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CATALOG OF RESIDENTIAL DEPTH-DAMAGE FUNCTIONS

Used by the Army Corps of Engineers in Flood Damage Estimation

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Stuart A. Davis and L. Leigh Skaggs

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USACE, Water Resources Support Center
Institute for Water Resources
7701 Telegraph Rd., Casey Building
Ft. Belvoir, VA 22060-5586

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A depth-damage function is a mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed to that water. The depth-damage relationship is the most important tool in the cost-benefit analysis of flood damage reduction projects. This reports presents a comprehensive catalog of residentail depth-damage functions used by Corps of Engineers district offices. These damage functions include those computed from National data of flood damage records as well as those originally computed on a project-specific basis and now in general use. This catalog should help analysts who perform flood damage estimates to carefully consider existing local damage functions, and has the functions compare with depth-damage functions used by other Corps of Engineers districts.

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CATALOG OF RESIDENTIAL DEPTH-DAMAGE FUNCTIONS USED BY THE ARMY CORPS OF ENGINEERS IN FLOOD DAMAGE ESTIMATIONS

by

Stuart A. Davis and L. Leigh Skaggs

U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources
Ft. Belvoir, Virginia 22060-5586

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PREFACE

This report was completed under the Flood Mitigation, Formulation, Planning, and Analysis research work unit at the Corps of Engineers, Institute for Water Resources (IWR). Mr. Stuart A. Davis is the principal investigator for the research unit. The Flood Mitigation work unit is part of the Planning Methodologies research program, which is under the direction of Mr. Michael R. Krouse, Chief of the Technical Analysis and Research Division at IWR. Mr. Steven R. Cone is the technical monitor of the Flood Mitigation work unit, under the direction of Mr. Robert M. Daniel, Chief of Economics and Social Analysis Branch at the Office of the Chief of Engineers.

The authors wish to acknowledge the contribution of Mr. Ridgley K. Robinson who is responsible for designing the format for and preparing most of the tables, graphs, and figures in this report. Ms. Katherine McCleese also prepared several of the tables in the report. Mr. Robert Norton provided the technical editing of the document. Ms. Arlene Nurthen was responsible for the document preparation and publication. Too numerous to list are the individuals in district and division offices who provided the depth-damage tables used by their offices, responded to the detailed survey questions, which are the basis for this catalog, and answered many follow-up inquires. Mr. Howard Leiken, Special Assistant to Administrator of the Federal Insurance Administration (FIA) patiently answered many questions regarding the FIA's damage functions.

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CHAPTER ONE

INTRODUCTION

"Let's not make the wrong mistakes."

- Yogi Berra

PURPOSE

The depth-damage relationship is the most important tool in cost-benefit analysis of flood damage reduction projects. Even so, the use of depth-damage functions is frequently a routine process that may involve little thought of how applicable a set of damage functions is to a particular situation. Sometimes depth-damage functions are embedded in computer programs which calculate expected annual damages, and the analyst is not necessarily aware of what the depth-damage functions look like or what assumptions support them. Depth-damage functions can vary tremendously in the magnitude of expected damage at given levels of flooding. Consequently, the selection of an appropriate depth-damage function can often make the difference of whether or not a project is economically justified.

This report is intended to be a comprehensive catalog of residential depth-damage functions used by Corps of Engineer field offices. It includes damage functions that were computed from National data of flood damage records, and damage functions originally computed on a project-specific basis and now in general use. It is hoped that this catalog will provide the stimulus for analysts who perform flood damage estimates to carefully consider their own damage functions, the history and assumptions behind those functions and how the functions compare with depth-damage functions used by other Corps of Engineer districts.

The Corps of Engineers has never sanctioned any particular set of depth-damage functions, nor is any endorsement implied here. Corps field offices have been encouraged to collect local flood information and use depth-damage information that reflects the type of flooding and the style of building found in the region, and the project area in particular. Since depth-damage functions should be valid for the area in question, the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Paragraph 2.4.6) encourages the use of "area depth-damage" relationships. However, National depth-damage functions issued by the Federal Insurance Administration (FIA) have been accepted for years for use in Corps feasibility studies, and the Army Audit Agency (AAA) has used the FIA depth-damage functions as a standard of reasonableness (Army Audit Agency, 1989, p. 15).

WHAT DEPTH-DAMAGE FUNCTIONS ARE AND HOW THEY ARE USED

A depth-damage function is a mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed to that water. In tables illustrating damage as a function of water depth, the first floor elevation is equivalent to 0 water height; negative numbers indicate heights below the first floor threshold. Depth-damage relationships are computed separately for structure and contents.

"Depth-damage relationships are based on the premise that water height, and its relationship to structure height (elevation), is the most important variable in determining the expected value of damage to buildings. Similar properties, constructed, furnished, and maintained alike, and exposed to the same flood stages and forces, may be assumed to incur damages in similar magnitudes or proportion to actual values" (Davis, et al., 1988, p. V-35).

Depth-damage relationships are generally expressed with content damage as a percentage of content value, and structure damage as a percentage of structure value, for each foot of inundation. Depth-damage functions can also be expressed in a specific dollar amount of damage for each depth; this, however, is only useful when applied to particular buildings at one point in time.

Many factors affect the amount of damages arising from a flood. The variable aspects of floods that impact on the damages include depth of flooding, time of year of flooding, velocity of floodwater, duration of flooding, sediment load, and warning time. Although all these factors may be relevant to the flood damages incurred, most historical assessment procedures have focused on only one explanatory variable, depth of flooding.

Because the depth-damage function is the primary relationship used in flood damage estimation work, various depth-damage curves have been developed. These can be specific to certain structures, such as an individual home, or averaged for a number of similar buildings, such as one story residential dwellings with basements. Details on calculating depth-damage functions are given in Chapter Two.

STRUCTURE DEFINITION AND VALUE DETERMINATION

Structure is usually defined as a permanent building and everything that is permanently attached to it. According to Engineering Regulation 1105-2-100 (paragraph 6-167), building values should be evaluated as an estimate of depreciated replacement value of the structure. Outside building values and land values are usually considered separately.

Sources used by several districts for making appraisals include the Marshall Valuation Service and the Marshall-Swift Residential Estimator Program, released by Marshall and Swift of Los Angeles, California, and the Boeckh Building Cost Guides, released by the E.H. Boeckh of Milwaukee, Wisconsin. These documents can be used for obtaining replacement costs for building construction in various parts of the country, using local construction cost multipliers by type of construction material and building size. These replacement values should be limited to depreciated conditions, however, or structural values will be overestimated.

CONTENT DEFINITION AND VALUE DETERMINATION

Household contents are usually defined as everything within the house, not permanently installed, such as rugs, portable dishwashers, and freestanding bookshelves.

The standard depth-damage relationships applied to residential property often incorporate content-to-structure value ratios. While property insurance companies often estimate the ratio of content value to structure value at 50 or 55 percent, ratios used by Corps districts have ranged from 25 to 75 percent. The ratio is now limited to 50 percent, unless supported by a local survey (ibid., paragraph 6-180). Several factors can influence the content-to-structure value ratio. The affluence factor is based on the principle that the ratio should increase with household income. It can also be assumed that basic necessities, such as clothing and appliances, and modest luxuries such as televisions and stereos, make the ratio above 50 percent for very poor households. Apartment and small condominium dwellers can also be expected to have higher valued items, when space becomes a limiting factor.

Appraisal of content values generally requires far more detailed work than structural appraisal because there is no easy way to approximate depreciated value for contents in the same way market value approaches depreciated replacement value for structures. By inventorying the contents of a sample of residences from the study area, pricing those contents using local store prices, and deducting an average percent of value for depreciation, the assumed content-to-structure value ratios can be corroborated or adjusted.

SCOPE OF THIS REPORT

This catalog is a basic introduction to depth-damage analysis. It is not a comprehensive guide to calculating depth-damage functions nor does it give extensive details on the various sets of depth-damage functions used within the Corps. The catalog does give a brief explanation of the concepts, procedures, and sources for depth-damage information, and it presents the damage functions used by Corps districts. The organization of the remainder of the catalog is described below.

Chapter Two offers a look at the methods for calculating depth-damage functions. The basic procedures and the advantages and disadvantages of each method are described.

Chapter Three describes the National Flood Insurance Program and the background and assumptions behind the damage functions which are the most widely used in the Corps.

All other damage functions are presented in Chapter Four. Chapter Four includes all the damage functions in a tabular format and all the assumptions or conditions on which the functions are based. The damage functions and assumptions are presented to enable a Corps field office to compare its own damage functions with those used by others. This will enable each field office to reassess the appropriateness of its own damage functions and to help determine if another set of damage functions might be considered for any particular building type.

Chapter Five presents a matter-of-fact, non-judgmental comparison of these damage functions. Chapter Six concludes with recommended policies on the development and application of depth-damage functions.

CHAPTER TWO

CONSTRUCTION OF DEPTH-DAMAGE FUNCTIONS

When estimating flood damages, an analyst may either use generalized depth-damage relationships, computed for the Nation, region, district, state, or project; or develop new depth-damage relationships. In computing new depth-damage functions, there are three basic approaches to determine the extent of damage occurring at various flood heights. These include post-flood surveys, synthetic damage estimates, and the adaptation of other damage functions to a specific region or locality.

Generalized depth-damage relationships were established for several types of residential buildings in 1970 and 1973 and updated annually by the Federal Insurance Administration (FIA); in 1979 by the Tennessee Valley Authority; and over the years by several Corps district offices. Standard relationships are common for residential structures because residential property is considered to be fairly homogeneous in susceptibility and layout of contents, and in types of building materials used.

BASIC CONSIDERATIONS

No matter what approach is used to estimate depth-damage relationships, a well-founded understanding of the effect of flooding and the type of damage that occurs at various depths of flooding is essential for judging the reasonableness of any estimates. A starting point would be to identify the susceptibility of contents, structure, and outside property to damage from immersion. Table 1 identifies the general effects of flooding on contents, structure, and outside property. The next step would be to determine what these effects mean in terms of percent damage.

TABLE 1

PHYSICAL EFFECTS OF FLOODS ON RESIDENTIAL PROPERTY											
Element of Property Affected	Effects of Flooding										
CONTENTS											
Furniture	X	X	X	X	X	X	X	X	X	X	
Clothing	X	X	X		X	X		X			
Glass									X		
Small tools	X	X			X		X	X	X		
Appliances	X	X	X		X	X			X	X	
Toys and play equipment	X	X	X		X	X	X	X	X	X	
Pets											X
Books and records	X	X	X		X	X					
Food stuffs	X	X			X	X			X		
House maintenance supplies	X	X	X		X	X	X	X	X		
STRUCTURAL											
Foundations and walls	X			X	X				X	X	
Basement floors	X		X	X	X		X		X		
Heating, ventilating, air	X	X							X	X	
conditioning equipment	X				X						
Electric equipment	X	X							X	X	
Electric wiring	X				X				X		
Plumbing and equipment	X	X	X	X	X	X			X	X	
House insulation	X	X			X	X					
Floors, stairs, partitions	X	X	X				X	X	X	X	
Doors, windows, woodwork	X	X	X				X	X	X		
Plaster and lath	X	X	X		X				X		
Painting, decorations	X	X	X			X		X	X		
Hardware	X	X				X					
OUTSIDE PROPERTY											
Land and soil	X			X	X						
Landscaping	X			X	X				X		
Utility connections				X	X						
Cars, motors, mowers, etc.	X	X	X		X	X					X
Driveway, walks, etc.	X			X	X				X	X	
Gardens, trees and produce	X	X		X	X						
Fences, gates, etc.	X	X	X	X	X		X			X	
Sheds, garages	X	X	X	X	X		X		X	X	
Wells, water supply				X	X	X					

One approach to estimating percent damage is in the construction of susceptibility tables, such as those constructed in Great Britain by Penning-Rowsell and Chatterton for residential contents (Penning-Rowsell and Chatterton, p. 30-31). These tables indicate the percent of remaining value of each item after being immersed in water.

For structural damage, Penning-Rowsell and Chatterton also included a detailed narrative of the effects of immersion on various types of construction. They then assembled a table that lists the item-by-item cost for repair of structural components, given five levels of inundation and short and long durations (less than or greater than 12 hours). Similar tables (which do not account for the effect of warning time) were used by New York District in making synthetic estimates of flood damage on the Green Brook Sub-Basin Damage Study (URS Consultants, Flood Damage Evaluation Guidelines for the Green Brook Sub-Basin Damage Study, 1988). This New York District work is illustrated below in the section on synthetic damage estimates.

The level of background detail considered by Penning-Rowsell and Chatterton is desirable, but not required, for an adequate evaluation of depth-damage functions. However, to assess potential damage there is a great deal to be gained from the simple exercise of identifying what is immersed at each foot of inundation and what specific damages might occur. Table 2 gives such a summary. This table is included only for illustration. Field offices are encouraged to create their own tables.

POST-FLOOD INTERVIEWS

The most precise method of gathering residential depth-damage information is through interviews of recent flood victims. During the interviews, damages are also estimated for elevations above and below the first floor level of a structure.

Development of depth-damage functions through post-flood interviews should include the following steps, which closely follow the procedures found in the National Economic Development Procedures Manual - Urban Flood Damage, Volume II: Primer for Surveying Flood Damage for Residential Structures and Contents, (Mill, et. al., 1991).

TABLE 2
Typical Residential Depth-Damage Function
($100,000 Structure, with $50,000 Contents)

Water Height	Structure Damage	% Damage to Structure	Content Damage	% Damage to Contents	Typical Damage
-8	0	0	0	0	Basement floor wet
-7*	$1,000	1	$1,500	3	Clean up, stopped drain
-6	$2,000	2	$3,000	6	Equipment affected, basement furniture damaged
-5	$2,800	3	$4,000	8	Appliances, stairs, dampness in house
-4	$3,200	3	$5,000	10	Basement furniture covered equipment damaged
-3	$3,700	4	$5,500	11	
-2	$4,200	4	$5,800	12	
-1	$6,200	6	$6,000	12	Basement ceiling, wiring affected
0	$8,000	8	$6,200	12	First floor-framing, floor wet
1	$11,000	11	$10,000	20	Furniture, insulation, walls, electric outlets damaged
2	$17,000	17	$14,000	28	Woodwork, doors damaged
3	$22,000	22	$17,000	34	Redecorating, windows, clothes, electronic equipment
4	$28,000	28	$21,000	42	Water comes over counter tops - appliances damaged
5	$33,000	33	$23,000	46	Second layer of drywall and paintings damaged
6	$35,000	35	$23,400	47	Replastering
7	$38,000	38	$23,700	47	
8	$40,000	40	$24,000	48	Ceiling lighting
9	$45,000	45	$26,000	52	Second floor framing, rugs
10	$50,000	50	$28,000	56	Similar to first floor
11	$52,000	52	$30,000	60	
12	$54,000	54	$32,500	65	

* Beginning damage elevation may depend on basement openings, foundation material, soil type, and velocity and duration of flooding.

1. Identify the Predominant Structure Types Within the Study Area. For purposes of floodplain inventory, categories of property are defined by similar susceptibility to flood damage. Both structural use and physical characteristics can be practical areas for categorization. Classification should be established based on the number of stories, the presence of a basement, and, possibly, building material. Separate categories can also be established for mobile homes, houses built on piers, various types of multi-family dwellings, and for different styles of housing, such as ranch, colonial, and Cape Cod.

2. Design the Questionnaire. A questionnaire should be designed to cover all the information needed to estimate content and structure values and to cover all damages intended to be included in the depth-damage functions.

3. Pre-test the Questionnaire. It is imperative that questionnaires be pre-tested, to ensure that the interviewers and respondents understand the questions and that there are no great difficulties in executing the survey. A survey is best pre-tested among a small sample of the population to be surveyed.

4. Draw Sample. A stratified random sample should be drawn, reflecting the structure categories determined in step 1.

5. Select and Train Interviewers. It is useful, although not imperative, to have interviewers with survey experience and some knowledge of structure and content value and damage determination.

6. Conduct Interviews. These interviews should occur soon enough after the event for the damages to be remembered and records to still be available, but long enough after the event for the great proportion of damage to occur and be discovered. The ideal time period would be between one to three months after the flood, although damage to items such as electrical appliances and insulation may not show up that quickly.

The interviewers should help clarify any questions that the interviewee may not understand, and possibly act as a resource regarding questions about value and damage when the interviewee is unable to answer a question. However, to the extent possible, the interviewer should allow the respondent to answer the questions as they are written and not bias the responses by giving opinions. Adequate supervision should be provided throughout the course of the interviews, to insure proper sampling, completeness of survey forms, and to handle any public relations problems that arise.

7. Assess Non-Responses. Determine if there is a systematic bias among those not answering the questionnaire. If there is a major group under-represented in the sample, their responses might be given added weight in the analysis.

8. Code and Edit Data. Screen the questionnaires for completeness, enter, and clean the data to be analyzed.

9. Analyze the Data. Tabulate the data to determine the total content value and damage, and the total structure value and damage. This information can be used along with water height to determine depth-damage functions. Depth-damage functions can be calculated to various degrees of precision. Two alternative methods are described below.

Cross-Tabulation Procedure. The cross-tabulation procedure is the simplest way to establish depth-damage relationships. At the simplest level, it involves taking the average of all the percent damage-to-structure and percent damage-to-contents observations for each one foot level of flooding. The actual analysis generally requires considerable data clean-up, including the elimination of incomplete records and outliers (extreme values). This approach is used because water height is commonly viewed as having the most influence on physical damage and because this method is relatively easy and quick. However, there are also problems with this procedure. Percent damages are expressed in relation to only one variable: water height; and there is no parameter to show the strength of the one independent variable in explaining variation in the dependent variable, percent damage. Further, there is limited information on distribution of the sample.

Regression Analysis. The best method of measuring the effects of several variables on percent damage is regression analysis. The strength of any one variable can be estimated along with the strength of the entire model in explaining the variance of percent damage. Regression analysis with depth-damage data is difficult, however, because of the problems in obtaining good measurements for all the important variables that influence percent damage. There may be a multitude of variables that effect the amount of damage, and very often the amount of variance in damage or percent damage that can be explained by a regression equation is low. The analyst also needs to be aware of errors in specifying regression equations, such as using explanatory variables that are too highly correlated with one another. In any case, only statistical packages that are adequately equipped to give interpretative statistics and diagnose errors should be used in regression analysis for calculation of depth-damage functions.

10. Document the Damage Functions. Although it is commonplace for depth-damage functions to be documented solely on a spreadsheet, it is far preferable to have a report which documents the development of the damage functions, the type of flooding, description of the population surveyed, housing characteristics, methods used to perform the survey, a copy of the survey form, and results of the analysis.

Advantages and Disadvantages of Post-Flood Damage Analysis

Post-Flood damage analysis is the only way for the analyst to get first-hand knowledge of what actually occurs under a specific set of flood conditions, and the only way that the analyst is certain of all the assumptions that go into the depth-damage calculations.

While this method of estimating elevation-damage curves is preferred, it can be time-consuming and expensive. The major limitation of the post-flood survey, however, is its dependence on a recent flood occurrence. Without recent flooding, it is necessary to make synthetic estimates or adapt other damage functions, as described below. When a flood does occur, it is often difficult to acquire the financial resources or personnel in time for a complete survey of a very large sample.

As mentioned above, post-flood damage surveys can be the most accurate method of calculating residential depth-damage relationships for several reasons. First, the analyst can determine firsthand the damages that actually occur for a particular level of flooding and for a particular type of flood occurrence. Second, the analyst can determine the age and pre-flood condition of all belongings and depreciate contents based on a pre-determined depreciation schedule. Third, the analyst can determine whether to include clean-up costs, and damage to outside property or any other particular type of damage. After these damage functions have been developed, there can be a thorough documentation of any information pertinent to a future user.

The major difficulty with post-flood surveys is the heavy investment in time and money that must be committed to do an adequate job. Second, when the resources and the inclination to do an adequate job do exist, there is no guarantee of any recent flooding. Conversely, if there has been major flooding, there is never a guarantee of resources to survey an adequate sample of properties. A further problem is that post-flood surveys generally only apply to a single flood event, and, therefore, damage estimates are only available at one elevation for each structure. However, if enough structures with similar characteristics are located at different elevations a representative depth-damage curve can be developed.

SYNTHETIC DAMAGE ESTIMATES

Synthetic flood damage functions are constructed from estimates of what damages would be for several hypothetical levels of flooding. It is possible to identify "typical" floor plans and layouts for a "typical" quantity of household contents. The steps in synthetic flood damage analysis are exactly the same as those used in post-flood surveys. The questions, of course, relate to what would be flooded at various levels of inundation and what damages would occur at these levels. Because damage estimates are more difficult in hypothetical situations, it would be helpful to have experienced interviewers, who also have some knowledge of making damage estimates.

Guidelines for making synthetic damage estimates were created for the New York District's Green Brook Sub-Basin Study, ("Green Brook Flood Evaluation Guidelines"). The Green Brook Guidelines document the procedures and per unit costs for estimating damage to both structure and contents of residential and non-residential property. The synthetic method was used where no recent damage information was available, and it represented the average susceptibility and costs of repair and replacement of structural components and household contents. Eleven sources were identified as being used in making these damage estimates. These included building costs indexes, consumer product catalogs, contacts with retailers, and the contractor's personal experience with flood damage estimates.

One of the tables included in the Green Brook Flood Evaluation Guidelines gave a percent damage by structural item. Table 3, which follows, gives examples of data from that table.

TABLE 3
PERCENT DAMAGE BY WATER DEPTH

Depth (Referred to First Floor Elevation)

Item	1.0'	2.0'	5.0'	9.0'
Sub Floors	100%	100%	100%	100%
Plaster Wall	12.5%	25%	62.5%	100%
Cabinets (lower)	20%	20%	100%	100%
Redwood Tongue & Groove Paneling	4%	8%	19%	30%

(URS, p. 7)

This information was combined with repair cost information in another table which gives the unit costs of repair and remodeling. An example is provided below in Table 4.

TABLE 4
REPAIR AND REMODELING COSTS

(January 1988 Dollars)

Item	Total Cost	Unit	Depth to Total*
Sub Floors	$ 1.35	sq. ft.	1.0 ft.
Plaster Wall	$ 2.15	sq. ft.	8.0 ft.
Cabinets (lower)	$90.00	linear ft.	3.0 ft.
Redwood Tongue & Groove Paneling	$ 5.25	sq. ft.	3.3 ft.

(URS, p. 6)

* Depth to total refers to the depth of water required before item has 100 percent damage.

Other tables in the Green Brook Flood Damage Evaluation Guidelines give a range in values and percent damage by depth of flooding above the first floor for content items.

There is also information on estimating commercial, industrial, and public damage, as well as damage to outside property.

The major value of synthetic damage estimation guidelines, such as those used by New York District, is to serve as a quick reference so that an interviewer need only determine the size of a building and the layout of the structure and its contents to estimate the amount of damage and a depth-damage function for the structure.

Advantages and Disadvantages of Synthetic Damage Analysis

The major advantage of the synthetic damage estimate method is that it does not require a flood event. Damages for up to four or five levels of flooding can be estimated, subject to the amount of patience of the interviewee. This method is generally quicker and less expensive than post-flood surveys.

The major disadvantage is the hypothetical nature of the assumptions. Synthetic damage estimates may require a good deal of skill from the analyst and more cooperation and acceptance from the residents being surveyed. Synthetic damage estimates require an understanding of the types of damages that might result from various levels of inundation and the costs of repair. Synthetic estimates also require an understanding of how the specific flood circumstances and type of building will affect the extent of damages. However, guidelines that provide susceptibility and unit costs of repair and replacement are an invaluable tool in making synthetic damage estimates.

ADAPTATION OF EXISTING CURVES

Several Corps districts have adapted either the FIA depth-damage functions or curves from other districts to their own flood situations. Although damage function adaptation is a common practice, there is little guidance on how it should be done, nor documentation of how it has been done.

Adaptation of existing depth-damage functions can be accomplished by the following steps:

1. Identify the predominate structure types.

2. Identify the flood conditions of the study area, district, or region. The flooding problem should be characterized as much as possible by identifying typical velocities, durations, warning lead time, and identifying whatever factors may complicate flood damage, such as ice jams, debris load, wave actions, or salt content.

3. Review other flood damage functions. Determine whether other depth-damage functions have compatible structure categories and similar type of flood hazards.

4. Determine adjustment factors for each curve. After finding a compatible set of depth-damage functions, examine the beginning damage water height, the shape of the damage functions, the inflection points, and the magnitude of damage. Scrutinize these observations for reasonableness and make adjustments in the damage functions to reflect differences in flood conditions and architecture.

Advantages and Disadvantages of Existing Curves

Adaptation of existing depth-damage functions is the least expensive and least time consuming method of establishing depth-damage functions. It does not require a complete survey, nor does it require any recent flooding. It allows the flexibility of using any well-documented source and using reasonable judgement to make adjustments to fit the curves to the situation in the region of interest.

Adaptation of existing depth-damage functions also has the potential to be the most precarious of the methods for deriving depth-damage functions. If the original damage functions are not well documented, if they do not closely parallel the target region, or if poor judgement is used in their adaptation, an inappropriate set of damage functions may result. At the very least, a sampling of local depth-damage relationships is highly recommended. Otherwise, using the FIA damage functions, which represent averages for the country, should be sufficient.

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