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Business Depth-Damage Analysis Procedures

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BUSINESS DEPTH-DAMAGE ANALYSIS PROCEDURES

by

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INTRODUCTION

Purpose

This research is a comprehensive examination of business depth-damage analysis in the United States. Previous research on business depth damage is detailed, but limited to specific geographic areas within individual Corps of Engineer districts. This study describes and compares these efforts. It describes parameters that significantly affect depth-damage relationships and develops a framework for predicting incidence of business flood damages.

Time, money and personnel constraints make flood damage surveys difficult for individual districts to conduct. This study is intended to help district economists by describing the process, comparing methods and contrasting the depth-damage function measurement criteria in use by various districts. The information in this report can be used to find sources that verify consistency and accuracy of damage functions and provide references for deriving mathematical functions.

This report is primarily intended for economists responsible for the economic evaluation of flood control measures. The survey of procedures described here should broaden the choices for appropriate procedures for evaluating business depth-damage relationships. Planners and hydrologists should gain the knowledge and understanding of the process and considerations economists must make in establishing or choosing, and applying these relationships, which are central to estimating flood damage.

flood plains; est. length *Additional keywords: flood control*
Scope of Study ←

This research examines methods used to assess flood damage to commercial, industrial, and institutional property. Information sources within and without the Corps, including flood damage estimation tools, data bases, and damage function measurements now in use have been analyzed. Procedures for estimating commercial and industrial damages and attitudes of district economists toward further work in this area are assessed.

Contributions came from each Corps of Engineer district office and two divisions offices, the Small Business Administration (SBA), Federal Insurance Administration (FIA), and Soil Conservation Service (SCS). A literature search included many district reports of flood damage computation.

Flood damage estimating procedures are summarized and compared by region. By comparing damage functions for a limited number of enterprises, the reader can find wide variations that occur between the districts.

THE DEPTH-DAMAGE FUNCTION

A typical depth-damage function could take the following form:

$$Y = a + bX + cX^2 + dX^3 + U$$

where "Y" is the dependent variable representing percent damage to structure or content. "a" is a constant representing the percent damage at the first floor level, "x" is a variable representing various powers of water height. Each new power is an inflection point where there is a change in the direction of the curve; "b", "c", and "d" are coefficients representing the relative importance of each power of water height to the regression. Any number of variables with appropriate coefficients can be added to the regression as long as each new variable is significant and is not too highly correlated with other independent variables.

"U" represents a random disturbance. The random disturbance includes both positive and negative deviations from the regression line. One cause of this disturbance is sampling error. The sample may be biased towards a particular group in the population. A second type of error is in specification. This can be due to omitting variables, adding variables that do not belong, or by having the incorrect mathematical format of the equation (i.e., the correct powers of variables should be specified, or the equation sometimes should be in a logarithmic form.) Finally, there are errors of measurement. These errors may have occurred while surveying, coding, or rounding. The errors described above can never be completely eliminated. Whenever regression analysis is used, it is necessary to apply some judgement in screening the data and interpreting the results. Post-flood data is not often plentiful for water heights outside the range of minus 4 to 5 feet above the first floor. When the data is sparse, little can be done except make an educated judgement of the likely damage. Screening is also necessary to eliminate extreme values that seem to have no basis in reality.

It should be noted that there are alternatives to regression analysis in determining the depth-damage relationship. Depth-damage curves can be determined by simply making a breakdown between water height and percent damage. Curves may be drawn using scattergrams of other curve-fitting techniques. These methods, however, are limited to one explanatory variable. These methods also do not give the t statistic for testing the significance of each variable. Also, they do not give confidence intervals for determining the range of values. The true value of a population is likely to fall within a confidence interval for a given probability. Finally, only regression analysis gives the R squared statistic, coefficient of determination, which shows the percentage of variance in the curve that is explained by the exogenous variable.



Use of Depth-Damage Functions

Whenever depth-damage relationships are computed, it is initially presumed that there is a reliable correlation between depth of water in businesses or public buildings and the percentage of flood loss to the value of the building's contents and structure. Predictable depth-damage relationships can be used to estimate the amount of damage from any given level of flooding, and consequently, assess the benefits of flood damage alleviation. There are several business depth-damage relationships now in use throughout the Corps of Engineers. These procedures developed from the special needs of each district, with relationships varying with geography and particularly with the type of flood which was typical of each region.

Depth-damage functions are used to compute the probable damage from a given level of flooding. Depth-damage functions are computed separately from structure and content for various categories of enterprise. The functions are predictors of either direct-dollar loss or percent value lost through a flood event. Damage functions can be applied to structures on an individual basis. The use of depth damage functions can be further illustrated by several graphs (Figures 1-4) that show how damages are determined by frequency for each reach. Figure 1 is the elevation-frequency curve, which tells us the frequency of flooding for each elevation. The graph indicates the percent chance of each elevation being inundated in any given year. Field surveys are then used to determine the value of property for each elevation. Value should be determined for each structure type and type of business for both structure and contents. Depth-damage functions are then applied to determine the potential damage for each elevation. This information is then combined with the elevation-frequency functions to establish a damage/frequency curve. For most districts, calculations are now performed using one of the computer programs described later in this report.

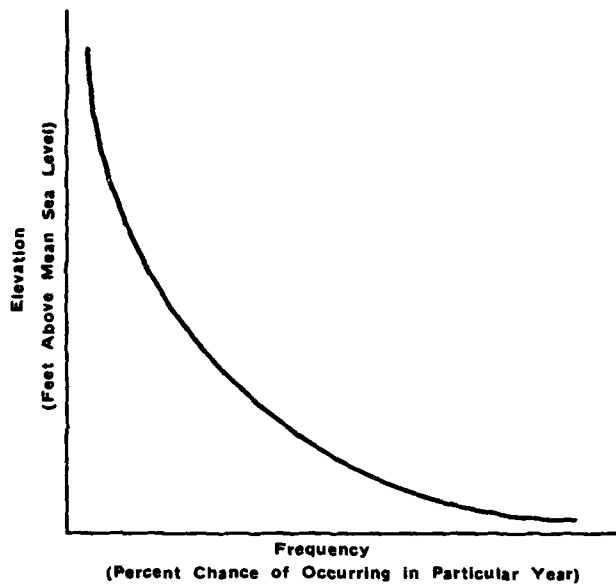


Figure 1

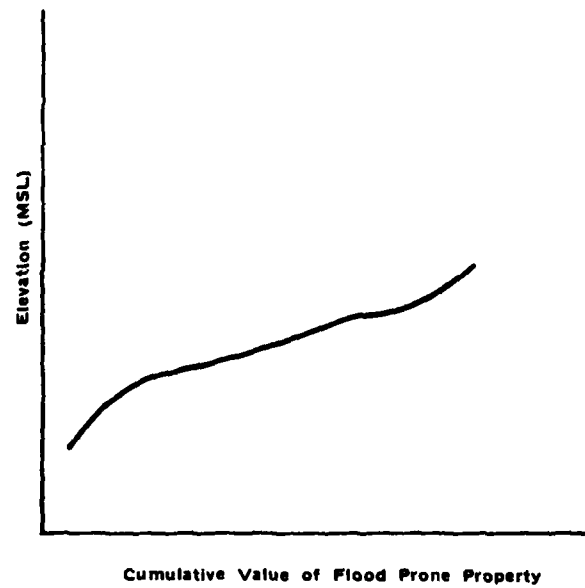


Figure 2

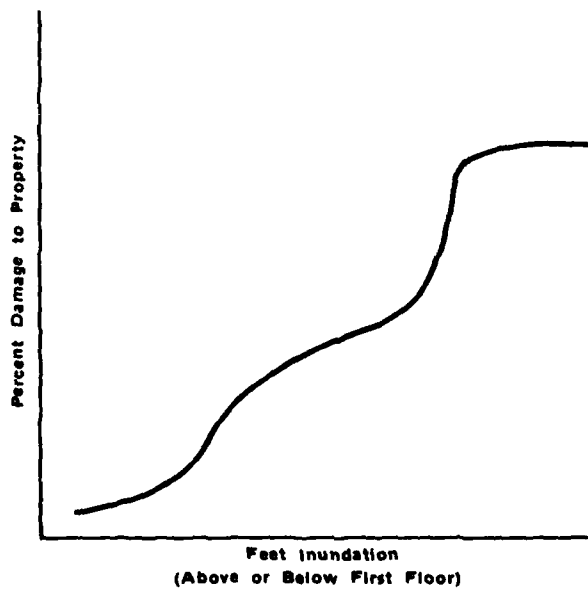


Figure 3

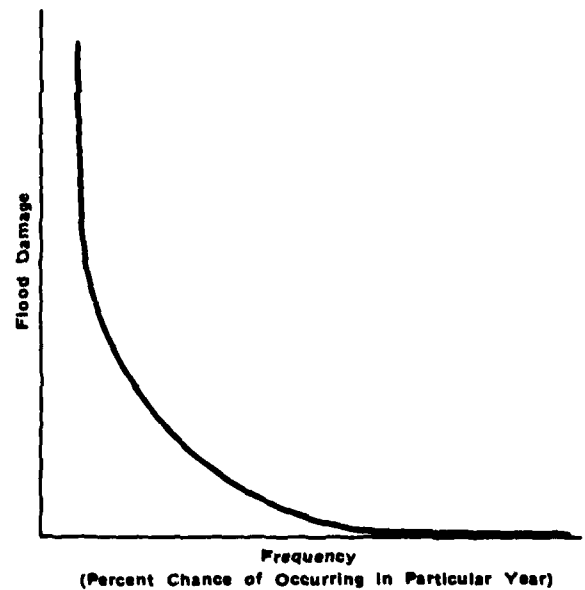


Figure 4

COMPUTATION OF DEPTH-DAMAGE RELATIONSHIPS

Depth-damage relationships can be computed by a regression equation with the percent-damage to structure or percent-damage to content as the dependent variable. Water height is the most important, and can be the only independent variable, in the regression. Water height accounts for the greatest variation in the percent damage-equation. Other variables that may be important in the regression are type of construction material, structure, age and condition of the building, square-footage; and velocity, sedimentation, salinity, and duration of the flood waters. However, except for structure type, these variables have seldom been isolated for any flood damage analysis in the United States. Sometimes structural and content-damage are computed as a combined total. Business inventory damages are often computed separately from damage to equipment and other fixtures.

For residential damage analysis, depth-damage computations are computed separately by structure-type. Structure-type categories are determined by the number of stories, and whether or not there is a basement. Basements are another factor. For commercial and industrial areas, depth-damage functions are computed for each type of business or activity. The business types can be broken-down by two, three, four, or even five-digit Standard Industrial Classification (SIC) codes or a rough equivalent of SIC codes that groups businesses with homogeneous damage relationships.

Actual dollar damage can be computed as an alternate percent-damage relationship. Where actual dollar loss is used as the independent variable, the price level needs to be adjusted by the time elapsed from the time and place of computation to application. A price index should be selected carefully. A useful national index would be the Department of Commerce Composite Construction Index, published monthly in the Survey of Current Business. Marshall and Swift Inc., the Boeck Company, and the American Appraisal Company all publish regional construction cost indexes. For example, if Vicksburg District wanted to make use of flood dollar damage curves for New Orleans in 1977, it would need to adjust the price level to its study area for 1983.

Categories of Building Structure

Residential damage functions are generally divided into seven categories, as modeled after the Federal Insurance Administration's original work: single story with and without basement, two or more stories with and without basement, split level with and without basement, and mobile homes. Significantly different damage relationships have been identified for all these categories. There is no reason to suspect that non-residential property cannot be divided into similar categories; although non-residential property may differ in the proportion of structures having basements, there may be a considerable proportion of business property more than two stories high, and there are very few non-residential properties occupying mobile homes. Similarly, separate damage functions can be established for construction material. For example, Mobile District's damage functions for the Pearl River include brick and block, wood, and metal structures, single and multiple stories.

Any category can be added to this list where there is a significant population of structures and a predictable relationship can be established for the structure type.

Critical Variables Affecting Business Damage Functions

Business depth-damage relationships are influenced by a number of variables. If variables are tested and found to be significant, they can be used to compute more reliable depth-damage relationships. Type of business and relative size of the structure are critical to any business-damage functions. Many types of commercial businesses - such as clothing and liquor stores - share structural damage curves but have different content curves. At the same time, a library and a bookstore might share the same content damage functions.

Size is a significant variable. Depth-damage relationships for a small food store may vary more from a large supermarket than a small pharmacy. Each business damage relationship should distinguish between small, medium, and large businesses.

Other important variables directly affecting structure damage include construction material, age and condition of the buildings. These are variables that have received little attention in the United States. However, Penning-Rowse and Chatterton (see Bibliography) have isolated some of these factors and built them into separate depth-damage functions at least for residential property. The homogeneity of the flood occurrence in Great Britain, in contrast to the great variety in the nature of flooding in the United States, makes it easier to isolate the non-hydraulic factors that account for variability in the depth-damage relationship.

The following is a table of factors: hydrologic, structural and institutional, that significantly effect the extent of damage from a given flood elevation. People involved in flood damage assessment are probably aware of most of these factors. However, with a few exceptions, these factors have never been given close analysis in terms of quantifying the effect that these factors actually have. Development of coefficients for these factors, or separate damage functions, would be an extremely expensive task. Even if the effects of these factors could be measured, they may not always be consistent enough for general application. That is something we have little data on; it still needs to be tested. Until such time when the effect of these factors can be adequately quantified, it is important to be aware of them, their direction, and relative magnitude. They can prove useful in selecting the most appropriate functions to apply in judging the validity of survey data.

Table 1
Variables in the Depth-Damage Relationship

VARIABLE	EFFECTS
<u>Hydrologic Variables</u>	
velocity	Velocity is a minor factor aggravating structure and content damage. It limits time for emergency flood proofing and evacuation. Additional force creates greater danger of foundation collapse and forceful destruction of contents.
duration	Duration may be the most significant factor in the destruction of building fabric. Continued saturation will cause wood to warp and rot, tile to buckle, and metal objects and mechanical equipment to rust.
sediment	Sediment can be particularly damaging to the workings of mechanical equipment and in creating cleanup problems.
frequency	Repeated saturations can have a cumulative effect on the deterioration of building fabric and the working of mechanical equipment. However, people exposed to more frequent flood situations may be more likely to respond to flood emergency warnings.
<u>Structural Variables</u>	
building material	Steel frame and brick buildings tend to be more durable in withstanding inundation and less susceptible to collapse than other material.
inside construction	Styrofoam and similar types of insulation are less susceptible to damage than fiberglass and woolfiber insulation. Most drywall and any plaster will crumble under prolonged inundation. Waterproof drywall will hold up for long floods. Paneling may be salvageable when other wall coverings are not.
condition	Even the best building materials can collapse under stress if the construction is poor or the condition is bad. Building condition should be a major determinate of depreciated replacement value.
age	Age may not be a highly significant factor in itself, except that it may serve as an indicator of condition and building material. It would be more accurate to survey the other factors separately.

Table 1 (con't)

arrangement of
contents

Content location is an important factor in determining depth-damage relationships. These relationships could be expected to be somewhat homogenous for commercial business, particularly chain stores. Industrial property should be surveyed individually to determine how the arrangement of contents will affect the depth-damage relationship.

Institutional Factors

flood warning

Major reductions in both content and structural loss can be made through flood fighting and evacuation activities when there is adequate warning.

REGULATION AND GUIDANCE

The Federal directive on flood reduction benefit calculation is found in the Water Resource Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation, approved by the President, 3 February 1983. The Principles and Guidelines (P & G) are intended to serve as guidance and not as specific or stringent planning evaluation requirements. Corps' district offices have latitude in the planning and evaluation procedures as long as the general guidelines are followed.

The procedures in the P & G most relevant to business flood damage analysis are as follows:

STEP ONE: DELINEATE AFFECTED AREA

The affected area is broadly defined as the entire metropolitan area when industrial property is involved. Otherwise, the affected area is confined to the floodplain and nearby areas considered as alternative sites for the activity that would use the floodplain, if protected.

STEP TWO: DETERMINE FLOODPLAIN CHARACTERISTICS

The floodplain should be surveyed to determine all relevant hydrologic, environmental, and economic characteristics. In addition to defining the actual flood boundaries, the likely depth, duration, and debris loads of the stream should be defined. Transportation and utilities are important for the economist to define in predicting potential damage. Most important is an inventory of existing activities that defines activity type (land use), value and age of structure in the floodplain, and more generally, the density per acre of each type of development.

STEP THREE: PROJECT ACTIVITIES IN AFFECTED AREA

Forecasting should begin with a look at existing demographic and economic projections. The P & G emphasize that new projections may depend on how plans can affect potential uses of the floodplain and the sensitivity of the plan to projections. Local officials should be consulted, in any case, to verify historical trends.

STEP FOUR: ESTIMATE POTENTIAL LAND USE

In this stage, estimates of land use potential are examined at a level of detail that is consistent with project needs.

STEP FIVE: PROJECT LAND USE

Land use projections should be made for both with and without project conditions. The characteristics of the land with and without the project should be compared with those characteristics sought by potential users. Floodplain use should only be identified cases where there is significant economic advantage, and that advantage is significant enough to justify the flood control plans.

STEP SIX: DETERMINE EXISTING FLOOD DAMAGES

The P & G stress the need to scrutinize historical flood data and to obtain up-to-date property appraisals. They encourage using area-specific depth-damage information. However, they also recognize the possible deficiencies of historical records due either to changes in hydraulic conditions, new development or lack of flood experience. Damages by activity can be estimated using "integration techniques and computer programs that relate hydrologic flood variables such as discharge and stage to damages and to the probability of occurrence of such variables." Previous Corps' Engineering Regulations did not specifically endorse the use of standard depth-damage relationships. But in practice, OCE and the Board of Engineers for Rivers and Harbors (BERH) encourage use of well-substantiated standard depth-damage functions, even if the functions are generic national curves or relationships developed for another area of the country.

STEP SEVEN: PROJECT FUTURE FLOOD DAMAGES

The P & G require a complete explanation of the projected flood damage for projects that are not economically justified on the basis of existing conditions, or where projected benefits may significantly alter the cost allocation for cost-sharing arrangements. Otherwise, the description of the future benefits can be abbreviated. The P & G further describe how future benefit evaluation must depend on estimating the number, size, value, and susceptibility of future units.

An increase in the value of residential contents can be expected from flood protection. An increase in income level of project area residents, known as the "affluence factor," can be used to increase projected content values up to 75 percent of the structural values, and beyond 75 percent if substantiated by empirical evidence. Regulation specifically states that the residential contents procedures does not apply to commercial or industrial property. There is, however, "recognized precedence," for a business affluence factor. An example is in the BERH review of the Phase 1 General Design Memorandum for the James River Basin at Richmond, Virginia. The Board acknowledged a 1.9 percent real growth rate in the value of non-residential property. While neither the existing guidelines nor previous E.R.s encourage use of a commercial/industrial affluence factor, the projected content value increases were accepted, based on information from area business leaders and historical data on increases in industrial and commercial contents. (Anderson, Thomas, "Summary of Issues and Coordination during BERH review of Phase I General Design Memorandum, James River Basin, Richmond, Virginia," Memorandum for Record, Ft. Belvoir, Va. June 1981). In 1977, IWR published the study: An Empirical Investigation of the Existence and Magnitude of a Commercial and Industrial Affluence Factor. This study of content-labor ratios on the Ohio River found insufficient data to make any judgement regarding commercial property. Industrial data indicated that there was a tendency to upgrade industrial equipment beyond what might be expected, but the results were not conclusive enough to establish an industrial affluence factor. More research was advocated. Once future value estimates are established, districts are encouraged to consider local flood characteristics of velocity, duration,

volume, debris load, and salinity along with the construction material and the nature of flood-proofing and flood-warning activities. In practice, when depth-damage functions can be found that are comparable to those that would occur in the study area, the functions have been accepted in the review process. Income loss reduction for business firms in the area where the loss occurred can be counted when the loss cannot be recovered at another location or at another time by the same firm.

STEP EIGHT: DETERMINATION OF OTHER COSTS OF USING THE FLOODPLAIN

The P & G give examples of costs of occupying the floodplain other than direct flood loss. These may include flood proofing, flood insurance cost, and the cost of modifying the use of the property.

STEP NINE: COLLECT LAND MARKET VALUE AND RELATED DATA

This step includes the procedure for calculating the benefits of a project due to changes in land use or more intense use of existing development.

STEP TEN: COMPUTE NATIONAL ECONOMIC DEVELOPMENT BENEFITS

This step summarizes the National Economic Development Benefits (NED), benefits categorized from an urban flood protection project. The categories include inundation reduction benefits, intensification benefits which reflect a more intense use of property with the same land use, and location benefits which reflect an increase in property market value and income level due to changes in land use brought on by the project.

SPECIAL PROBLEMS IN ANALYSIS OF BUSINESS PROPERTY

Relative Importance of Non-residential Damage

While standardized depth-damage functions are usually applied to residential flood damage, business depth-damages are far more often assessed on an individual basis. Business damages deserve more attention per unit because the character and susceptibility of non-residential property can vary widely for each type of business. The value per unit is also much higher. Commercial development is the highest economic use of property because it is valued higher per square foot than any other land use. It is also susceptible to the greatest flood damage per square foot.

Variability of Flood Damage

Content Damage

In their 1977 report, The Benefits of Flood Alleviation, Penning-Rowell and Chatterton (Ibid., p. 38) put potential loss to a typical grocery store in England at nearly 250 pounds per square meter - or nearly \$50 a square foot - for inundation of six feet of floodwater. Content damage was analyzed by D. J. Parker in 1973. Susceptibility ranged from 55 percent for liquor stores to 100 percent for perishable food and reading material in property that was completely submerged (ibid, p. 40-41).

Business structural damage is more homogeneous than content damage. Huntington District, for example has recently adopted standard structural damage functions for both industrial and commercial property. It also has rejected standard content damage functions. Huntington's standard structural damage functions are based on construction material and square feet. Buffalo District's structural surveys, which were done by the Hydrology Branch, include a very detailed analysis of variance in the first floor level and permeability of the building fabric and entryways.

Industrial Damage

Industrial property damage also relates to products and equipment. Penning-Rowell and Chatterton's estimates ranged from 33 British pounds per square meter (or more than \$6 a square foot) for mean damage to the food, drink and tobacco industries. Mean damage was more than 84 British pounds per square meter (or \$16 square foot) for the metal and engineering industries. These figures compare to an average of about 50 pounds a square meter or approximately \$9.50 per square foot for residential property.

Industrial and institutional damage analysis is complicated by the limited experience of each Corps' district. Every district has a wealth of experience in working with residential and commercial property, but many have not had to deal with a variety of industrial properties. Several Corps' districts, including Galveston and Fort Worth, use general damage curves to estimate commercial damage. But they would not consider such generalizations for industrial property since each location is so different. Other district economists are inclined to adopt standard commercial damage functions, but also would not consider standard industrial relationships.

Production Loss

Other "business losses" include the costs of unused capital, labor, and lost profit or non-recoverable production or sales. "Non-recoverable" is a term with no absolute definition. Several district economists classified determination of non-recoverable business loss as an "art" and not a "science".

One major criterion is whether the firm has the time to make up the production loss, or lost sales. For example, a manufacturer who operates on a 24-hour production schedule would have a difficult time making up the loss. In the other extreme (in a flooded clothing store), customers could either delay buying the product or the sales could be made by another outlet of the chain in the vicinity. When a customer has to travel extra distance to make his purchases, or a product has to be brought in from a distant location, business loss would be computed from the additional transportation expenses.

Robert Kates gave a thorough explanation of production loss determination in his study, Industrial Flood Loss Damage Estimation in the Lehigh Valley, University of Chicago Press, 1965. Kates was encouraged that the similarity of the production process between industries should make it easier to determine and apply flood production loss functions. Field interviews were used to estimate potential production downtime and the amount of capital stock and labor that would be idle. Production losses were then determined by combining stage outage functions with daily production. Kates distinguished between loss to the establishment and loss to the nation. Permanent production losses and the costs of deferred or transferred production were considered national costs. Permanent loss included the fixed and variable costs, profits, and returns to the employees. These costs can be estimated by determining the value added by the activity. Deferred or transferred costs were estimated at two percent of the value of product. (Kates, *ibid*, p.53)

Damage to Business Records

Unfortunately, many businesses keep their only copies of tax, sales, and inventory records in flood-prone locations. When flood waters destroy records, it takes many days to replace them. Costs should be estimated by computing the opportunity value of the labor required to replace the records.

Non-physical and Emergency Costs

One of the most thorough studies of non-physical property loss was Louisville District's post-1978 flood study in Frankfort, Kentucky. This study calculated that non-physical damage accounted for nearly \$10 million dollars, or approximately 20% of the total damages in the 1978 flood. Over half of those costs were the loss of employee wages and costs borne by government agencies during administration of flood damage repair and non-emergency disaster relief programs. The Frankfort study also made a thorough accounting of income, rental, and employment loss to businesses, transportation costs, income loss, administrative cost and repair costs for public utilities.

Emergency costs were distinguished from other non-physical costs. They accounted for \$6.6 million or 13% of the total costs of the 1978 flood. Emergency costs included the administrative costs of disaster relief agencies, the direct costs for flood fighting activities, evacuation, transition, and reoccupation costs (which are primarily related to residential costs); law enforcement and health related activities; and the administrative costs of handling the emergency.

Louisville District developed non-physical and emergency damage functions for flood fighting on the Kentucky River at Frankfort. The damage functions are aggregations and cannot be applied directly to other areas. What can be followed, however, is the thorough exercise of counting all the emergency, administrative, and other non-physical costs which are often not assessed.

Care should be taken to insure all the variables are well-defined and that none of the costs are double-counted.

PROCEDURES FOR BUSINESS DEPTH-DAMAGE ANALYSIS

There are three basic measures for estimating depth-damage relationships for individual projects. These include the applications of generalized damage functions, post-flood damage surveys, and synthetic depth-damage estimation. All three of these generalized measures are well-used and have their own advantages and drawbacks. This section describes how each of these measures are used and gives suggestions on how they can be implemented.

An important factor in determining depth-damage functions is that they are seldom linear relationships. Curves will most often be quadratic or cubic, with one or two inflection points indicating a change in the marginal rate of flood damage at that water height. The shape of damage functions is an excellent guide to test the validity of each application.

Generalized Damage Functions

Generalized damage functions can be computed from either post-flood surveys or synthetic estimates. In some instances, application of generalized curves can be just as accurate as building-by-building estimations, and it is always far less expensive and less time-consuming to apply. Generalized functions can be developed by a district for one project -- or at the other extreme -- can be developed for the whole nation. For example, most residential analysis within the Corps is based on flood damage functions from the Federal Insurance Administration's (FIA) flood claims file for 1974. Whenever generalized curves are applied, they should be field-checked. Every area should be surveyed to determine if the damage functions are applicable. Building material and condition of the structures are particularly important. Masonry structures, for example, can generally withstand flood damages much better than cinder block and frame buildings.

Seasonality can also be an important factor in application of commercial and industrial damage content functions. Building material is a prime example of a product that might be stocked more heavily in the spring and the summer. Dry good inventories are especially high just before Christmas. The user of these procedures should be aware of whether the generalized damage functions apply to any particular season. Just as with agricultural damages, commercial and industrial damages can vary with seasonal probability.

A final problem with the application of generalized damage functions is the difficulty in accounting for the effects of flood warning. Content damage and damage to outside vehicles can both be substantially reduced when there is sufficient time available. In his 1964 book, Choice of Adjustments to Floods, Gilbert White describes his study of LaFollette, Tennessee, in which he determined the percent dollar damage loss avoidable at various water heights to residents, restaurants, and groceries. He also accounted for the effects of the number of hours lead-time, duration of flooding, flood frequency, and flood velocity in determining avoidable flood damage. White's estimates are merely an example of what a district might use in analysis of potential effects of flood warning.

Post-Flood Damage Surveys

Post-flood damage surveys have long been believed to be the most reliable way of predicting flood damage. The post-flood surveys that have been done provide a wealth of information. When there has been an opportunity to conduct them, the surveys have been very thorough, and can be of greater value for estimates of future damage. Even so, detailed flood damage surveys are far from being a matter of course. There are often inadequate funds and time to do the job, or just lack of specific authorization to study the area.

Post-flood surveys, like all other large surveys done by the Government, must be done with a set of questions approved by the Office of Management and Budget (OMB) to comply with Public Law 77-831, the Federal Reports Act of 1942, as interpreted by Army regulation 335-15. In 1979, OCE gained approval for several sets of questions which included nearly everything anyone would want to ask in a post-flood study. The questions are published in a compendium of OMB approved questions (U.S. Army Engineer Institute for Water Resources, 1984). The approved questions are found in Appendix A of this report. The questions must reference OMB approval No. 49-R0363. Questions should be selected carefully. The questionnaire should not be too long, yet it should still be thorough enough to cover all important details about flood damage and the nature of the flood hazard.

Post-flood surveys, potentially, at least, elicit greater cooperation from those being interviewed than in synthetic damage analysis. People are aware that they have a flooding problem -- having just experienced one -- and are generally more than willing to talk about it. The flood victim can better judge the full extent of his loss than someone who is making a synthetic estimate. Occasionally, someone may be concerned that his casualty loss claim to the Internal Revenue Service is being investigated.

Penning-Rowse and Chatterton claim, however, that post-flood damage assessment is notoriously unreliable. They claim that post-flood damage surveys tend to underestimate damage that may not be apparent until months after the flood event (Penning-Rowse and Chatterton, 1979, p.2). This claim was borne out by the experiences of this author in post-flood surveys of River Des Peres in St. Louis, Missouri. Many victims claimed that damages to furnaces, refrigerators, floors, walls, carpeting and insulation did not show up until it was too late for them to make flood relief claims. The "hidden damage problem" would be largely solved by waiting until one year after the event so that most heating and air conditioning equipment and insulation will have a chance to operate. The effects of rust, mildew, and warping, will then have run their course. The memory of loss, and the damage record should still be around after a year.

Post-flood surveys yield only one damage point for each building. For damage categories with limited cases, it may be necessary to combine post-flood surveys with synthetic damage-estimates to obtain depth-damage functions.

Synthetic flood Damage Approximation

Where there is no recent flood history, damage estimates can be synthesized by survey of damage potential at various water heights.

Synthetic damage analysis is often the only way to compute flood loss potential. This type of survey has gained a great acceptance and is used by most Corps' districts in figuring cost/benefit or specific control projects. Synthetic damage surveys can be done with the same set of OMB-approved questions described previously for post-flood surveys. Damages can be computed at several levels of potential inundations, an adequate number to determine damage functions for every structure.

Synthetic damage estimates have a number of difficulties. The most severe is the time and money involved. Synthetic flood surveys can take anywhere from 30 minutes for a small commercial structure to two days for a large industrial complex.

Due to their hypothetical nature, synthetic damage relationships should be done by people very experienced in post-flood surveys. The surveyor should be familiar with what is and isn't damaged in a flood. Direct loss to buildings, fixtures and inventories is relatively easy to estimate, compared to damage to outside property, damage to business records, clean-up and emergency costs, business closing costs, and traffic rerouting. Each of these items is much simpler to estimate from the benchmark of a previous flood. In any case, attempts should be made to compare the validity of synthetic damage estimates with similar post-flood experience.

Two further problems with the synthetic estimate process are the high dependency on the store manager's or the plant manager's ability to make susceptibility estimates and their cooperation in making these estimates. Both these problems are particularly serious with synthetic damage estimates.

A refinement of the synthetic damage estimation process was suggested by Robert W. Kates in his 1965 study of the Lehigh Valley. Citing the 1960 Stanford Research Institute's report on flood loss in California, Kates commented on the problem of high variance in the nature of flooding and susceptibility in using generalized functions. In his report, Kates described the process that was used in a detailed synthetic survey of the Lehigh Valley. The study included taking elevations at several points within each building, noting window elevation and critical damage levels for equipment, other fixtures, and inventory. Plant officials gave the gross values of buildings and contents. Depreciation was then deducted from the value of buildings and equipment and salvage values were determined for merchandise and raw material. Depth-damage curves were then computed for each structure with inflection points determined by critical points of damage for equipment, storage of valuable inventory and the height of building openings. Kates showed equipment and inventory damage functions for one industrial plant. Both curves had two inflection points where there were significant changes in the rate of property damage increase. These damage functions were combined for structure, content and production loss for a series of selected flood stages.

Many Corps' districts use procedures similar to that used by Kates. The surveys have the same general purpose, but vary significantly in detail, particularly in questions dealing with secondary or indirect flood loss, such as production loss or transportation rerouting.

Flood Survey Variables

For the purposes of consistency in business post-flood and synthetic damage surveys, it is suggested that a set of variables with standard definitions be established for business damage surveys. Below is a proposed set of definitions. These should not be taken to preclude any other definitions for variables that might be applicable to business damage surveys.

Name of Business

Type of Business - One to four word description of the type service provided or the nature of the product manufactured, transferred, or sold.

SIC Code - Three digit product code as defined by the 1972 Standard Industrial Classification Manual, published by the Office of Management and Budget.

Community - City, town, or county (as specific as possible).

State

Drainage Basin - specific stream of immediate drainage basin, and the major river basin of which it is a part.

Type of Flooding - Check all that apply: overbank flooding, poorly drained land, high groundwater, hurricane or tropical storm, flash flooding from heavy rainstorm, area of consistently heavy rain, snowmelt and ice blockage, tsunami, sedimentation, non-permeable soil, rock and earth slide, storm surges, over-irrigation, and sheet flooding.

Complicating Factors - Frequency of inundation (percent chance of flooding occurring in any one year), duration of flooding (the amount of time the structure is inundated per given flood frequency), velocity (probable cubic feet per second at the building location for given elevation flood), sediment load, and poorly defined flood plans (victim unaware of flood threat).

Value of Buildings - Depreciated replacement value of buildings (exclusive of any land value).

Description of Buildings - Single story with or without basement, two or more stories with or without basement, split level with or without basement, and trailer.

Construction Material - Outside material: brick, wood (indicate type of siding used), steel, or block.

Condition - Good
Fair
Poor or Dilapidated

Size - Number of square feet for each building.

Age - Number of years since building opened.

Value of Inventory - Depreciated value of merchandise or raw materials. Value is figured at costs to business or institution.

Description of Inventory - Brief description of material used in production, or handled or sold by business or institution.

Value of Equipment and Fixtures - Items not legally defined as real estate, but permanently stored or used by business or institution. Value is determined by depreciated replacement cost to business or institution.

Description of Equipment and Fixtures - Listing of types of equipment and fixtures used in business operations.

Value of Contents - Combined value of inventory and equipment.

Damage to Structure - Estimated cost of restoring building to pre-flood condition.

Damage to Inventory - Depreciated replacement value of damaged inventory less marketable salvage value.

Damage to Equipment and Fixtures - Depreciated replacement value of damaged equipment less marketable salvage value.

Damage to Contents - Combined total of inventory, equipment, fixture damage.

Water Height - Number of feet above or below the first floor of each structure.

Cleanup Hours - Number of hours spent for each given salary level. This would include additional administrative tasks, as well as actual cleanup expenses.

Cleanup costs - Product of hours spent by salaries of individuals involved. Cleanup costs should also include material costs, plus the costs of any contract services.

Closing time - The amount of time the operations were either shut down, or the capacity was limited to some degree.

Payroll Loss - Number of employees out of work, length of time, and wages.

Unutilized investment - Estimated value of land, buildings, inventory, fixtures and equipment, multiplied by the amount of down time, the interest rate, and the probable return on investment.

Emergency Hours - The number of hours spent to minimize the potential flood loss, by attempting to prevent the floodwaters from entering the building, and by moving potentially damageable items.

Emergency Costs - Product of hours spent in emergency operations and the salaries of the individuals involved.

TOOLS FOR ANALYSIS

The following is a set of tools important for business depth-damage analysis.

Real Estate Appraisal

Accurate flood damage assessment cannot be done without property appraisal. Detailed flood surveys of every building can be made based on historical flood losses or damage estimates made for hypothetical flood levels. However, any application of depth-damage relationships, whether for general use or one particular study, requires an accurate property appraisal. Appraisal is as important as hydraulic frequency curves and depth-damage functions in accurately determining the benefits of a flood control project. Appraisals are easily obtained from community real estate assessments. Assessments are usually given separately for land and improvements. Where land and improvements are listed together, real estate agents can generally furnish appraisals of undeveloped lots of comparable size and with access to utilities in the same areas.

Very often the appraisal information is significantly out-of-date. Adjustments can be made in the price levels to account for the time periods since the appraisals. When appraisals are made, they may not have been made at 100 percent of the market value. Sometimes a fixed percentage is used and adjustments can be made accordingly. In any case, discussions should be held with local real estate agents to compare the average market values of businesses of various sizes and conditions.

Another source that is used by several districts is the Marshall Valuation Service. Marshall and Swift documents can be used for obtaining replacement costs for building construction in various parts of the country. Local construction cost multipliers are listed for masonry and frame construction for all state and large metropolitan areas and most medium-size communities. Square and cubic foot construction costs are given for foundations, flooring, walls, roofing, heating systems, plumbing, building appliances, as well as garages and outside property. The guides are updated quarterly and available on computer.

The service can be particularly useful in hypothetical flood damage assessment. The cost of replacing nearly every type of building fabric can be determined. At various elevations, susceptibility indexes and values can be applied to determine the cost of replacing the building material. Susceptibility indexes are described below. Marshall Valuation Service is published by the Marshall and Swift Company in Los Angeles, California.

Field Sampling Procedures

Sampling procedures can generate enormous cost and time savings with little significant loss to the accuracy of the final product. The potential of several sampling techniques should be evaluated for various types of flood loss. This work unit would focus on flood damage assessment to both urban and agricultural property. Comprehensive surveys would be made of



the study areas for both post-flood and synthetic damage situations. Post-flood surveys can include a number of areas that were flooded during late 1982 and 1983.

Various types of sampling techniques can then be applied and evaluated for the reliability at which the samples compare to the comprehensive surveys. Formulas for computing optimal survey size would be recommended, along with ways of determining sampling groups and damage classification. This work would require the heavy involvement of field offices that have experienced recent flooding and are willing to try new methods for flood damage assessment.

Susceptibility Indexes

Susceptibility indexes are a measure of destruction to the value of a product when it is inundated. D.J. Parker's susceptibility indexes do no more than any depth-percent damage function at levels of inundation. What Parker's susceptibility index does illustrate is that many items have salvage value after inundation. Other than this, there has never been any thorough study of the salvage value of various building materials, equipment or inventories. Educated judgments of material losses are made for hypothetical flood damage estimates. Corps' economists and even insurance adjusters that are making these estimates may have a wealth of experience on which to base their judgments, but they are still made without a statistical basis. Adequate susceptibility indexes can be developed from post-flood samplings of building materials, fixtures, and inventories. Surveys should be done far enough following a flood event that all the flood damage is apparent. Susceptibility indexes should be applied to hypothetical flood damage estimates to verify generalized damage functions.

Building Collapse Curves

The variability in the susceptibility of building materials is well illustrated in the Portland District's building collapse curves developed for its study of the Willamette River System. The curves are found in Appendix C. The report estimates the condition that would be likely to cause a complete collapse for four classes of buildings for given depths and velocity of flooding, and number of stories of buildings. The building collapse curves indicate that velocities of up to 6 feet per second can make even the strongest buildings collapse when the water is 10 feet above ground. This set of building collapse curves is specific to the hydraulic conditions and the building construction in the Willamette Valley area.

Fire Insurance Rate maps

The Sandborn Map Company of Pelham, New York maintains a series of detailed maps that cover every city in the United States. The maps show the outline of every permanent structure at the scale of one inch to 50 feet for central business districts to one inch to 200 feet for less congested areas. The maps give the use, construction material, and number of stories of each building. The maps are drawn to scale so that physical dimensions can be measured from the maps. The age of the maps varies considerably, but there are many large cities that are updated annually.

Flood Damage Computation Programs

Many Corps' districts have their own computer programs to calculate flood damage. The programs have advantages and limitations geared to the needs of each district. This section describes the programs district economists may want to consider in analyzing commercial and industrial flood damage.

HEC Programs

The Hydrologic Engineering Center (HEC) has three flood damage evaluation programs. Structural Inventory for Damage Analysis (SID), Damage Reach Stage Damage Calculation (DAMCAL) and Expected Annual Flood Damage Computation (EAD). The linkage of these programs is shown in Figure 5, taken from the SID Users' Manual.

SID is the newest of the three programs. It has been applied in Detroit, New York, St. Louis and Little Rock Districts. SID was developed as an alternative to DAMCAL. It can be used to assess damage to individual or small groups of structures. SID can be used with spatial data management systems. Input to SID includes: (1) a structure ID, (2) a damage reach assessment, (3) the reference flood elevation, (4) the stage damage function assignment, (5) a structure reference elevation, and (6) a damage category assignment. The outputs of SID are elevation damage functions for each damage category.

DAMCAL accomplishes the same output as SID, with somewhat grosser input. DAMCAL uses existing and future land use categories and average values at various elevations of damage categories. DAMCAL was written to feed into the EAD program for managing spatial data for use in quick comparison of alternatives for structural or nonstructural plans.

SID and DAMCAL are linked to EAD, either manually or through a linkage program called HECDSS. EAD computes average annual damages and inundation reduction benefits based on information on flood plain management plans and stage frequency values. Damages are shown by land use and reach for existing conditions with and without the projects.

Baltimore District

DAPROG II was recently developed by Baltimore District to compute stage damage figures for commercial and residential property. It also computes utility and emergency costs. Estimated replacement values and elevations of each structure are calculated for the program along with stage frequency and depth-damage functions. The results are entered manually into HEC's EAD program to compute average annual damages.

Fort Worth District

Fort Worth District uses a series of flood damage programs that are a modification of a model developed by Albuquerque District. The program can be used to compare the average annual benefits of a range of flood control alternatives. Stage damage curves can be determined from a sampling of commercial, industrial, and public buildings or taken from damage functions that are otherwise used by Fort Worth District.

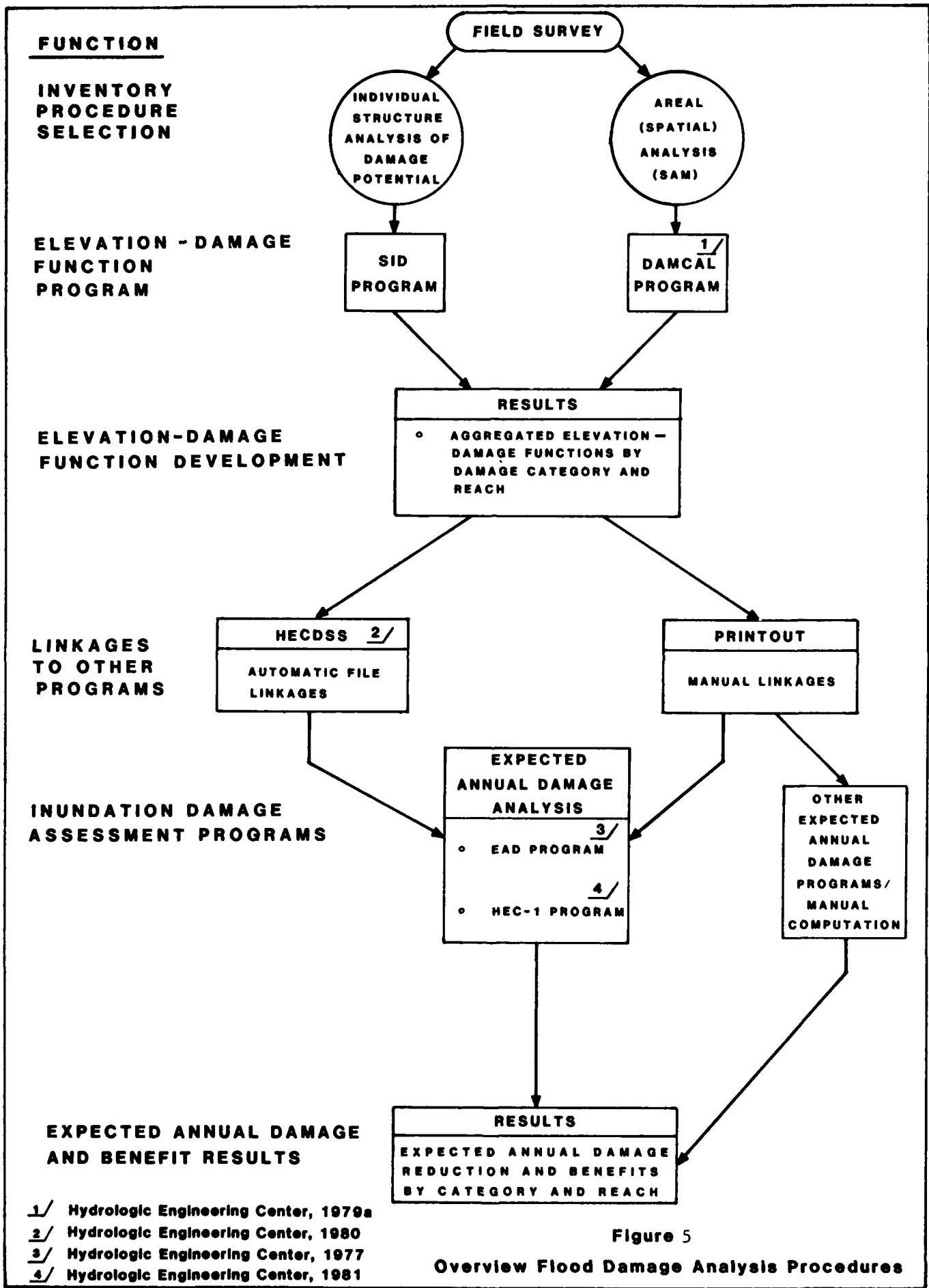


Figure 5

Overview Flood Damage Analysis Procedures

One program is used to develop Stage Damage Functions for flood conditions by stream or reach, by flood zone, by property type and by contents and structures of the buildings. Any number of streams or river reaches can be run sequentially during the program and river reaches can be selected by damage centers and backwater profiles. Output of the program is made by two-digit SIC codes. The next program determines average annual damages by integrating stage dollar damage curves with the stage frequency curves. Recent enhancement of the program has been made to evaluate up to ten profiles, including 1- and 2-year floods. Average annual benefits can be determined for evacuation and flood warning schemes.

Los Angeles District

The Los Angeles District uses two programs to estimate average annual flood damages. These programs work much in the same way as HEC'S SID and EAD programs. The first program, DEPREP, is used to calculate stage damage relationships by flood zone, use, and reach from data which is made available for individual structures, and by stage frequency relationships. The information from DEPREP is linked to the second program DAMAGES manual. The linkage is done manually so that the economists can understand exactly what the problems are in each individual area and so they can also better understand any problems with the data. The DAMAGES program is then used to compute average damages and flood damages prevented for each plan.

Soil Conservation Service (SCS)

The SCS uses a program called URB I to compute average annual damages to buildings and structures. The URB I has basically combined the capabilities of SID and EAD. Characteristics of each individual unit are entered into the program along with the hydraulic characteristics of each reach. Average annual damages are computed for the entire area between each cross section and broken down by structure and contents.

DISTRICT DEPTH-DAMAGE EVALUATION PROCEDURES

Corps' Districts use a wide variety of procedures in evaluating non-residential flood damages. Table 2 illustrates this diversity. All applicable procedures are marked in the table. Some districts use either a combination of measures or are in a transition period where they may be adopting a set of generalized damage curves.

There is a predominance of districts that compute depth-damage relationships for every nonresidential structure and make no generalization whatsoever. However, there is a growing number of districts which are using generalized curves or have taken major flood damage surveys that could be a basis for adopting standard damage functions.

Lower Mississippi Valley

Memphis District

Memphis District economists use the damage functions developed by the Tennessee Valley Authority in 1969 for commercial and industrial depth-damage estimates. They have found these functions to be consistent with surveys done in its own district, and more realistic than other functions it has seen. They also believe that the survey, which included over 40 communities in the Tennessee Valley, would be particularly applicable to the Memphis region content functions combined over 100 categories of businesses. Separate content functions were developed for some of the more common types of businesses. Other businesses were consolidated into "S" and "U" shaped curves. Structural damage functions were further consolidated into kinked curves which have a steep linear rise, until damages reach 60 to 80 percent and top out. The curves recognize separate building collapse elevations for frame and masonry structures. (See the section on damage function comparison (pg. 37) for further illustration).



TABLE 2
 Procedure Used for Computation of Non-residential Depth-Damages

	Standard Damage Curves from Another Source	Standard Damage Curves from Own District	Standard Curves Limited to Commercial Damage	Standard Damage Curves Limited to Structural Damage	Damage Curves Compute by Project	Structure by Structure Inventory
Lower Mississippi Valley Division						
Memphis District	X					X
New Orleans District	X		X			X
St. Louis District		X	X			
Vicksburg District	X					
Missouri River Division						
Kansas City District						X
Omaha District		X				
New England Division					X	
North Atlantic Division						
Baltimore District		X				X
New York District		X				
Norfolk District			X			X
Philadelphia District						X
North Central Division						
Buffalo District						X
Chicago District						X
Detroit District	X	X				
Rock Island District					X	
St. Paul District						X
North Pacific Division						
Alaska District*						
Portland District	X	X				
Seattle District						X
Walla Walla District	X					
Ohio River Division						
Huntington District		X		X		X
Louisville District						X
Nashville District	X			X		X
Pittsburgh District						X
Pacific Ocean Division					X	
South Atlantic Division						
Charleston District	X		X	X		X
Jacksonville District	X	X				
Mobile District		X				
Savannah District	X					
Wilmington District	X					
South Pacific Division						
Los Angeles District						X
Sacramento District					X	
San Francisco District	X					
Southwestern Division						
Albuquerque District		X				
Ft. Worth District		X	X			
Galveston District		X	X			
Little Rock District		X				X
Tulsa District	X					
TOTALS	13	13	6	3	4	17

*No Flood Control work at this time.

New Orleans District

In 1979, rainstorms brought water pounding into the New Orleans area. A post-flood survey and hypothetical flood estimates were used to develop business depth damage relationships based on type of business. These depth-damage relationships may be used on other New Orleans District flood control projects. The New Orleans' survey does not measure industrial flood damage, which will still be estimated by interviews. Although information was collected for both structure and content damage, the results were used primarily to develop content depth-damage relationships. Only two separate structure-damage functions were computed. Content damages were felt to be a bigger problem to assess, subject to more variation, but varying somewhat consistently with the type of structure.

The survey is one of few, if not the first, to make a thorough comparison between fresh water and salt water flood damage. Separate fresh and salt water functions were computed for each category of 15 commercial and public uses. The survey found consistently higher damages for salt water flooding.

St. Louis District

The St. Louis District developed its own commercial flood damage curves as part of the Blue Waters Ditch General Design Memorandum in East St. Louis, Illinois. The damage functions are indicative of a broad range of flooding problems that are common throughout the St. Louis region, including overbank river flooding, localized storm drainage, small stream flash flooding, and high groundwater levels. Hypothetical industrial flood damages are determined from interviews and on-site plant surveys. In the past, insurance adjusters have estimated industrial damage.

Vicksburg District

Vicksburg District uses the damage functions Stanford Research Institute developed for the California Office of the U.S. Soil Conservation for all commercial and industrial damage calculations. The functions are considered to accurately approximate the type of damage found in the Vicksburg District. The cost of detailed surveys are believed to be greater than the possible gain.

Missouri River Division

Kansas City District

In 1977 a flash flood struck one of Kansas City's commercial districts, the "first shopping center in America". The Kansas City District surveyed damages, gathering information for commercial curves. However, Kansas City District still makes thorough surveys as part of ongoing depth-damage analysis. Experience in Kansas City District has shown inconsistent commercial depth-damage relationships. Clothing stores were mentioned as having significant variance. Drugstores and supermarkets can have content damage in excess of flood level. A small amount of moisture can contaminate

food and drug, and state regulations strictly prohibit resale. The only exception would be small gas stations and other small businesses where standard relationships are computed and applied for individual studies. Interviews at each industrial plant are considered essential.

Omaha District

Omaha District has compiled depth-damage functions for 79 types of businesses and public buildings. Curves were derived primarily from other Corps' districts. The Marshall and Swift evaluation method is used to establish the replacement value of each property. Industrial property is evaluated on an individual basis.

New England Division

New England Division does not rely on generalized damage functions. Sampling is done to compute project-by-project depth-damage functions for light commercial businesses, such as self-service gas stations and fast-food restaurants. Larger commercial damage relationships are studied on an individual basis. Expected loss on all other property is estimated from interviews with plant managers or comptrollers. The division distributes a questionnaire which estimates project's business losses and emergency costs.

North Atlantic Division

Baltimore District

Baltimore District uses a modification of the damage functions it developed after a massive 1963 post-flood survey of the Susquehanna River Basin. The most recent and extensive post-flood survey study is the Baltimore District's work on the Wyoming Valley in Pennsylvania. Between 3,500 and 4,000 commercial and industrial properties were included in a 1978-79 survey. Most buildings in the sample were damaged in the flooding from the 1972 Tropical Storm Agnes. (Actual flood damage estimates were used to establish a total of four points. In the damage function, estimates of replacement costs were based on Marshall-Swift Appraisal Manuals.) The results of the survey have been used only in the Wyoming Valley General Design Memorandum. Baltimore personnel would like to investigate the potential of applying the Wyoming Valley data to generalized damage curves, but this would require additional funding. The study also lack information on structure and content value. Values can be estimated only in square feet by type of business.

New York District

New York District has also performed a recent and extensive survey of potential flood damage. The Passaic River Basin is a heavily urbanized watershed, and is susceptible to catastrophic flood damage. Interviews were completed for 652 commercial properties and 753 industrial properties. Depth-damage relationships were computed for 10 categories of commercial business and 35 categories of industrial properties based on type of business operation, product or service with which the company dealt. These categories are further broken down by size and type of foundation. The survey was

conducted in 1980 and early 1981. Some parts of the survey represent actual experience from 1977 to 1979 flooding and the rest is based on hypothetical damages at selected water heights.

Norfolk District

Norfolk District has done limited flood control work in recent years involving industrial and commercial structures. A comprehensive survey of large industrial plants was completed in 1980 on the James River through Richmond, Virginia. The businesses were considered too large and too important for use of generalized curves. Depth-damage relationships were developed for small, medium and large commercial establishments such as drugstores, banks and hardware stores. It is not known whether the Richmond survey will be applicable to Norfolk District work.

Philadelphia District

The Philadelphia District conducts a comprehensive survey for potential commercial and industrial flood damage on every project. Questions are selected from the set questions approved by OMB in 1979. The focus of the interviews may vary based on type of business being surveyed and the results of the surveys are checked for reliability against the 1963 Baltimore curves.

North Central Division

Buffalo District

Interviews are done for every commercial and industrial establishment. Damages are estimated for hypothetical flood elevation. Buildings in the flood survey may not have consistent first floor elevations and so care is taken to insure that each point on the damage survey reflects a consistent elevation of flooding and a consistent height above or below the first floor. This precaution is more important with large businesses than with smaller residential property. Where appropriate, inventory levels are adjusted for time of year, and estimates are made of probable damages in projecting business loss. Interviews vary in length from 30 minutes for small commercial structures to several days for a large manufacturer.

Chicago District

Chicago District's flood control studies are extensively residential. Where commercial and industrial buildings are involved, each unit is considered unique and unit-by-unit surveys are considered necessary.

Chicago District has developed a model for estimating flood induced travel costs. The model was used to calculate indirect business losses on the Little Calumet Basin in Indiana.

Detroit District

Detroit uses 1974 Federal Insurance Administration (FIA) damage curves for all structure damage estimates. The most appropriate residential curve is applied

to the business structure which is being evaluated. The content value of each business is appraised and adjustments are made in FIA content damage curves after an open-ended interview with representatives of each business. A set of generalized damage curves were just developed for the lower portion of the Clinton River study after a structure by structure survey. The results of that study were applied to the Upper Clinton River Basin, which is under a survey level study detailed enough for project authorization.

Rock Island District

Rock Island District uses a standard interview format to estimate commercial and industrial flood damage. Standard commercial damage relationships are computed for each project, based on the interview sample. Benchmarks are then applied to each commercial structure, based on size in square feet. Whenever possible, historical records are used to estimate potential flood damage.

Rock Island District's industrial survey groups firms by SIC code. Specific questions are related to value of raw material, production, finished material, plant, inventory, and equipment. Output and employment questions are used to estimate business loss, with the extent of benefits determined by whether the percent of the product that the firm supplies within that industry. Any expansion or moving plans are noted to aid in estimating future benefits.

St. Paul District

In survey level studies, St. Paul District surveys every type of existing business. Damages are estimated for hypothetical flood heights. Letters are sent in advance explaining the purpose and format of the interview. A person familiar with the entire operation is requested to be available to answer questions on value of building and contents, gross revenue, nature of employment, number employed. For some national firms, it will be necessary to contact the regional office to determine the necessary information. St. Paul has a large collection of damage records from recent flood surveys in the district. There is the possibility of using the information to compute depth-damage curves for general use in the district data base.

North Pacific Division

Alaska District

The Chena River Study Project is the only flood control study undertaken by Alaska District in recent years. There was very little industry and a number of commercial and public buildings in the survey. No damage curves were involved in the study. Alaska District has recently done an appraisal of ice jam flooding from the Kuskokwin River at the Community of Aniak, Alaska. Primarily one story homes are affected and no project-specific depth-damage relationships have been established.

Portland District

Most commercial damage in Portland District is estimated from a modified version of the 1963 Baltimore depth-damage functions. The Baltimore study may

have been the largest flood damage survey ever undertaken in the United States, since more than 60,000 structures were included in this survey of the Susquehanna Basin. Portland economists made significant changes in the curves after a survey of Oregon's Willamette River system. Changes were primarily due to differences in construction material. In particular, far less brick and more frame construction is used in the Pacific-Northwest than the East, and so structural damages tend to be higher in the Northwest. To illustrate these differences, Portland District developed a set of building collapse curves which indicate the elevation and velocity that it would take to cause the collapse of a structure. (See page 21 and appendix C for further description).

Seattle District

Seattle District surveys all commercial and industrial property. It is presumed that even the same type of businesses have wide differences in inventory and fixtures. Survey forms are used to determine the inventory and value of each building. The Marshall and Swift Real Estate Appraisal Manual is used to determine current building costs. The Fire Insurance Rating Board manuals are used for data on building construction to determine replacement costs and separate replacement costs are estimated for each building material. These figures are checked against estimates provided by building appraisals. Questionnaires are delivered one day prior to the interviews. Up to eight interviews at large commercial or industrial sites can be completed in a day, provided the business are in the general proximity of one another.

Walla Walla District

Walla Walla District uses Baltimore District's 1963 depth-damage functions; because of the size and quality of the survey, the percent damage functions are believed to be appropriate for Walla Walla. District economists estimated structure values from county tax records. Adjustments in appraisals may be made after field-checking a building's condition. Walla Walla does not have a great number of industrial properties in its flood control studies. Industrial content value is gathered from field interviews. There were minor modifications made in the Baltimore data after a comparison with flood damage from major floods in Southeastern Idaho.

Ohio River Division

Huntington District

Huntington District has recently developed a set of business structural flood-damage functions, based on a survey following the 1977 flooding along the Tug Fork River Basin. The new set of structural functions will be used on all business flood damage analysis. Content damages will still be determined by interview at each property.

Louisville District

Louisville District computes its depth-damage functions from interviews. A complete inventory is taken for every major flood survey. Hypothetical flood

damage is estimated at every business in a detailed study. Public enthusiasm for the survey is not a problem because of recent major floods. The survey form is brief and straightforward: structural description, flood condition (up to five levels of flooding can be described), physical damages, loss in professional wages and emergency costs. The average commercial property can be surveyed in 30 minutes. Large industries require approximately three hours.

Nashville District

Nashville District uses the most appropriate of the 1970 Federal Insurance Administration's depth-damage curves for computing commercial and industrial structure damage. Damage is estimated from open-ended interviews with no set format. Where a significant number of flood claims have occurred, the local office of the Small Business Administration supplies records of damage claimed and paid.

Pittsburgh District

Pittsburgh District uses information gathered by personal interviews in computing depth-damage relationships. There is no standard set of curves. However, a large damage survey was undertaken for the Upper Sewickley Creek Basin in Westmoreland County, Pennsylvania. The flood survey was done after 1972 Tropical Storm Agnes. Damage functions were established for 13 land use categories including open space, five categories of residential land use, urban and suburban commercial property, industrial, agricultural, pasture, infrastructure, and institutional facilities. Four categories of undeveloped land use were identified as not subject to any damage.

The generalized damage curves were applied in a spatial analysis of the basin in one of the first flood control studies to use the aid of the aforementioned SID program developed by the Hydrologic Engineering Center.

Pacific Ocean Division

Pacific Ocean Division has a variety of flood experiences that include tsunamis (severe tidal waves), and areas with almost continual heavy rain to near desert conditions. These extremes make it difficult to project flood damage based on generalized functions for Hawaii, let alone on data from other states. Flood damage relations are estimated by SIC code for each project. Most commercial structures are concrete block with steel frame. Structure damage generated by the same type of flood should have a fairly consistent depth-damage relationship. Inventory value and damage are viewed as much less consistent and less likely to be subject to reliable curves. POD has an extensive collection of business depth-damage information which was collected through interviews conducted in many parts of Hawaii and Guam.

South Atlantic Division

Charleston District

All industrial damage and commercial content damage are estimated by interview. Commercial structure damage functions were obtained from the Wilmington District. Field interviews are completed for commercial damage. The average 30-minute industrial interview follows OBM-approved questions. Charleston has few industries in the floodplain. Questionnaires are sent out in advance. Charleston uses a program based on percent damage. This influenced the decision to use curves based on percent damage rather than actual dollar loss.

Jacksonville District

Jacksonville District uses the most recent set of commercial and industrial depth-damage functions from the Galveston District. Industrial relationships are determined entirely through interviews.

The Puerto Rico Office, in an area which is subject to even a greater degree of high-velocity, short-duration flooding than the rest of the district, has developed its own set of commercial and industrial curves.

Mobile District

The Mobile District has developed depth-damage relationships for 1979 and 1980 flooding on the Pearl River. The depth-damage functions include 20 categories of commercial, industrial and public buildings. The relationships were gleaned from a survey of approximately 1,000 buildings. It has not been determined whether the Pearl River Survey will replace the Galveston functions which Mobile still uses for most of its depth-damage calculations.

Savannah District

Savannah District now uses depth-damage functions taken directly from Mobile District's survey of the 1977 flooding. It is anticipated that these functions will be used to compute all Savannah commercial and industrial flood damages. The functions list percent of damage by relative size of building from 0 to 12 feet above the first-floor level. Each function has an average replacement value of structure and contents and average square feet of each type of enterprise.

Wilmington District

Industrial and large commercial business damages are estimated from surveys of every structure. These damages are derived from a series of unstructured interviews with no standard list of questions. The interviews are done in person and average one hour to complete. The Wilmington Commercial program has over 50 depth-damage curves adopted from the Galveston District. The curves show depth/percent-damage by 1-foot intervals from 0 to 14 feet.

South Pacific Division

Los Angeles District

Los Angeles District uses the interview process to determine the depth-damage relation for each business and institutional property. No special commercial and industrial curves are used. Equipment damage, which often accounts for much of the business flood loss, is believed to be extremely unpredictable. The location and the portability of the equipment are important factors. Flood warning and evacuation lead times can also make a great difference in the extent of business loss. The example of a Baltimore district study for the Harrisburg, Pennsylvania area was cited as documenting a large evacuation potential. Business losses and traffic rerouting costs are also determined by the open-ended interview process. Interviewees are selected on the phone several days before the interview. The interviewers are provided worksheets as a guide on information to solicit.

Sacramento District

Sacramento District economists conduct complete surveys of floodplain property whenever possible. When resources do not permit complete surveys, they use depth-damage relationships developed by the Department of Housing and Urban Development for the Tennessee Valley Authority in 1969. These functions have structure and content damage functions for groups of businesses with varying "U" and "S" shaped damage functions. Whenever one of these damage functions is applied, spot checks are made to test the applicability to the local situation. Building collapse curves are applied when there is evidence that water depth and velocity may combine to cause a structure to fail. Interviews are conducted for all industrial properties except when doing reconnaissance reports.

San Francisco District

San Francisco District uses a set of depth-damage functions from the Stanford Research Institute Report entitled A Study of Procedures in Estimating Flood Damage to Residential and Industrial Properties in California. District economists compiled composite damage functions for commercial and industrial property.

Southwestern Division

Albuquerque District

Adobe construction is common for small retail buildings in the southwestern United States. Adobe is easily destroyed by floodwater. Concrete, cinder block and steel typical in the rest of the United States are common for Albuquerque's industrial and large commercial structures. Commercial damage curves are adapted from those used by Galveston District, with local adjustments made after a flood survey in Pueblo, Colorado. Industrial

property damage is assessed by individual survey. Albuquerque uses a program developed by Los Angeles District to compute the expected annual flood damages.

Fort Worth District

Fort Worth District has adapted damage curves developed by Galveston District. There are over 200 different commercial, industrial and institutional damage curves. They have separate functions for structure, inventory and equipment. On very detailed studies, the Fort Worth economists will conduct interviews at the industrial plants, each requiring between six and eight hours to several days.

Galveston District

Galveston began keeping a large file of flood damage records in 1968 under a contract with the Federal Insurance Administration, using FIA claim forms. The initial survey was very comprehensive, with 10,000 properties included. A thorough room-by-room survey was made for every building. The damage functions that were computed have been continuously kept up-to-date with new flood damage information, including a survey of the 1979 study of flood damages from Hurricane Claudette. Galveston maintains 145 different types of nonresidential flood damage functions, 85 of which are business curves. The rest are public and institutional property. There are separate functions for structure, fixtures and inventory. The condition and age of all property is considered in application of all damage functions. Galveston economists have found that the time of year can make a big difference in the amount and composition of inventory at some businesses.

Little Rock District

Little Rock began developing its depth-damage functions after the survey of a major flood in Little Rock. A library of 40 to 50 commercial curves were developed from questionnaires and extensive interviews in the Ft. Smith, Arkansas, area.

Tulsa District

Tulsa District uses damage coefficients derived from Galveston District's program which they can access via the Southwest Division Computer System in Dallas. The Galveston commercial functions were adapted with minor modifications after a recent application to the Mingo Creek Study in the Tulsa area.

SOURCES OF INFORMATION OUTSIDE THE CORPS OF ENGINEERS

Soil Conservation Service

The Soil Conservation Service (SCS) has done extensive work with commercial and industrial flood damage assessment, and is the best source of this type of information outside the Corps. A major SCS effort was a set of depth damage functions developed in 1961 for the State of California with the help of Stanford Research Institute (SRI). The SRI report is still being used by San Francisco District for its commercial flood damage analysis.

Although SCS work has traditionally been in rural areas, the increasing urban flood problems have brought SCS to work in areas such as Cook County, Illinois, and San Jose, California. As in the Corps, SCS state and county offices have a great deal of latitude in depth-damage analysis procedures. Coordination should be made with nearby offices to compare procedures.

Small Business Administration and Federal Insurance Administration

The Small Business Administration (SBA) and the Federal Insurance Administration (FIA) maintain large files of flood damage claims. Both would be extremely useful for computation of national and regional curves. Unfortunately, the SBA file does not give information on depth of flooding and the FIA file does not distinguish the type of small business in recording flood claims. The SBA data has been useful to Nashville District in undertaking flood surveys where the street address and flood elevation can be traced to information in the SBA file. Some districts have made use of the most appropriate FIA residential structure damage curves to apply to business structures. One district applies FIA's small business curves to compute commercial structure and content damages. The FIA data would be useful in producing nationwide damage functions if businesses were identified by the product or service they provided or by the two-digit SIC code.

Tennessee Valley Authority (TVA)

The Tennessee Valley Authority uses a family of small business flood damage functions that were developed by the Department of Housing and Urban Development (HUD) in 1969. This information is detailed in a report entitled, Small Business Research for Flood Insurance Rate-Setting. Modifications have been considered to these damage functions, but have never been executed. Open-ended interviews are used to determine potential industrial and large commercial damages.



COMPARISON OF DISTRICT DEPTH-DAMAGE FUNCTIONS

This section contains a series of depth-damage function comparisons for several districts. Damage functions are shown for inventory; equipment and fixtures; structure; and content, which is a combination of inventory, and equipment. Damage function comparisons are shown for Ft. Worth, Sacramento, Mobile, New Orleans, and the Tennessee Valley Authority. The content comparisons are illustrated for the same types of businesses and structural curves are shown for the same construction types. The reader should be cautioned that although these curve comparisons may represent a large number of enterprises, the sampling of data bases should be much larger before any statistical inference is made. Such inference cannot take place without a centralized compilation of the raw data. The conclusions reached from these comparisons are as follows:

1. As could be predicted, damage functions are much higher in nearly all cases for inventory than either equipment and fixtures, or structural damage. Some perishable commodities may not have to get inundated, sometimes a little moisture can be enough to do a good deal of damage. Inventory is less likely to have significant salvage value than building fabric or more permanent contents, particularly since it is generally for sale and not for continued use on the premises. Nearly all inventory functions in this sample had over fifty percent damage at five feet and above. (See Figures A-1 through A-5 in Appendix A.)

2. Inventory damage relationships were homogenous in shape, but not in magnitude. Department stores, restaurants, clothing stores, and groceries, all had very similar shaped curves with inflection points close to the same levels of inundation and roughly the same slopes.

3. Differences between damage function at lower levels can be particularly significant in application to benefit estimation. The great majority of all flood events never get more than two feet above the first floor level. Because of the disparity in percent damage for lower levels of inundation, noted above, field checks are highly recommended before application of any curves. Note that damage functions for Mobile District show significant damages at the first floor level. Since the probability of flooding is particularly high at this level, there is a big difference in the average annual damages.

4. It should be noted in Figures A-16 through A-21, that the content damage functions derived by the Tennessee Valley Authority and New Orleans District were very similar, both in shape and in magnitude for almost every type of enterprise. While this is not large enough a comparison from which to make any significant generalization, it does show that there can be a certain amount of consistency in damage function generation.

5. Figures A-22 and A-23 are a comparison of industrial structure damage function that were developed by Mobile District for the Pearl River Study. Comparisons are shown for wood, masonry, and metal buildings and for both single and multiple story buildings. In both cases, masonry structures



suffered less damage than either metal or wood structures, and wood structures suffered the most. The differences appear to be significant enough to justify separate damage functions.

6. Differences in the damage functions may be due to a number of factors. Geographic differences are related to the nature of flood events or to the nature of the buildings involved. Typical building fabric may vary between regions, and the building fabric typical in one region can affect content as well as structural loss. Business practices, building layout, involvement in flood warning and emergency activities are also determinants. Other significant factors would be the data collection procedures, and the definition of the damage variables used by the individual districts and their contractors.

7. Note that damage functions for drug store and food store inventory as noted in Figure A-8 may depend as much on state health codes as actual damage. Protection against consumption of contaminated food and drugs may require complete disposal, even with minimal flooding with inundation well below the level of food and drug stock.

**GENERAL ACCESS DATA BASE OF BUSINESS
FLOOD DAMAGES AND DEPTH-DAMAGE FUNCTIONS**

The following is a proposal to create a data base of nonresidential flood damage for general Corps of Engineers' access. The data base would enable district economists to compare their damage estimates with other districts in the same region and with other districts with similar flooding problems. The information could also be used for computation of business depth-damage functions where no better source of information existed. This nonresidential data base would initially include flood records from as many as eight Corps of Engineers' districts. These are New York, Baltimore, Huntington, Mobile, New Orleans, St. Paul, Galveston, and Detroit. These districts have recently completed large, comprehensive surveys of flood damage, or potential damage, to nonresidential property. A description of the information they collected is in table 3. More recent information from these and other districts can be added to the data base as it becomes available.

The Corp's computer network would be used to create the central file. The data would not have a standard format since the nature of the variables change from district to district. Separate record types would be created for each district or each separate data format. The data base user would have the option of combining information from various data bases with common variables. For example, if New Orleans and Mobile data bases both have information on water height, structure type, property damage, and property value, the record types could be combined for processing to determine standard damage levels for the South/Gulf Coast area. The data base preprocessor could be used to isolate damage records for unique types of industries. The table below describes the type of information available on each of the district flood damage files, and illustrates the potential strength of being able to make selections based on individualized need.

Just as a central data base of flood losses can be useful for computing damage functions tailored to particular situations, it could also be useful in giving individuals the opportunity to choose between an array of damage functions. Damage functions would be collected from Corps of Engineer field offices, the Soil Conservation Service, Tennessee Valley Authority, state government, or any academic source that may have conducted research on this subject. The damage functions would be illustrated periodically in reports that would describe the flood conditions upon which each set of functions is based, definitions of variables used in computing the damage functions, and the dates that damage surveys were undertaken. The damage functions would also be set up for interactive computer access. They would afford an up-to-date file of damage functions immediately accessible for flood damage calculation programs.

TABLE 3
Categories of Information Found in District Depth-Damage Data Bases

	ST. PAUL	NEW YORK	NEW ORLEANS	MOBILE	HUNTINGTON	CALVESTON	DETROIT	BALTIMORE
Name of Business or Institution	X			X	X	X	X	
Type of Business or Institution	X	X	X	X	X	X	X	X
SIC Code	X	X	X					
Community	X	X	X	X	X	X		
State	X	X	X	X	X	X	X	X
River Basin	X	X	X	X	X	X	X	X
Type of Flood	X		X	X	X	X		X
Value of Buildings	X	X	X	X	X	X	X	
Description of Buildings	X	X	X		X	X		
Construction Material	X	X			X	X		
Condition		X						
Size	X	X	X		X	X		X
Value of Inventory	X		X	X	X	X	X	
Description of Inventory	X		X		X			
Value of Equipment and Fixtures	X		X	X	X	X		
Description of Equipment and Fixtures	X		X	X	X			
Value of Contents	X	X	X	X	X	X	X	
Description of Contents	X	X	X	X	X			X
Damage to Structure	X	X	X	X	X	X	X	X
Damage to Inventory	X		X	X	X	X		X
Damage to Equipment and Fixtures	X		X	X	X	X		X
Damage to Contents	X	X	X	X	X	X	X	X
Water Height	X	X	X	X	X	X	X	X
Clean Up Hours	X		X		X	X	X	
Clean Up Costs	X				X	X	X	
Closing Time	X				X	X		
Payroll and No. of Employees	X		X		X	X		
Closing Costs	X		X		X			
Emergency Costs	X			X			X	

CONCLUSION & RECOMMENDATIONS

Residential damage evaluation has been given considerable attention primarily from the analysis and application of Federal Insurance Administration nationwide functions. The national FIA functions are used more than all other residential damage functions combined. Business damage analysis has been given far less attention than residential damage functions. There is more skepticism of the consistency of business damage relationships. But the biggest problem has been the lack of any organization to serve as a clearing house for business damage information.

There has probably never been a nationwide set of depth-damage relationships for commercial, industrial and institutional property, other than the FIA's damage functions which combine all businesses together. This subject has never received comprehensive study in the United States. Commercial and industrial properties are prone to more damage per unit and more damage per square foot than residential property; therefore, for more accurate results, it is essential that business damage be given close attention. Funds for detailed study are becoming scarce. Therefore, it has been the goal of this research, and should be the goal of any future research, to develop more accurate methods of projecting flood damage with the limited funds that will be available for comprehensive study.

It should be noted that lack of a comprehensive flood damage data base is not due to any lack of interest. Many economists throughout the Corps would like the cost-savings and reliability of a national data base. There is a consensus of district economists of the need for a central nonresidential data base for various types of structural damage and homogenous types of commercial contents for business such as fast food restaurants and self-service gas stations. Standard damage functions depend on a demonstrated reliability. There is no interest in any imposed set of national curves. Corps' economists will still want a choice of damage functions. There is also a good deal of skepticism about any set of industrial content damage functions. The nearly unanimous belief is that industrial content damages are variable for any type of consistent relationship.

The current situation is that there is a plethora of procedures for evaluating non-residential flood damages. The various procedures have been summarized in this report. The number of procedures in use, and apparent differences between them, does not imply a deficiency in the system. It does imply that there are a lot of untapped sources of information and that referencing, and the possibility of a centralized data source, may be useful.

Some of that referencing has been done in this report. This report may be used as a vehicle to facilitate sharing of information and technology between Corps of Engineers' field offices. Its intent is to encourage Corps' economists to contact their counterparts in other districts directly to share the use of damage functions, data bases, survey procedures, and other information. In sharing this information, economists can compare information on the type of flood situation they are evaluating, i.e., the typical velocity, duration, and sediment load, along with the construction material used in most structures.

A set of variables for depth-damage surveys, along with a suggested set of standard definitions is provided in this report. District economists are encouraged to collect information on each of these variables so that more can be known about the extent and reliability of these variables to the depth-damage relationship. It is suggested that general acceptance be made of these, or another set of standard definitions, so that when the effects of the variables are analyzed it can be assumed that the same variables are being analyzed for each study.

Based on the findings of this study, it is concluded that a great deal more can be done to assist Corps of Engineer field offices in determining accurate depth-damage relationships. The following are recommended actions that would provide valuable assistance to Corps' economists:

1. Compile District Damage Functions

We propose development of a data base of business damage functions as references for districts throughout the Corps. The data base could be used by districts to compare their own depth-damage functions with those of other districts, or to compute damage functions based on their own needs and geographic areas. The damage functions would be available in reports and on micro-computer disks. The reports will explain the method of calculation, including whether the functions were based on actual damages or synthetic, the geographic area for which the functions were calculated, the type of flooding involved, and the price level on which the functions were based. If the functions are given in absolute dollar amounts, the base price year will be given. The micro-computer disk will be in a format that would have compatibility when transferred by modeum, with most Corps micro- and mini-computers.

This effort would take approximately four months and cost \$40,000. This cost includes \$25,000 for compilation and documentation, \$10,000 for programming, \$2,500 for illustration, and \$2,500 for printing and distribution.

2. Compare Damage Functions

Damage curve comparisons have been made for several types of businesses in different regions of the country. The functions contain a high degree of

variance between districts for the same type of business. Future work can make more detailed statistical comparisons between damage functions, and explore reasons for this variance. In further study, it may turn out that several sets of commercial and institutional damage curves emerge as particularly reliable and could be recommended for national or regional use.

This effort would take approximately four months and cost approximately \$25,000. This cost includes \$20,000 for analysis and documentation, \$2,500 for illustration, and \$2,500 for printing and distribution.

3. Establish a Cooperative Depth-Damage Collection Effort

A valuable source of depth-damage information would be a coordinated effort to evaluate potential and actual post-flood damages. This effort would be established so that every district involved is using similar questions with the same terminology. District representatives would meet to determine what OMB-approved survey questions should be used, what questions may need to be added to the survey lists, how terms found in these questions should be defined, and what might be the appropriate format to use for storing and processing the data. There would be a list of Corps' questions that districts would be encouraged to use in their damage surveys. Additional questions could be added to meet the needs of specific studies. Data would be formatted for the Corps of Engineers' central mainframe computer system. The data could be used to calculate generalized national and regional damage functions. It is recommended that generalized functions be computed for commercial, industrial, and institutional structures, based on building material and size. Attempts should also be made at computing reliable content damage functions for some types of homogeneous commercial businesses based on two-digit SIC codes. District offices could access the data directly, or download the information to a district computer to calculate their own functions.

Funds should be provided for coordinating this effort, programming and analysis at the national level. Many districts do not have the funds to carry out depth-damage surveys, let alone the costs of coordinating the effort with other districts. Funds should be provided to reimburse district coordination costs and part of the data collection costs for this research and development effort.

Two years and \$120,000 are required for this project. That includes \$10,000 for central coordination activities; \$40,000 for the districts' role in data collection, attending meetings and other contacts during the study; \$25,000 for calculation of national damage functions and documentation of the system and the damage functions into a report; \$20,000 for printing and computer processing; \$5,000 for printing and distribution of reports, and \$20,000 for start-up funds for districts undertaking new surveys.

4. Calculate Susceptibility Indexes.

As a barometer of the susceptibility of flood-prone property, it is recommended that susceptibility indexes be computed for a range of commercial and industrial products and for various building fabrics

completely submerged for various lengths of time. This would be an updating and expansion of the work done earlier by D.J. Parker. This information would be useful in computing and verifying depth-damage functions. The information could be applied to individual businesses, particularly industrial plants, that have large quantities of a given stock or type of equipment. This study would make extensive use of existing data from insurance companies and agencies that deal with disaster assistance.

This project would take six months and cost \$36,000; including \$30,000 for data gathering and analysis, \$5,000 for computer programming, and \$1,000 for printing and distribution of the findings.

5. Develop Field Sampling Techniques.

Field sampling techniques to develop accurate estimates of potential flood damage with limited samples should be vigorously pursued. As stated earlier, these techniques may become necessities in the future if study funds continue to dwindle. Sampling procedures would be the product of a joint effort of statisticians and economists experienced in flood damage surveys. The goal would be to reduce the necessary work, without drastically reducing the reliability of the product. This research will attempt to answer such questions as, when sampling techniques can be applied, how to select representative businesses, how to judge the degree of accuracy of a given sample, and what statistical procedures are necessary to analyze sample data.

This project would take one year and cost \$73,000. The estimate includes \$15,000 for initial conceptualization and survey design, \$10,000 for a sampling of damages of a particular project, \$15,000 to complete a survey of the entire population for the project area, \$10,000 to analyze and compare the sample and population surveys, \$20,000 to reconcile the differences and establish sampling procedures, and \$3,000 for printing and distributing information.

6. Clarify Procedures for Evaluating Secondary Flood Control Benefits.

A great deal more needs to be done to clarify the procedures used for evaluating secondary flood control benefits. As an example, there is a wealth of resources available for evaluating business losses. Nevertheless, some confusion exists as to when potential business loss can be counted as a benefit and what the best procedures are to compute business losses. This project will require a review of natural hazard literature on the quantification of secondary hazard costs, the applicable Corps' regulations, and a sampling of studies that have estimated secondary benefits. Proposed guidelines and suggested methods for evaluating secondary benefits would be reviewed by field offices and discussed in at least one conference.

This effort would take one year and cost \$50,000. The cost includes \$15,000 for a literature review, \$20,000 to develop and document procedures, \$12,500 for field review, including conference cost, and \$2,500 for printing and distribution.

Summary of Recommended Projects

	Costs	Time
Compilation of District Damage Functions	\$40,000	4 months
Comparison of District Damage Functions	\$25,000	4 months
Cooperative Data Collection	\$120,000	2 years
Documentation of Susceptibility Indexes	\$36,000	6 months
Development of Field Sampling Techniques	\$73,000	1 year
Clarification of Secondary Flood Control Benefits	\$50,000	1 year
Total	\$344,000	

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APPENDIX A

FLOOD DAMAGE FUNCTION COMPARISON

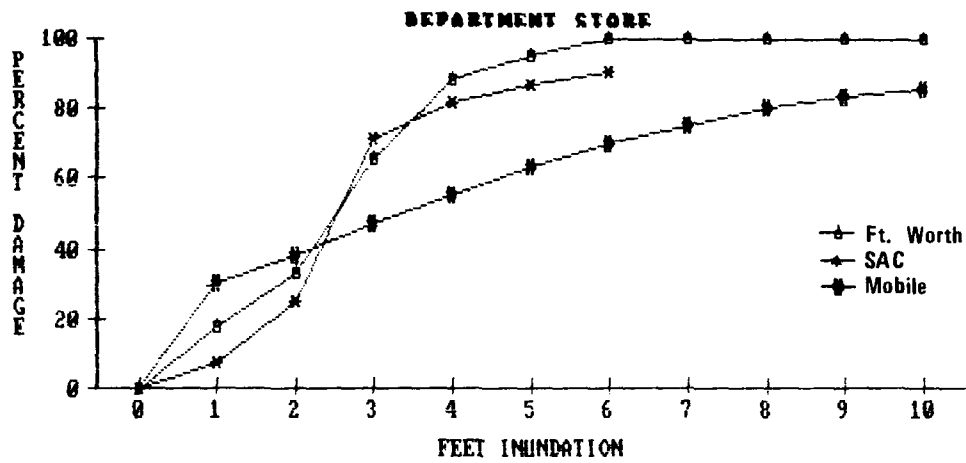


Figure A-1
Inventory

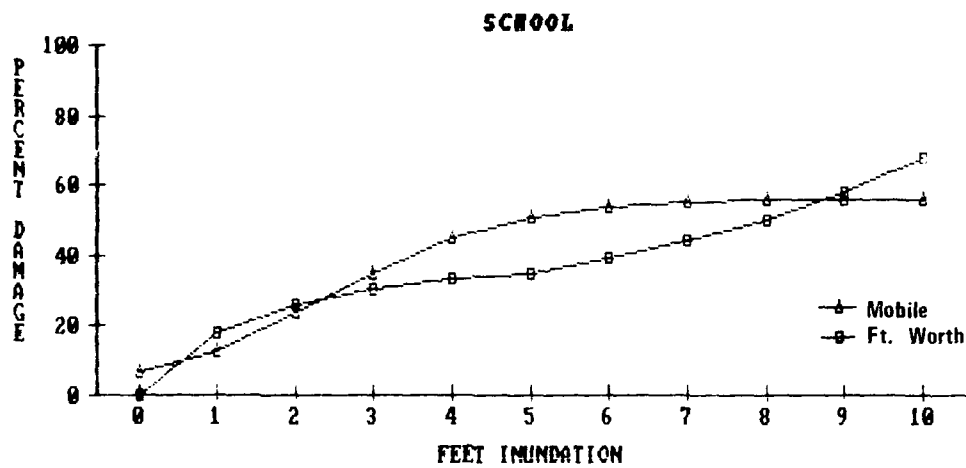


Figure A-2
Inventory

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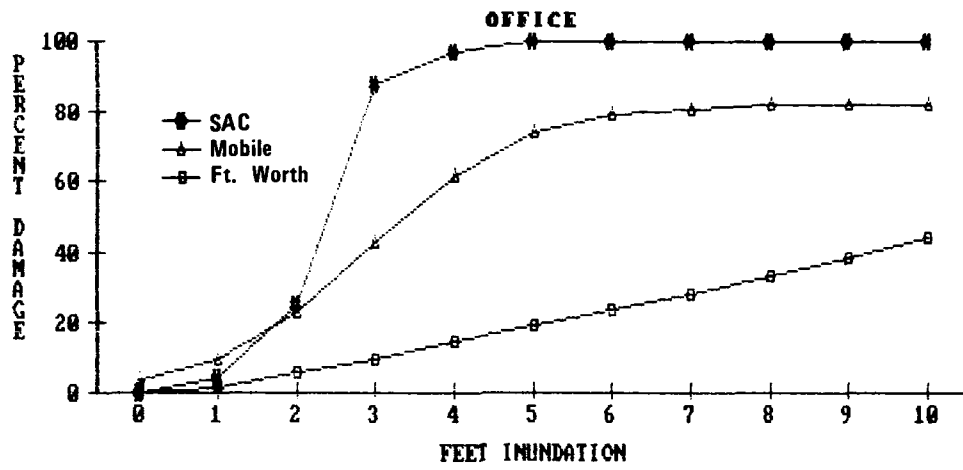


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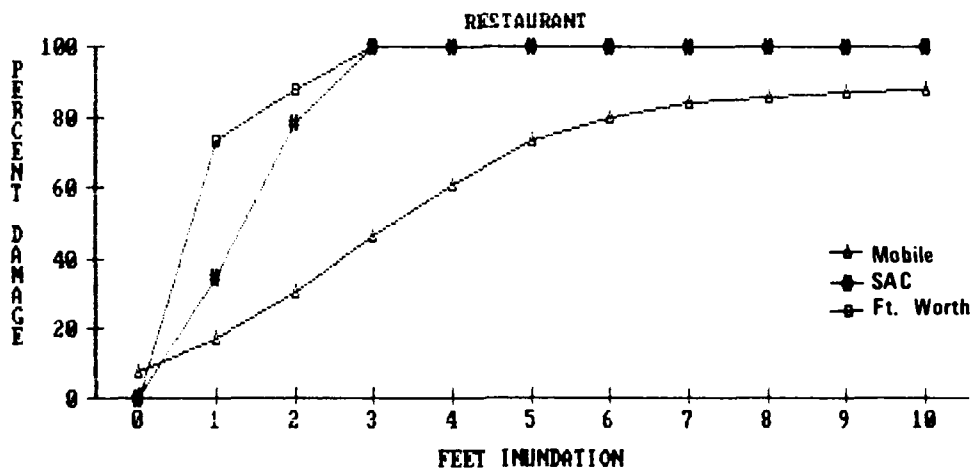


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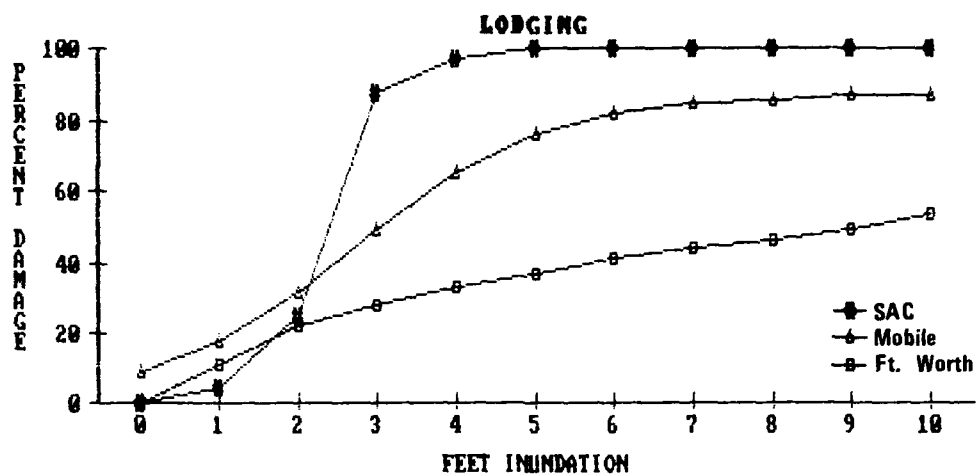


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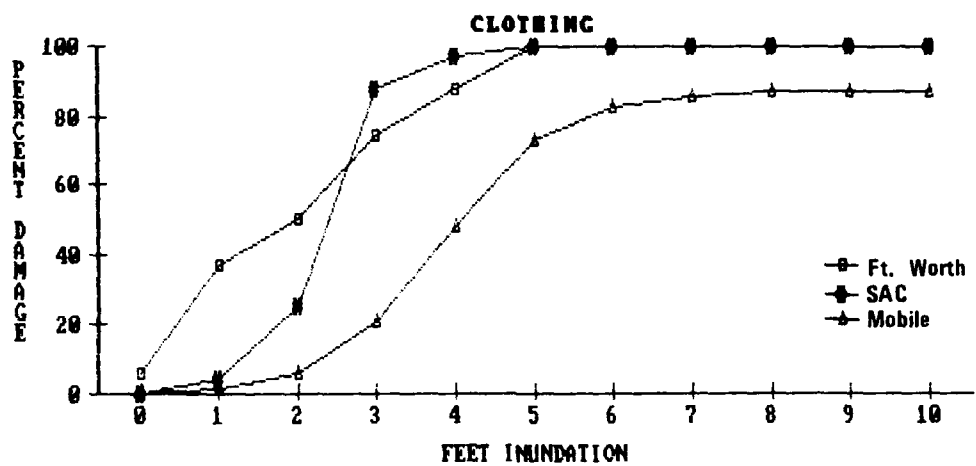


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Inventory

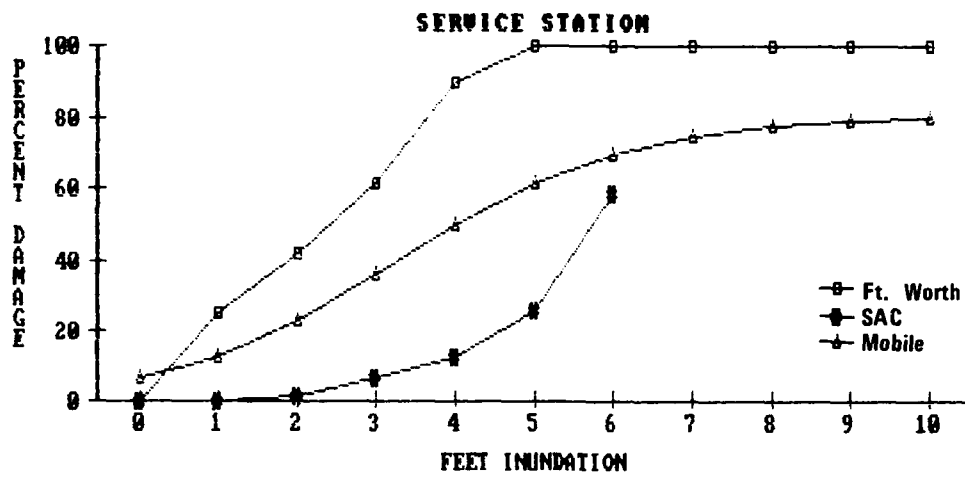


Figure A-7

Inventory

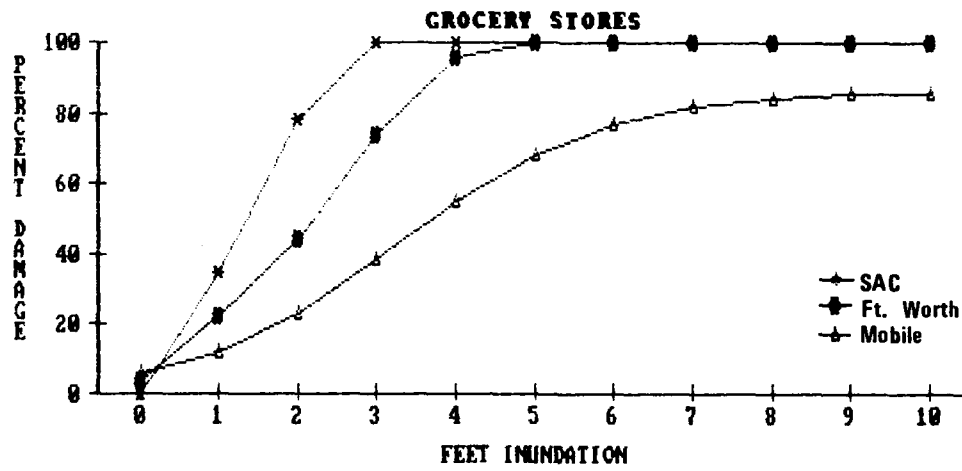


Figure A-8

Inventory

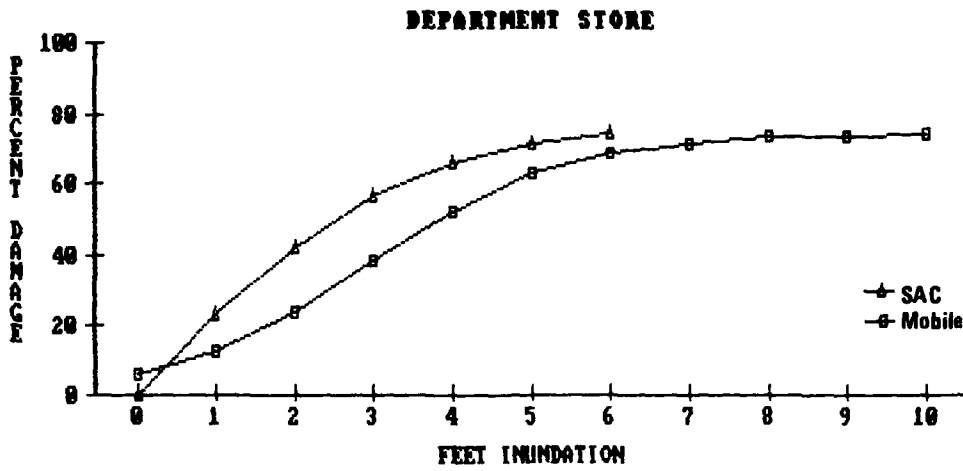


Figure A-9

Equipment

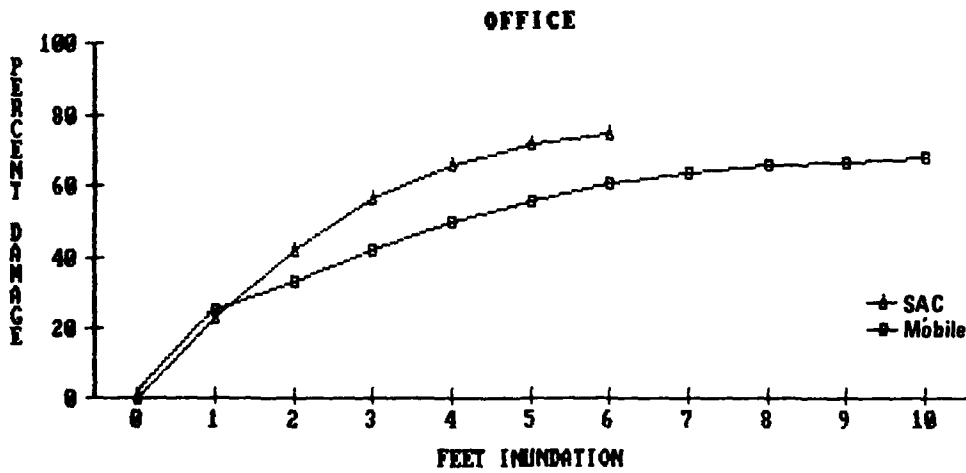


Figure A-10

Equipment

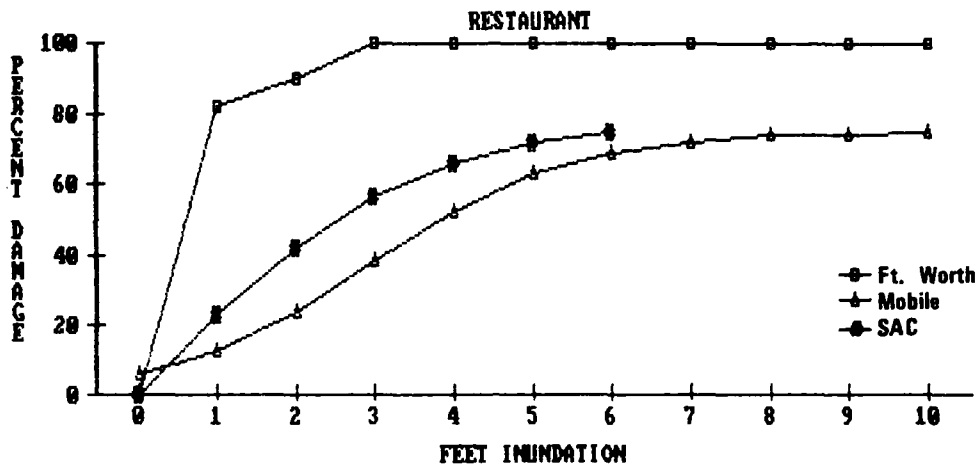


Figure A-11

Equipment

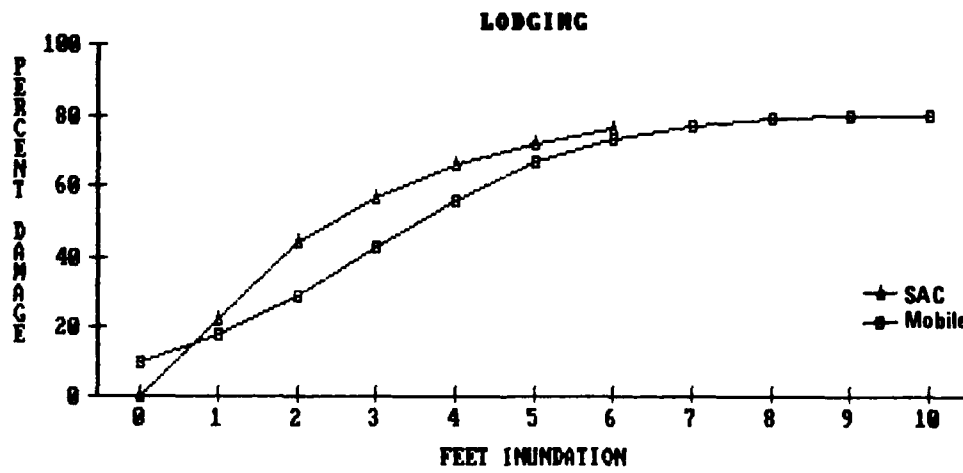


Figure A-12

Equipment

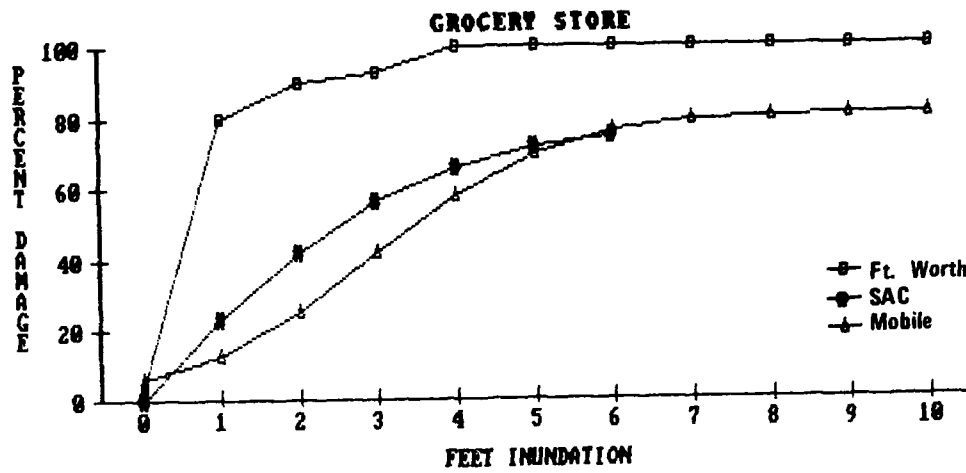


Figure A-13

Equipment

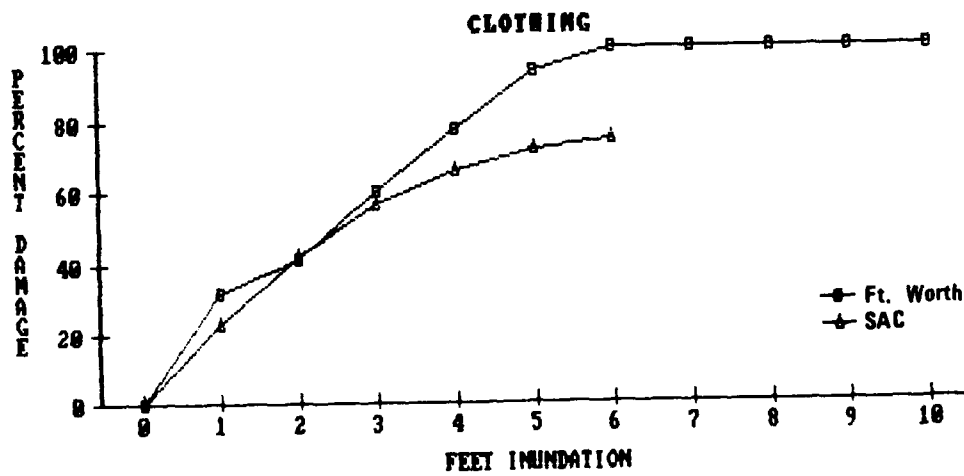


Figure A-14

Equipment

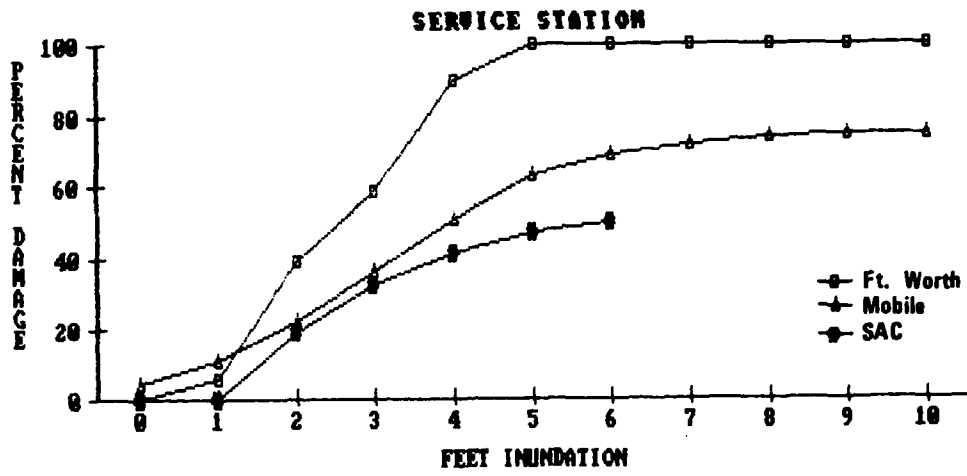


Figure A-15

Equipment

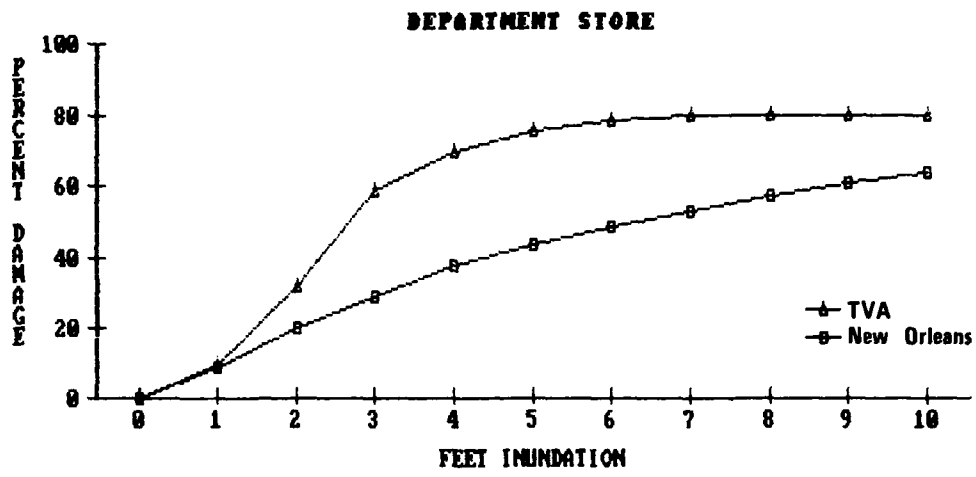


Figure A-16
Contents

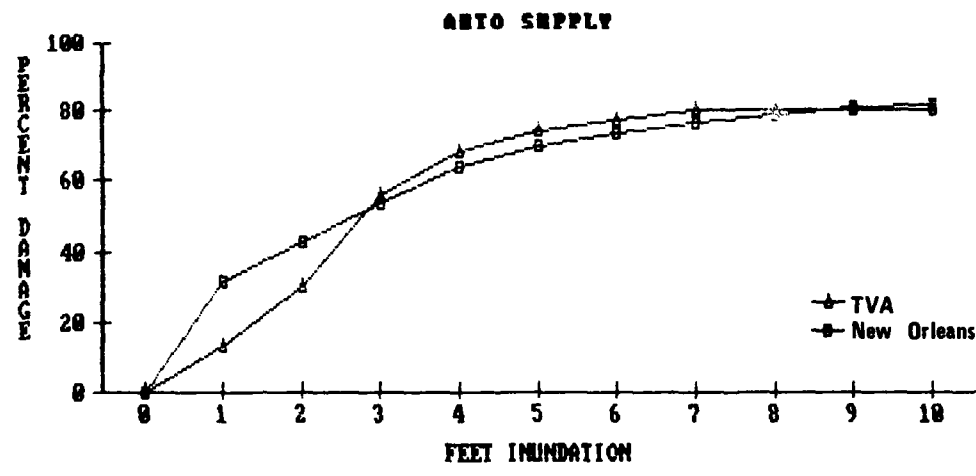


Figure A-17
Contents

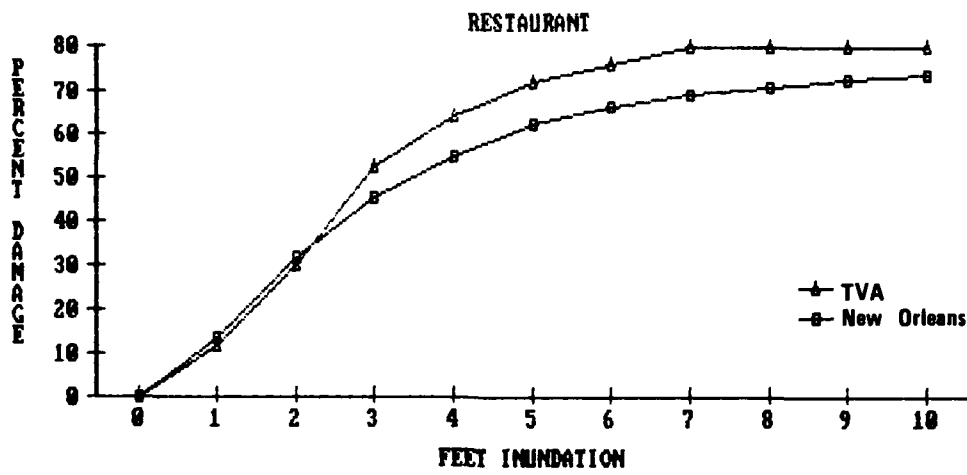


Figure A-18

Contents

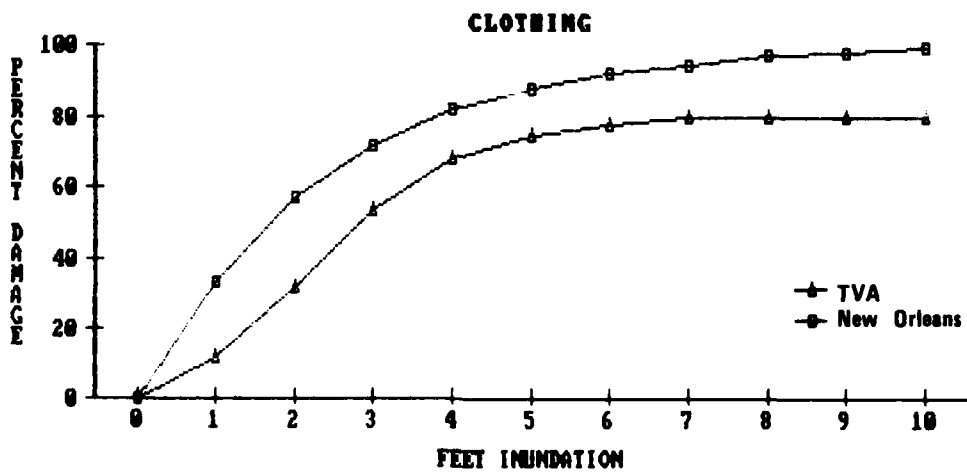


Figure A-19

Contents

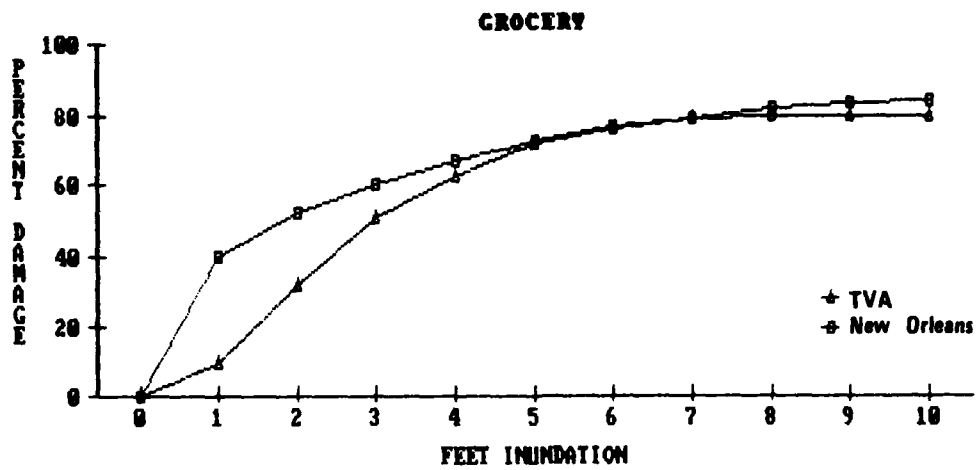


Figure A-20

Contents

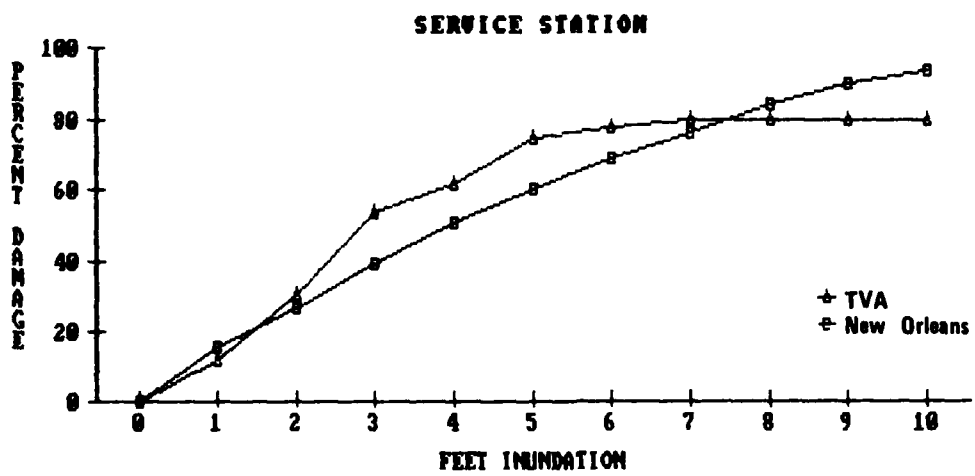


Figure A-21

Contents

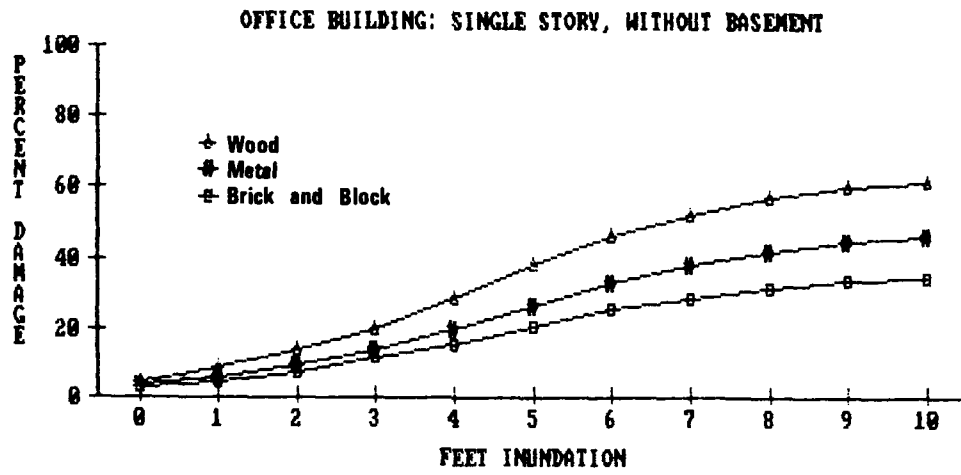


Figure A-22

Structure

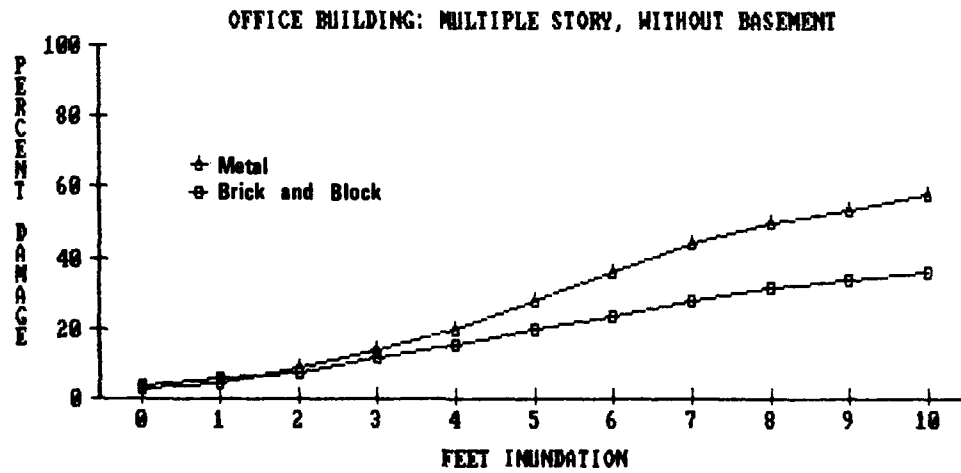


Figure A-23

Structure

APPENDIX B

APARTMENT, COMMERCIAL AND INDUSTRIAL,
GOVERNMENT, TRANSPORTATION, AND UTILITIES FLOOD DAMAGE QUESTIONNAIRE

APARTMENT, COMMERCIAL & INDUSTRIAL GOVERNMENT
TRANSPORTATION, AND UTILITIES
FLOOD DAMAGE QUESTIONNAIRE

OMB APPROVAL NO. 0702-0016 - Expires 31 October 1986

1. What is your address (or township, range, and section)?
2. How long have you been at this address? (Check one)
 - a. Less than 1 year _____
 - b. 1 - 2 years _____
 - c. 3 - 4 years _____
 - d. 5 - 6 years _____
 - e. 7 - 8 years _____
 - f. over 8 years (please specify) _____

3. Regarding the Structures:

a. Principal structure

(1) Type _____

(2) Age _____

b. Other facilities

(1) Type(s) _____

(2) Age(s) _____

c. Other than principal structure. are there any other highly damageable items on your property?

(1) Moveable (cars, trucks, trailers, etc).

(2) ~~Not readily moveable~~ (landscaping, electrical equipment, trailer on blocks, etc).

4. What is the size of your property?

Square footage under one roof _____. Site acreage _____.

5. If this is a multi-unit structure, how many units (both residential, industrial, or commercial) are there? _____

a. How many units are on the ground floor? _____

b. How many (if any) living quarters units are partly or wholly below ground level? _____

6. Does the structure have a basement? _____

Note the number of subbasements if any. _____

If there is a basement and its square footage is less than the ground floor, how many square feet? _____

How many stories are above grade? _____



How many stories above ground have the same square footage as the ground floor? _____

How many stories (if any) have less square footage/floor than the ground floor? _____, square feet/floor _____

7. What type of sanitary sewage system do you have?

- a. _____ Local sewer connection.
- b. _____ Septic tank.
- c. _____ Private lagoon
- d. _____ Other
- e. _____ Don't know

8. Please check the type of drainage system used in your area to handle runoff during heavy rainfall.

- a. _____ Storm sewers
- b. _____ Ditches or culverts
- c. _____ Other
- d. _____ Not sure

9. While at this location, approximately how many times did this (type of facility) experience flood damage? (Check one) List dates if possible. _____

- | | |
|-----------------------------|---|
| a. _____ 1 time | a. _____ Never |
| b. _____ 2-4 times | b. _____ Infrequent (less than one per year) |
| c. _____ 5-7 times | <u>OR</u> |
| d. _____ 8-9 times | c. _____ Frequent (one to six times per year) |
| e. _____ 10-12 times | d. _____ More than six times per year |
| f. _____ More than 12 times | |
| g. _____ Don't remember | |

10. Were you aware of a flood problem before moving here? _____ If no, would you have moved here if you had known? _____ If yes, since moving here, have you experienced?

- a. _____ Much more flooding than expected
- b. _____ A little more flooding than expected

c. _____ About as much flooding
as expected

d. _____ A little less flood-
ing than expected

e. _____ A lot less flooding
than expected

f. _____ No flooding was ex-
perienced

What are the advantages of this site that offset the risk of loss due to flooding?

11. If you have sustained loss due to flooding, has any damage been caused by impact of debris carried by the floodwaters?

_____ yes _____ no
If so, approximately what percentage of the total damages was caused by debris?
_____ %

12. While at this location:

a. What was the deepest flooding experienced?

(1) Less than 2 inches

(1) Basement _____ inches

(2) 2 - 6 inches OR

(2) First floor _____ inches

(3) 7 - 12 inches

(3) Ground floor _____ inches

(4) Over 12 inches

(4) Second floor _____ inches

(5) Other _____

b. Date of flooding

c. Location where depth was measured

OR

a. 0-1 foot

e. 7-8 feet

b. 1-2 feet

f. 9-10 feet

c. 3-4 feet

d. 5-6 feet

13. On approximately what date did you experience the worst flooding during the last () years?

Month _____

Year _____

14. What is your estimate of the market value of this (type of facility)?
of its contents _____? of the land on which it stands? _____

Would your land be damaged by flooding? _____ If so, to what extent at various depths? _____

The following format is suggested:

<u>MARKET VALUE</u>	<u>ASSESSED VALUE (if applicable)</u>
Structure _____	_____
Land _____	_____
Contents _____	_____
Other _____	_____

15. Would the value of this property increase if recurrent flooding were eliminated? If yes, by how much? _____

16. Are the insurance rates you pay higher than rates for structures outside the flood problem area? _____ Do you have flood insurance? _____ If yes, what is the insured value minus deductible? _____

17. What is the distance from the ground level to the first flood level? _____
From the ground level down to the basement floor level? _____ At what level does damage begin? _____

18. Under what conditions did (or does) flooding occur? (Check all that apply).
If you know, please include season of the year, time of day, etc. _____

- a. _____ During any type of rainfall
- b. _____ During (or after) extremely heavy rainfall
- c. _____ During spring thaws
- d. _____ During dry weather
- e. _____ Other (please specify)
- f. _____ During higher than average tides
- g. _____ During extremely high tides only
- h. _____ Include dates of flooding, when possible

19. How did the water enter? _____
(Check each that applies)

- a. _____ Through windows or doors from street, river, creek or stream overflow
- b. _____ Sewer backup due to clogged sewer line between building and street

- c. _____ Sewer backup -- no obstruction in sewer line between building and street
- d. _____ Seepage through cracks in walls or floors
- e. _____ Don't know
- f. _____ Other (Please specify)

20. Was flooding due to electrical failure and inability of sump pump to remove ground water? _____

21. How long was water present? _____

- | | |
|------------------------|-------------------------|
| _____ less than 1 hour | _____ 4-24 hours |
| _____ 1-2 hours | _____ more than 24 hour |
| _____ 2-4 hours | _____ 2 days |
| _____ 3 days | _____ 4 days (or more) |

22. How long does it take for flood waters to recede from....? _____

23. Was there significant erosion to your property due to either high velocity of flood water or high elevation? _____
 If so, how much land was lost and to what depth? _____

24. What type of flooding was it --- backwater or headwater? _____
 OR (Was the flooding problem caused by water backing up from downstream?)

25. What was the source of flooding? (Name of river, creek, etc.) _____

26. Cause of flooding? (Rainfall-related or obstructions such as ice jam) _____

27. Before you moved to this location what, if anything, had been done to reduce flood damage?

28. While at this present location, what, if anything, have you or others done to flood proof it? (List approximate costs)

Describe each flood proofing measure including how effective and limits of effectiveness (water height, duration of flooding, etc.).

- a. Measures _____
- b. Effectiveness _____
- c. Water height _____
- d. Duration _____

29. While at this present location, what has been the impact of the things done to reduce flood damages? _____

(Check one)

- a. _____ No impact --- condition remains unchanged
- b. _____ Minor lessening of flood damages
- c. _____ Moderate lessening of flood damages
- d. _____ Major lessening of flood damages
- e. _____ Flood damage eliminated
- f. _____ Flood damage has worsened

30. Describe time, cost and activities that result from preparing for flooding. How often do you do these activities? What percentage of the time are they unnecessary because the flood does not reach expected height?

31. Do you take any measure to minimize your flood damages once flood stage or flooding conditions appear imminent? _____
If so, do you: (please identify major items)

- a. _____ Move items from basement to first floor;
- b. _____ Move items from basement to second floor or higher;
- c. _____ Move items from first floor to second floor or higher;
- d. _____ Evacuate items from the building;
- e. _____ Other (please identify) _____

Can you always count on labor being available for your flood fight activities?

32. If you do take measures to minimize your flood damages, please estimate a dollar amount or a percentage by which you decrease your potential flood damages. _____

33. How many hours of warning would you need to take practical emergency measures to protect your family and minimize physical losses? _____

34. In hours, how much warning did you have before the _____ flood occurred? _____

35. Flood Warning

Is your area protected by some type of:

- | | | |
|--|-----------|----------|
| a. flood warning system | YES _____ | NO _____ |
| b. temporary evacuation plan | YES _____ | NO _____ |
| c. other type of flood preparedness plan | YES _____ | NO _____ |

If so, please describe: _____
Please evaluate the effectiveness of this (system) (plan).

36. How much advance warning time do you generally have before a flood _____

37. Do you feel that the above described flood warning/preparedness plan has reduced your past flood losses?

a. _____ YES HOW _____

b. _____ NO _____

If so, by how much have your flood losses been reduced for specific floods?

<u>Flood Date</u>	<u>Reduction in losses</u>			
	0%	5-10%	10-25%	25-50%

38. For the _____ flood, how much time did you spend in flood prevention (i.e. shields, relocating contents, sand bagging, etc.)? _____

39. Do you know if any measures were taken by public agencies to reduce damages to your area? _____ If so, what were they? _____ Have they been effective? _____

40. Has your facility been flooded in the past? _____ If so, please describe your damages by type and amount, as the water level increases from where damage begins. _____

<u>Month/Year</u>	<u>Depth of water above first floor (ft)</u>	<u>Damage sustained (\$)</u>
_____	_____	_____

41. Based on past experience, or your best estimate, please furnish damage estimates for the following depths of flooding above your first floor -- (with) (without) flood warning.

<u>Depth of flooding(below (above) first floor (ft)</u>	<u>Damage to structure(\$)</u>	<u>Damage to contents(\$)</u>	<u>Other ^{1/} damage</u>	<u>Damage to vehicles(\$)</u>
---	--------------------------------	-------------------------------	-----------------------------------	-------------------------------

Total Damage(\$)

1/ Break out shutdown time, business cost, and emergency costs.

42. Have you noticed a more rapid deterioration of sidewalks, walks, driveway, etc. which are flooded than those areas which have not? _____ How often is major maintenance or replacement required on those flooded _____ not flooded _____?

43. Were the various repair costs at the time of the flood higher than normal for such repair? _____

44. Did you incur any emergency expense associated with preparing for the flood? (Sandbagging, truck rental, storage, etc) _____ Specify amounts _____

45. What emergency measures did you take to prevent damage? _____
How much did these measures cost? _____ How much damage was prevented? (\$)

46. Did you take any of the following emergency measures?

- a. Raise damageable items above floor level _____
- b. Sandbag around your property _____
- c. Place plastic or other sealer around openings to keep water out _____
- d. Evacuate damageable property _____
- e. Did you allow the basement to flood in order to prevent walls from collapsing? _____ yes, _____ no.

47. For the (last)(most serious flood event) or (flood of...) please estimate the number of person-days spend away from the job because of flooding problems.

- a. number of days lost from work _____.
- b. estimate the effect of flooding on employees income due to missing days of work _____.
- c. estimated increase in transportation costs due to flooding _____.
- d. to what extent will the lost income reflected in b. above be made up in this facility or elsewhere? _____.

48. Can you estimate the loss in profit for your establishment during period of flooding (most recent floods)?

49. Has there been any loss of production for your establishment during periods of flooding (most recent floods)? If so, how much loss and the dollar amount? Has the loss of production been made up by other firms or offices?

50. For the (last) (most serious flood event) or (flood of...) estimate the number of person-days spent cleaning up _____ Cost? _____

51. Did the flood cause damage to your water supply? _____
If so, what were your losses due to this damage? _____

52. What are the present uses of basement areas (or areas below ground elevation) in your building? (Check all that apply)

- a. Parking garage _____
- b. Heating equipment _____
- c. Hot water heater _____
- d. Garden apartment(s) _____
- e. Storage for residents _____

- f. Other storage
- g. Laundry equipment
- h. Workshop
- i. Air conditioner
- j. Common use area (social, party, recreation room(s))
- k. Other

53. During periods of shutdown resulting from flooding, what is the value of your fixed overhead that continues even though you are not operational?
\$ _____

54. What are your annual average sales? \$ _____

55. What is your average annual operating costs (sales less net income)?
\$ _____

56. What amount of your lost business would be recovered following continuation of normal operations after flooding? _____ percent

57. What is the relationship of sales to inventories in your operation, i.e., what percent of inventories do you keep on hand?

58. Do your inventories increase in a direct proportion to increased sales?
_____ yes _____ no Please explain _____

59. Do you know other businesses which would be adversely affected if your business were to close down during flooding? This could be businesses that supply inputs to you or business to which you supply products. If your business was closed down due to flooding, would they have alternatives which will allow them to continue production at their current levels?

60. If your equipment were damaged during flooding, could you estimate the repair costs and salvage value of the equipment (at stages of flooding)?

61. What type of water supply system do you have?

- (a) _____ public
- (b) _____ private
- (c) _____ do not know

62. How often do you have flood-related repairs? _____

63. Does preparing for the flood emergency cause you to reduce business operations? _____

64. Will you use your employees to help clean up and repair damages due to flooding? _____. If not, which service will you use? _____

65. Identify and estimate the value of each major item and describe it including its position relative to the main floor.

a. Items _____

b. Values _____

66. a. How are major items damaged? _____

b. What are the repair costs?

(1) Under 1 foot _____

(2) 1 to 2 feet _____

(3) 3 to 4 feet _____

(4) 5 to 6 feet _____

(5) other _____

67. Please indicate and describe any critical point where damages dramatically increase _____

68. Has there been settling of your first floor? If yes:

a. To what extent (in feet)

b. Do you anticipate any problems as a result?

c. Do you anticipate further settling?

Do you or this business own, have a mortgage on, or rent this structure.

69. "During the past floods, have you experienced a disruption of utilities (water, gas, electricity, etc.)?"

70. "As a result of past flooding, have you considered selling and/or moving to a flood-free area?"

71. "Have any of your vehicles, including cars, trucks, campers, trailers, etc., been damaged by flooding at this address?"

72. What is the average daily sales volume? _____

73. What is average daily employment? _____

74. What is the average hourly or daily wage, including fringe benefits?

75. If your company is involved in manufacturing, what is average daily production (units of output)? _____

76. How many days of production or sales were lost due to flooding?

Specify"

- number of days flooded _____

- number of days required for cleanup. _____

- number of days lost for other reasons (indicate the reasons--e.g.,

transport problems, start-up time, employees absent due to cleanup of residential properties).

77. If applicable, how much lost production can be made up by:

- overtime (specify increased production cost for overtime after the flood event)? _____

- transfer of production to other plants within the company (specify the increased cost)? _____

- deferred production to times or seasons in which excess capacity typically occurs (explain)? _____

78. If applicable, how much lost sales can be made up by:

- transfers of sales to other stores/outlets within the company at other locations. _____

- increased sales at the same store/outlet after the flood event (deferred purchase)? _____

- transfer of sales to other stores outside the company? _____

79. Aside from actual losses due to flood events, does the threat of flooding affect productivity or sales volume? (If so, explain.)

80. Has the threat of flooding influenced decisions regarding:

- purchases of new production equipment?

- construction of new buildings?

- expansion of production or sales capacity?

(If yes, explain each.) _____

81. Do you have any plans to build new facilities at different locations in the subject area? (Explain.)

82. If the flood threat were eliminated by structural measures,

- would decisions to purchase new equipment, build new buildings or expand capacity be different?

- would you still make the same plans regarding new locations?

(Explain each response.)

83. If a diaster or emergency was declared in your area, did you receive assistance or loan from any of the following?

a. Small Business Administration: Loan \$ _____ Interest _____
percent Number of years _____

b. Other Federal, State or local agency (specify) _____

84. In case of diaster or emergency in the area, were you an owner-occupant within a multi-family structure Yes___No___. If yes, did you receive assistance or loans from any of the following:

a. Small Business Administration: Loan\$_____ Interest _____
percent Number of years_____

b. Temporary Housing from_____ to_____

c. Limited Home Repair\$_____

d. Individual-Family Grant Program \$_____

e. Red Cross \$_____

f. Other \$_____

85. If a disaster or emergency was declared in your area and you were owner of a single family unit, owner of a unit within a multi-family structure, or tenant, did you receive assistance from any source or incur disaster related expenses?

Yes _____ No _____ If yes, answer questions applicable to you from the following:

- a. FDAA Individual Family Grant Program (IFGP). Grant \$ _____.
- b. FDAA Temporary Housing or nonassisted living away from damaged home.

Period from _____ to _____. Number of occupants of temporary housing unit _____.

Difference in daily driving mileage and time due to location of temporary housing. Mileage ^{at \$17 per mile} _____ and time ^{at} _____ average hourly wage \$ _____. Other expenses incurred due to living away from the damaged residence. Daily average \$ _____. Evacuation and relocation expenses \$ _____. Continuing fixed costs on the damaged residence of one percent (or as applicable) of pre-flood value of damaged residence for monthly investment cost \$ _____ and .2 percent (or as applicable) for monthly cost of utilities \$ _____.

- c. FDAA Limited Home Repair Assistance. Amount \$ _____. Expenses of leaving and returning to the damaged home \$ _____. Square footage of unusable living space within damaged home. Feet _____. Fair market rent of unusable living space at 25c per square foot (or as applicable) per month \$ _____ and cost of utilities consumed in unused part of the residence \$ _____. Cost of unusable garage based on five percent of the fair market rent per square foot per month \$ _____.

Cost of unusable furnished basement based on 20 percent of the fair market rent per square foot per month \$ _____. Cost of unusable unfurnished basement based on 10 percent of the fair market rent per square foot per month \$ _____. Period of permanent repair from _____ to _____. Other expenses incurred during the permanent repair period \$ _____.

- d. Subsidized SBA or FmHA home repair loan. Loan \$ _____.
From _____. Interest ____ percent. Number of years ____.
Cost and expenses of obtaining the loan.
- e. Nonsubsidized loan. Loan \$ _____. From _____.
Interest ____ percent. Number of years _____. Cost and expenses of
obtaining the loan \$ _____.
- f. Assistance from ASCS \$ _____.
- g. Assistance from other Federal, State, or local agency (specify)
_____.
- h. Food stamp assistance \$ _____.
- i. Disaster unemployment assistance \$ _____.
- j. Assistance from Red Cross \$ _____. Mennonite Disaster Service
\$ _____. Salvation Army \$ _____. Other \$ _____.
- k. Expenses incurred in flood fighting \$ _____.
- l. Did you assist other flood victims? If so, amount \$ _____.
- m. HUD housing rehabilitation assistance (Section 407, Housing and Community
Development Act). Amount \$ _____. If all or part of this
assistance was earmarked for flood proofing such as raising structure,
indicate \$ _____.

86. If a disaster or emergency was declared in your area and your business property or activity was affected by the disaster and your business property or activity was within the disaster site or the impact area adjacent thereto, did you receive assistance from any source or incur disaster related expenses?

Yes _____ No _____. If yes, answer questions applicable to you from the following:

- a. Subsidized SBA business repair loan. Loan \$ _____. Interest _____ percent. Number of years _____. Cost and expenses of obtaining the loan \$ _____.
- b. Nonsubsidized loan. Loan \$ _____. From _____. Interest _____ percent. Number of years _____. Cost and expenses of obtaining the loan \$ _____.
- c. Assistance or loan from any other source (specify) _____.
- d. Did you receive assistance from HUD Urban Development Action Grant (UDAG) program? If so, specify _____.
- e. Was your business closed temporarily as a result of the disaster? If so, give estimates of costs incurred:
Salary paid to employees who did not work \$ _____.
Employee income losses \$ _____.
Fixed costs of closure \$ _____.
Overhead \$ _____.
Loss of profits from lost sales \$ _____.
Expenses related to reopening other than repair cost \$ _____.

f. Upon re-opening, was there a part of the business still closed for repair? If so, give estimates of costs incurred.

Salary paid to employees who did not work \$ _____.

Employee income losses \$ _____.

Fair market rent of unusable business space at \$ _____ per square foot, per year during the repair period from _____ to _____.

Cost of utilities consumed in unused business space \$ _____.

Overhead \$ _____.

Loss of profits from lost sales \$ _____.

Other expenses related to restoration of unused space other than repair cost \$ _____.

g. Was your business closed permanently as a result of the disaster? If so, give estimates of costs incurred.

Liquidation of lease, if applicable \$ _____.

If owner of closed business buildings, estimate fixed costs based on the fair market rent for affected buildings \$ _____.

Liquidation of business inventory \$ _____.

Other expenses related to going out of business \$ _____.

h. If your business was located in the impact area and did not experience closure but your sales and work force were affected, estimate the following:

Salaries paid to employees who did not work \$ _____.

Employee income losses \$ _____.

Loss of profit resulting from reduced sales \$ _____.

i. Did you incur expenses in flood fighting? \$ _____.

- j. Would you be willing to estimate the losses of your out-of-town distributor? Estimate \$_____. If this is not possible, please give the name and address of your distributor.

Name _____

Address _____

Telephone Number _____

- k. If this facility is a trucking or transportation company, please estimate your loss as a result of cancelled trips \$_____ and associated cost \$_____.

- l. If this facility is a utility company, please estimate the cost of restoration, replacement and repair of your facility including administrative cost \$_____ and associated costs \$_____.

- m. If this is a non-profit organization (church, civic club, charitable organization, youth organization, etc.), please estimate your assistance effort (specify) \$_____.

RIVER SUBREACH NO. _____ FLOOD _____

FIRM NAME _____

ADDRESS _____ TYPE OF BUSINESS _____

INTERVIEW DATE _____

BY _____

BUILDING TYPE _____ BUILDING SIZE _____ FT BY _____ FT; _____ SQ FT
 (BLOCK/BRICK) (STEEL) (WOOD)

BUILDING FLOORS _____ GARDEN LEVEL _____
 (BASEMENT/1st/2d/3rd/____) (1st/2d/3rd/____)

STREET ELEVATION _____ (MEAN SEA LEVEL)	REPLACEMENT VALUE (\$1,000)	19__	19__	19__	19__
		ACTUAL WITH FLOOD FIGHT	MINUS FEET	WITHOUT FLOOD/ FIGHT	PLUS FEET
GROUND ELEVATION _____					
ELEVATION AT (ENTRY) (1st FLOOR)		FT	FT	FT	FT
WATER SURFACE ELEVATION		FT	FT	FT	FT
DEPTH OF FLOODWATER OVER (ENTRY) (1st FLOOR)		FT	FT	FT	FT
DAMAGE TO TRANSPORTATION:					
1. Roads, Bridges, Streets, Walks, Parking	\$	\$	\$	\$	\$
2. Rail Beds and Tracks					
3. Rerouting Trains, Trucks, Cars & Buses					
4. Docks & Loading Facilities					
DAMAGE TO BUILDINGS (Material & Labor Cost)					
5. Foundation and supports					
6. Floors (Steel) (Concrete) (Wood)					
7. Floor Covering (Ceasar (Ceramic) (Linoleum) (Carpet)					
8. Exterior Walls (Block/Brick (Metal) (Wood) and Insulation					
9. Windows					
10. Interior Walls and Ceilings					
11. Doors and Moldings					
DAMAGE TO BUILDING UTILITIES (Type and Location) B = Basement; G = Ground Floor; R = Roof					
12. Sewer Systems (Storm) (Indust) (Sanitary)					
13. Water Supply Systems (Treatment) (Pipes)					
14. Water Systems (Hot Water) (Softening)					
15. Communication Systems (Bell) (Other)					
16. Electric Power Transformers (On Pole/Ground)					
17. Elec. Service Entrance and Meters					
18. Engines/Generators/Alternators					
19. Other Elec. Control Panels and Cir. Breakers					
20. Wiring, Switches, Outlets, Lighting					
21. Fuel Supply (Oil Tanks) (Gas Pipes/Meters)					
22. Heating (Oil) (Gas) (Elec.) (Air) (Water) (B/G/R)					
23. Air Cond. (Gas) (Elec.) (Cool) (Clean) (Dehumidify) (B/G/R)					
DAMAGE TO EQUIPMENT, APPLIANCES & FURNITURE					
24. (Conveyors) (Elevators) (Escalators) (Auto. Doors)					
25. Foundry Furnaces and Welding Equipment					
26. Machine Tools and Patterns					
27. Other Motors and Engines					
28. Compressors					
29. Refrigeration Units					

1/ May be difference in water level due to flood fight.

	REPLACEMENT VALUE (1K=\$1,000)	ACTUAL WITH FLOOD FIGHT	MINUS FEET	WITHOUT FLOOD FIGHT	PLUS FEET
30. Hand and Paint Tools		\$	\$	\$	\$
31. Other Equipment					
32. Display Cases, Counters, and Bins					
33. Appliances (Oven/Range/Hood & Fan) (Refrig.) ()					
34. Furniture (Office)(Furnished Apartment)					
35. Apartment Tenant Property					
DAMAGE TO					
36. Parts/Raw Material					
37. Partly Assembled/Processed Product					
38. Merchandise					
39. Inventory or grain in storage					
GENERAL COSTS					
40. Flood Fight					
41. Evacuation (Owner)(Tenant)					
42. Loss of Wages					
43. Removal of Debris & Damaged Items					
44. Disinfecting, Other Cleaning/ Rehabilitation					
45. Replacement of Records					
46. Loss of (Sales)(Rent) Due to Inter- ruption of Business \$ /wk)(mo)					
47. Loss of Gross Income due to Inter- ruption of Business \$ /wk)(mo)					
48. Loss of Net Income Due to Inter- ruption of Business					
49. Alternative Operating Costs					
50. Number of Employees					

NOTES & SKETCHES:

APARTMENT UNITS ONLY: (GARDEN LEVEL/1st/2d/3rd/) OR (BASEMENT/1st/2d/3rd/)

NO. OF BUILDING	EFFICIENCY	1 BR	2 BR/1 BATH	2 BR/2 BATHS	3 BR	4 BR	NO. OF GARAGES	TOTAL UNITS
Duplex								
3-Plex								
4-Plex								
5-Plex								
6-Plex								
8-Plex								
12-Plex								
18-Plex								
24-Plex								
TOTALS								
Av. Rent:								
B or GL								
Av. Rent:								
1st, 2d, 3rd								
Av. Sq Ft/Apt.								

Av. Sq Ft Hallways _____ (Tile)(Carpet) on (Concrete)(Wood) _____
 Av. Sq Ft Utility Room _____ (Tile)(Carpet) on (Concrete)(Wood) _____

_____ No. of Employees - Apt/Public/Business
 _____ Average Wage/Month, Including Benefits
 _____ Man (day) (week) (month) on Flood Fight
 _____ Man (day) (week) (month) on Layoff
 _____ Man (day) (week) (month) on Cleanup/Removal
 _____ Man (day) (week) (month) on Disinfect
 _____ Man (day) (week) (month) on Other Cleanup and Rehabilitation
 _____ Man (day) (week) (month) to Restore Records

PLANNED GROWTH/EXPANSION/REMODELING:
 BUILDING _____
 UTILITIES _____
 EQUIPMENT _____
 INVENTORY _____
 SALES/RENT _____
 No. Units _____

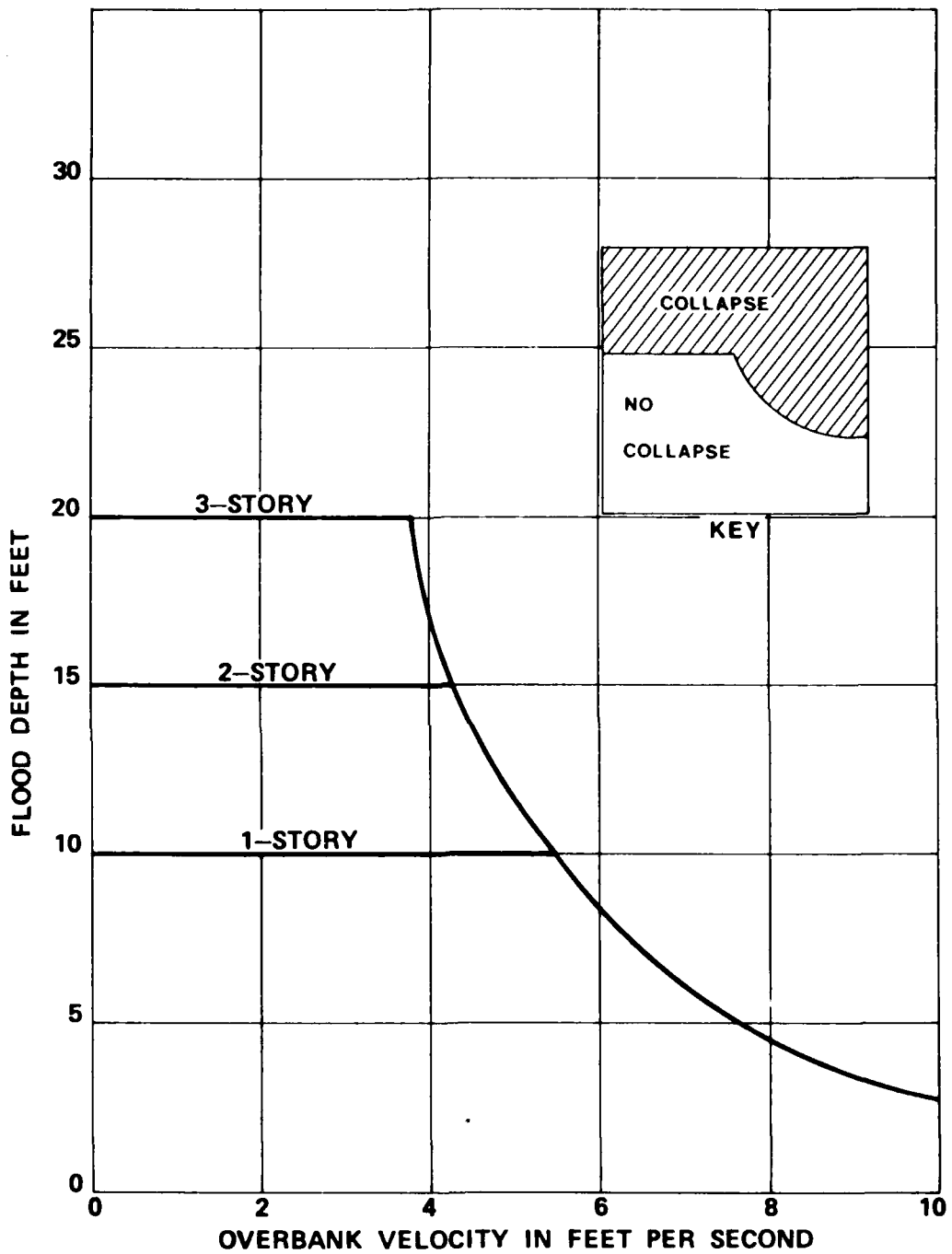
APPENDIX C

BUILDING COLLAPSE CURVES

Appendix C

The charts in this section illustrate the combination of depth-damage and velocity that are likely to cause buildings of various construction material and structure type to collapse. These functions were developed by the Portland District Corps of Engineers for the Wilamette River System. The functions were developed for the following classes of buildings:

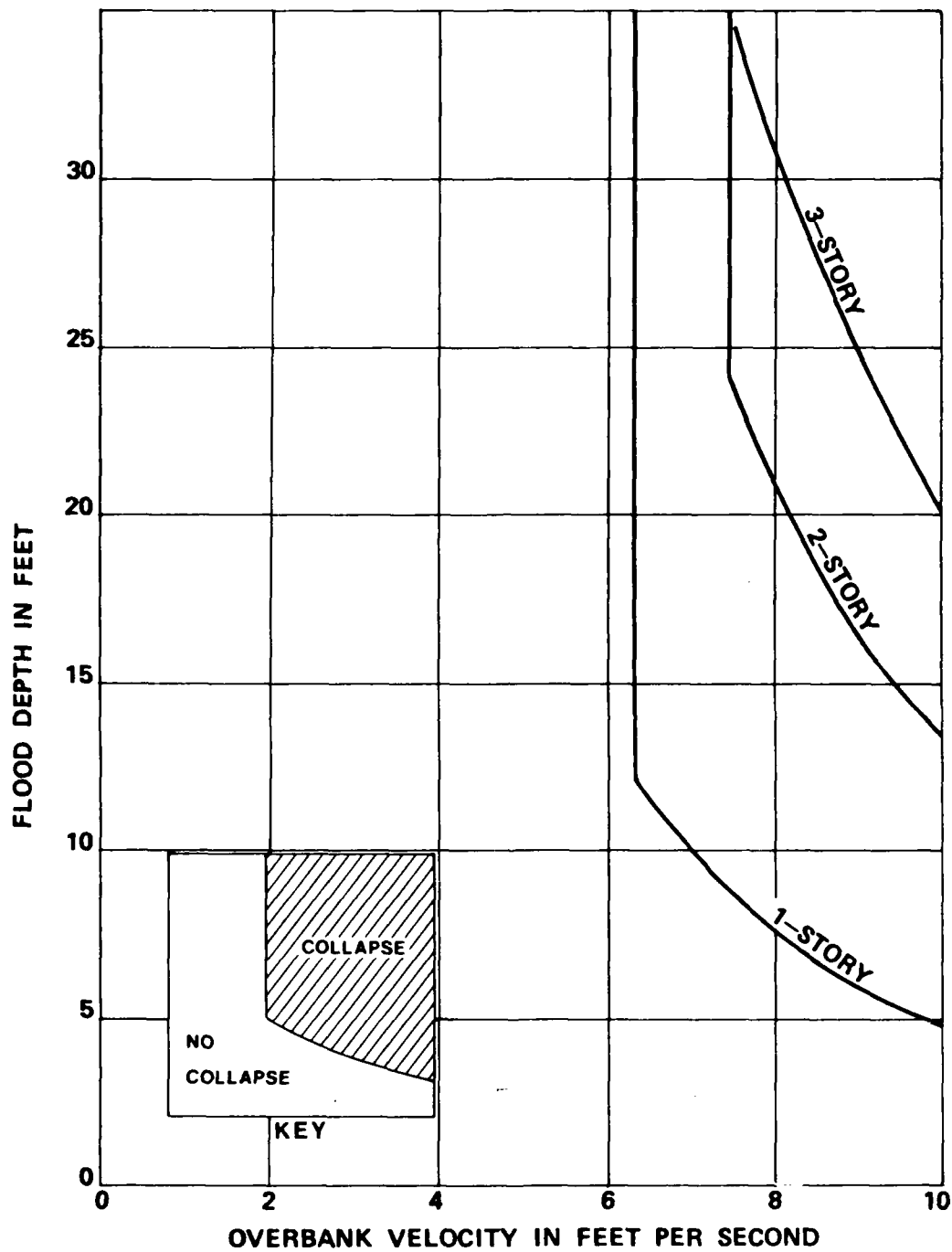
- o Class A - Structural steel columns and beams with nonbearing walls.
- o Class B - Reinforced concrete columns and beams with nonbearing walls.
- o Class C - Masonry or concrete load bearing walls.
- o Class D - Wood or steel studs in bearing walls with wood or steel frame.



BUILDING COLLAPSE CURVE
CLASS D WOOD BUILDING

FIGURE
 C-1

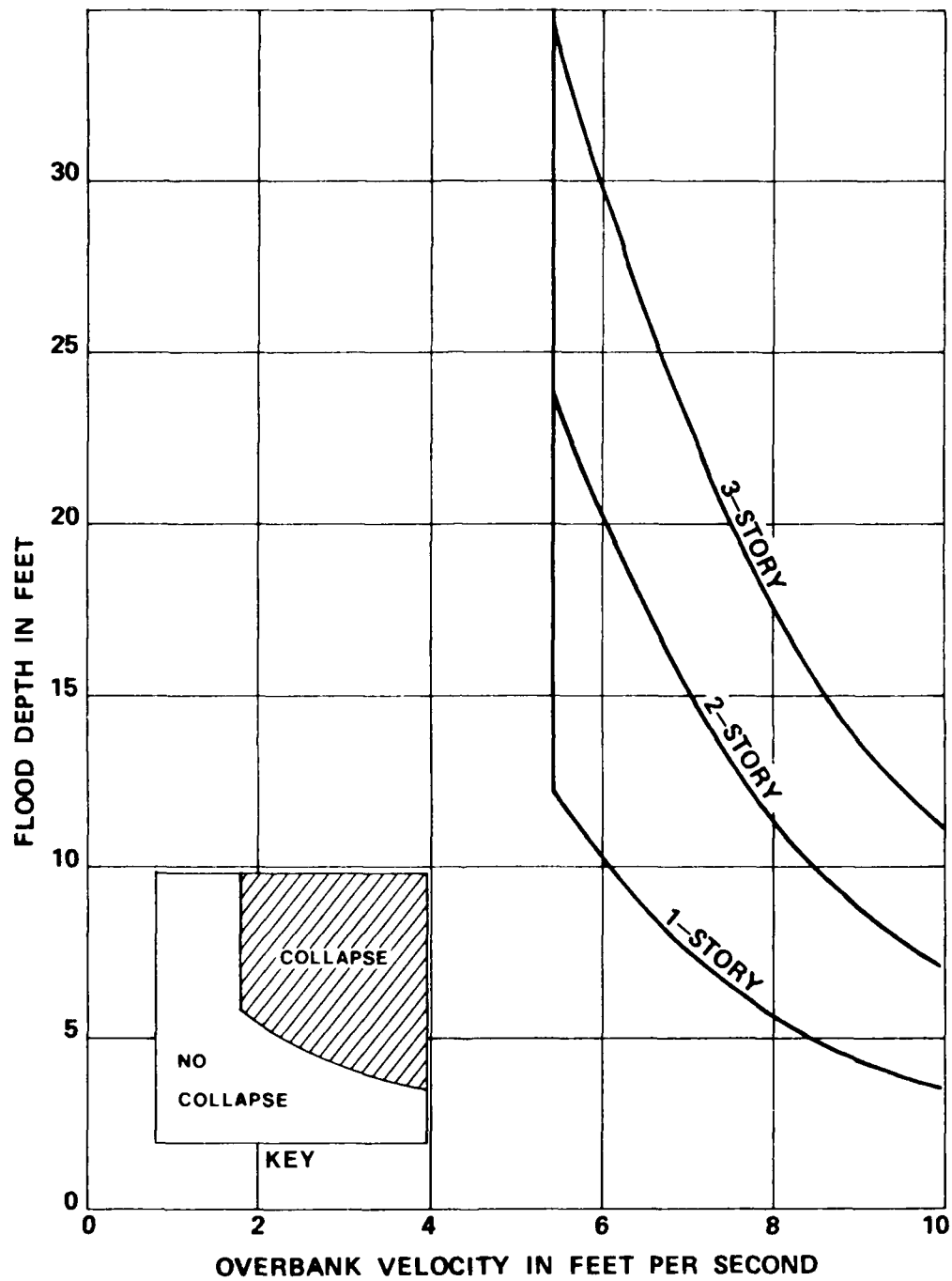
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**BUILDING COLLAPSE CURVE
CLASS C BUILDINGS**

FIGURE
C-2

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	BUILDING COLLAPSE CURVE CLASS D STEEL BUILDING	FIGURE C-3
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