall

$f_a = (995+1320+9\times54)/30$
$= 93.4$

and the expression $f_a/F_a + f_m/F_m = 93.4/192 + 48.86/300$
$= 0.65 < 1$ O.K.

FOOTING DESIGN

Dead load = 995 lb./ft.
Live load = 1320 lb./ft.
Wall = 54 lb./ft.^{2} x 9 ft. = 486 lb./ft.
TOTAL LOAD = 2801 lb./ft.

Assume 2500 psi concrete, an allowable bearing pressure of 2,000 psf, and a 9 inch thick footing.

Net pressure = 2000 - 9/12(150)
= 1888 psf

Footing width = Total load/Net pressure
= 2801/1888
= 1.48 ft. use 1'-6"

The 1'-6" results in a net pressure = 2801/1.5 = 1867 psf

The allowable tensile stress is

$F_t = 5(0.65)\sqrt{2500}$
$= 162.5$ lb./ft.^{2}

Moment on the footing = $(5/12 + 8/(4\times12))^2\ 1867/2$
= 318 ft. lbs.

Set the allowable tensile stress equal to the actual.

Since $f = M/A$

and $S = I/C$
$= bH^3/12 \times 2/H$
$= bH^2/6$

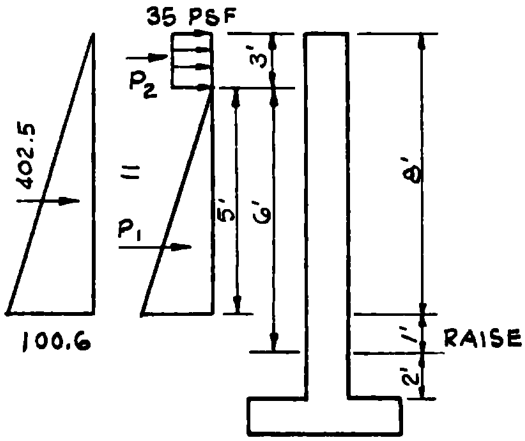
$H^2 = 6M/(b\ f_t)$
$= 6(318)(12)/(18 \times 162.5)$
$= 7.84$ in.^{2}
$H = 2.8$ in.

Use 9" (ACI 15.9.1)

Minimum reinforcing = 0.002(18)(9) = 0.32 use 2#4's

SUMMARY ONE FOOT RAISING - For the one foot raising, 8" CMU wall with a 9"x1'-6" footing will be adequate. The footing should contain 2 #4 bars and the walls reinforced as shown on page 7. The basement slab will be similar to building #1.

CONSIDER RAISING THE STRUCTURE 3 FEET



Finding the total force acting on a new wall

$$p = \gamma HK$$
$$= (110-62.4)(5)(0.5)$$
$$= 119 \text{ psf}$$

$$P_1 = 0.5(119)5$$
$$= 297.5 \text{ lb./ft.}$$
$$P_2 = 3(35)$$
$$= 105 \text{ lb./ft.}$$

TOTAL FORCE = 402.5 lb./ft.

$$\text{Maximum } M = 0.1283\, wl$$
$$= 0.1283(402.5)8$$
$$= 413.1 \text{ ft.-lb.}$$

Using the same loads as with the one foot raising, except for the increased wall load, and assuming 8" CMU with "N" mortar.

$$f_a = (995+1320+11\text{x}54)/30$$
$$= 97 \text{ psi}$$

$$F_a = 0.2\, f'_m\, R$$
$$= 0.2(1000)(1-[12(11)/(40\text{x}7.625)]^3)$$
$$= 184 \text{ psi}$$
$$f_m = 413.1(12)/81$$
$$= 61.2 \text{ psi}$$

and

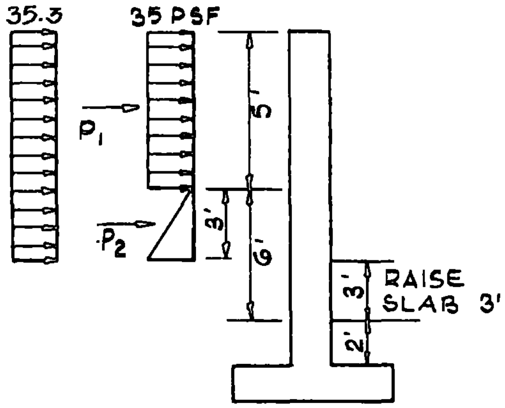
$$F_m = 0.3\, f'_m$$
$$= 0.3(1000)$$
$$= 300 \text{ psi}$$

Resulting in

$$f_a/F_a + f_m/F_m = 97/184 + 61.2/300$$
$$= 0.73 < 1 \quad \text{O.K.}$$

SUMMARY THREE FOOT RAISING - 8" CMU wall will be adequate to replace the existing basement walls and raise the first floor an additional three feet. The walls and reinforcing will be as shown on page 7, with a footer the same as the one foot raising.

RAISING THE STRUCTURE 5 FEET



$P_1 = 5(35)$
$= 175$ lb./ft.
$P_2 = 0.5\ p(3)$
$= (0.5)(0.5)(110-62.4)(3)(3)$
$= 107.1$ lb./ft.
TOTAL FORCE = 282.1 lb./ft.

for a uniform loading
$P = 282.1/8 = 35.3$

Maximum $M = wl^2/8$
$= 35.3(8)^2/8$
$= 282.4$ ft.-lbs.

Comparing this moment with that of the 1 and 3 foot raisings it can be seen that the 8" CMU is adequate.

FOOTING DESIGN

Using the live load previously computed and increasing the dead load for the additional wall height the loading used is

Dead Load = 995 + 13(54) = 1697 lb./ft.
Live Load = 1320 lb./ft.

Keeping a 9" thickness for the footer the net pressure is 1880 psf and the footer width required is

3017/1888 = 1.6' use 1'-8"

resulting in a net pressure of

3017/1.67 = 1810 psf

which yields a moment equal to

$(6/12 + 8/(4\text{x}12))^2 \text{ x } 1810/2$
$= 402$ ft.-lbs.

Set the allowable tensile stress equal to the actual and solve

$$f_t = M/S$$
$$= 6M/(bH^2)$$

for H^2

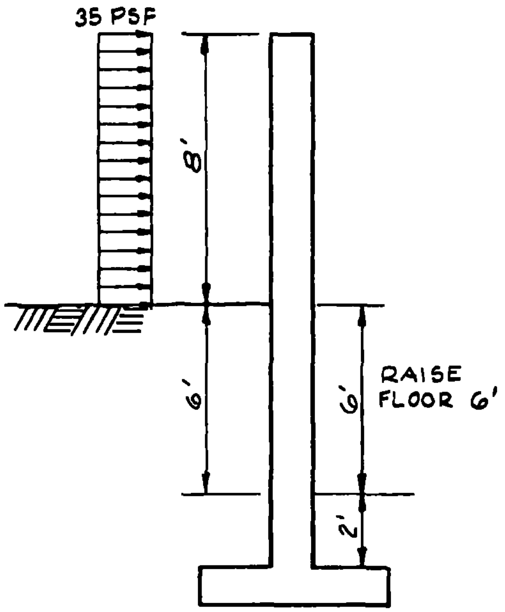
$$H^2 = 6M/(b\ f_t)$$
$$= 6(402)(12)/(162.5\text{x}20)$$
$$H^2 = 8.88 \text{ in.}^2$$
$$H = 2.98 \text{ in.}$$ use 9" minimum

Minimum steel requirements

$A_s = 0.002(20)9$
$= 0.36$ in.^{2} use 2 #4's

SUMMARY FIVE FOOT RAISING - The 5 foot raising will require new 8" CMU walls as shown on page 22 with a 9" x 1'-8" footer. A new concrete basement floor will be built 4" thick with 6x6-W2.1xW2.1WWF.

RAISING THE STRUCTURE 8 FEET



For this raising the basement floor will be at grade. Consequently, the only loading will be the dynamic load of 35 psf.

Maximum $M = wl^2/8$

$= 35(8)^2/8$

$= 280$ ft.-lbs.

As seen previously the 8" CMU is sufficient for the moment calculated.

FOOTING DESIGN

Use the previous total load computed (under 5' raising) and add the additional 3 feet of wall for the 8 foot raising.

TOTAL LOAD = 995 + 1320 + 16 (54)

= 3179 lb./ft.

Assuming a 9" thick footer the net pressure remains 1888 psf. The computed footing width is 3179/1888 = 1.68' use 1'-8"

The revised net pressure is 3179/1.67 = 1907 psf which yield a moment of

$$(6/12 + 8/(4\times12))^2 \times 1907/2$$

$$= 424 \text{ ft.-lbs.}$$

Solving for H as done previously

$$H^2 = 6(424)(12)/(162.5\times20)$$

$$H^2 = 9.61 \text{ in.}^2$$

$$H = 3.1 \text{ in.} \quad \text{use } 9"$$

Minimum steel requirements

$A_s = 0.002(20)(9)$
$= 0.36 \text{ in.}^2$ use 2-#4's

SUMMARY EIGHT FOOT RAISING - As with the 1, 3 and 5 foot raisings the existing basement should be removed and replaced with a new 8" CMU foundation with reinforcing at 16" on centers. The footing for the walls should be 9"x1'-8" with 2-#4 bars. The basement floor will be similar to that of building #1.

C. SUMMARY OF ANALYSES - Based on the assumptions made at the beginning of this section, it has been found that the existing foundations which were considered to be 8" CMU wall were adequate to support the additional layers of block required for the various raisings. However, in order to support the higher raisings being considered it will be necessary to place fill in the interior and around the exterior of the house. When an older foundation is encountered, such as stone, replacement of the foundation wall with new CMU and appropriate footings is recommended.

III

WATERPROOFING STRUCTURES

III WATERPROOFING STRUCTURES

A. Assumptions - This section of the design analyses will be concerned with keeping a house totally free from infiltration by flood waters. The assumptions made pertaining to this section are:

1. No water will be permitted in the basement

2. Maximum depth of flood waters will be to the top of the foundation walls.

3. The saturated weight of the soil (γ sat) is 110 to 120 lb/ft^3.

4. The compressive strength of concrete will be 4,000 lb/in^2.

5. The yield strength of reinforcing (f_y) is 40,000 lb/in^2.

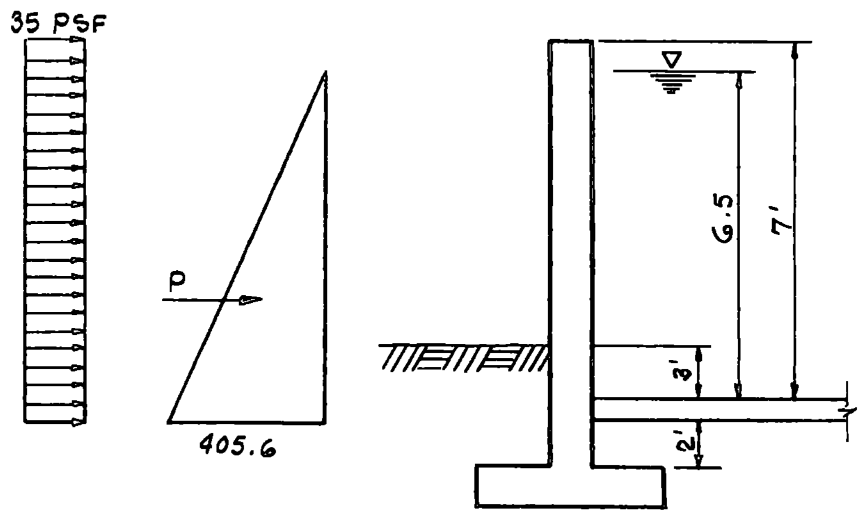
6. Aluminum to be used for closure structures will be type 6061-T6.

B. Calculations -

BUILDING #1

General information the same as given under Section II Appendix B.

Assume the existing CMU walls can be waterproofed with an exterior coating. Check for adequacy of the existing wall to withstand the dynamic and hydrostatic pressures.



Determine the moment to be exerted on the wall assuming $\phi = 30^o$ and $\gamma = 110\#/Ft^3$.

$$M = wl/^2/8 + 0.1283Wl$$

where w = the dynamic load previously computed
W = the hydrostatic pressure
$= \gamma_{water} h^2 K$
$= 0.5 (62.4)(6.5)^2$
= 1318 lb/ft.

$M = 35(6.5)^2/8 + 0.1283 (1318) 6.5$
= 1284 Ft.-lbs = 15,408 in-lbs.

Using this moment and the section modulus of the block the tensile stress is computed as:

$$F_t = \frac{M}{S}$$

$= 15,408$ in-lb/81 in^3
$= 190$ lb/in$^2 > 16$ lb/in^2
therefore, the existing walls are inadequate.

Attempt to reinforce the walls with 16" pilasters at 8' on centers. The ratio of pilaster spacing to pilaster width is 12 in/ft(8 ft): 16 in = 6. Based on this ratio the pilaster coefficient (F) is given as 1.4 (Ref. TM-5-809-3). Using this factor the effective thickness of the wall is found by multiplying the 1.4 by the actual thickness of the CMU block (7.625)

$$T = 1.4(7.625) = 10.675 \text{ in.}$$

The equivalent section modulus is computed using
$S = (4t'/T) [(t')^2 + 3(T-t')^2]$
where t^1 is the shell thickness of the block (1.25 in.)

$S = 4(1.25)/10.675 [(1.25)^2 + 3(10.675-1.25)^2]$
$= 125.6$ in^3

Check to see if K is within the Kern
$K = e/T$
where e is defined as $M/(N + W'H/2)$

@ mid-height using Nmin = 300# and Nmax = 900#
$N+(w'h)\ 2$
$= 300 + 54(6.5)/2$ and $900 + 54(6.5)/2$
$= 475.5$ $= 1075.5$

resulting in

$e = 15,408/475.5$ (Nmin) $= 32.4''$

$e = 15,408/1075.5$ (Nmax) $= 14.3''$

$K = 32.4''/10.675'' = 3.04$

$K = 14.3''/10.675'' = 1.34$

Since K is near the Kern (T/6) the analysis is primary that of a compression problem where the allowable axial compression is given as

$$F_a = 0.20\, f'_m\, R$$

For type 'N' mortar $f'_m = 1000$
For walls $R = 1-(12H/(40T))^3$
Thus

$$\begin{aligned} F_a &= 0.20(1000)\ [1-(12H/(40T))^3] \\ &= 0.20(1000)\ [1-(12(6.5)/(40(10.675))^3] \\ &= 199 \end{aligned}$$

Check to see if

$$f_a/F_a + f_m/F_m < 1$$

For Nmin

$$\begin{aligned} f_a/F_a + f_m/F_m &= (475.5/36)/199 + (15408/125.6)/300 \\ &= 0.48 < 1 \end{aligned}$$

For Nmax

$$\begin{aligned} f_a/F_a + f_m/F_m &= (1075.5)/36/199 + (15408/125.6)/300 \\ &= 0.56 < 1 \end{aligned}$$

For Nmax plus the live load

$$\begin{aligned} f_a/F_a + f_m/F_m &= [(1075.5+1800)/36]/199 + 15408/125.6)/300 \\ &= 0.81 < 1 \end{aligned}$$

$$\begin{aligned} f_a &= (1075.5 + 1800)/36 \\ &= 79.9 < 200 \end{aligned}$$ O.K.

Compute the tensile strength and check against allowable

$$\begin{aligned} f_t &= f_m - f_a \\ &= (15408/125.6) - 79.9 \\ &= 27.7 > 16 \end{aligned}$$ N.G.

Determine the maximum horizontal span of 8" CMU

$$f_t = M/S$$

where s = section modulus for 8" block (101 in^3)

and $M = wl^2/8$

$$f_t = (wl^2)/(8S)$$

solving for l^2 yields

$$l^2 = (f_t \times 8 \times S)/w$$

where w = the hydrostatic and dynamic loading

$= 35 + 62.4(6.5)$

$= 440.6$

$$l^2 = (32\ lb/in^2 \times 8 \times 101\ in^3)/(440.6\#/ft. \times 12\ in/ft)$$

$$l^2 = 4.89\ ft.$$

$$l = 2.21\ ft.$$

8" CMU wall can only span 2.21' horizontally.

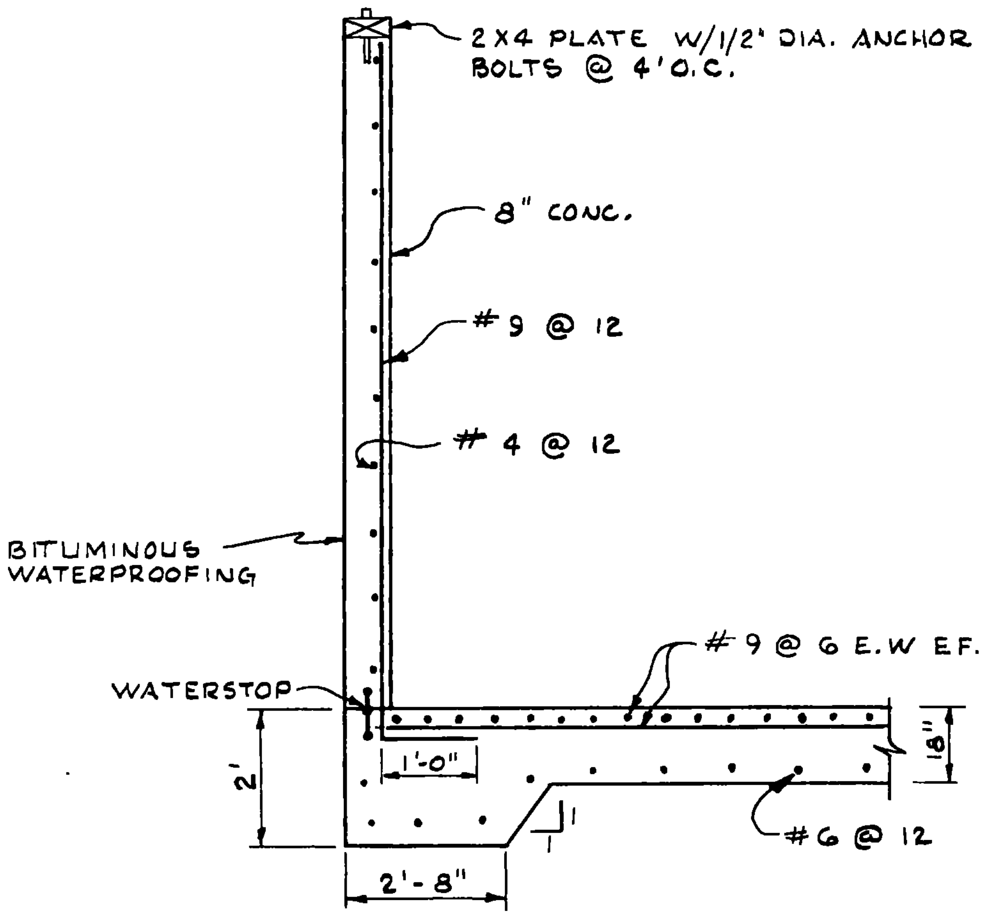
The maximum moment the wall can support vertically is

$$f_t = M/S$$

$$16 = M/.81$$

$$M = 1296\ in\text{-}lbs$$

The only feasible way to floodproof this building would be to remove the CMU wall and replace it with 8" of concrete wall reinforced with #9's @12" vertically and #4's @ 12" horizontally. The slab would be 18" thick with #9's @ 6"



CLOSURE STRUCTURES FOR DOORS AND WINDOWS
Reference: Aluminum Design Manual
Use type 6061-T6 Aluminum

F_b = 19 Kips/in^2 with $b/t < 17$

$F_b = 23.7 - 0.27\ b/t$ for $17 < b/t < 38$

$F_b = 19{,}200/(b/t)^2$ for $b/t > 38$

WINDOWS - Compute the thickness of plate required to cover the window openings.

Maximum head of water - 3 ft.

$W = \gamma H^2/2$
$= 62.4(3)^2/2$
$= 281$ lb.

$M = 0.1283\ wl$
$= 0.1283(281)3$
$= 108$ ft-lbs. $= 1297$ in-lbs.

$f_b = M/S$
where $f_b = 28{,}000$ psi
$S = bd^2/6$ (b=30 in)
solving for d
$d^2 = (6M)/(30\ f_b)$
$= (6 \times 1297)/(30 \times 28{,}000)$
$d^2 = 0.0093$ in^2
$d = 0.096"$ use 1/4"

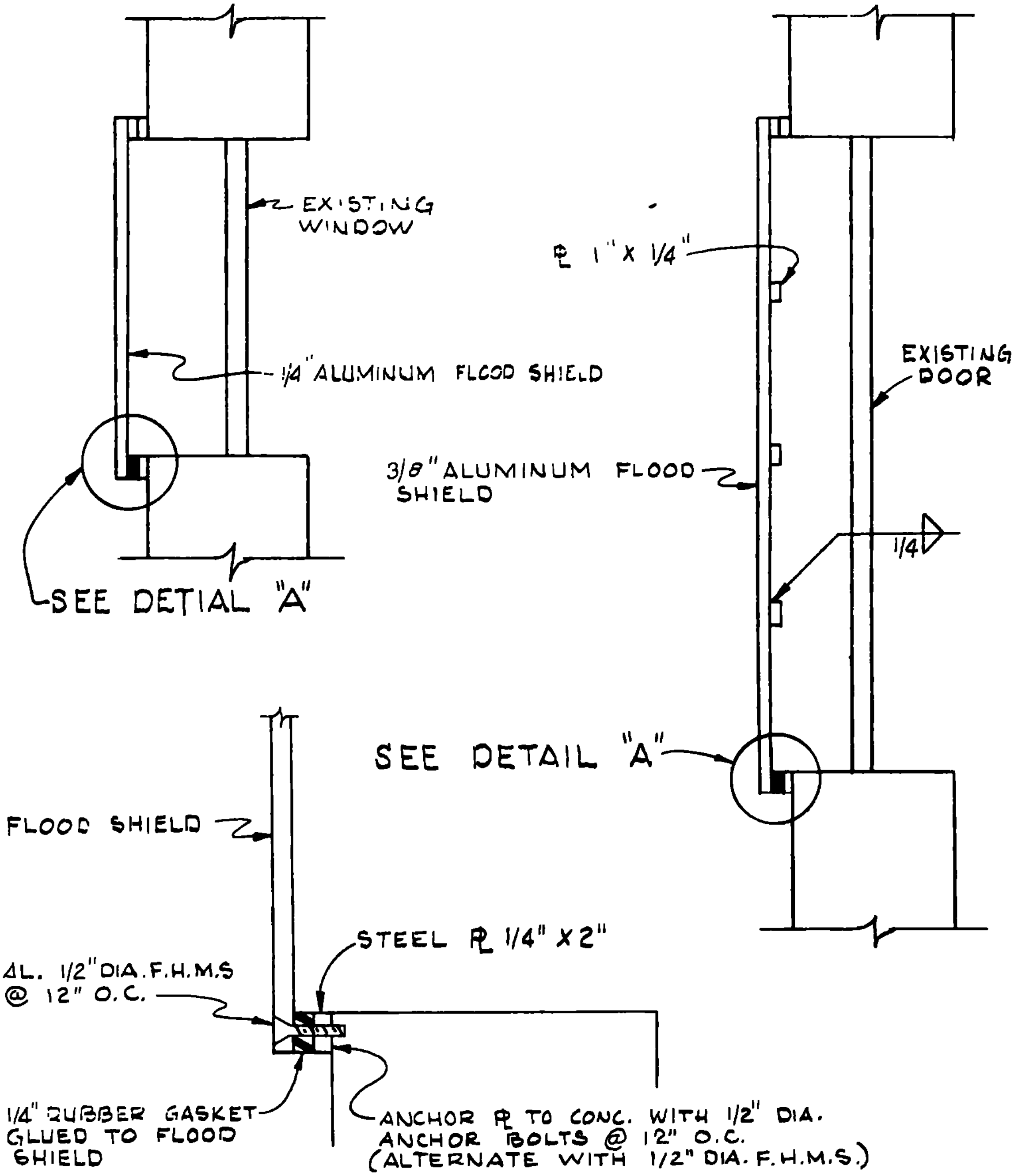
DOORS - Maximum head of water against door = 7 ft.

$W = 62.4(7)^2/2$
$= 1528.6$ lb

$M = 0.0283\ wl$
$= 0.1283(1528.6)7$
$= 1373$ ft-lb $= 16{,}476$ in-lb

Solving for d as done previously for the windows

$d^2 = (6 \times 16{,}476)/(30 \times 28{,}000)$
$d^2 = 0.115$ in^2
$d = 0.34"$ use 3/8"



DETAIL "A"

TYPICAL CLOSURE STRUCTURE

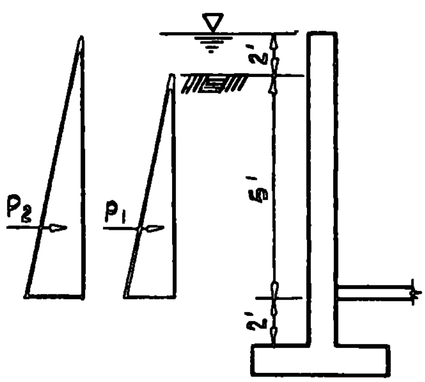
BUILDING #2

See description under House Raising

This house had approximately 4 feet of water above grade. There is no way feasible to waterproof this house. The windows and doors could receive flood shields to prevent direct ingress of floodwaters. However, water would seep through the building materials. The basement could be waterproofed as shown in Bldg #1.

BUILDING #3

As previously stated, this building's maximum flood level experienced was 12 feet above grade. It is not feasible to waterproof the house for the entire depth of maximum flooding. Consider waterproofing the basement.



Pressures exerted on the basement walls

$P_1 = 0.5(110-62.5)(5)(0.5)(5)$
$= 298$ lbs
$P_2 = (62.4)7(1)(0.5)(7)$
$= 1529$ lbs.

The maximum moment is given as:

$M = 0.1283$ pl
using an average l of 6 feet
$M = 0.1283(298+1529)6$
$= 1406$ ft.-lbs.

The loading on the walls as previously calculated (page 11) are:

Non-load bearing wall dead load = 360 lb/ft
Bearing wall
dead load = 735 lb/ft.
live load
Roof = 15 psf
1st Floor = 50 psf
Total = 65 psf
live load to bearing wall = 65 psf(30'/2) = 975 lb/ft

Assuming 8" CMU

$B_p = 16$ in. $T_w = 8'$ $W_p = 8'$
$R_p = 12\ W_p/B_p = 6$ $P_F = 1.4$

Solving for the effective thickness and the section modulus

$T = 1.4(7.625) = 10.625$ in.
$S = (4t'/T)[(t')^2 + 3(T-t')^2]$
$= 4(1.25)/10.675\ [(1.25)^2 + 3(10.675 - 1.25)^2]$
$= 125.6\ in^3$

AT MID-HEIGHT

Considering the dead load of the non-bearing wall (N = 360 lb/ft) check the Kern (T/6)

$K = e/T$

where

$e = 12M/(N + W'H/2)$
$= 12(1406)/(260 + 54(6)/2)$
$= 32.3$ in.

$K = 32.3''/10.675''$
$= 3.03$

Computing the axial and flexural compressure stresses including the live load in the axial stress.

$f_a = N/A$	$f_m = M/S$
$= 1497/30$	$= 1406(12)/125.6$
$= 49.9$ lb/in^2	$= 134.33$ lb/in^2

Checking the tensile stress

$f_t = f_m - f_a$
$= 134.33 - 49.9 = 84.4 > 16$ (allowable) N.G.

Reinforce the walls with 24-inch pilasters

$T_p = 3T_w$; $B_p = 24''$; $F = 2$

The effective thickness of the wall with pilasters is

$T = F(t)$
$= 2(7.625)$
$= 15.25''$

and the effective section modulus is computed as:

$S = 4(1.25)/15.25\ [(1.25)^2 + 3(15.25 - 1.25)^2]$
$= 193.3$ in^3

Thus the actual flexural compressive stress is

$f_m = 1406(12)/193.3$
$= 87.28$ lb/in^2

Yielding a tensile stress of

$f_t = f_m - f_a$
$= 87.28 - 49.9 = 37.38 > 16$ N.G.

The results indicate that the existing walls are unable to support the pressures that would be exerted upon it, if it could be waterproofed.

Consider waterproofing this building the same as building #1.

Check the slab thickness

Dead load of house

Roof and 1st floor	= (15 psf + 10 psf) x 150 sf = 37,500 lbs.
Walls	= 360 lb/ft x 160 l.f. = 57,600 lbs.
Foundation Walls	= (8/12)(150 lb/ft^3)(6 ft)(160 l.f.) = 96,000 lbs
	TOTAL DEAD LOAD ABOVE SLAB = 191,100 lbs.

Buoyant Force = γ HA
= 62.4(7)(30 x 50)
= 655,200 lbs.

Using an 18-inch slab
Weight of the slab = 1.5(30 x 50)150
= 337,500 lbs.

TOTAL DEAD LOAD = 337,500# + 191,100#
= 528,600# $<$ Buoyant Force N.G.

Try a 2-foot slab
Weight of slab = 2(30 x 50)150
= 450,000 lbs.

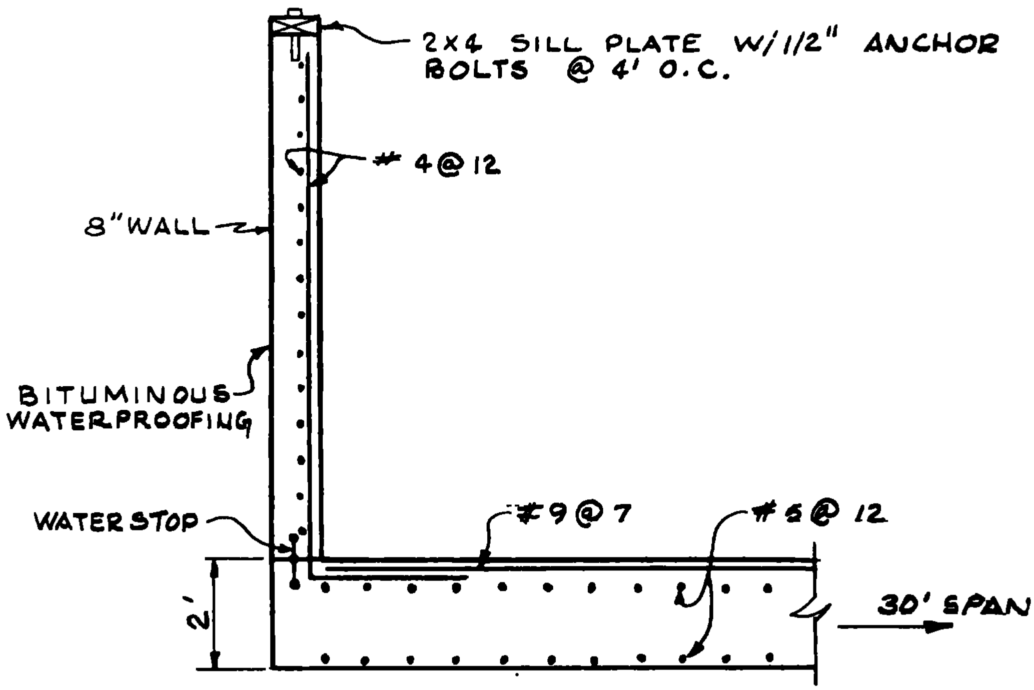
TOTAL DEAD LOAD = 450,000# + 191,000#
= 641,100# $<$ 655,200#
probably O.K.

REINFORCEMENT IN WALLS AND SLAB
For the 8" walls
A_s = M/(ad)
= 1.406/(1.44(6)
= 0.16 in^2 use #4's @ 12"

For the slab
The moment on the slab is
M = $wl^2/8$
= 62.4(7) $(30)^2/8$
= 49,140 lb-ft
= 49.14 Kip-ft

Top Steel
A_s = M/(ad)
= 49.14/(1.44(22))
= 1.55 in^2 use #9's @ 7"

Bottom Steel
Minimum Requirements = 0.002(12)(24)
= 0.58 in^2 use #7's @ 12"



Replacement of the existing walls with the reinforced concrete walls shown is the only means to waterproof this basement. This will not protect the entire structure from the maximum flood experienced since this flood was above the first floor level. Basement window and door closure structures are shown on page 30.

BUILDING #4

See description under HOUSE RAISING

This structure is completely above grade. The maximum flood level was approximately 2 feet above the first floor. The only means of waterproofing this building is to raise it. The basement could be waterproofed by removing the existing foundation and replacing it with a new reinforced concrete foundation.

C. Summary of Analyses - Assuming that an existing CMU wall could be waterproofed with an exterior bituminous coating, the wall was analyzed to determine if it could withstand the pressures exerted upon it. The results indicated that existing concrete block walls would be inadequate. Since it was previously assumed that the old stone foundations were considered inadequate for raisings, it is reasonable to assume they cannot be waterproofed. Consequently, in order to waterproof a basement a new foundation must be designed with the necessary flood shields over openings. It is recommended that openings be eliminated wherever practicable.

IV

INVESTIGATION OF EXISTING CONCRETE FLOOR

IV INVESTIGATION OF EXISTING CONCRETE FLOOR

A. Assumptions - The purpose of this section is to determine the height of water above the bottom of the slab that an "ideal" existing concrete basement floor could withstand. Although none of the houses inspected had such an "ideal" flooring for purposes of analyzation, it is assumed that existing slabs are 4' thick with 6x6-W2.1xW2.1 WWF. Live loads on the slab are neglected. It is assumed that there will be no seepage through the walls or joints.

B. Calculations - Based on the assumptions made the maximum moment the slab can support is found by

$$M = A_s ad$$

where: M = moment exerted on the slab (Kip-Ft.)
a = a constant based on the concrete and steel strength (obtained from the A.C.I. Reinforced Concrete Design Handbook)
d = distance from the top of slab to the reinforcing (in.)

$$M = 0.042\ (1.44)\ 2.5$$
$$= 0.151 \text{ Kip-Ft.}$$

Taking the average basement dimensions of the houses inspected as 41.5'x28.1'. Setting b = 41.5 and a = 28.1 the ratio of b/a is approximately 1.5. Based on this ratio the acceptable moment is set equal to:

$$M = 0.078\ Wa^2$$

where: W = the net force on the slab
= unit weight of water x the height of water less the dead load of the slab.
= (0.0625H - 0.05)

Using the M previously caculated

$$0.151 = 0.078\ (0.0625\ H - 0.05)(28.1)^2$$
$$H = 1.64' = 19''$$

C. Summary - Based on the assumption that the existing basement floors are "ideal" the total head of water placed on the exterior of the building could not exceed 10" before the slab would fail. Assuming that the slab could be anchored with a 2"x2"x1/4" angle with 1/2" anchor bolts at 5' on centers and a 50 pound per square foot live load, the maximum head the slab could withstand would be 1.5'.

APPENDIX C

REAL ESTATE

APPENDIX C
REAL ESTATE

I. GENERAL CONSIDERATIONS:

1. Except as discussed in the following, all procedures and benefits described in Section II will apply to the acquisition and relocation of those dwellings in the project area.

2. As the project is currently proposed, a study of each house in the flood plain would be conducted to determine what flood damage reduction alternative should be selected to protect the house. The major factors considered in the selection of the alternative are cost and effectiveness.

3. Essentially, it is the intent of Public Law 91-646 that displaced homeowners have the option to move their house, to build a new house, to move to a comparable house on the market or to rent a replacement dwelling. When the Corps determines that a house must be relocated to a non-flood plain site a conflict arises with PL 91-646. In effect, the homeowner is directed to relocate in one manner only and, therefore, he is not afforded all of the rights under PL 91-646.

a. Non-structural flood damage reduction projects are intended to be an environmentally desirable, and economically attractive alternative to structural flood protection measures. Because the house relocation alternative is one of the more expensive alternatives considered, it is desirable to keep its costs as low as possible in order to make such projects economically attractive to those communities which need them the most.

b. The conflict may be resolved if the project authorization is very specific in outlining where Public Law 91-646 will or will not apply.

4. If the Corps is considering the raising, floodproofing, or utility relocation alternatives described in this report, then the right to enter upon the homeowner's property to do the work should be secured by the instrument obtained from the homeowner which authorizes construction. Most homeowners will probably want to have their dwellings floodproofed, but if a homeowner does not desire to take advantage of the program, he has the right to refuse it.

5. Naturally, any Federally assisted flood damage reduction program will require the support and cooperation of a local governmental body such as a borough or town council. It is important that such programs not be implemented without an effort to minimize the chance of further residental

development in the area at some future time. Although the only way to limit such development absolutely is by the imposition of a restrictive easement, this approach would, in most cases, be impractical because of the acquisition cost. A more realistic approach is enactment of zoning restrictions by the local municipality. Although there is no way to insure the permanence of such restrictions, as any assurance made along these lines by local officials could not bind their successors, it would appear that non-residential zoning restrictions, once enacted, would have a high survival factor.

6. Prior to any project involving the relocation of homeowners, the Corps must study the housing market to determine if adequate replacement housing is available. When a project is authorized, the acquisition of residential properties should be accomplished in a manner so as to minimize adverse effects on the local housing market.

II. PUBLIC LAW 91-646:

1. Unless certain provisions of Public Law 91-646 are specifically superceded by the project authorization, all persons who would be displaced from their residences as a result of this project would receive the benefits provided for such persons in accordance with PL 91-646 and corresponding state laws in addition to the purchase price of any property which would be required for the project.

2. Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, which applies to all land purchases for federally assisted projects provides for the following:

a. Every reasonable effort shall be made to acquire real property promptly by negotiation.

b. The owner or his designated representative shall be given an opportunity to accompany the appraiser during his inspection of the property.

c. Before the start of negotiations, an amount would be established as just compensation and a prompt offer would be made to acquire the property for the full amount so established. In no event shall the amount offered be less than the acquiring agency's approved appraisal of the fair market value of the property. The owner must be provided with a written statement which explains the derivation of the amount established as just compensation.

d. An owner would not be required to surrender possession of real property until he is paid the agreed purchase price or in the case of condemnation, until a deposit is made with the court for the benefit of the owner of the amount established by the acquiring agency as just compensation.

e. The construction or development of a public improvement would be scheduled to the greatest extent practicable to give the owner at least 90 days written notice to move.

f. If the acquisition of real property would leave the owner with an uneconomic remnant, an offer must be made to acquire the entire property.

3. Public Law 91-646 requires that all persons displaced by land acquisition action of a federally assisted program be fully advised as to the relocation benefits available to them in order that any adverse impacts would be minimized. In general, the law seeks to provide displaced residents with housing at least equal to that which they were required to vacate.

4. Persons who are displaced must be assisted in moving into other housing meeting minimum standards with respect to decency, safety, and sanitation. All relocation benefits are entirely separate from and in addition to the price paid for the property acquired.

5. The acquiring agency must provide a relocation advisory service which shall:

a. Determine the relocation assistance requirements of those persons displaced.

b. Provide current and continuing information on the availability, prices, and rentals of comparable decent, safe, and sanitary housing for sale or rental and of comparable commercial properties and farms, and locations for displaced business.

c. Assure that within a reasonable period of time prior to displacement, comparable decent, safe, and sanitary replacement dwellings would be available, equal in number to the number of, and available to such dwellings and reasonably accessible to their places of employment.

d. Assist a person who is displaced from his business or farm operation in obtaining and becoming established in a suitable replacement location.

e. Supply information concerning Federal and State housing programs, disaster loan programs, and other Federal or State programs offering assistance to displaced persons.

f. Provide other advisory services to displaced persons to minimize hardships to such persons in adjusting to relocation.

6. Benefits for displaced persons consist of the following:

a. Moving expenses including:

(1) Actual reasonable expenses of moving personal property (for a distance usually limited to 50 miles) resulting from their displacement, such as packing, storage, and transportation costs; or,

(2) A dislocation benefit of $200 and a moving allowance of up to $300, the exact sum to be determined from a schedule established by the District Engineer, instead of reimbursement for actual moving expenses.

b. Direct losses of tangible farm or business property where the cost of moving exceeds the value of the property.

c. Searching expenses to find a new site for business or farm (no searching expense allowed for locating a replacment dwelling).

d. Actual moving expenses for business or farms. (An optional payment for businesses or farms would be allowed in certain circumstances in lieu of actual expenses. This payment would range from $2,500 to $10,000, depending on the income of the business or farm. Businesses would have to meet additional criteria to qualify for this payment.)

e. To homeowners who owned and occupied their homes for 180 days or more prior to initiation of negotiations to acquire the property, a replacement housing payment not to exceed $15,000. This payment would consist of:

(1) The amount which when added to what was paid for the acquired dwelling would equal the cost of a comparable decent, safe, and sanitary replacement dwelling.

(2) Increased finance costs incurred because of higher interest rates on a new mortgage.

(3) Reasonable closing costs paid incident to acquiring the replacement dwelling.

f. Replacement housing payment not to exceed $4,000 for:

(1) Tenants who occupied their homes 90 days or more before initiation of negotiations to acquire the property, homeowners who owned their homes for less than 180 days but at least 90 days and homeowners who have owned their homes for more than 180 days who decided to rent their replacement dwelling. This benefit would be based on the additional rent necessary to rent a comparable decent, safe, and sanitary replacement dwelling over a four-year period.

(2) Tenants of at least 90 days occupancy and homeowners who have possession at least 90 days but less than 180 days who decide to buy a replacement dwelling. This sum would be based on the amount needed for a down payment and closing costs associated with purchasing a comparable replacement dwelling which is decent, safe, and sanitary.

g. Costs of conveying property to the acquiring agency.

7. To obtain any supplemental benefits resulting from the purchase or rental of replacement housing, such housing must be decent, safe, and sanitary and it must be purchased (or rented) and occupied within one year after receiving the final payment for the acquisition of one's existing property or the date of moving from such property, which is later. Further, all applications for benefits must be made within 18 months of the above applicable date.

8. Any homeowner who derives income, such as rents, from Federally acquired property which also contains his residence may be eligible for both the benefits listed above for homeowners and those applicable for business or farm operations.

9. No one can be forced to move from his dwelling as part of a "non-structural" project unless a comparable replacement dwelling which is decent, safe, and sanitary is available to him. In certain hardship cases, supplemental benefits might be paid to persons before their actual expenses occur where such payments are necessary to assure satisfactory and speedy relocation.

APPENDIX D

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APPENDIX D
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