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**EVALUATION AND IMPLEMENTATION OF  
URBAN DRAINAGE AND FLOOD CONTROL  
PROJECTS**

by

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June 1974

**ENVIRONMENTAL RESOURCES**



**CENTER**

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Fort Collins, Colorado**

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EVALUATION AND IMPLEMENTATION OF  
URBAN DRAINAGE AND FLOOD CONTROL  
PROJECTS

Completion Report

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Colorado State University  
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Norman A. Evans, Director

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EVALUATION AND IMPLEMENTATION OF  
URBAN DRAINAGE AND FLOOD CONTROL PROJECTS

Summary of Report

Drainage and flood control problems in an urban region are a direct result of human interference with normal drainage patterns. In a growing metropolitan area, the thrust of drainage solutions should be in two basic directions, prevention and remedial works.

Preventive activities take the form of flood plain management together with good planning. As rural areas urbanize, flood plains can be developed in such a manner so as to preclude or minimize future damages and problems from flooding. Also, as urbanization proceeds, adequate local drainage should be provided along with streets, roads, schools, parks and other public facilities, consistent with wise levels of public investment.

Situations that require remedial action are those where flood plains have been improperly occupied and developed and where local drainage problems have not been adequately considered and handled. In these cases, positive steps are needed, usually by a public agency, to remove the hazard or alleviate the inconvenience caused by flooding.

Drainage and flood control activities can be placed into structural and non-structural categories. Structural activities incorporate both preventive and remedial categories and include installation of storm sewers, culverts, inlets, adequate curb and gutter, channelization and detention facilities. Non-structural activities also overlap both preventive and remedial functions and include flood plain management (preventive), flood plain warning (remedial), and flood insurance (remedial).

Structural activities relating to urban drainage and flood control (UDFC) provide a *service* for the improvement of living conditions in urban areas. As a service, it provides for three types of needs: (1) the need for flood damage mitigation and protection; (2) the need for rapid drainage of public facilities for the basic purpose of convenience; and (3) the need for environmental management such as cleansing of streets and washing away collected dust and pollutants.

Urban drainage and flood control activities require an assessment of the benefits derived by those being relieved of potential flood damages. In many situations, urban storm drainage needs become urgent because of the advancing urbanization of an area. Sometimes the direct beneficiaries are those who are relieved of potential flood damages while, at the same time, advancing urbanization is the culprit. The service concept recognizes the fact that a drainage system accommodates additional stormwater generated by urbanization. The service concept is important in the identification of the full range of drainage and flood control benefits and beneficiaries.

Urban Drainage and Flood Control must compete with other urban programs for funding from the limited public purse. It is important to be able to describe and enunciate all of the benefits that these projects provide so that they can compete for funding. This is only one of the evaluation-related problems that confront the public works manager responsible for urban drainage and flood control. Other types of evaluation problems are: the determination of the merit of individual projects, the ranking of competing UDFC projects to determine priorities, the determination of optimal investment timing and the determination of the incidence of costs and benefits on different population sectors so that



project costs can be equitably apportioned.

Benefit-cost analyses of UDFC projects can be useful in all of the above situations. The design of such a study must, however, be specified according to the ultimate use of the output of the study. The term "Benefit-Cost Analysis" (BCA) as applied to UDFC projects, must be viewed as wider than the traditional BCA which recognized only economic efficiency as a viable benefit. Benefits and costs should be normally considered in the four categories recommended recently by the U. S. Water Resources Council: economic efficiency, regional development, environmental impact, and social benefits. In the case of UDFC projects, the latter may well be the most significant, particularly in the case of the so-called *minor* type of project. UDFC systems must be distinguished into minor or major systems, both for implementation purposes and for benefit-cost studies because public benefits differ considerably between the two types of systems.

The state-of-the-art of conducting benefit-cost studies for urban drainage and flood control projects is not far advanced. The distinction between minor and major projects has only recently received wide acceptance. The evaluation problem is plagued by our inability to quantify indirect, secondary and intangible benefits associated with UDFC projects. In the case of the major flood control project, attention has mostly been focused on the potential reduction in flood damages associated with such projects. This attention is probably due to the visibility of flood damages after severe floods as well as the availability of data for quantifying such benefits. It was found during this study, however, that the state-of-the-art of estimating damage benefits is rather primitive and there currently exists a wide latitude in the practices of

agencies in making such estimates. At the local level, little estimating data is available to conduct this type of study.

For minor urban drainage and flood control projects, it is normally not feasible to carry out a detailed Benefit-Cost Analysis because of the intangible nature of the predominant benefits. An analysis such as the type recommended by the Water Resources Council (displaying benefits and costs in a set of *accounts*) may be feasible. This has not yet been demonstrated for local drainage, however. This does not mean that drainage engineers are behind the times because such analyses have not yet been demonstrated for many public programs at the local level. This is primarily because of the difficulty in quantifying and even identifying benefits.

In all types of Benefit-Cost Analyses, it is important to identify the recipients of benefits by population sector so that project costs can be equitably apportioned. This type of *incidence analysis* must be included as part of a viable BCA.

A methodology for the analysis of benefits and costs of UDFC projects is presented in this report. The purpose of presenting this methodology is to identify the state-of-the-art of performing such analyses, to present the necessary data to complete the analysis and to present the methodology before the profession to solicit comments on its usefulness. The initial methodology is basically limited to a consideration of direct benefits resulting from flood damage reduction although plans are to extend the methodology considerably in the future. Estimating curves for flood damage reduction are presented for certain classes of residential structures as an aid to the analyst.

This methodology is not presented as a complete solution to the problem but rather a tool for the analyst, something that he can display

before the decisionmaker to increase the amount of information available. In order to present a complete or comprehensive benefit-cost methodology, all types of costs and benefits as well as incidence analyses should be presented.

The state-of-the-art of quantifying intangible benefits is not advanced to the point yet where these benefits can be consistently quantified for UDFC projects.

The important questions of finance, politics and the legal aspects of implementation must not be neglected. Although this report does not address specifically techniques for funding UDFC projects, this is recognized as a problem area closely associated with Benefit-Cost Analysis. The report describes the traditional methods of financing UDFC projects and comments on the usability of BCA to assist in the financing process. Concerning legal aspects of implementation, there are a number of problems associated with defining and identifying benefits so that assessments can be made for financing projects. This problem has not been solved but the report identifies the state-of-the-art of establishing benefits so that additional investigation can be conducted.

All public programs such as public safety, water supply, library services, urban drainage and flood control and others should be subjected to the type of analysis presented here to identify precisely the benefits from expenditures of public funds and the recipients of the benefits. Only when this type of information is displayed for the decisionmakers can the political process of public participation insure the most acceptable allocation of public dollars. By advancing the state-of-the-art of Benefit-Cost Analysis for UDFC projects, we also are advancing toward unveiling benefits from other public programs.

In that sense, the work reported in this report is a contribution to the field of public sector productivity and a usable management tool for public works and urban administrators concerned with making the best use of public funds.

EVALUATION AND IMPLEMENTATION OF  
URBAN DRAINAGE AND FLOOD CONTROL PROJECTS

By Neil S. Grigg, Leonard Rice, Leslie H. Botham and W. J. Shoemaker

Abstract

Urban drainage and flood control (UDFC) systems provide a service to urban areas with three basic components; flood control, convenience drainage and environmental sanitation. This service is one of many provided by local government and must compete for public funding with other more visible programs such as education, transportation and public safety. The evaluation problem for UDFC arises when the merit of individual UDFC systems must be determined, when competing UDFC projects must be ranked, when optimal investment timing is sought and when the incidence of UDFC benefits and costs must be known. The results of all of these evaluations affect the funding of the UDFC sector, in competition with other public programs. UDFC systems are normally identified as *minor* or *major* in character, the former providing for the drainage of frequent runoff events, the latter providing for the rarer runoff events. The major UDFC system normally provides substantial flood damage reduction benefits while the minor system provides intangible benefits. An interim methodology for evaluating major UDFC projects is presented. It considers mostly flood damage benefits because limited data on them is available. Planned extension of the methodology will incorporate more formally intangible and indirect benefits. Because of the legal problems associated with identifying and quantifying benefits a state-of-the-art survey on the legal basis for establishing benefits is presented. It contributes to the difficult area of financing and

implementation, necessary if UDFC are to be ultimately provided where they are needed. Economic evaluation procedures must furnish the information needed for financing and implementation or they are only an academic exercise.

## CHAPTER I

### INTRODUCTION

Drainage and flood control problems in an urban region are a direct result of human interference with normal drainage patterns. In a growing metropolitan area, the thrust of drainage solutions should be in two basic directions, prevention and remedial works.

Preventive activities take the form of flood plain management together with good planning. As rural areas urbanize, flood plains can be developed in such a manner so as to preclude or minimize future damages and problems from flooding. Also, as development takes place, adequate local drainage should be provided along with streets, roads, schools, parks and other public amenities, a function of good planning and implementation.

Situations that require remedial action are those where flood plains have been occupied and poorly developed and where local drainage problems have not been adequately considered and handled. In these cases, positive steps are needed, usually by a public agency, to remove the hazard or alleviate the inconvenience caused by flooding.

Drainage and flood control activities can be placed into structural and non-structural categories. Structural activities incorporate both preventive and remedial categories and include installation of storm sewers, culverts, inlets, adequate curb and gutter, channelization and detention facilities. Non-structural activities also overlap both preventive and remedial functions and include flood plain management (preventive), flood plain warning (remedial), and flood insurance (remedial).

Many of the structural activities relating to urban drainage and flood control (UDFC) constitute a *service* provided to improve living conditions in urban areas. As a service, it provides three types of needs: (1) the need for flood damage mitigation and protection; (2) the need for rapid drainage of public facilities for the basic purpose of convenience; and (3) the need for environmental management such as cleansing of streets and washing away collected dust and pollutants.

Remedial structural drainage and flood control activities require an assessment of the benefits derived by those being relieved of potential flood damages. In many situations, urban storm drainage needs become urgent because of the advancing urbanization of an area. Sometimes the direct beneficiaries are those who are relieved of potential flood damages while, at the same time, urbanization is the culprit. The service concept recognizes the fact that a drainage system accommodates additional stormwater generated by urbanization. The service concept is important in the identification of the full range of drainage and flood control benefits and beneficiaries.

Multi-purpose use of urban drainage and flood control projects often provides additional benefits. For example, effective regulation of flood plains encourages compatible uses such as parks, recreation areas and farming, providing open space in urban areas. Flood plain regulation does not prevent flood plain development, but encourages wise use. Streams and gulches traversing urban areas can be developed by the public to not only carry flood waters, but to provide recreational facilities and transportation corridors as well. Other multi-purpose considerations include pollution control, reduction of traffic disruption, access control for emergency vehicles, and erosion reduction.



This report basically focuses on the question of evaluation financing, and implementation of urban drainage and flood control projects. The question of evaluation is discussed in terms of benefits and costs, even though many of these cannot yet be quantified. Financing and implementation are covered insofar as they are related to the results of the evaluation process.

The report is addressed primarily to the remedial structural category of urban drainage and flood control problems and to cases where the investment of public funds is a feasible solution. This limitation of scope is not intended as an indication of priorities, but is necessitated by the step-by-step approach of the research and the limited time and funds available for the effort. Preventive, non-structural approaches can also be evaluated using the same techniques, but the analyst must be extremely careful as he considers these approaches because they require detailed consideration of local priorities, projections of future growth patterns and the incidence of costs and benefits on local citizens. These considerations should be included in evaluation reports as guides to decisionmakers. The analyst must be careful not to distort benefits and costs or to improperly assume local priorities when undertaking this type of evaluation.

This report presents interim findings because the research is still underway. The material presented herein provides a broad approach to UDFC projects and represents a beginning step into the important problem area of evaluating, financing and implementation. Follow-on research will provide additional means for evaluation of the full range of UDFC projects.

## Scope of the Report

The problem of evaluating urban drainage and flood control projects is familiar to engineers in the public sector. Public works managers are faced with the problems of securing funds for UDFC projects, which requires that project benefits be clearly enunciated and defined. There is strong competition for public funds with other urban needs such as transportation, parks, hospitals, welfare, and schools, and clear definition of project benefits will assist in the competition for project funds. Once public funds are obtained for a project, it is the responsibility of the public works manager to make best use of the funds obtained. Again, a comprehensive identification of costs and benefits can assist in the development of a *best* solution for the funds available or for the objective in mind.

The decisionmaking process for urban drainage and flood control projects has both political and economic-technical aspects. Basic decisions with regard to public projects are made in the political process, but the political process depends heavily on sound economic and technical input. Economic and technical analysis can provide information as to the best use of the public dollar to the extent that public goals and benefits can be quantified. Economic and technical analyses provide input to legislative bodies, who make the decisions that are necessary for implementation.

Economic considerations utilize primarily the traditional *systems analysis* process. Technical considerations insure that sound solutions are being evaluated. The political process is not nearly as well defined as the economic and technical processes. The economic analysis is emphasized in this report and the presentation should be helpful in

the economic evaluation of drainage and flood control projects and for providing inputs to the political process as well.

Urban drainage and flood control structural activities are first classified into the following components according to type of service rendered such as: (1) flood protection, (2) drainage, and (3) environmental management. Public benefits and costs associated with each type of service and details of the current state-of-the-art of quantifying these benefits and costs are discussed. Because direct benefits (mostly associated with flood damage reduction) have the longest history of quantification, data is presented for use in estimating these benefits. It was found that the analysis of direct benefits is not currently well understood because data has previously not been widely available.

The inclusion of indirect and intangible benefits is discussed and pertinent literature is referenced to aid in the understanding of these benefits so they can be considered in the evaluation process. Follow-on research is planned that will develop a formal methodology for considering these indirect and intangible benefits.

An interim methodology for evaluating direct costs and benefits of urban drainage and flood control projects is presented in Chapter III. It is intended that this methodology receive extensive review, leading to substantial improvements in the next phase of the research effort.

The problem of incidence of benefits and costs is also considered. Incidence relates to the question of who pays and who benefits. Suggestions are made for including answers to the problem of incidence in the benefit-cost analysis process. Ideally, the result of a benefit-cost analysis should yield total benefits and costs for each population group affected by a project. Net benefits could then be displayed in an

aggregate fashion for economic efficiency effects, and in a segregated fashion for distributional effects pertaining to each group. Environmental and social costs and benefits could be included.

Finally, the report covers a number of legal questions associated with the project implementation and financing. There are a number of hurdles to be overcome in this area and the discussion seeks to highlight these problems in the interest of identifying the hurdles so that implementation can be facilitated.

There have been several working papers prepared under this project. They are listed as references at the end of this chapter. Recent activities of the Urban Water Resources Research Council of the American Society of Civil Engineers (ASCE), together with efforts of several individuals have resulted in a number of research and applied publications regarding urban drainage and flood control. An early comprehensive work was the report by the American Public Works Association (APWA) in 1966 entitled, "Urban Drainage Practices, Procedures, and Needs" [2]. This report, prepared under the guidance of the APWA Urban Drainage Committee contains nineteen suggestions for research needs. Of these, some ten are directly concerned with methods of implementing and financing urban drainage and flood control projects, an important problem area for the public works official. For access to the list of ASCE Urban Drainage publications, see [1]. The Urban Drainage and Flood Control District helped sponsor a comprehensive UDFC Criteria Manual which has been widely adopted [4]. Also, a recent comprehensive study sponsored by the Denver Regional Council of Governments has produced some useful UDFC reports [3].

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## CHAPTER II

### DIMENSIONS OF THE UDFC IMPLEMENTATION PROBLEM

Urbanization, or the organization of people into human settlements, creates a demand for all types of services. Some of these services are furnished privately, through the market system, and some are furnished by the public sector. There is strong pressure that equal services should be provided all citizens regardless of their income level. There is also strong pressure toward the conflicting goal that services should be provided to the extent that users are able to pay for them.

In cities, urban governments "provide a host of tangible and intangible services. They regulate, tax, and subsidize in order to facilitate the efficient performance of firms and households as well as to achieve certain socially desirable objectives." Following the basic classification scheme of Hirsch, tangible urban public services can be placed into the categories shown on Table II-1 which provides six service categories, two of which include elements of urban drainage and flood control [11].

Urban drainage and flood control (UDFC) really encompasses several services. As pointed out by Jones [15], the urban drainage system has two components, a *minor* system which provides for the drainage of frequent runoff events, and a *major* system which accommodates the rarer, more severe events. From this basic distinction, two functions can be seen for UDFC which fit into the framework of Table II-1, a protection from natural hazards (flood control), and management of urban runoff, (an environmental management service) the latter providing a drainage

Table II-1. Major Tangible Urban Public Services

I. Protection Services:

Criminal justice system  
Fire protection and damage mitigation  
Natural hazard protection and damage mitigation  
(Floods, earthquakes, windstorms, etc.)

II. Human Resources Development Services:

Education  
Parks and recreation  
Cultural activities  
Health  
Welfare

III. Environmental Management Services:

Management of urban runoff (Quality and Quantity)  
Control and management of wastewater (Quality and Quantity)  
Water quality management (Local ground and surface waters)  
Air quality management  
Solid waste management

IV. Utility Services:

Water supply  
Energy delivery  
Communications

V. Transportation Services:

Mass transit management  
Management of streets, bikeways and walkways

VI. General Governmental Services:

Administration  
Budget control  
Executive  
Legislative



and a sanitation function. This distinction is important because when proposed UDFC projects are being evaluated, it must be shown that anticipated benefits exceed costs. The benefits from natural hazard protection clearly will be distinct from those provided as an environmental management service, and should be counted up separately.

The environmental management services provided by urban drainage systems have formerly included only consideration of runoff *quantity* but, as pointed out several years ago by the ASCE Urban Water Resources Research Council [1], and more recently by Condon [5], *quality* aspects are crucial, especially in advanced stages of urbanization. This report is basically concerned only with quantity but the role of UDFC projects in quality management must soon be recognized. As of now, urban drainage systems do not usually contain provisions for control and treatment of stormwater. This is expected to change rapidly, however.

#### Types of Evaluation Problems

There are really two general types of evaluation problems; those for personal use and those leading to arguments for convincing others. Problems related to UDFC fall into both of these categories, but it is convenient to assume that they are all of the latter type such that information remains completely objective.

The life cycle of an urban drainage and flood control (UDFC) project extends from the first perception of a need through planning, programming, budgeting, design, construction and operation. If the project completes this cycle it will have cleared many socio-political, technical and economic hurdles. The project should not reach the

budgeting stage if it does not:

1. Satisfy needs of a group of citizens and
2. Accomplish this in a sufficient manner to warrant funding from a limited financial resource base. That is to say, the project must win the right to be funded in a complex evaluation process.

In order to gather information needed for this complex evaluation process three hierarchies of information are needed:

1. The operational goals and objectives of the UDFC system. (To be distinguished from general, broad urban goals). e.g., "To provide adequate drainage for minor runoff events (say 2-year frequency) at minimum annual cost." Of course, the selection of such an operational goal should be subject to a tradeoff analysis after the cost of achieving the goal is known.
2. The measures of effectiveness needed to determine the extent to which alternative projects meet the above goals. (Costs and Benefits).
3. The coefficients and ranking scales needed to arrange the measures of effectiveness into a decision-making order.

In the analysis of UDFC projects, several distinct evaluation sub-problems appear. A good systems analysis or planning process will begin with establishment of objectives and measures of effectiveness, move into formulation of alternative solutions, evaluation and tradeoff analysis, and finish with a selection or decision stage. The use of this procedure depends on the stage of planning or implementation,

however, and the requirements for evaluation will differ accordingly. A useful framework for evaluation and implementation strategy formulation is the Planning-Programming-Budgeting System (PPBS), which seeks to tie planning with implementation more closely, a problem throughout the public sector. Use of PPB Systems in urban governments has recently become of heightened interest because of the need to improve the return from public expenditures. A recent example of the use of PPBS was in the City of New York under the Lindsay administration. In this context, the intent was to use PPBS to ensure that "...decisions involving the allocation of resources were to be made only after the review of explicit statements of agency objectives, or at least crude analysis of alternative programs for meeting those objectives, and of detailed estimates of the relative costs and benefits of those programs [21].

Using PPBS as a framework, the following types of UDFC evaluation problems are readily apparent:

1. Planning Stage

How to determine the merit of individual projects in order to determine if and the conditions under which they should be implemented. In some cases, projects which passed evaluation in this stage would be shown on a *master plan*. This is sometimes called the *program evaluation study* [11].

2. Programming Stage

How to rank competing UDFC projects to determine priorities, optimum investment timing and desirable sequences of implementation. These are sometimes called *inter-program comparison studies* [11].

### 3. Budgeting Stage

How to objectively but competitively display *total* public benefits of UDFC projects to ensure adequate funding for UDFC in the annual urban budgeting process. How to determine and quantify benefits by incidence on different population sectors in order to equitably apportion project costs between and within public and private entities. The latter are sometimes called *inter-group comparison studies* [11].

#### Elements of the Evaluation Problem

In the economic approach to decisionmaking, the basic problem is to select an alternative plan which best meets the goal of a particular program. In using economic tools it is important to display alternatives in a fashion such that they can be readily compared. This is a difficult conceptual and analytical problem. Tolley [22] lists six classes of alternatives which are experienced in flood control planning. These all represent options for decision-makers which should be considered. Table II-2 gives the classes of alternatives presented by Tolley with some illustrations of UDFC choices that fit his framework.

The U. S. Water Resources Council (WRC) recently undertook a comprehensive study of planning and evaluation procedures for water resources projects [9,23]. In preparing this document, they made a detailed analysis of evaluation techniques including the use of the traditional benefit-cost ratio. The evaluation technique they selected does not display benefit-cost ratios but presents the same

Table II-2. Classes of UDFC Alternatives

<u>Class of Alternative</u>	<u>UDFC Application</u>
1. Alternatives of Objective	Provide 1, 2, 5, 10, 50 or 100 year protection? Provide drainage in all of city or only in selected portions? etc.
2. Engineering Alternatives	Structural or non-structural programs? Pipes, channels, culverts, bridges, detention basins or other?
3. Management Alternatives	Automatic Control? Diversions? Transbasin transfers? Upstream land management? Early warning systems? Zoning?
4. Institutional Alternatives	Mostly a political problem. Includes local or multijurisdictional solutions, financing, etc.
5. Timing and Size Alternatives	Best staging of construction and implementation. Distribution of sizes of facilities.
6. Location Alternatives	Location and configuration of UDFC facility network.

information in a set of *accounts*. A summary of the implications of this procedure was recently given by the Director, USWRC, and is reproduced below [9].

**What is the major significance of the revised Principles and Standards for planning water and related resources?**

They place environmental concerns on a basis equal to economic development. This allows planners to truly recognize the environmental tradeoffs in resource planning.

In addition to considering those objectives, the consideration of adverse and beneficial effects of regional development and social well being recognizes other aspects of water resource planning. The display of four accounts—national economic development, environmental quality, regional development and social well being—gives the Congress and others an opportunity to evaluate fully the projected effects and tradeoffs of alternative plans.

As the Principles and Standards are written now, formulation of alternative plans will be based on national economic development and environmental quality objectives. Basically a recommended plan must have net economic development benefits except where the deficiency in net benefit results from benefits foregone or additional costs incurred to serve the environmental quality objective. In other words, a plan with no net economic benefit could be recommended if it has overriding long-term environmental benefits.

Also there is a provision of the Principles that says a departmental secretary or agency head may make an exception to the net economic benefit rule if he determines that the circumstances unique to the planning and formulation processes warrant an exception. What this means is that under unusual circumstances it is possible to go forward with a plan that does not have net benefits under either of the objectives. Obviously, the economic development and environmental quality objectives make up the significant accounts; however, beneficial and adverse effects on regional development and social well being will be displayed where appropriate to give further assistance to the decision maker.

**What effect will the new Principles and Standards have on the public's role?**

The initial impact insofar as the public is concerned will relate to identifying and specifying the issues to attain the objectives early in the planning processes. The plan formulation requires that public participation be sought early and continually throughout the process. There will be at least two alternative plans formulated; one a plan that best optimizes contributions to the national economic development objective and one that best serves the environmental objective. Other plans contributing to the objectives will then be formulated to develop the balance of optimum resource use. The public will have a very direct and strong input in selecting that balance.

Under the new Principles and Standards the public can participate on the basis that there are alternatives to react to. Previously, with the national economic development approach, there was just the one type of plan and the reaction was limited to "take it or leave it." With a number of alternatives expressing the concerns of different groups that have special interests as well as the public in general, a greater incentive to participate will be generated. I might just add, though, that in this matter of alternative planning, there could be cases where an agency could come up with just one plan. In other words, where there are no conflicts and the plan is basically for a single purpose, there may be no logical alternative. This would be considered an exception.

In carrying out the Principles and Standards some flexibility is called for on the part of the planners and agencies in working with the public. Critical items in this planning process include that of agencies working with the public in actually screening out alternatives at an early date, and then displaying and arraying the final plan. In this manner the public will certainly have an early voice in the matter of initiating the particular plans that will be taken in coming up with alternative plans.

All principal agencies have been developing guidelines and procedures for public participation. In my estimation, the Corps of Engineers has gone about as far as anybody with its "fish bowl" type of planning. I can perceive that with this new approach to planning there will be refinements in agency efforts to obtain meaningful and significant public participation.

**Will there be an attempt to set common values on non-monetary measurements?**

The new Principles and Standards provide that measurements will be in quantitative or qualitative terms appropriate to the definition of the component being evaluated. It is not envisioned that we would try to have common value units. There have been, however, various evaluation systems which have been developed and are going through the process of refinement. A great deal of work has been done on methods of documenting non-monetary effects, however, there is not a precise system available at the present time. I can foresee that implementation of these Principles and Standards will stimulate progress towards defining positive ways of identifying effects in a descriptive way.

In the past the decision maker, which has been Congress or the Executive Branch, could determine to support or not support a particular project based on the simplicity of the benefit-cost ratio. Under this new approach a benefit-cost ratio will not be displayed. On the other hand, Congressmen and others will have a full accounting of the effects of a project to assist in their decision making. "[9].

**SYSTEM OF ACCOUNTS**

ACCOUNT	BENEFICIAL EFFECTS	ADVERSE EFFECTS	NET BENEFITS
National Economic Development			
Environmental Quality			
Social Well Being			
Regional Development			
Region 1			
Region 2			
Rest of Nation			

**PLAN EFFECTS N.E.D. OBJECTIVE**

BENEFICIAL	ADVERSE	NET
Increased Output	Resources Required	Effects Can Be Netted
Externalities	Externalities	

**PLAN EFFECTS E.Q. OBJECTIVES**

BENEFICIAL	ADVERSE	NET
PROTECT AND IMPROVE NATURAL BEAUTY	DESTROY NATURAL BEAUTY	GENERALLY EFFECTS CAN NOT BE NETTED
PRESERVE NATURAL AND CULTURAL SITES AND ECOLOGICAL SYSTEMS	DESTROY NATURAL AND CULTURAL SITES AND ECOLOGICAL SYSTEMS	
IMPROVE QUALITY OF WATER, LAND AND AIR	REDUCE QUALITY OF WATER, LAND AND AIR	
EROSION CONTROL	INCREASED EROSION	
PRESERVE FREEDOM OF CHOICE CONCERNING IRREVERSIBLE EFFECTS	IRREVERSIBLE COMMITMENT PRECLUDING FUTURE CHOICE OF USE	

The selection of the set of *accounts* does not rule out the use of Benefit-Cost Analysis (BCA). Actually, the use of the WRC procedure is a *form of BCA* in that total benefits and costs are displayed, broken into categories rather than aggregated together.

Benefit-Cost Analysis (BCA) actually began as a tool for the economic evaluation of water resources projects, mandated by the Flood Control Act of 1936. Since that period, a large critical literature of BCA has arisen and a number of shortcomings have been identified. An excellent review of BCA has recently been published by Prest and Turvey [17] while the books by Howe [12] and James and Lee [14] demonstrated its applicability to water resources problems. BCA really only addresses economic efficiency in its original form, going back to the 1936 Act where it was required that project benefits exceed cost regardless of who they accrued to. Now that decisionmakers are more concerned about environment, about equity and about social objectives, the direct use of BCA is more limited but by using techniques such as the WRC *accounts*, BCA can be extended. Benefit-cost analysis can be a "...potentially valuable contribution to decisionmaking in the public sector," but that "...the results of (BCA) should not be believed merely because they come from an analysis...Benefit-Cost Analysis does not guarantee good answers. At its best, it should provide logical ground rules for constructive debate on the real issues." [8].

#### Minor and Major Drainage Systems

Considering the control of runoff quantity only and using Jone's terminology of *minor* and *major* systems [15], the difference between the two systems can be shown in a definitive fashion. Consider a *typical* small urban catchment where drainage is basically tributary to a local



street (Figure II-1a). If there is no storm sewer all flow will be carried in the street itself, which will act as a *channel* as shown on Figure II-1b. If depth of flow is measured from the gutter flow line, a depth-frequency curve for annual maxima can be developed for each street section (Figure II-2). The methodology for development of this curve is a subject of controversy among urban hydrologists because of a number of unresolved problems, but for the purpose of this discussion it is convenient to assume that the relationship has been established. Figures II-1b and II-2 show two basic depths; depth "A" reflects a *minor* flow which is contained within the gutter itself whereas depth "B" shows the entire street flooded, up to the building line. On Figure II-2, depths A and B are shown as about one and 100 year flows respectively, but this is only a hypothetical example.

For an actual case, the relationship shown on Figure II-2 might turn out to fit some prescribed probability distribution such as, for example, log-normal. If the corresponding probability density function is drawn, the relationship shown in Figure II-3 results. If a depth is selected on the abscissa of Figure II-3 (such as depth B), the area under the curve to the right of the depth represents the probability that, in a given year, the depth will be exceeded (exceedance probability). Because of the typical skewed shape of this distribution, it is attractive to delineate the curve into two portions, the frequent depths and the rare depths as shown. The exact point of division is, of course, subject to debate.

As an attempt to show the spectrum of benefits of urban drainage and flood control projects, and to relate them to the objectives of the corresponding UDFC systems, Figure II-4 is presented. It shows

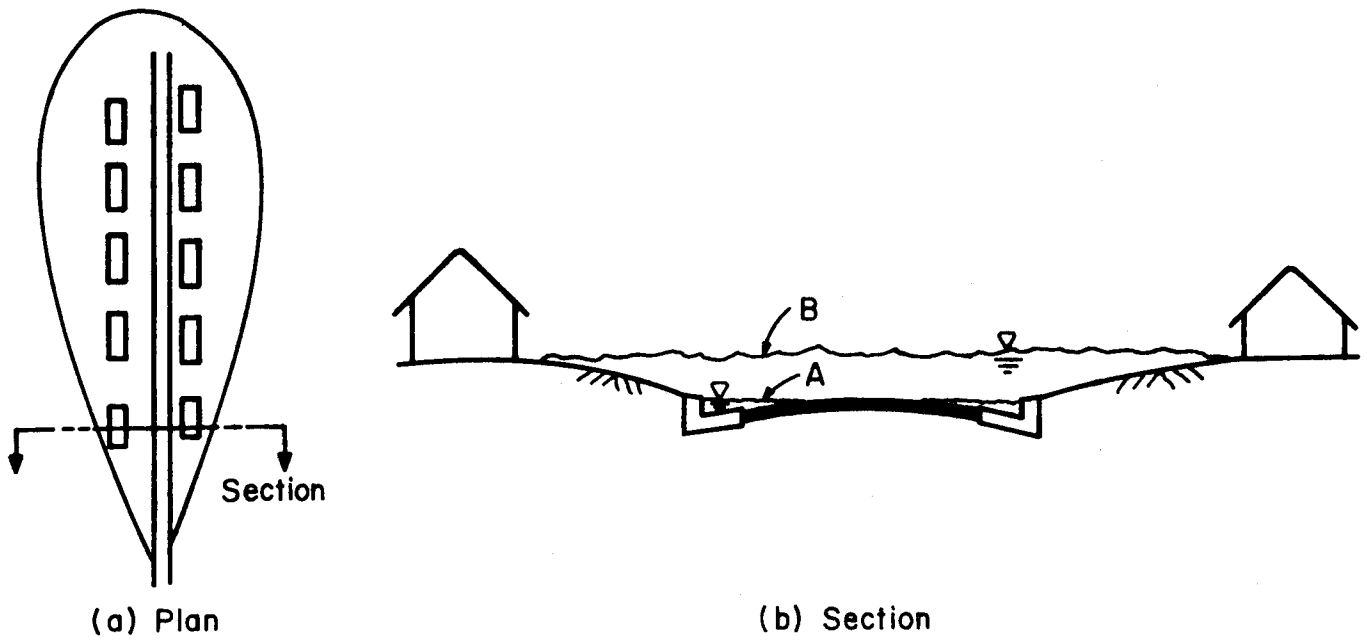


Figure II-1. Simplified Urban Catchment with Street Cross Section

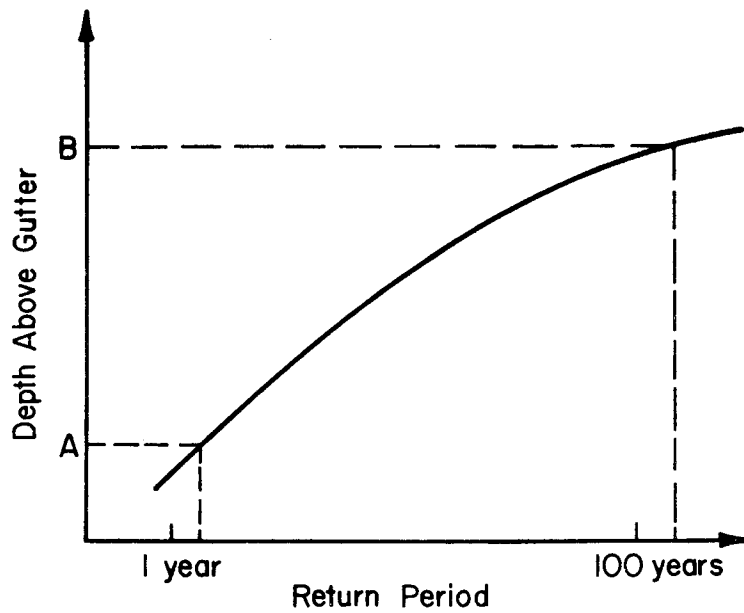


Figure II-2. Depth-Frequency Curve

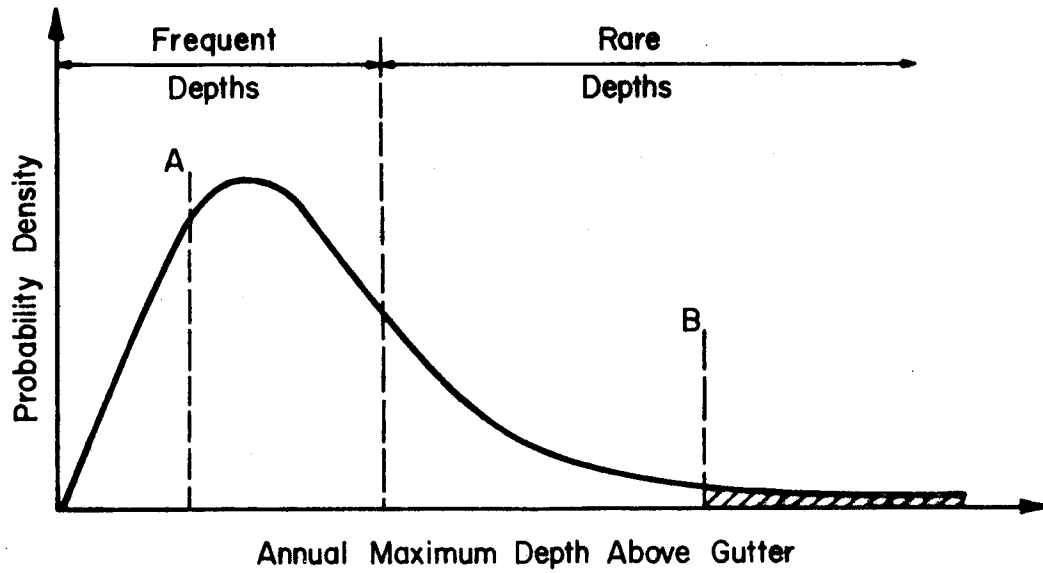


Figure II-3. Probability Density Function for Annual Maximum Gutter Depth

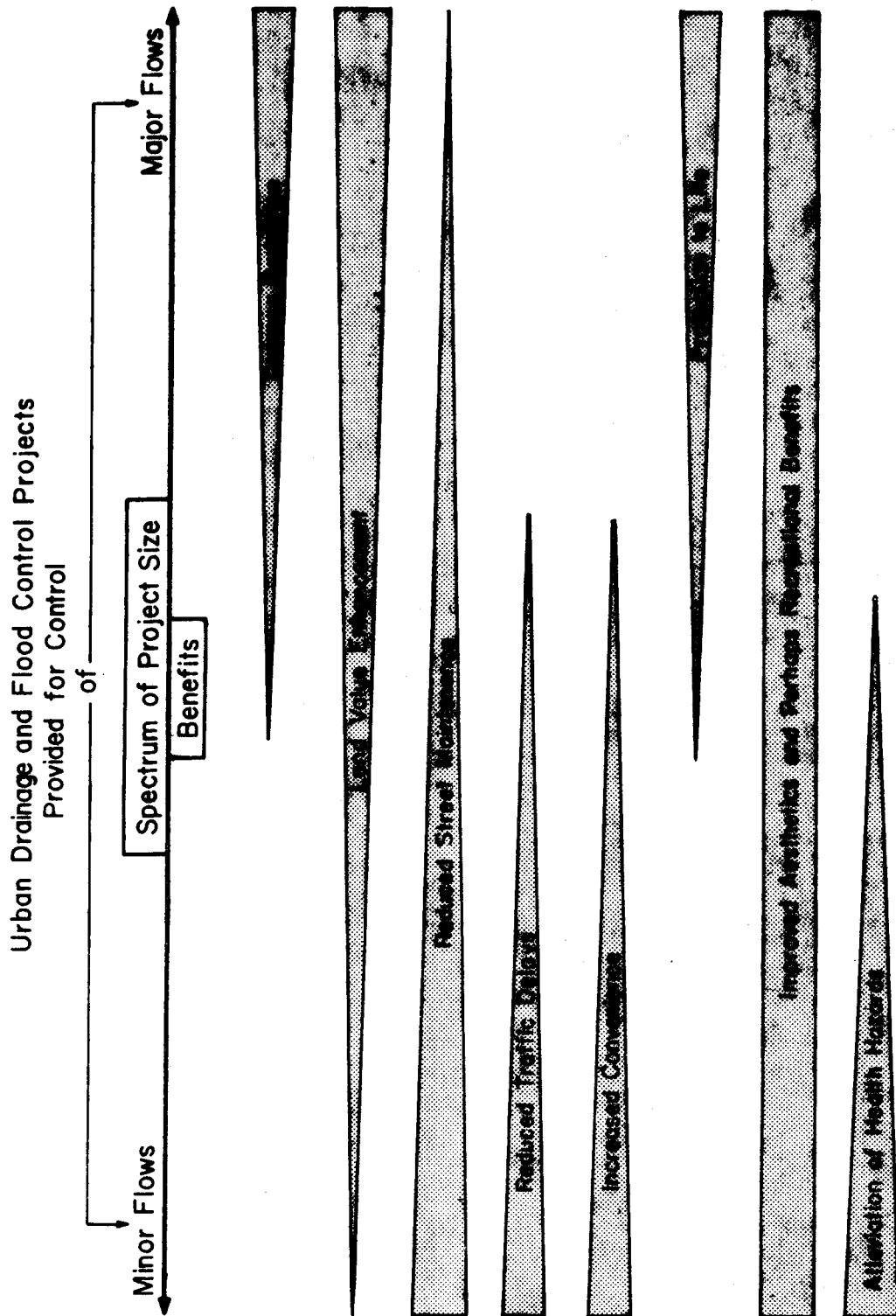


Figure II-4. Spectrum of Benefits from Urban Drainage and Flood Control Projects

the benefits as a spectrum in the sense that Figure II-3 showed a spectrum of runoff events. Figures II-3 and II-4 are therefore related through UDFC projects which would seek to control runoff events of different frequencies. This spectrum of benefits would at first glance, appear to be cumulative. That is, if a UDFC project is built to control a rare runoff event it automatically will control lesser flows. This is not necessarily true. For example, a major runoff project which prevents damage does not automatically provide convenience, although this feature can be built into the project. Figure II-4 can be expanded somewhat into a classification of benefits and costs from UDFC projects as shown in Table II-3.

#### The Problem of Repetitive Occurrences

Figure II-4 lists certain project benefits that might be experienced *each time* a small flow occurred. Examples of these are increased convenience and reduced traffic delays. Figure II-3, a probability distribution for annual maxima, provided no way to consider repetitive occurrences of runoff events of less than one year return period. A basic dilemma for storm drainage criteria which specifies a "2-year design" or a "5-year design" is how to consider this problem. It is conceivable that two regions, one semi-arid and one humid, could have identical depth-frequency relations such as Figure II-3, but that the humid region could have a hundred light rainstorms for each one on the semi-arid area and that the convenience benefit for the storm drainage system in the humid area would be correspondingly greater.

#### The Problem of Intensity of Use and of Land Value

Figure II-4 shows benefits which will vary with intensity of use of streets and with adjacent land value. Using convenience again, this

Table II-3. Inventory of Costs and Benefits of UDFC Projects

BENEFITS

I. Tangible

A. Direct

Reduced flood damage to  
public and private  
facilities  
Reduced probability of loss  
of life  
Land value enhancement

B. Indirect

Reduction in traffic delays  
Reduced income, rental, sales,  
and production losses  
Reduced cleanup and mainten-  
ance costs  
Reduced emergency relief costs  
Increased possibilities for  
recreation opportunities

II. Intangible

Reduced inconvenience  
Increased sense of security  
Alleviation of health hazards  
Improved aesthetic environment

COSTS

I. Tangible

A. Direct

Construction costs  
Land aquisition costs  
Costs of non-structural  
programs, including flood  
plain zoning  
Evacuation and emergency  
program  
Administration costs

B. Indirect

Insurance subsidy costs  
Increased reconstruction costs  
due to the magnitude and  
extent of flood damage

II. Intangible

Environmental and social costs

benefit depends on the number of persons who escape inconvenience as a result of an UDFC project. This factor is somewhat recognized in the common practice of providing higher capacity UDFC facilities in areas of more intensive use. Concerning land value, the increase resulting from implementation of an UDFC project will be a function of land use. The same UDFC project might add \$100,000 to the value of property in an affluent neighborhood while adding only \$10,000 in a less affluent.

#### State-of-the-Art of Evaluation Capability

Current practice in many U. S. cities is to design both major and minor UDFC systems based upon somewhat arbitrary criteria. Of course, this is also the practice for establishing most types of environmental quality standards. Minor systems are designed for 1, 2, 5, 10-year or some other frequency based upon the discretion of local decisionmakers (often with millions of dollars of construction cost at stake) whereas major systems often point to the 100-year flow because of recent federal pressure through the implementation of the Flood Insurance Act of 1968 and other legislation. This setting of standards reflects an implicit weighting of benefits and costs. The setting of standards also "...states the goals of a program, ...a measuring stick to determine the program's progress and a basis for determining what actions should be taken by the program" [7].

It has been common practice for public officials to basically use minimum cost criteria in the selection of UDFC projects for implementation. Cost minimization is a valid criteria, but it does not insure the most cost effective use of the public dollar, particularly when social, environmental and distributional effects must be considered. One of the objectives of this report is to confirm the existence of other criteria and

to document procedures for evaluating the cost effectiveness of proposed UDFC improvements and presenting the results so that decisionmakers can make the choice with more definitive data.

Selection between competing UDFC projects based on the minimum cost criteria will normally opt for the project having the least cost which provides a specified level of protection. In the systems framework, this is equivalent to fixing effectiveness and minimizing cost. The alternative approach is to fix cost and maximize effectiveness. The latter would be a more economically efficient approach for UDFC projects considering the nature of the urban budgeting process.

If an urban capital budget is allocated over the services shown on Table II-1, urban drainage and flood control will receive some share according to the perceived needs for UDFC expenditures. This will depend somewhat on the evaluation process described earlier in the PPBS stages. It may be that a city is committed to solving drainage problems  $D_1, D_2, \dots, D_N$  sequentially, at fixed levels of effectiveness. Project  $D_2$  would not begin until  $D_1$  is completed and so on. If this is the case, a fixed effectiveness, minimum cost solution is indicated. If, however, the city decides to solve these drainage problems by allocating the urban drainage budget,  $B$ , between the projects;  $B_1$  to  $D_1$ ,  $B_2$  to  $D_2$  and so on, then a fixed cost, maximum effectiveness approach is called for. Of course, there are many complicating factors such as the *all or nothing* character of UDFC projects, the question of project timing, and others. If the maximum effectiveness approach is used, a careful accounting of benefits for each alternative project will be required.



James [13] has presented a procedure for considering the level of protection as a variable in the economic analysis by minimizing total cost, roughly equivalent to maximizing net benefits.

In the analysis of UDFC problems, BCA *per se* is currently most useful as a partial evaluation tool for alternative major drainage projects because the direct benefits are quantifiable. In using BCA for this application, it is important that the display procedure for project benefits be formulated consistently. In other words, the display of benefit-cost information is difficult to understand and information should be presented in a clear fashion. Different types of benefits should not be quantified and mixed together when they are based on subjective criteria or if the quantification procedure is questionable.

#### Evaluation of Major UDFC Projects

The most visible UDFC problems are those associated with the major drainage system. These problems sometimes include risk to life, property damage and other severe consequences. For this reason it is easier to identify the benefits for major UDFC projects than for minor projects.

An excellent economic technique for evaluating such projects was recently presented by James [13]. A more detailed description is presented in a text by James and Lee [14] and a comprehensive benefit-cost methodology entitled, "Benefit-Cost Analysis for Urban Drainage Planning, Interim Methodology," has recently been prepared [19], the essence of which is presented later in this report. These approaches identify the reduction in average annual flood damage as the major benefit resulting from UDFC project implementation. This benefit is one of a number of expected tangible benefits from a major UDFC project and can be readily

quantified although empirical data is badly needed. Other benefits should be included in the economic analysis of UDFC projects (see Table II-1) and techniques for doing this are being developed.

Reduction in average annual flood damage is one of the goals of UDFC. However, the damage reduction benefit should be regarded as important to the extent that the damage reduction goal is important, but not more. An important consideration is that damage reduction primarily benefits the few property owners in the flood plain. If the UDFC project is funded from general taxes, income will be transferred from the taxpayers to flood plain occupants, creating incentive to occupy the flood plain.

It is suspected that damage reduction has been given priority in evaluation of UDFC projects because of its visibility. Nevertheless, the accuracy with which potential damages can be estimated is dependent on the availability of reliable depth-damage relationships which are only in an early stage of development [5].

Economic analysis of major UDFC projects should proceed as outlined by James and Lee [9] or by Rice [13]. The latter is to be preferred because he presents detailed data and estimating curves for direct use. The results of the analysis should be used with perspective, however, considering first the UDFC objectives and then letting tangible, quantifiable benefits take their proper place in the decisionmaking sequence.

#### Evaluation of Minor UDFC Projects

The problem of evaluating minor UDFC projects is not currently one which can usually be solved using benefit-cost analysis. Referring to Figure II-4, it was shown that the principal benefits for minor UDFC

systems are normally those associated with convenience, aesthetics, etc. and not normally with damage reduction, though in many areas, property damage will occur even during small, frequent rainstorms.

The evaluation problem for minor projects must, for the time being, remain one of setting standards and criteria, then finding acceptable, minimum cost solutions for meeting the standards. This approach is the one currently relied on in most environmental fields, including air and water pollution control.

There are a number of questions which must be answered before a rational approach can be taken to the problem of setting standards for minor UDFC systems in a particular local area. Some of these are as follows:

1. What is the cost function for citywide UDFC protection, relating cost to design level? (Figure II-5 illustrates this function for a single drainage basin).
2. What is the community willingness and ability to pay for UDFC systems, a resource allocation question.
3. What is the frequency of operation of systems of different design levels as contrasted to the frequency of occurrence of extreme events? (Figure II-6)
4. What is the intensity of use of the streets and adjacent land where UDFC will be provided and how necessary is UDFC for adequate use?
5. Will the stormwater collected by the UDFC system eventually have to be treated, and if so, is there a way to design the system to fit into this projected need?

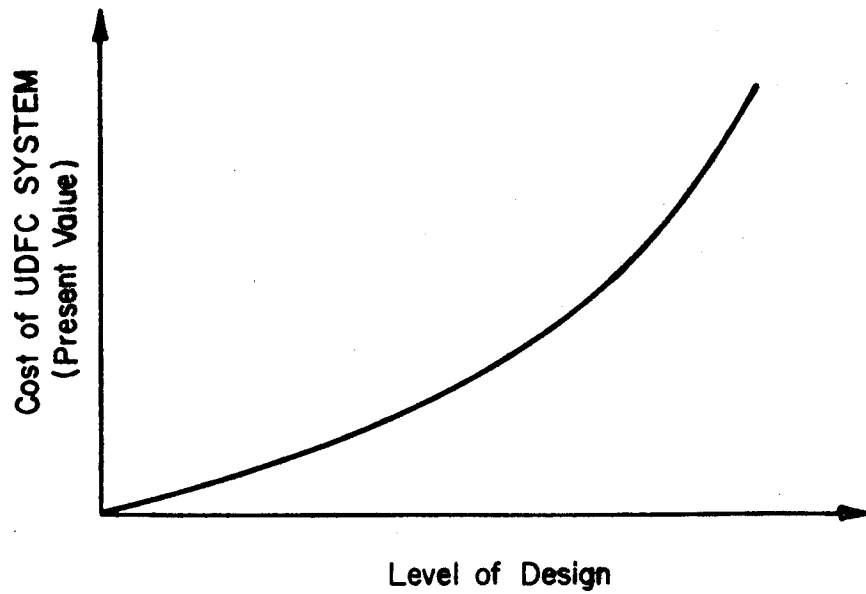


Figure II-5. Cost Function for Minor UDFC Systems in a Drainage Basin

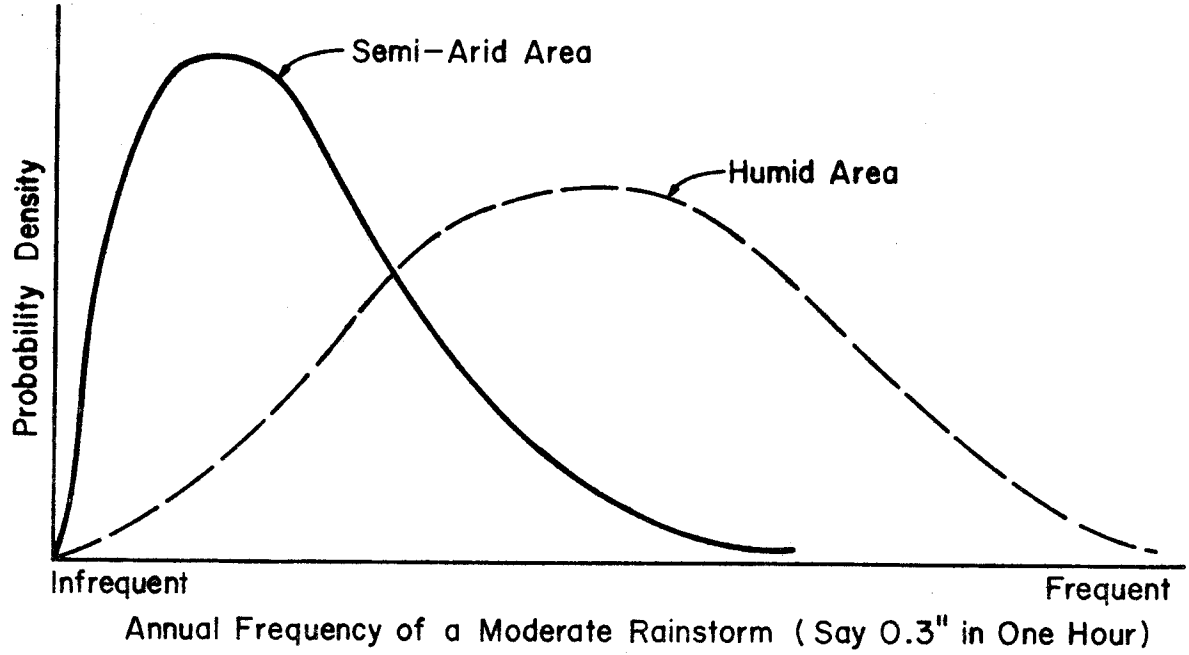
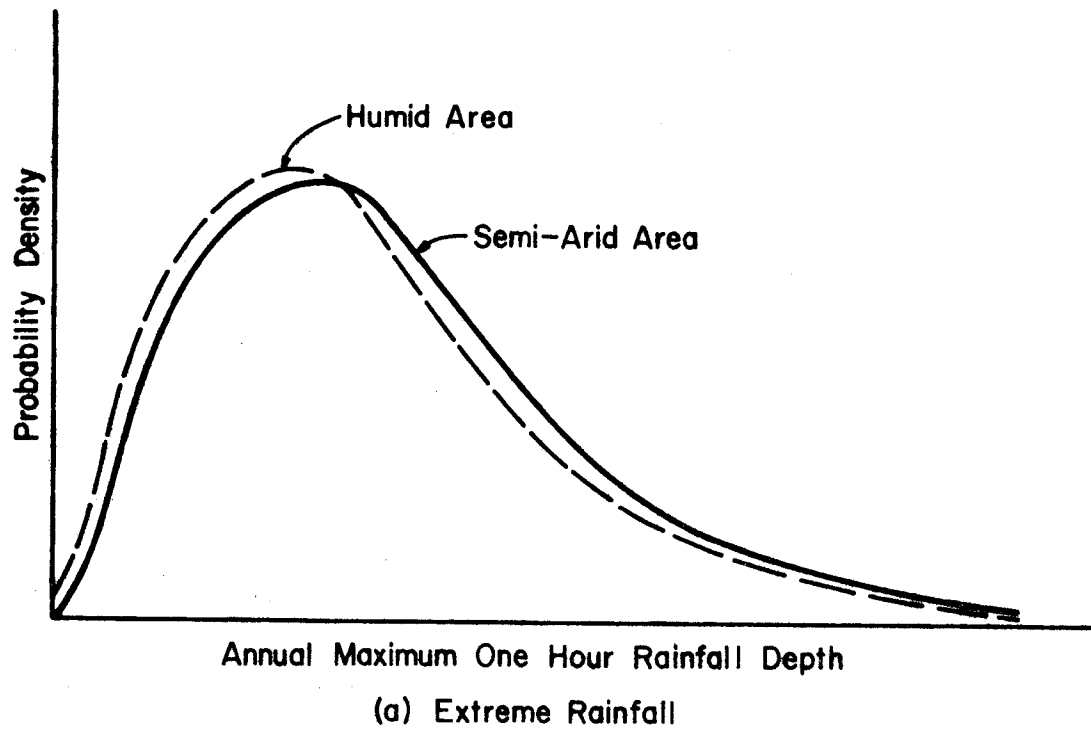


Figure II-6. Hypothetical Frequency Relations for Rainfall in Humid and Semi-Arid Areas

6. What level of design of the minor UDFC system will maximize the benefits shown on Table II-4 and minimize the costs?

These questions, particularly number 6, are difficult to answer and must be currently considered by political means primarily until more economic information becomes available to shed light on the answers to these questions. The evaluation problem of minor UDFC projects thus becomes one where each community answers for itself the foregoing questions, then finds minimum cost feasible projects which meet the UDFC needs.

#### Classification of Costs and Benefits

Table II-4 presented an inventory of costs and benefits normally associated with UDFC projects. It shows damage reduction in perspective, as only one of several benefits realized from such projects. These costs and benefits can be useful in the following four evaluation procedures:

1. Determination of project feasibility
2. Development of information for justifying and promoting projects
3. Development of criteria for ranking competing UDFC projects
4. Determination of the incidence of costs and benefits on population subgroups.

#### The Problems of Estimating Indirect and Intangible Costs and Benefits

Regardless of the type of evaluation problem faced, a basic problem is the determination and quantification of a proposed project's expected benefits. This is one of a number of technical problems inhibiting formal systems analysis procedures. Some other related problems are, according to Keeney and Raiffa [16]:

1. Lack of systematic procedures for isolating problems,
2. Difficulty in identifying objectives and measures of effectiveness for particular situations,
3. Specifying possible consequences of alternative courses of action, (concerns flow of costs and benefits over time and their incidence on particular groups),
4. Difficulty in considering the relative judgment and preferences of the decisionmaking group and the group who will be affected by the decisions made.

For urban drainage and flood control projects it is relatively simple to estimate *some* benefits as compared to other public services shown on Table I-1. Hirsch states that evaluation studies of urban programs are plagued by "...difficulties in estimating indirect benefits and in handling intangible and incommensurate costs and benefits [11]. Estimation of benefits is really an approximate approach for the estimation of public demand for services, assuming the analyst can estimate accurately and the public behaves *rationally*. The emphasis should be on the estimation of the benefit-cost conditions for incremental project implementation according to the interest of different groups [11].

There is a pressing need for a definition of the term "benefit" in the legal sense so that determinations can be made of project beneficiaries for evaluation purposes. This is a problem which transcends the drainage problem and is extremely important [20].

When flooding occurs in urban areas the category of damage normally reported in the press and therefore receiving most attention, is direct damage to property. This is, however, only one of five empirical categories of flood damages. Benefits would be associated with reduction of

damages in the following categories: [3]

1. Direct damages
2. Indirect damages
3. Secondary damages
4. Intangible damages
5. Uncertainty damages

Additional benefits not associated with damage reduction are listed in the inventory of costs and benefits given on Table II-4.

Additional information on the problems and opportunities associated with estimating indirect and intangible costs and benefits is given later.

#### Direct Benefits

In urban areas, direct damages occur basically to structures and their contents, to public facilities such as roads, utilities, and associated facilities, and to vehicles. Damages to property vary according to the type of property, its value, and the cost to restore it to its original condition. In the evaluation of flood control projects, reduction of direct flood damages is usually identified as the primary benefit. A later section of this report discusses the damage estimation problem in detail.

It is correct to compute such benefits but, as previously described, these benefits are experienced mostly by flood plain occupants whereas, in many cases, costs are borne by the general taxpayer. This, in effect, represents an income transfer and an incentive to occupy the flood plain. Alternative drainage management strategies are not readily comparable under this benefit definition unless an incidence analysis compares the benefit-cost analysis. The incidence analysis compares the benefits with the costs for the major subgroups affected by the UDFC project being



considered. For example, a benefit-cost analysis should be performed for each major subgroup (private and public, or flood plain occupants and non-flood plain occupants) in conjunction with the overall benefit-cost analysis which considers all of the benefits and all of the costs. The overall benefit-cost analysis will identify the most economical alternative without considering the question of equity. It will indicate the most cost effective alternative regardless of which groups benefit and which groups pay. The incidence analysis will indicate the most economical alternative from the points of view of the various subgroups concerned. Thus the extent of any *income transfer* will be identified and can be minimized by appropriate alternative selection.

Estimation of the total flood damage is a difficult process because usable data are not available for estimating flood damage for commercial and industrial establishments and for estimating damage for all categories due to the velocity of flow. The state-of-the-art for estimating flood damage to residential structures and contents is summarized later.

The inventory of benefits presented in Table II-1 contains a reduced probability of loss of life. Quantification of this benefit requires estimation of the value (or damage due to loss) of a human life and the probability of loss for given floods. Placing a dollar value on the value of life is a controversial concept, although the judicial system of this country does it frequently, principally in automobile accidents and negligence disputes. The engineer should consider quantification of the value of human life for estimating this benefit; value judgments of the public and the decisionmaking body concerning this subject will weigh in his decision. A method for computing the value of human life is presented by Buehler [4]. The probability for loss of life for various design

floods will affect the magnitude of the benefit and must be estimated by the engineer. Consideration would, of course, be given to encroachment of development into the floodway, flood depths and velocities, and the steepness of the rising flood hydrograph. As in the case of all controversial items (whether benefits or costs), the benefit-cost analysis can be performed with and without the debatable benefit, so that the effect on the alternative selection can be understood and considered.

Land value enhancement benefits, where applicable, can be estimated by considering the increased value that land will have when removed from the flood hazard area. A considerable literature exists on this question in the economics journals.

#### Indirect Benefits

Indirect benefits include reduction of indirect damages such as: lost business and services, the cost of alleviating hardship, safeguarding health, rerouting traffic and related phenomena. Description of the above indirect benefits is very difficult and estimation of them is usually made by taking percentages of direct damage reduction benefits. Data for estimating benefits resulting from reduction of indirect damages are not available as for direct benefits. One set of estimates which was used in one study by the Corps of Engineers is as follows: [3]

1. Residential - 15%
2. Commercial - 35%
3. Industrial - 45%
4. Utilities - 10%
5. Public facilities - 34%
6. Agriculture - 10%
7. Highways - 25%
8. Railroads - 23%

Recent UDFC studies from the Denver area have made attempts to identify some of the intangible benefits directly. One of the more visible intangible benefit categories is recreation opportunities which can also be included in the indirect benefit category. Recreation benefits can be quantified and are routinely done so by government agencies.

### Secondary Benefits

Secondary damages may occur when the economic loss caused by flooding extends farther than the losses to those whose property is directly damaged. For example, people who depend on output produced by damaged property or on hindered services may feel adverse affects [3]. Secondary benefits would result if the secondary damages were reduced by implementation of an UDFC project. Other secondary benefits include the generation of work in an area due to construction of the proposed UDFC project. Secondary benefits are generally considered outside the scope of UDFC project evaluation because of their complex nature.

### Intangible Benefits

With the recent issuance of the Water Resources Council Planning Standards [23] intangible costs and benefits have received greater attention. Among the categories of intangible damages and benefits are environmental quality, social well being and aesthetic values. It is normally not feasible to estimate monetary values of intangible damages and benefits, but these should certainly be considered as part of the total analysis for project jurisdiction. There are several research projects underway which intend to present methods of estimating the magnitude of intangibles but hard quantitative information is not anticipated within the near future.

The value of intangible benefits should not be overlooked, and should be stressed in the narrative of the engineer's report. Once enumerated, proper evaluation of them will be made by the decisionmaking body. Such benefits may be responsible for alternative selection among closely ranked alternatives.

The occupants of flood hazard areas suffer a hardship because of the everpresent uncertainty of when the next flood will occur and how serious it will be. It has been shown that people are willing to pay annual insurance premiums exceeding their expected annual losses to avoid financial disaster or even the financial inconvenience of irregular budgeting [3]. The excess premium amounts to an *uncertainty damage*, elimination of which would become a benefit. The calculation of this sense of security benefit is not straightforward and requires a study of practices in insurance buying within the study area. This type of benefit is not usually included in evaluation of UDFC projects. When unidentified, this benefit is usually included with the intangibles.

The state-of-the-art of evaluating environmental intangibles was recently reviewed in a report by Coomber and Biswas [ 6]. The purpose of the study was to "consider the possibility of accurate assessment of the values of environmental intangibles." They demonstrate that *relative* values of intangibles are easier to estimate than *absolute* values. They argue for uniformity and consistency in the application of intangible benefits and costs, a need which is rather obvious when the influence of the analyst is considered. They are honest and to the point in admitting that the attention given to recreational benefits (as one type of *intangible* benefit) may be excessive and that there is currently no way to estimate the important social benefits that cannot be estimated through demand functions.

Estimation of recreational benefits is at a different stage than estimation of damage reduction benefits. The empirical data base is weaker and unknown elasticities of the demand functions introduce a large uncertainty into their use. There does exist an abundant literature on this topic, however.

An interesting discussion of intangible benefits was presented recently as part of a Denver area UDFC study [25]. In this study recreational benefits were computed based on an estimate of the public's willingness to pay for various types of recreational opportunities. The discussion of intangibles presented is reproduced below in order to stimulate further discussion about this topic.

#### Intangible Benefits (from [25])

"Natural resource planning organizations in recent years have begun to recognize the importance of the intangible components of resource utilization. Almost by definition, intangible benefits were until recently considered to be immeasurable and were not included as a part of a project evaluation.

Intangibles include those components of environmental appreciation which are not directly quantifiable in terms of dollar value or dollars spent for their usage. Normally, intangibles accrue from the aesthetic, scientific, educational, historical, and recreational aspects of natural and man-made environments. One additional intangible benefit, peculiar to residents of flood hazard areas, is the peace of mind which can be enjoyed by those safeguarded from future flood damages.

Much of the basin of Lena Gulch, as well as the channel adjacent area, has been gradually urbanized since 1935. All indications are that this urbanization will continue to intensify in the future. The types of urbanization range from typical Denver area suburban residential developments to rural sprawl and commercial installations.

The 11 miles of channel provide many opportunities to identify intangible benefits, revive additional ones which have been destroyed by the urbanization, and create new ones. Certainly open space and recreational opportunities abound. This is fortunate because recently the people of Jefferson County voted to tax themselves for open space and recreational development. This has the effect of proclaiming this type of land use a high priority item for the people of Jefferson County. If the Lena Gulch drainageway improvements are properly implemented, much interest in the area will be found at the city, county, state, and federal government levels. This attention in itself will tend to foster better land use decisions based upon the public good within the basin.

The inclusion of intangible benefits in the land use decision-making process presents obvious advantages. The methods by which they can be included, however, are not so obvious. Benefit/cost analyses have been used to weigh the merits of various alternative courses of action in terms of economic efficiency. This requires that all benefits and costs be relegated a dollar value or they are not included in the benefit/cost decision-making process. Reducing to economic terms items such as aesthetic experiences and peace of mind can be quite arbitrary and subjective. There is a real danger that such determinations are not more than a numbers game which can be adjusted to achieve whatever result is desired by the analyst. It would appear that intangible benefits and costs would be more appropriately included in the decision-making process as effects to be considered in addition to the benefit cost analysis and not as a part of it.

Although the appropriateness of reducing intangibles to dollar values is certainly open to question, several techniques have been developed by researchers to estimate the value of intangibles in terms of dollars. N. H. Coomber and A. K. Biswas ("Evaluation of Environmental Intangibles," 1973) have written an excellent summary of the various techniques available. Numerous estimating algorithms have been developed based upon evaluations of willingness to pay, consumer demands, the availability of alternative recreation, measurements of psychological stimulation, and others. Some of these techniques are more arbitrary than others and some are totally impractical.

One of the least subjective and most practical techniques is to evaluate intangible benefits in terms of someone's willingness to pay for that benefit. In the case of privately owned recreational and scenic areas, the admission charge is generally representative of the value of an experience. In the case of publicly owned facilities, monetary values are indirectly expressed in the expenditures incurred in a recreational trip or the cost of admission at a similar private area.

Several intangible benefits were identified for each of the Lena Gulch drainageway improvement alternatives. Dollar values for these benefits were estimated on the basis of the principles of the "willingness to pay" method. For those areas designated as grass-lined channels, the intangible benefits were estimated for recreational and commuter bike paths, walking and hiking activities, and picnic areas. For each detention basin, an estimate of the benefits derived from winter ice skating and sledding, summer picnics, and educational field trips were included where appropriate. The dollar value of intangibles is summarized in Tables VII-3, 4 and 5.

The relatively natural condition of Apex Gulch above Heritage Square along the slopes of Lookout Mountain is a valuable asset to Lena Gulch which could be preserved. Natural mountainous drainageways within a few minutes drive of urban sprawl will undoubtedly prove an invaluable natural resource in future generations. Because this area is presently in private ownership with limited access and because no public land acquisition program was included in any of the three alternatives, no intangible benefits were calculated for Apex Gulch.

No dollar value was included for the sense of security and social order enjoyed by the residents along Lena Gulch as a result of the recommended improvements. Any evaluations in this area under the present scope of work would have been quite arbitrary and highly speculative. A proper determination of these benefits would require an extensive study conducted by a highly qualified team of sociologists, urban planners, and engineers. The importance of these intangibles, however, should not be ignored. Rather, they should be carefully weighed as a most important element in the land use decision-making process. The recognition of the existence of these intangible benefits separate from the benefit/cost analysis is an essential step toward achieving proper flood plain usage."

One of the difficulties inherent in considering intangible costs and benefits in evaluation of small UDFC projects is that the cost of analysis may be excessive. Some of the rather experimental techniques such as described in [6] or subjective techniques such as [25] might be better left out of small project evaluation studies. Some recent promising approaches which might be applicable to large projects, particularly those with multipurpose components, have been reported recently, however [2]. According to this research, it was concluded that aesthetic and recreational benefits are neither intangible nor insignificant. Furthermore, they concluded that ultimately, increase in real estate value near urban water projects can be shown to measure these benefits. These techniques remain to be tested further but they do show promise for improvement in the assessment of benefits.

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## CHAPTER III

### INTERIM METHODOLOGY FOR ANALYSIS OF BENEFITS AND COSTS OF UDFC PROJECTS

This chapter contains an interim methodology for performing benefit-cost analyses of UDFC projects. The methodology has undergone some review and criticism but additional refinement is necessary. Although it is a methodology for analysis of both minor and major UDFC projects, its application should be initially restricted to those projects where flood damage reduction is a principal objective. The reason for this is that minor projects must currently be justified mostly because of convenience and environmental management benefits and acceptable techniques for quantifying these do not currently exist.

The methodology is based mostly on current techniques used on UDFC planning projects in Denver, Colorado by the Urban Drainage and Flood Control District. It is intended to serve as a starting point for the development of a more refined and highly relevant benefit-cost methodology.

The primary objective of benefit-cost analysis is to compare the costs and benefits of alternative flood control measures with related benefits to determine which measures maximize the return from the expenditure of public funds. The *return* must be measured with respect to public goals and objectives which are normally not precisely known to the analyst. The principal objective of urban flood control projects is normally taken to be the reduction of flood damages to public and private property but a city can specify its goals in other areas if they desire. To properly carry out a BCA, however, the local priorities must be known.

Benefit-cost analysis, if properly carried out and cogently presented, can be a beneficial tool in public decisionmaking. Important features are:

1. The project benefits and costs are presented in the common denominator of dollars.
2. The public investment is measured over an appropriate time period. This advantage is often overlooked but is highly significant.
3. The techniques of benefit-cost analysis allow for comparing and ranking multiple alternatives. The method can handle a large number of alternatives with less confusion than normal narrative presentations.

Some common objections to BCA are:

1. Too much reliance can be placed on the results of the analysis by the decisionmaking body. Benefit-cost analysis is based upon a series of assumptions about physical events. The assumptions are only approximations of reality, not reality itself, and the results of the analysis should be viewed with this in mind.
2. The prejudices of those making the analysis are always incorporated into the analysis. For example, open space is valueless to some groups and therefore not considered as a benefit, while to others it may be a primary objective.
3. The question arises as to who receives benefit from a public works improvement--the community at large, certain sections of private enterprise and/or certain residential areas. This information is not always revealed in a BCA.

Before benefit-cost analysis can be useful, flood control criteria must be formulated to establish the constraints of the analysis. In addition, the engineering investigation must be completed, including the hydrologic and hydraulic analyses and the formulation of alternative flood control measures.

#### Formulation of Flood Control Study Criteria

Before the flood control study is undertaken, some criteria must be established. The following are among the questions that should be considered:

1. Is the desired level of protection fixed or variable?
2. If the level of protection is fixed, will the recommended alternative be the lowest cost, the one that maximizes the net benefits for a fixed cost, or the one that maximizes the net benefits with no constraint on the project cost?
3. Will the project financing be fixed or variable?
4. Will the study consider only direct benefits or will secondary or indirect benefits be quantified and included?
5. Which secondary benefits will be quantified? Should loss of life be quantified?
6. Which types of alternatives should be investigated?

Other criteria should be set where applicable. The answers to the above will depend on local preferences and in fact may be specified in the contract. This methodology has assumed that the desired level of protection is fixed, the financing is variable, and the recommended alternative will be the one that maximizes the net benefits, defined in terms of local priorities.

## Hydrologic and Hydraulic Analyses

As an input to BCA, flood hazard areas under existing and various future development conditions must be defined. Because the extent of flooded land, the magnitude of potential damage and the cost of preventive and corrective measures all depend on the magnitude of flood flows derived from the hydrologic studies, it cannot be over-emphasized that the hydrology is of primary importance to the analysis. The most reliable hydrologic techniques consistent with the scope of the project and the basic data available should be utilized in the analysis.

The benefit-cost analysis should include the computation of the future flood hydrology for a range of recurrence intervals (at least three) including the 100-year event. The recurrence intervals should be chosen to give a representative spread in the peak flows, i.e., low, medium and high. This will be used to define the base line conditions from which the effectiveness of each flood control alternative will be measured. Derivation of runoff hydrographs is necessary.

Development of the future hydrology will require estimation of the type and extent of future development. This information should be available at the planning departments of the local jurisdictions within the study area. Lacking any usable data, the engineer must make the best predictions possible, to the extent of using the services of local planners if desirable. Local planners will be familiar with the existing development, local subdivision regulations, community preferences and other factors that will affect the type of development. The limit of the development will depend on factors such as topography, soil type and political boundaries. Encroachment into the floodplain is an item of considerable significance, since flood damages are directly related

to development within the floodplain. This will be affected by existing regulations such as floodplain ordinances, community awareness of flooding potential and consequences, and development pressures. The engineer must estimate the probable encroachment which would result without the benefit of the results of his flood control study.

It is also desirable to know how the present situation compares with the future in terms of the flood magnitudes and resulting damages. This will require the development of flood hydrology for the existing situation. The same recurrence intervals should be used as for the future hydrology.

Floodplains are delineated on topographic maps yielding estimates of the depths, lateral limits and velocities of the flooding. Appropriate hydraulic study techniques should be utilized.

#### Formulation of Alternatives

Once the magnitude of the flooding problem is defined, specific alternative measures for solution are formulated to accommodate the design flows. The engineer should be aware of the effect that each alternative will have on the flood hydrology. The formulation of alternative solutions is a creative process and requires the engineers best efforts. It is not discussed in depth here, being beyond the scope of this report.

#### Benefit-Cost Analysis

The following benefit-cost analysis is presented for use. The procedure is presented in step-by-step fashion with an example given to help explain the steps.

## STEPS IN BENEFIT-COST ANALYSIS

1. Examine flood hazard area and classify by land use.
2. Determine flood damage categories by land use.
3. Eliminate unlikely damage categories.
4. Divide study area into reaches.
5. Develop cost data.
6. Identify benefits and collect supporting data.
7. Obtain and develop appropriate depth versus damage tables or curves.
8. Analyze the do-nothing flood damages.
9. Compute the average annual flood damage potential.
10. Compute the flood damages and the average annual flood damage potential for alternatives.
11. Compute the benefits for each flood control alternative.
12. Compute the costs for each flood control alternative.
13. Select the time horizon.
14. Select an appropriate discount rate.
15. Convert all benefits and costs to a common time frame.
16. Compare the benefits with the costs and prepare them in display form for decisionmakers.



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15. Convert all benefits and costs to a common time frame.
16. Compare the benefits with the costs and prepare them in display form for decisionmakers.

### Example Benefit-Cost Analysis

The example is based upon the Little Dry Creek Master Plan project located in Douglas and Arapahoe Counties, Colorado, undertaken for the Urban Drainage and Flood Control District [15] by the firm of McCall-Ellingson & Morrill Inc., consulting engineers, as assisted by the firm of Lyon, Collins & Co., Inc., local governmental consultants. This basin was chosen as a case study because of the varied conditions encountered and the detail of the analysis conducted. To broaden the scope of the example, certain elements and conditions not found in the Little Dry Creek basin have been added. It must be emphasized that each project will present a unique situation in terms of flood hydrology, development characteristics, alternative solutions and other features, therefore the step-by-step description must be considered as a guide to performing benefit-cost analysis and not as a rigid formula. As in other portions of the urban drainage master planning process, a significant degree of engineering judgment is required to achieve an acceptable and realistic solution.

### Step 1 - Examine Flood Hazard Area and Classify by Land Use

The following types of land use are typical:

#### Land Uses - Little Dry Creek Basin

- A. Public streets, bridges, culverts and utilities.
- B. Public unimproved open space.
- C. Public improved open space.
- D. Private unimproved open space (grazing).
- E. Private improved open space (farming).
- F. Single family residential.
- G. Multi-family residential.

- H. Trailer and mobile home parks.
- I. Commercial (retail).
- J. Industrial.
- K. Other.

In addition, a survey of special or unusual hazards from flooding should be made. Only one major special hazard existed in the Little Dry Creek basin--the covered underground parking area of the Cinderella City parking structure.

Step 2 - Determine Flood Damage Categories by Land Use

Determine the types of damages which might occur in the drainage basin according to the land use.

<u>Land Use</u>	<u>Potential Damage Description</u>
A. Public streets, bridges, culverts and utilities.	<ul style="list-style-type: none"> <li>1. Wash-outs damaging structures and necessitating repair or replacement, including structure damage or failure due to debris pile up.</li> <li>2. Interrupted traffic or services.</li> <li>3. Removal of debris and cleaning.</li> <li>4. Loss of life.</li> </ul>
B. Public unimproved open space.	<ul style="list-style-type: none"> <li>1. Erosion.</li> <li>2. Removal of debris and cleaning.</li> </ul>
C. Public improved open space.	<ul style="list-style-type: none"> <li>1. Damage to facilities in waterways.</li> <li>2. Erosion.</li> <li>3. Removal of debris and cleaning.</li> </ul>
D. Private unimproved open space (grazing).	<ul style="list-style-type: none"> <li>1. Erosion.</li> <li>2. Loss of livestock.</li> </ul>
E. Private improved open space (farming).	<ul style="list-style-type: none"> <li>1. Erosion.</li> <li>2. Loss of life.</li> <li>3. Loss of livestock.</li> <li>4. Damage to farm equipment.</li> <li>5. Damage to stored goods.</li> </ul>
F. Single family residential.	<ul style="list-style-type: none"> <li>1. Structural damage.</li> <li>2. Contents damage.</li> <li>3. Removal of debris and cleaning.</li> <li>4. Erosion.</li> <li>5. Missed work.</li> <li>6. General inconvenience.</li> <li>7. Loss of life.</li> </ul>

Land Use

Potential Damage Description

- |   |   |
|---|---|
| G. Multi-family residential.                            | 1. Structural damage.<br>2. Contents damage.<br>3. Removal of debris and cleaning.<br>4. Loss of renters, increased vacancies, or reduced rental income.<br>5. Erosion.<br>6. Missed work.<br>7. General inconvenience<br>8. Loss of life.                          |
| H. Trailer and mobile home parks.                       | 1. Structural damage.<br>2. Contents damage.<br>3. Removal of debris and cleaning.<br>4. Loss of renters, increased vacancies, or reduced rental income.<br>5. Erosion.<br>6. Missed work.<br>7. General inconvenience.<br>8. Loss of life.                         |
| I. Commercial.  | 1. Structural damage.<br>2. Contents damage.<br>3. Inventory loss/damage.<br>4. Removal of debris and cleaning.<br>5. Loss of business income.<br>6. Loss of sales taxes.<br>7. Loss of salaries to employees.<br>8. Special police protection.<br>9. Loss of life. |
| J. Industrial.  | 1. Structural damage.<br>2. Contents damage.<br>3. Inventory loss/damage.<br>4. Removal of debris and cleaning.<br>5. Operating loss-days idle.<br>6. Loss of salaries to employees.<br>7. Loss of life.  |
| K. Special Situations--<br>such as Underground Parking. | 1. Vehicular damage.<br>2. Loss of life.  |
| L. Other  |   |

Step 3 - Eliminate Unlikely Damage Categories

Once specific categories and potential damage have been identified, a number can be eliminated due to the unlikeliness of their occurrence or to the insignificance of the loss. In the Little Dry Creek study the following damage categories were eliminated for the reasons set forth below:

<u>Land Use/Damage Category</u>	<u>Elimination Reason</u>
A. Industrial - all damage.	No industries in study area.
B. Public unimproved open space - all damages.	Damage insignificant.
C. Public improved open space - all damages.	No land in study area inundated.
D. Private unimproved open space (grazing).	Insufficient land in study area inundated.
E. Private improved open space (farming).	Insufficient land in study area inundated.
F. Special Police Protection - Commercial.	Structural damage insufficient to allow looting.
G. Structural damage to bridges by trailers and other floating debris.	Field review indicated low probability of damage.
H. Interrupted traffic or services - public streets and utilities.	Alternate traffic routes and estimated brevity of service interruptions make category too small for inclusion.
I. Erosion - all land uses.	Judged insignificant to warrant inclusion.
J. General inconvenience - all land uses.	Undoubtedly will occur but insufficient data to place dollar values.

Systematically examining each land use/damage category to eliminate from consideration those unlikely to occur in a particular drainage basin will save the analyst considerable time in data collection and manipulation.

#### Step 4 - Divide the Study Area into Reaches

Divide the study area into manageable reaches for aggregation of flood damages. It may be advantageous to have the divisions correspond to the design points of the hydrologic analysis and/or political boundaries.

#### Step 5 - Develop Cost Data

Perhaps the most familiar portion of the benefit-cost analysis is the development of cost data. For each proposed physical facility, the

following cost data must be included:

- A. Site acquisition.
- B. Construction and engineering.
- C. Fiscal and administrative.
- D. Annual principal and interest payments (if debt financed).
- E. Annual operation and maintenance.
- F. Insurance.

A table reflecting the annual costs over the life of the improvement will be constructed in Step 11. If debt financing is to be utilized, the site acquisition and construction cost should be reduced by the principal to be repaid over the term of the bonds and the cash outflow of both principal and interest should be reflected in each year's cost. Structure replacement costs should be included where applicable. The table of costs will be converted to a present worth or an average annual worth in Step 14.

#### Step 6 - Identify Benefits and Collect Supporting Data

Benefits include, but are not limited to, the following: [9]

- A. Tangible Benefits
  - 1. Direct Benefits:
    - a. Reduced flood damages.
    - b. Reduced probability of loss of life.
    - c. Land value enhancement.
  - 2. Indirect or secondary Benefits:
    - a. Reduced traffic delay.
    - b. Open space and recreation benefits.
    - c. Reduced income loss.
    - d. Reduced production and sales loss.
    - e. Reduced roadway maintenance.

## B. Intangible Benefits

1. Reduced inconvenience.
2. Social environment benefits.
3. Sense of security benefits.

Tangible direct benefits can be quantified. This does not imply that they are more important than intangibles or indirect benefits. Indirect and secondary benefits are not as readily quantified as direct benefits. See the discussion in the next chapter regarding them. Intangible benefits cannot normally be quantified and must be handled qualitatively. The bulk of the numerical benefits which will be included in this example will be reduced flood damages. Values for the potential for loss of life can also be included, see [2].

Where benefits are not presented quantitatively, they can be included in narrative form. This applies to direct, indirect and intangible benefits. The WRC system of *accounts* in Chapter II is an attempt to do this. Where quantification of benefits is considered controversial, it is recommended that the engineer prepare his benefit-cost analysis with and without the benefits in question so that their effect on the recommended alternative can be observed.

Engineering data are required from the hydrologic and hydraulic analyses which include:

- A. Existing and future flood hydrographs for the range of recurrence intervals of interest.
- B. Delineation of the future floodplains on adequate topographic mapping which reflects the existing channel situation. The assumed future development patterns will be overlaid on these projected floodplains and



future flood damages will be computed. It will be the reduction in this potential flood damage that will make up the bulk of the direct benefits for each flood control alternative and the sensitivity of the BCA to the development assumption should therefore be recognized.

- C. Aerial photographs which may be useful in the economic analysis.

Other data which will be necessary for the analysis are:

- A. Structural Data - Residential and Commercial

For Little Dry Creek structural data were obtained from computer printouts of the County Assessor's records of properties located in and around the floodplain. The data obtained for each property were:

Legal description

Property address

Assessed valuation of structures

One of the difficulties in the use of the structural value data rested with the inability to retrieve only those parcels which were affected by flooding. Although the assessor's files can be assessed on a parcel by parcel basis, the time involved in determining and keypunching the permanent parcel number was prohibitive. Therefore, each parcel in a given quarter section was printed out, thus placing the burden of parcel identification on the analysts. Although this was a less costly procedure than preselection of parcels, it was a burdensome, time consuming task particularly in the densely developed areas.

All structure values from the County Assessor's records were divided by 0.3 to yield the market value because property under Colorado law is assessed at 30% of actual value.

#### B. Content Data - Residential

In Colorado personal property is no longer assessed, and good sources of data on value of contents of residential units do not exist locally. The cost of developing contents cost data by survey of individual units is not generally warranted. Instead, a factor of 50% of the structure value was used in lieu of more definite data. This problem is discussed further in the next section.

#### C. Content and Inventory Data - Commercial

In the Little Dry Creek Basin two major commercial areas exist in portions of the floodplain. County Assessor data as to the value of contents and inventory exist but are not a matter of public record. To utilize this data while observing rights of privacy, the County Assessor's office took a random sample of contents and inventory value. This sample was used as an average value of contents and inventory per commercial outlet.

#### D. Structural and Content Data - Trailers and Mobile Homes

There did not exist adequate public data on the value of mobile homes and their contents. It was necessary to contact a number of new and used mobile home sales offices to obtain an average per unit value of each mobile unit.

#### E. Removal of Debris and Cleaning - Public Land

Estimates of the number of hours of debris removal necessary in public land uses such as streets and bridges was made on the basis of the personal experience of the analysts. The average per hour rate of the public employees who would be involved in the work was multiplied by 2.25 to cover cost of materials and fringe benefits.

#### F. Missed Work, Removal of Debris and Cleaning - Residential Land Uses

For each residential land use inundated, two days per unit were estimated as necessary to do the cleaning. The two days were assumed equal to the daily pay of an employee earning \$12,000 per year. The per day rate was based upon the 1970 census data on median income adjusted to fit the specific characteristics of the homes in the floodplain. This calculation also was designed to cover lost income from missed work.

#### G. Removal of Debris and Cleaning - Commercial Land Use

An estimate of three employees working for four days was made for each commercial unit inundated. An hourly rate equivalent to that of the going rate of a retail clerk was used to price the employees' time.

#### H. Street, Bridge and Utility Damage Data

Estimates of the nature of the loss and the cost to repair or replace public facilities were made from field review of the floodplain. Recent unit cost data from various public projects were used in these estimates.

#### I. Loss of Renters - Multi-family and Mobile Home Land Uses

The number of rental units which were inundated was counted and an average monthly rental per unit (apartments and mobile homes) was determined from actual rental rates. A vacancy of 1.5 months per unit inundated was estimated.

#### J. Loss of Business Sales and Sales Tax

In the Englewood portion of the Little Dry Creek basin a high loss in business sales was anticipated due to the large commercial areas. To determine the amount of this loss, daily gross sales per store were developed using the area by area sales tax statistics maintained by the

City of Englewood. A per day loss sales figure was estimated for each store inundated. Sales tax was computed and included.

#### K. Loss of Employees' Salaries

No loss of employees' salaries was anticipated as it was believed that most would be involved in clean-up or have the chance to put in make-up hours later. Had the character of the flood damage and the nature of the businesses affected been different, a loss would have been estimated.

#### L. Vehicular Damage

A large underground parking facility exists at Cinderella City Shopping Center in Englewood. The egress from that area can become impossible should a number of drivers attempt to leave at the same time. The probability of such a situation arising was calculated and used as the basis for estimating this special damage situation.

#### M. Financial Data

Financial personnel of jurisdictions financing the drainage improvements (cities, counties, and drainage districts) should be contacted to obtain the cost of their borrowed money and the interest at which they can invest their idle funds. Municipal bond dealers that finance projects like urban drainage projects should also be consulted to see what interest they would require to finance money for the jurisdictions involved. The estimated amount of money to be financed will affect the selection of the discount rate.

#### Step 7 - Obtain and Develop Appropriate Depth Versus Damage Tables or Curves

Flood damages are calculated with the use of depth of flooding versus dollar damage tables and curves for various types of structures. Several government organizations have compiled data of this type including the

Federal Insurance Administration (FIA). The Corps of Engineers, the Soil Conservation Service (SCS), and the Tennessee Valley Authority (TVA). This is discussed in greater detail in the next section. It is felt that presently the FIA has the most acceptable data for estimating flood damages for residential structures, and their data was accordingly used in this study. See Tables III-1 and III-2. The FIA data are only valid for residential structures and generalized curves for commercial and industrial areas do not exist. These must be handled on a case-by-case basis. See the additional discussion in the next section, along with a graphical comparison of the depth versus damage data of the several agencies mentioned.

#### Step 8 - Analyze the "Do-Nothing" Alternative

The floodplains, delineated in the hydraulic analysis for future conditions, are theoretical and represent what would happen if the design storm occurred today and the basin had its future development and runoff characteristics.

Overlay the anticipated future development pattern on the undeveloped portions of the floodplain maps. Estimate probable encroachment into the floodplain, using previous encroachment as a guide, but also considering such factors as existing floodplain regulations, community awareness of flooding potentials, and development pressures. For a sophisticated analysis, alternative development futures can be considered. Do not assume encroachment based on the rights-of-way required for the flood control alternatives. The estimated encroachment limits represent what might happen without the benefit of the results of the flood control study being conducted. Flood damages computed for this condition will result if no flood control measure is acted upon (the do-nothing alternative).

Table III-1

## FEDERAL INSURANCE ADMINISTRATION

SEPTEMBER 1970  
 Depth Damage Curves\*[5]  
 Set A

## STRUCTURES-RESIDENTIAL AND SMALL BUSINESS

<u>Depth in Feet</u>	<u>Curve No.</u>						
	01	03	05	10	13	18	23
	<u>Damage in % of Total Value</u>						
-3.0					.0	.0	.0
-2.0					3.	3.	3.
-1.0	.0	.0	.0	.0	6.	5.	5.
First Floor .0(0.1)	8.0	4.	3.	8.	10.	7.	6.
1.0	22.	10.	11.	50.	24.	14.	16.
2.0	30.	16.	20.	71.	31.	31.	22.
3.0	35.	20.	25.	82.	37.	26.	26.
4.0	39.	24.	29.	87.	41.	30.	30.
5.0	41.	27.	31.	89.	44.	33.	32.
6.0	44.	30.	33.	91.	46.	35.	35.
7.0	46.	32.	34.	91.	48.	38.	36.
8.0	48.	34.	41.		49.	40.	44.
9.0	50.	39.	46.		50.	44.	48.
10.0		42.	50.			46.	52.
11.0		45.	53.			47.	55.
12.0		47.	55.			48.	57.
13.0		49.	58.			49.	58.
14.0		50.	59.			50.	59.
15.0			60.				60.

<u>Classification</u>	<u>Curve No.</u>
One story, no basement	01
Two or more stories, no basement	03
Split level, no basement	05
One story with basement	13
Two or more stories with basement	18
Split level with basement	23
Mobile home, on foundation	10

\* Taken from Flood Damage Factors - Depth Damage Curves, Elevation-Frequency Curves, Standard Rate Tables, Federal Insurance Administration, September, 1970.

Table III-2

## FEDERAL INSURANCE ADMINISTRATION

SEPTEMBER 1970  
 Depth Damage Curves\* [5]  
 Set A

## CONTENTS-RESIDENTIAL

<u>Depth in Feet</u>	<u>Curve No.</u>								
	27	29	46	51	31	41	33	56	38
	<u>Damage in % of Total Value</u>								
-3.0			.0	.0		.0		.0	
-2.0			8.	5.		81.		10.	
-1.0	.0	.0	8.	5.	.0	81.	.0	15.	.0
First Floor .0(0.1)	5.	5.	21.	10.	1.	83.	2.	18.	3.
1.0	35.	16.	40.	22.	3.		19.	31.	30.
2.0	50.	28.	58.	34.	4.		32.	44.	56.
3.0	60.	37.	70.	43.	5.		41.	52.	72.
4.0	68.	43.	76.	48.	6.		47.	58.	79.
5.0	74.	47.	80.	51.	6.		51.	61.	84.
6.0	78.	49.	82.	52.	6.		53.	63.	87.
7.0	81.	50.	83.	53.	6.		55.	64.	88.
8.0	83.	51.	85.	56.	6.		56.	66.	90.
9.0	85.	55.		59.	10.		62.	69.	90.
10.0		58.		64.	23.		69.	73.	
11.0		65.		71.	47.		75.	76.	
12.0		72.		76.	64.		78.	79.	
13.0		78.		78.	74.		80.	80.	
14.0		79.		79.	81.		81.	80.	
15.0		80.		80.	83.				
16.0		81.		81.					

<u>Location</u>	<u>Curve No.</u>
All on first floor	27
All on first two floors	29
All on first floor and basement	46
All on first two floors and basement	51
All above first floor	31
All in basement	41
In split level	33
In split level with basement	56
Mobile home on foundation	38

\* Taken from Flood Damage Factors, etc. (same as Table 1)

The effectiveness of each alternative will depend primarily on how much it reduces the damages from this do-nothing case.

For the do-nothing alternative, compute the flood damages for the existing development and for the projected development. For areas of uniform flood damage potential (i.e., a residential area of uniformly valued homes), per acre factors can be developed for damages for a range of flood depths. The floodplain can then be divided into areas of equal flood depth, i.e., 0-2 ft., 2-4 ft., and 4+ ft. Flood damages are then found by applying the per acre damage factors. The per acre damage factors can be computed by estimating typical exposures for each damage category and applying the individual damage factors. Table III-3 summarizes the procedure for obtaining area damage factors for 3 and 4 ft. flood depths for a sample low density residential area.

For existing areas that are not homogeneous with respect to flood damage, a more detailed analysis must be performed. For each damage category the value exposed to flooding must be known. For example, estimation of the structural damage to a particular residential unit requires knowledge of the value of the structure. The exposure is multiplied by the damage factor taken from the appropriate depth versus damage curve. Dollar damage is estimated for each damage category, and tabulated as in Table III-4.

Estimation of future flood damages for presently underdeveloped areas will require the development of weighted per acre flood damage factors. These factors should be weighted to reflect the probable percentage that each land use will be of the total undeveloped area. This information was obtained or estimated in the hydrologic analysis, and an example is given in Table III-5.



Table III-3

PER ACRE FACTORS FOR ESTIMATING  
FLOOD DAMAGES IN HOMOGENEOUS AREAS

Land Use : Low Density Residential, 3 units per acre.

<u>Damage Category</u>	<u>Exposure Per Acre</u>	<u>4 Foot Flood Depth</u>		<u>3 Foot Flood Depth</u>	
		<u>Damage Factor</u>	<u>Damage Per Acre</u>	<u>Damage Factor</u>	<u>Damage Per Acre</u>
1 Story Structure	\$85,800	.39	\$33,462	.35	\$30,030
1 Story Content	42,900	.68	29,172	.60	25,740
Streets	6,000	.80	4,800	.40	2,400
Utilities	12,600	.50	6,300	.20	2,520
Lawns, Open space	3,520	1.00	3,520	1.00	3,520
Vehicles	13,500	.75	10,125	.68	9,180
Life	288	1.00	288	-	-
Cleanup	250/day	8 days	<u>2,000</u>	6 days	<u>1,500</u>
Total Damages			\$89,667 Per Acre		\$74,890 Per Acre

Table III-4

DAMAGE TABULATION SHEET FOR NON HOMOGENEOUS AREAS

Reach: Frequency: 100 yrs. Condition: Developed

Type of Damage: One Story Residential Structure

Structure Value	Number of Inundated Structures for Flood Depth						Flood Damage
	0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.	5-6 ft.	
\$30,000	15	5	1				\$177,300
\$40,000	6	1					\$ 74,000
\$50,000	1						\$ 12,500
<b>Number of Structures</b>	22	6	1				
<b>Total Value</b>	\$740,000	\$190,000	\$30,000				
<b>% Total Value Damaged</b>	25	35	41	46	49	52	
<b>Total Flood Damage</b>	\$185,000	\$66,500	\$12,300				\$263,800

Table III-5

WEIGHTED FACTORS FOR ESTIMATING  
FUTURE FLOOD DAMAGES FOR UNDEVELOPED AREAS

<u>Land Use</u>	<u>Estimated % of Area</u>	<u>4 Foot Flood Depth *</u>		<u>3 Foot Flood Depth *</u>	
		<u>Damage/Acre</u>	<u>Weighted Damage/Acre</u>	<u>Damage/Acre</u>	<u>Weighted Damage/Acre</u>
Low Density Residential	54	\$89,667	\$48,420	\$74,890	\$40,441
Medium Density Residential	16	131,683	21,069	109,440	17,510
High Density Residential	13	166,830	21,688	138,348	17,985
Commercial	1	189,918	1,899	156,141	1,561
Industrial	15	21,055	3,158	14,980	2,247
Park, Open Space	<u>1</u>	<u>3,000</u>	<u>30</u>	<u>2,500</u>	<u>25</u>
Totals	100		\$96,264 Per Acre		\$79,769 Per Acre

\* Includes damage to structures, contents, streets, utilities, vehicles, lost sales and cleanup.

Available depth versus damage tables reflect flood damage due to standing water. In addition, there is a potential for damage due to the velocity of the flood water. Erosion and structural damage due to undermining are possible if the velocities are significant. Data for estimating this type of damage are not readily available, and it is recommended the velocity head be added to the flood depth when velocities exceed 8 fps, to account for some of the damage that might occur.

If a comparison of the existing and future flood damages is desired, then flood damages must be computed for the existing situation using the *existing floodplains* defined in the hydraulic analysis, which are based on the existing flood hydrology.

Step 9 - Compute the Average Annual Flood Damage Potential

Total the flood damages for each reach and recurrence interval.

Tables such as the one below should be constructed:

Table III-6

SUMMARY OF FLOOD DAMAGES FOR REACH

Area: Little Dry Creek above Cinderella City

Reach: Station 113+21 through 129+00

Frequency: 100 years

Conditions: Developed

Structure & Content Value Damage

	<u>Amount</u>
Residential	\$420,000
Commercial	623,000
<u>Other Damages</u>	
Loss of Sales	210,000
Removal of Debris - public	12,000
Removal of Debris - Residential	2,000
Removal of Debris - Commercial	6,000
Damage to Public Utilities	3,000
Loss of Rents	4,000
Loss of Life	500
Total Damage	<u>\$1,280,500</u>

For each reach, and for the entire stream, construct a graph of total flood damage versus probability of occurrence in any given year. The graph will be similar to Figure III-1. From this graph, it is possible to interpolate flood damages for flood events other than the ones investigated. A damage versus probability curve will be required for the existing development situation (if a comparison is desired between the existing and future flood damages), and for each flood control alternative. Compute the area under the curves, which is the average annual flood damage potential in dollars per year.

Figure III-1 has a great deal of utility for calculating flood damages of numerous alternative solutions. If a peak discharge scale is constructed corresponding to the probability scale, flood damages can be computed quickly for any sized detention facility. For example, assume that a certain sized detention reservoir is being considered just upstream of the reach under study, and that hydraulic studies have determined that it will reduce the peak 100-year discharge from 20,000 cfs to 14,000 cfs, the 25-year discharge from 10,000 cfs to 7,000 cfs and the 10-year discharge from 7,000 cfs to 3,000 cfs. By entering the curve on the peak discharge scale we can determine the expected flood damages in the reach downstream of the dam. The damages would be \$90,000 for the 100-year event, \$65,000 for the 25-year event, and \$30,000 for the 10-year event. A new damage versus probability curve can be constructed, and a new equivalent annual flood damage potential calculated.

If flood damages within the existing channel are small compared to the total flood damages, then Figure III-1 can be used to compute flood damages of channelization alternatives. Basically, it is only necessary to know the carrying capacity of the stream without channelization and

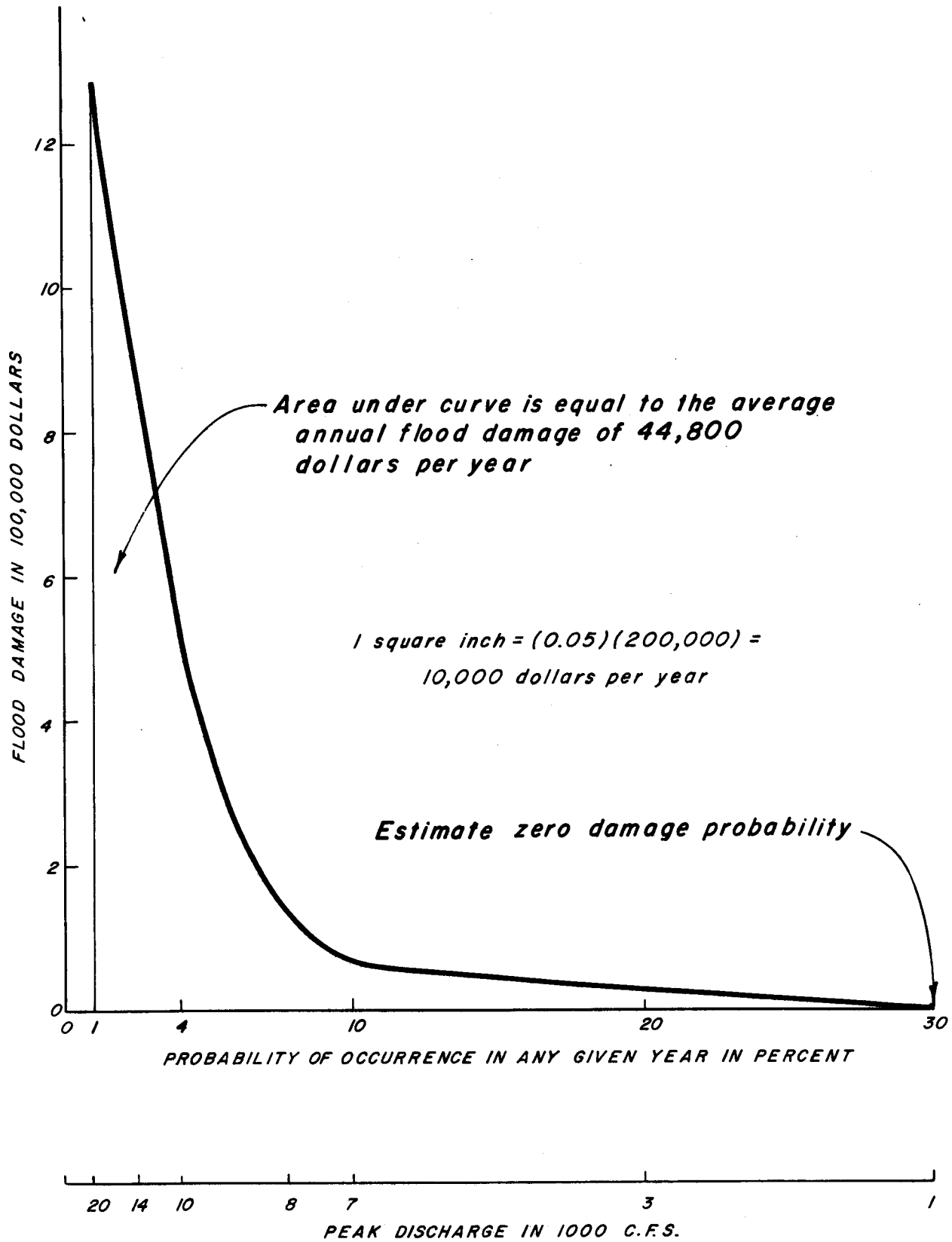


Figure III-1. Flood Damage vs. Probability Reach  
 113 + 21 to 129 + 00  
 Developed Conditions

the capacity with channelization. For example, the stream under study has a capacity of 2,000 cfs. Channelization will increase that capacity to 5,000 cfs--an increase of 3,000 cfs. The 100-year flood damages are now the equivalent of  $(20,000-3,000) = 17,000$  cfs, or \$1,200,000. Flood damages will also be reduced for the other recurrence intervals and can be estimated by shifting 3,000 cfs on the peak discharge scale. A new damage probability curve can be constructed and the equivalent annual flood damage potential calculated for the channelization alternative. If flood damages within the existing channel cannot be neglected, then an overbank flood damage versus probability curve must be constructed by subtracting the amount of the damage within the channel before this procedure can be used.

#### Step 10 - Compute Flood Damages and Average Annual Flood Damage Potential for Alternatives

Repeat Steps 8 and 9 for each flood control alternative under consideration.

#### Step 11 - Compute the Benefits for Each Flood Control Alternative

The reduction in the annual flood damage potential is the principle *benefit* realized if the flood control improvement is constructed. The average annual benefit is illustrated graphically in Figure III-2 which compares the damage probability curves of the future situation with the curve for the first alternative. Quantify the other tangible benefits identified in Step 6 and tabulate as in Table III-7.

#### Step 12 - Compute the Costs of the Various Flood Control Alternatives

Costs considered in this step should include at least all of those listed in Step 5. Prepare a table that reflects end-of-the-year costs over the project life. Such a table might resemble Table III-8 which follows.

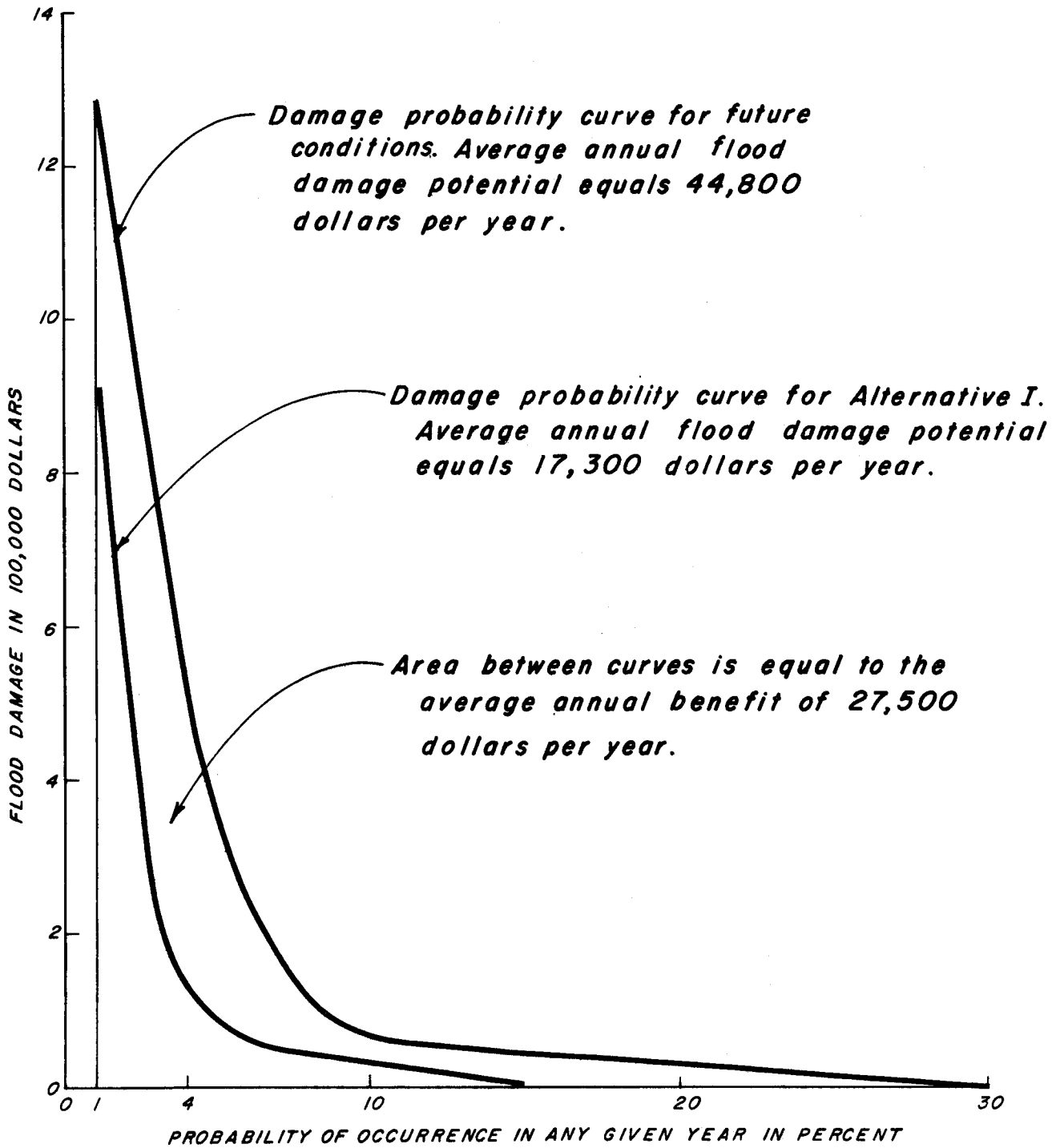


Figure III-2. Average Annual Direct Benefits Reach  
 113 + 21 to 129 + 00  
 Alternative I



Table III-7

BENEFITS FOR ALTERNATIVES

<u>Alternatives</u>	<u>Average Annual Flood Damage</u>	<u>Average Annual Flood Damage Reduction*</u>	<u>Other Annual Benefits</u>			<u>Present Worth Factor @ 5%**</u>	<u>Present Worth of Benefits</u>
			<u>Increased Land Utilization</u>	<u>Open Space and Recreation</u>	<u>Total of Annual Benefits</u>		
Present - Do Nothing	\$44,800						
Alt. #1 - Detention Dams	\$17,300	\$27,500	\$1,000	\$3,000	\$31,500	18.2559	\$575,061
Alt. #2 - Channelize	\$ 2,500	\$42,300	\$5,000	0	\$47,300	18.2559	\$863,504
Alt. #3 - Conduits	\$ 1,000	\$43,800	\$6,000	0	\$49,800	18.2559	\$909,144
Alt. #4 - Dams With Channelization	\$ 7,000	\$37,800	\$4,300	0	\$42,100	18.2559	\$768,573
Alt. #5 - Floodplain Zone	\$ 8,200	\$36,600	0	\$5,000	\$41,600	18.2559	\$759,445

\* Includes all of the tangible benefits identified in Step 6, except those for increased land utilization, open space and recreation.

\*\* P.W. Factor =  $\frac{(1+i)^n - 1}{i(1+i)^n}$ , where  $i = .05$  and  $n = 50$ .

Table III-8

SUMMARY OF END OF YEAR COSTS OVER PROJECT LIFE

Alternative 1

Item	Year 0-1	Years 2-30	Years 31-50	Present Worth Factor @ 5%	Present Worth of Costs @ 5%
Site Acquisition	\$100,000	0	0	(.9524)	\$95,240
Construction	\$ 97,000	0	0	(.9524)*	\$92,383
Fiscal and Administrative	\$ 2,000	\$2,000	\$2,000	(18.256)**	\$36,512
Principal and Interest	\$ 2,500	\$2,500	0	(15.372)	\$38,430
Maintenance and Operation	0	\$2,000	\$2,000	(.9524)(18.160)	\$34,591
Other	\$ 500	\$ 500	\$ 500	(18.256)	\$ 9,128
Present Worth Total @ 5%					\$306,284

\* PW Factor for fixed future amount =  $\frac{1}{(1+i)^n}$ , where n = number of years and i = discount rate = .05

\*\* PW Factor for equal annual amounts =  $\frac{(1+i)^n - 1}{i(1+i)^n}$ .

The period of loan repayment does not have to correspond to the project life if debt financing is to be utilized.

#### Step 13 - Select Time Horizon

The time horizon is the number of years over which the project is to be viewed. The selection of time horizon should be based upon one factor: the physical life of the improvements which will prevent or control flooding. If the improvements have a useful life which is less than the frequency at which project design floods occur and the analyst wishes to extend the cost-benefit examination to that point, it is necessary to show the replacement of the facilities as a project cost. For this example a 50-year project life was chosen.

#### Step 14 - Select an Appropriate Discount Rate

Selection of an appropriate discount rate is more important. The discount rate will bias the analysis and may change the recommended alternative [8]. Selection should be based on the information collected in Step 6 and reflect at least the cost of borrowed capital for the amount which is expected to be financed. Five percent per year was used in this example.

#### Step 15 - Convert all Benefits and Costs to a Common Time Frame

Comparison of benefits and costs must be made for the same time frame. Benefits stemming from reduced flood damages occurring annually over the life of the project cannot be compared directly, for example, with construction costs which occur over a short period of time at the beginning of the project. All benefits and costs must be converted to either present worth or annual worth before comparison, using compound interest factors, which account for the time value of money. In this example, all benefits and costs were converted to present worth. See

the last two columns of Tables III-7 and III-8.

Step 16 - Compare the Benefits with the Costs and Select the Most Economical Alternatives.

Evaluation and selection of alternatives is possible with a number of methods, including the benefit-cost ratio, net benefits (using either present worth or annual values) and incremental rate-of-return [8,13]. Some alternative concepts may suffer because their benefits may be difficult to identify or quantify but this is an inadequacy in the techniques of benefit evaluation and not a fault of the particular economic evaluation technique selected.

For simplicity, the net benefit method is presented here. It offers less opportunity for computational error and will save time especially if any last minute changes are made which require a rerun of the benefit-cost analysis. It is not uncommon, for example, for decisionmakers to ask what effect a change in the per acre ROW cost or what effect the addition or deletion of certain costs or benefits would have on the recommended alternative. The results are not affected by the classification of certain items as costs or *disbenefits* which is sometimes a problem with the benefit-cost ratio method [8]. The net benefit is simply the value of the benefits minus the value of the costs. Present or annual worth dollars can be used. Table III-9 is an example of the procedure for displaying net benefit information.

Table III-9 presents net benefits from the classes of benefits considered. Along with this should be presented qualitative information concerning other costs and benefits, particularly information concerning social and environmental benefits and costs, and information about distributional effects. There are numerous ways to accomplish displays of this type. A suggested procedure would be to place the

Table III-9

Display of Net Benefits

<u>Alternatives</u>	<u>Present Worth of Costs @ 5%</u>	<u>Present Worth of Benefits @ 5%</u>	<u>Net Benefit (Benefits- Costs)</u>
Present - Do Nothing			
Alt. #1 - Detention Dams	\$ 306,284	\$575,061	\$ 268,777
Alt. #2 - Channelize	\$ 705,000	\$863,504	\$ 158,504
Alt. #3 - Conduits	\$1,532,000	\$909,144	\$-622,856
Alt. #4 - Dams With Channelization	\$ 400,000	\$768,573	\$ 368,573*
Alt. #5 - Floodplain Zone	\$ 435,000	\$759,445	\$ 324,445

\* Most economical alternative has largest positive net benefit.

benefits and costs into categories according to the Water Resources Council *accounts* and to display them accordingly. Another technique is to formulate a matrix of benefits and costs, by category and by incidence on different population groups, a latter approach demonstrated to apply to transportation problems. These techniques will be more fully described in a later report.

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CHAPTER IV  
STATE-OF-THE-ART OF ESTIMATING FLOOD DAMAGE  
IN URBAN AREAS

When flooding occurs in urban areas the category of damage normally reported in the press and therefore receiving most attention, is direct damage to property. This is, however, only one of about five empirical categories of flood damages [3].

The five categories are:

1. Direct damages
2. Indirect damages
3. Secondary damages
4. Intangible damages
5. Uncertainty damages

Direct Damages

In urban areas, direct damages occur basically to structures and to public facilities such as roads, utilities, and associated facilities. This appears to be the major category of flood damage which should be considered. Damages to property vary according to the type of property, it's value, and the cost to restore it to it's original condition. There is a fair amount of data available for estimating damages to residential property, but little data is available for estimating industrial and commercial damages [7]. The main contribution of this chapter is an in-depth analysis of the currently available data for estimating residential flood damage.

Indirect Damages

Indirect damages include the value of lost business and services,

the cost of alleviating hardship, safeguarding health, rerouting traffic, delays and related phenomena [3]. The description of indirect damages is very difficult and has not been delineated to the extent that they can be individually estimated. The current state-of-the-art is to take the indirect damages as percentages of direct damages. One set of estimates that has received wide distribution was by the Corps of Engineers [10] and is as follows:

1. Residential - 15%
2. Commercial - 35%
3. Industrial - 45%
4. Utilities - 10%
5. Public facilities - 34%
6. Agriculture - 10%
7. Highways - 25%
8. Railroads - 23%

#### Secondary Damages

Secondary damages may occur when the economic loss caused by flooding extends farther than the losses to those whose property is directly damaged. For example, people who depend on output produced by damaged property or on hindered services may feel adverse affects [3]. Normally, the secondary damages tend to be offset by secondary benefits and are not included in damage estimates.

#### Intangible Damages

With the recent issuance of the Water Resources Council Planning Standards, intangible costs and benefits have received greater attention. Some categories of intangible damages are: environmental quality, social well being and aesthetic values. It is currently not possible to estimate monetary values of intangible damages, but these should be

considered as part of the total analysis for project justification. There are several research projects underway leading to methods of estimating the magnitude of intangible damages but we do not expect hard quantitative information on this subject in the near future.

#### Uncertainty Damages

The occupants of a flood plain suffer because of the everpresent uncertainty with regard to when the next flood will occur and how serious it will be. The uncertainty damage cost may be calculated as an amount in excess of the expected value of the damages that flood plain occupants are willing to pay to avoid a flood loss [3]. It has been shown that people are willing to pay annual insurance premiums exceeding the expected the annual losses to avoid financial disaster or even the financial inconvenience of irregular budgeting [3]. The calculation of uncertainty damages is not straightforward and requires a study of practices in buying insurance.

#### Estimating Direct Residential Flood Damage in Urban Areas

Estimating potential flood damages is an important problem in planning federal, state or local water resources projects. The economic importance of this has increased with the implementation of the Flood Insurance Act of 1968 and the recent Flood Disaster Prevention Act of 1973. There is a paucity of published data for use by engineers in making damage estimates, however. Actual flood damage data from surveys remains in the files of agencies and insurance companies. A water resources project with flood control may include structural, non-structural, or a combination of measures. In any case, damages to be prevented by

the potential flood control project must be estimated in order to evaluate alternatives.

The seriousness of the lack of urban flood damage data was described in a 1968 ASCE study,

"Because damage is primarily related to the flood, damages are likewise evaluated with a sense of probability of occurrence...The contemporary absence of a satisfactory body of hydrologic and economic field data on urban storm drainage system floods constitutes a liability of monumental proportions in the assessment of those floods and their associated damages." [1]

This study went on to advance suggestions for a research program to supply the needed basic data. These points are related to overall urban hydrology data needs in a companion study by ASCE in 1969 [2]. These two references make a good starting point for reading on urban drainage and damage problems. Of course, the general flood control literature is also applicable to this question and an excellent starting point is the paper by White [18].

This chapter presents a discussion of damage estimation methods in use by engineers for calculating expected annual average flood loss (AAFL) which is taken here to include only direct damage to buildings and contents. It is recognized, of course, that other factors enter into the calculation of loss, but this discussion is limited to direct damage. *There are three factors that enter into calculation of AAFL; stage-discharge relationships for each reach of a river or drainage basin, discharge-frequency data, and depth-damage curves.* These are combined to give damage-frequency curves, the area under which yields the AAFL. In many flood plains where velocity and duration of flooding do not affect flood damages appreciably, general depth-damage curves

can be used in conjunction with the above hydrologic data to estimate the AAFL. The curves presented in this paper are for this purpose. Hopefully, the discussion generated by the paper will enrich the literature in this important subject area.

The sources of data for the curves shown are estimating tables and curves prepared by federal agencies. These curves are mostly based on generalized original data compilations from diverse sources. Some potential sources of such estimating curves would be reluctant to release their curves because of the difficulty in gathering, analyzing and presenting such data as discussed in [1]. Therefore, in presenting these curves the writers are not suggesting that they be unquestionably accepted for use but that they be considered for use and, if no estimating curves are currently available to some agencies, perhaps they can be adopted.

The paper is specifically restricted to residential structures and contents. The enormous variability of commercial structures renders damage estimation more complex. Some estimating values are available [8,15] but by and large, this problem is not as well understood as the residential damage question.

#### Current Practices of Estimating Direct Damages

The techniques used to calculate direct damages can be classified in various ways. White uses two main classifications; synthetic techniques and stage-damage curves [19]. The authors have chosen three categories to illustrate these techniques; aggregate formulas, historical damage curves, and empirical depth-damage curves. White's synthetic techniques would encompass both the aggregate formulas and historical damage techniques.

Brown and James have published examples of the aggregate formula approach [4,9]. For example James [9] suggests that for estimation purposes,

$$C_D = K_D U M_S h A \quad (1)$$

Where:

$C_D$  = flood damage cost for a particular flood event

$K_D$  = flood damage per foot of flood depth per dollar of market value of structure

$U$  = fraction of flood plain in urban development

$M_S$  = market value of structures inundated in dollars per developed acre

$h$  = average flood depth over inundated area in feet

$A$  = area flooded in acres

The historical damage curve method is presented by Eckstein [6].

As shown on Figure IV-1, historical damages of floods are plotted against flood stage. For current validity, damage costs must be corrected to present values by including additional construction (i.e., the development of the flood plain) and by correcting for inflation.

The historical stage-damage curve can be used to calculate AAFL by first using flood frequency and hydraulic methods to determine a damage-frequency curve. The relation for AAFL may then be calculated as the area under the damage-frequency curve, where, for computation,

$$AAFL = \sum_{i=1}^{N-1} \left[ \frac{D_i + D_{i+1}}{2} \right] (P_{i+1} - P_i) \quad (2)$$

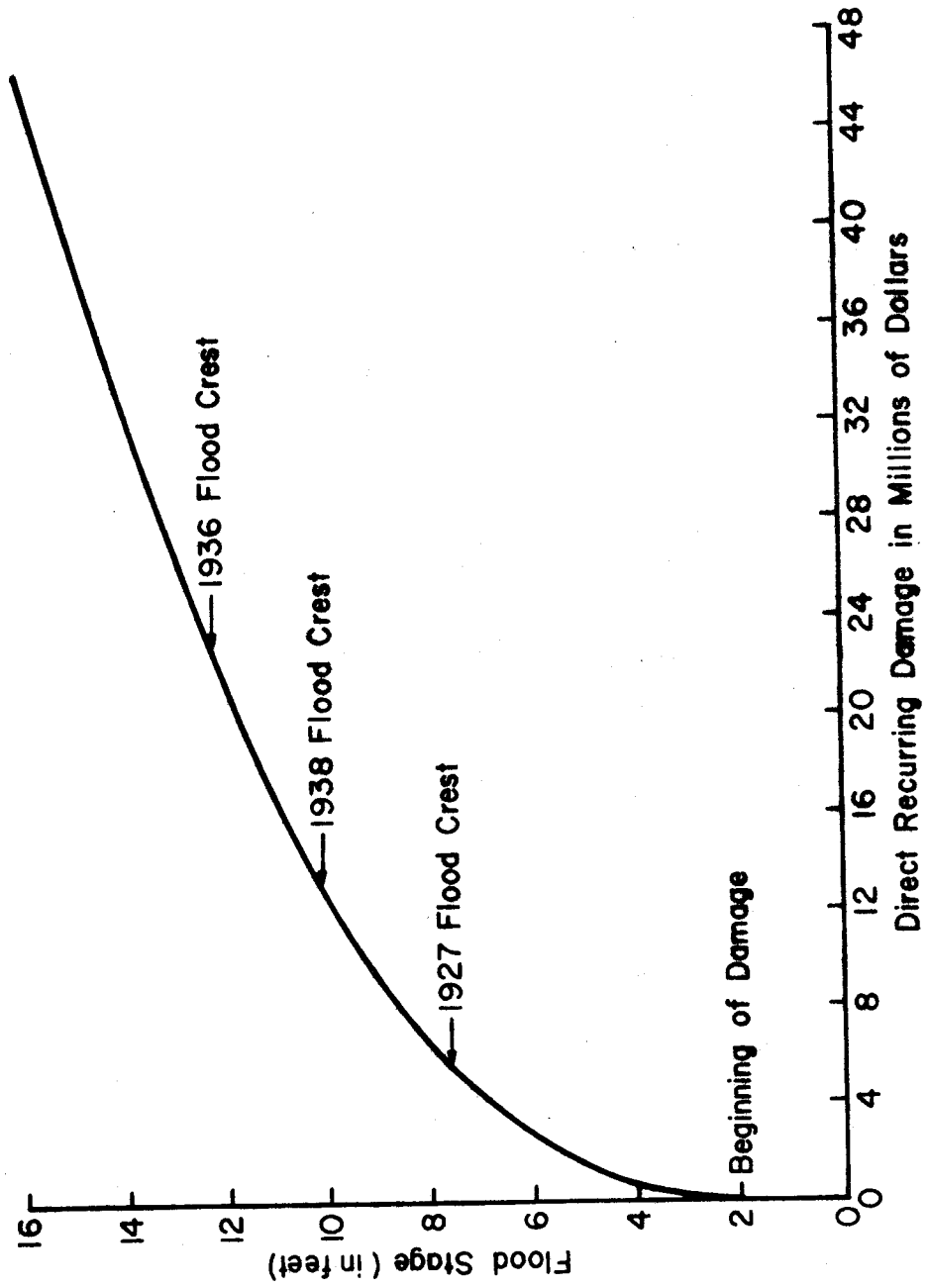


Figure IV-1. Historical Depth-Damage Curve

Where:

$D_i$  = the damage for the  $i^{\text{th}}$  flood selected

$P_i$  = exceedance probability of the  $i^{\text{th}}$  flood

$N$  = the number of flood magnitudes used in computation

The third and most common method requires a property survey of the flood plain and either an individual or aggregated estimate of depth vs. damage curves for the structures occupying the plain [5,12]. This information is then related to stage-frequency curves to determine the required damage-frequency curve. This method can be applied with the degree of detail appropriate to the project size and cost.

#### Use of Depth-Damage Curves

Generally speaking, four inputs are needed to compute the AAFL. These are: the first floor elevations of the structures in the flood plain (or the elevation where floodwater enters the building), the stage-frequency curve for the stream reach, the depth-damage curves for the structures in the study reach, and the value of the structures (with contents) in the flood plain. This is illustrated in Figure IV-2. Structures can include roads and other facilities such as utilities but damages to these are usually negligible in comparison to houses and businesses.

One of the problems for an engineer when using the damage tables available is that the value of the structure and the value of the contents are normally computed separately. When making a first estimate or studying a small project, a "rule-of-thumb" must normally be used to relate value of contents to structure value or separate surveys of contents and structure values must be performed. The latter is uneconomical for small projects and first estimates, so a method is needed to



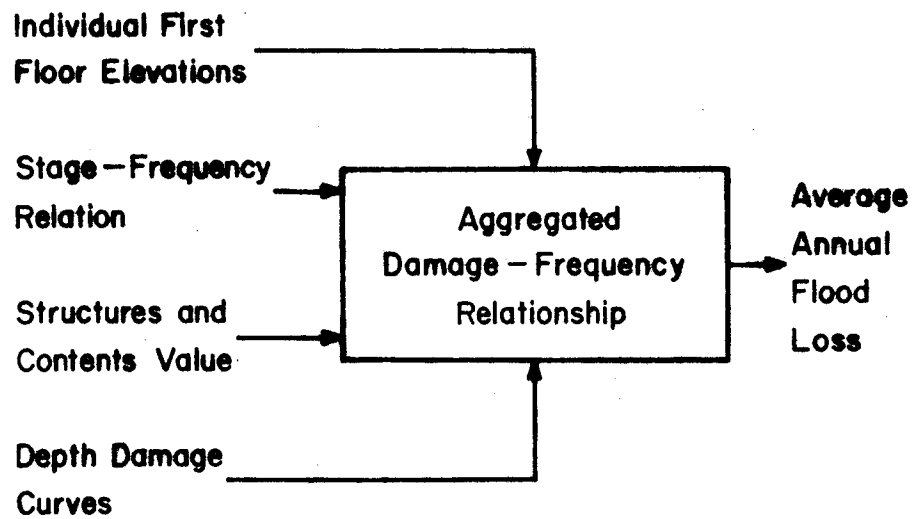


Figure IV-2. Computational Procedure for Average Annual Flood Loss

combine the damage to structures with damage to contents to yield a total depth-damage relationship. There are mixed feelings regarding the validity of such a combination. Some feel that contents must be valued separately because their value varies relative to the value of the structure over time. Others feel the two quantities can be combined without loss of accuracy.

A statistical survey relating structure value to contents was conducted by the Stanford Research Institute (SRI) [8]. From their data, a regression equation was developed with the following results:

$$100 \frac{V_c}{V_s} = 42.0818 - .00072 V_s \quad (3)$$

Where:

$V_c$  = market value of contents

$V_s$  = market value of structure in dollars

The standard error was 15.49 and the coefficient of correlation was .32 revealing that the value of the contents varies considerably in relation to the value of the structure. *It does appear that the value of contents declines relative to the total value of structure as the value of the structure increases.* For example, assuming the above relationship, the contents of a \$20,000 house would be around 28% of \$20,000 or \$5,500. There is some evidence that the ratio does not continue to decline as the market value of the structure increases beyond \$35,000.

A flood study conducted in 1964 by a Federal agency used 32% of the structure value to compute the value of the contents. A major insurance company uses 50% and states that this may be high or low,

depending on the circumstances. Another Federal agency feels that 30% of the structure value is a good approximation for the value of the contents.

When depth vs. percent-damage data is available separately, a combined relation for a given flood event can be developed as follows: Assuming contents to be valued at 30% of structure value,

$$V_t = V_s + V_c \quad (4)$$

$$D_t = D_s V_s + D_c V_c \quad (5)$$

$$\frac{D_t}{V_t} = \left[ \frac{D_s}{1.3} + \frac{D_c}{4.33} \right] \quad (6)$$

Where:

$V_t$  = total market value of structure and contents

$D_t$  = total damage to structure and contents in dollars

$D_s$  = fraction of the structure damaged

$D_c$  = percent of contents damaged

This relation can be used to develop combined curves for total percent damage as a function of stage for different types of property.

#### Depth vs. Percent-Damage Curves

The following graphs were compiled in order to demonstrate variations in depth-damage data available. The curves are based on tables and curves obtained from references [12,13,14,16]. Some assumptions were necessary to plot the curves on an uniform format and the curves in the references are given as guidelines only, not as verified data. Nevertheless it seems worthwhile to compare the relationships in use so that engineers can be guided in their selection of estimating

values. It should be noted that the Federal Insurance Administration (FIA) curves shown are the earliest versions and may be revised. FIA appears to be making a credible attempt to synthesize data and develop reliable estimating curves, and engineers interested in this subject should stay in touch with their work.

Figure IV-3 through IV-6 show depth-damage curves for four main types of residential structures. Figure IV-7 shows a comparison between one type of house with and without a basement. Figure IV-8 is the result of a study conducted by the TVA [12] which indicated that houses of one type had similar depth-damage curves regardless of actual value. The classes of structure plotted on the graph represent four price ranges of one-story houses without basements. However, one study cast some doubt on this popular assumption that houses of one type have similar depth-damage curves.

The relationship shown on Figures IV-3 through IV-8 may be used by engineers for estimation purposes. The wide variation in the curves waves a flag of caution, however, as recognized by the agencies using the curves. Because of the many flood damage mitigation studies now underway, it seems that some guide should be available. For the case where the engineer is comparing alternative flood control measures, any reasonable stage-damage curve will provide a relative measure of damages. The pitfall would be to assign too much accuracy to resulting estimates.

Based on the curves presented, the FIA relationships appear to be the most reasonable for estimation purposes, if for no other reason than that they "split the middle." The FIA has based their curves on a substantial data base and the curves certainly appear reasonable. Having the advantage of the previous studies of the other agencies, it is expected that the middle range would be the one selected by FIA.

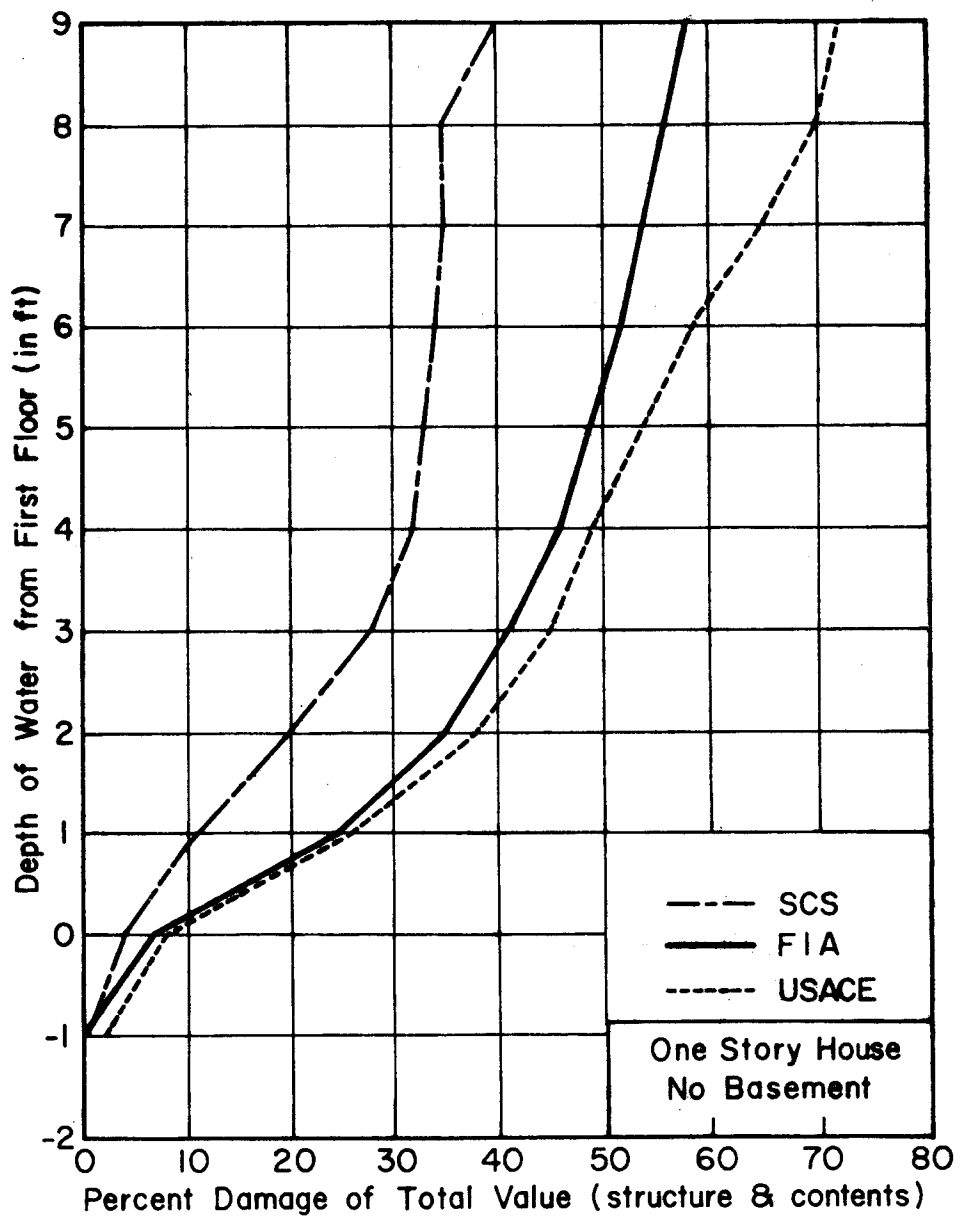


Figure IV-3. Depth-Damage Curves  
One Story House, No Basement

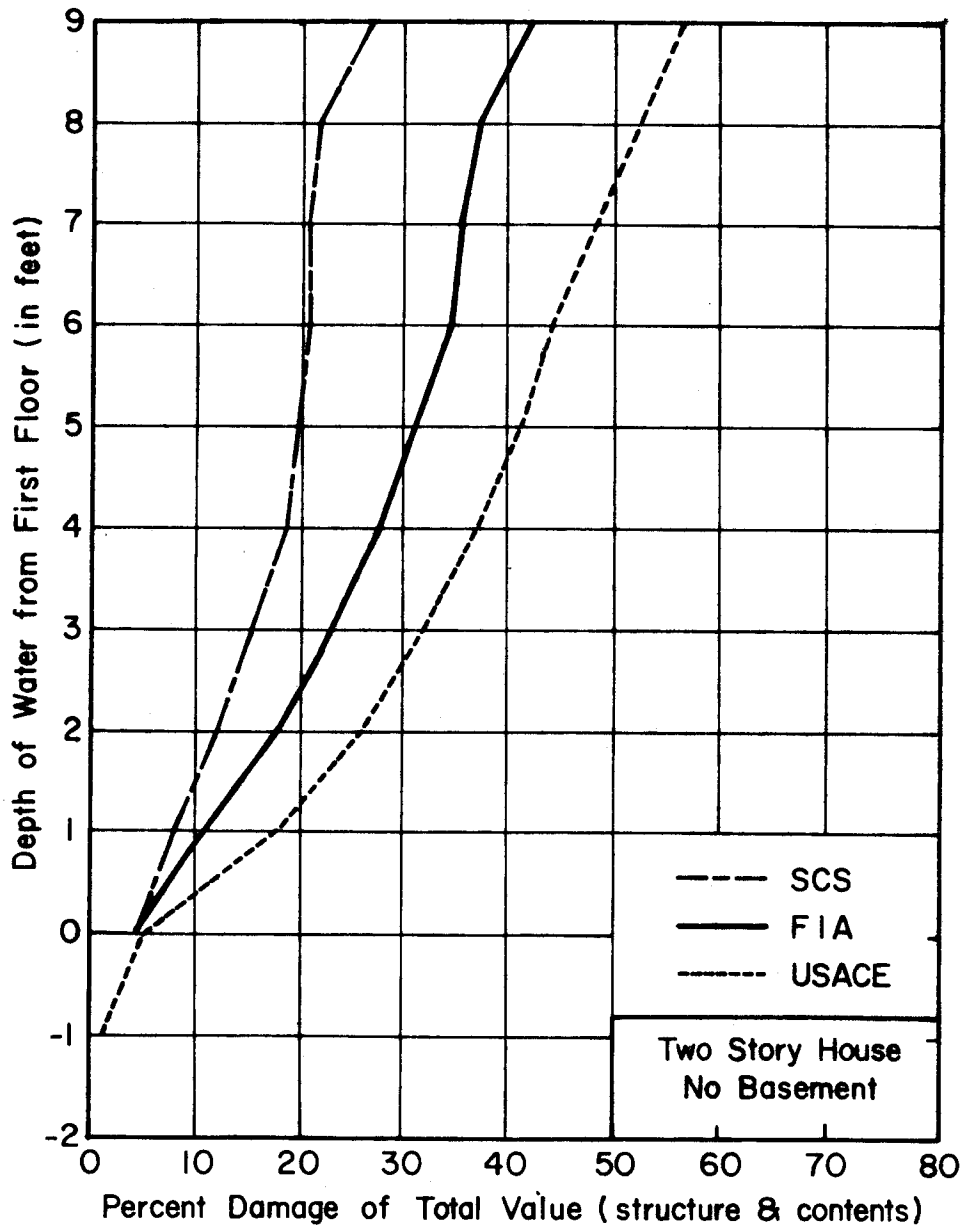


Figure IV-4. Depth-Damage Curves  
Two Story House, No Basement

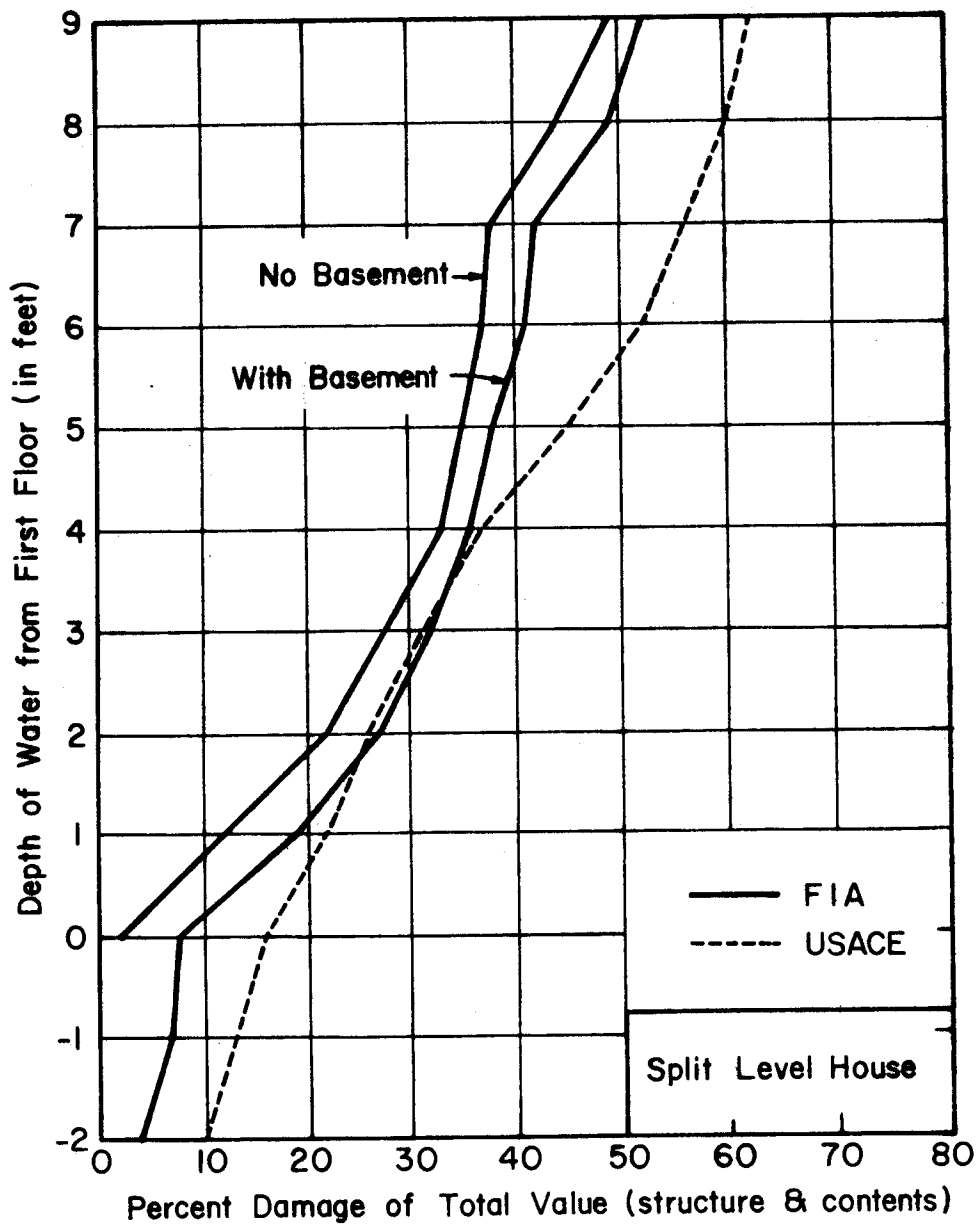


Figure IV-5. Depth-Damage Curves  
Split Level House

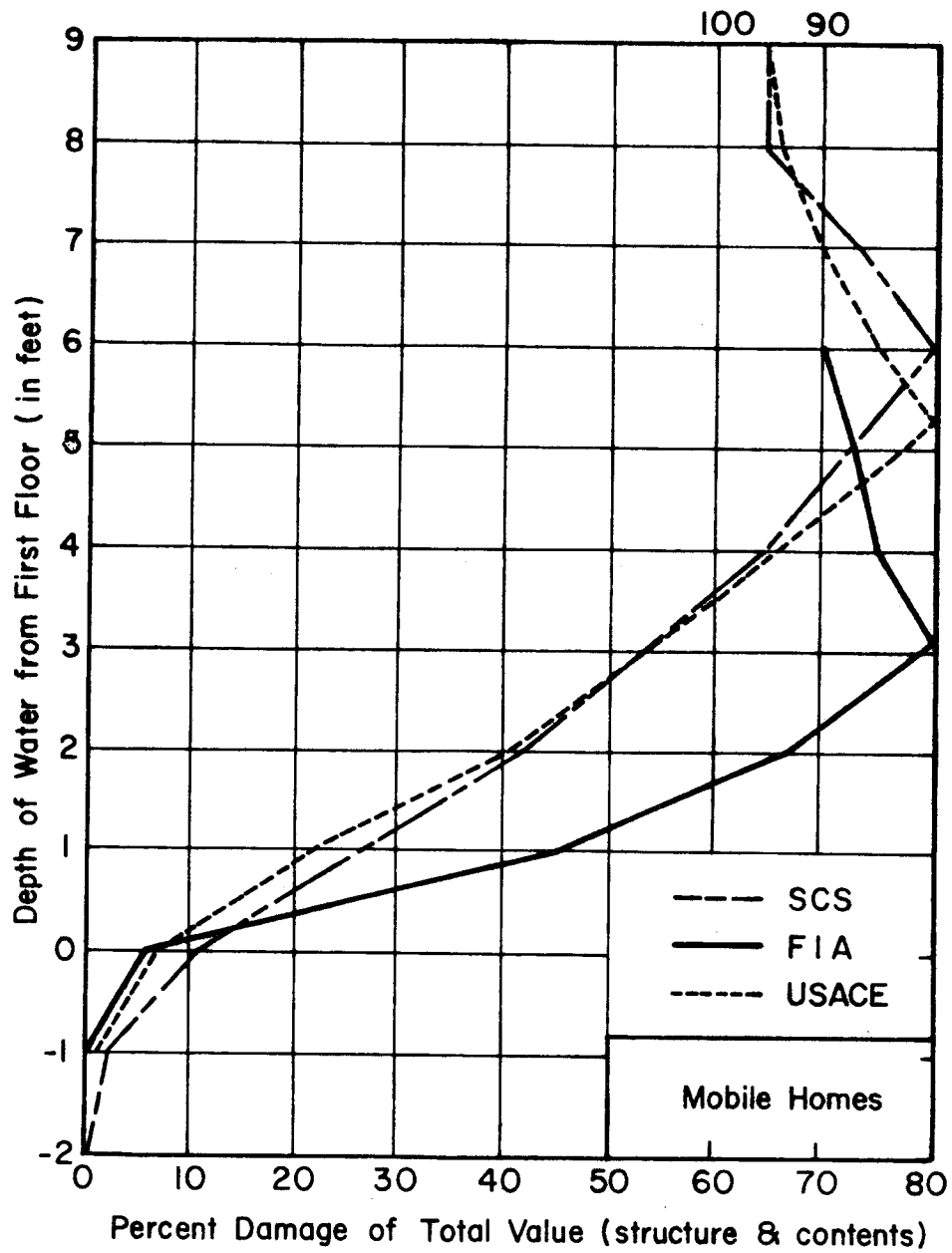


Figure IV-6. Depth-Damage Curves,  
Mobile Homes



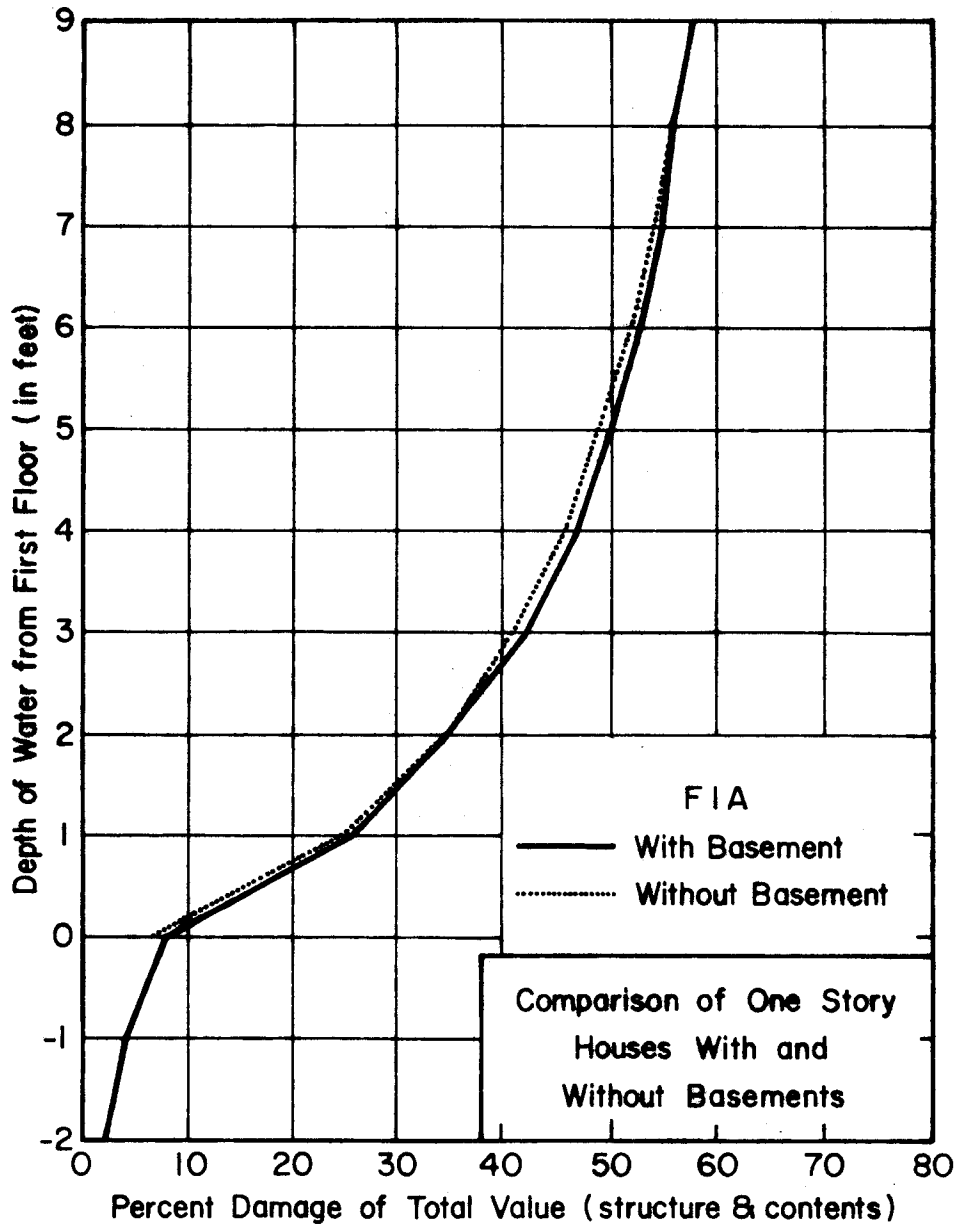


Figure IV-7. Comparative Depth-Damage Curves With/Without Basements

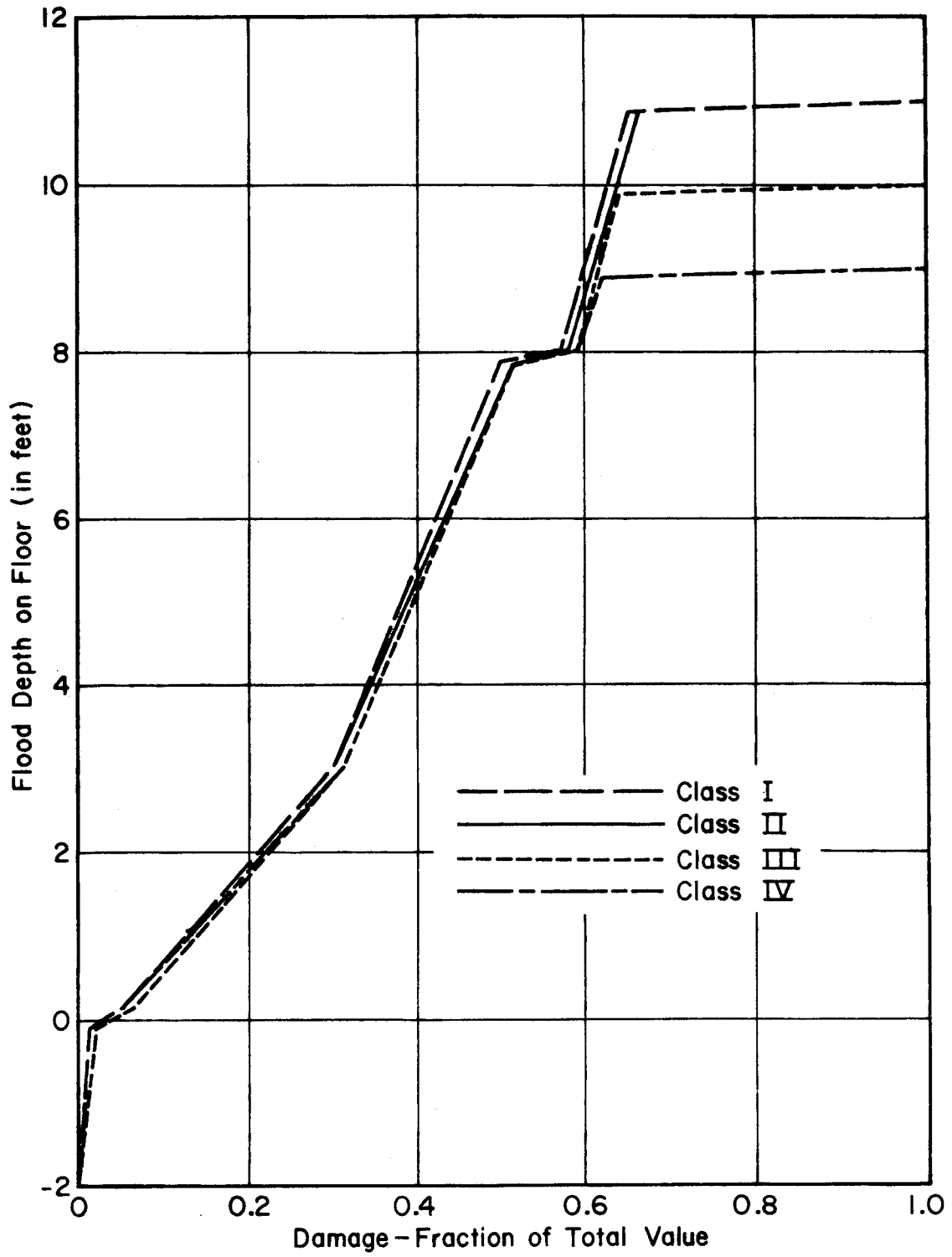


Figure IV-8. Depth-Damage Curves for One Structure, Four Value Classes [12]

## Conclusions

A great deal of additional research on flood damage estimation procedures is needed. As with many other water problems the basic need is accurate data that can be used to define empirical relationships. Further work is needed to relate the value of contents to the value of the structure. Perhaps the insurance industry will ultimately develop this data. There are many unanswered questions, such as whether structures of one type have the same depth-damage curves regardless of their values. Studies to relate the time variation of structure value to the value of the contents are needed. More data about commercial and industrial damage is needed. In one case reported, commercial damage is 70% of flood damage [5].

Research by the federal agencies involved in flood studies has resulted in the accumulation of useful information for damage estimates. Though the agencies are continually updating their information, consulting engineers and local agencies need useful information now for use in smaller scale projects. The curves presented in this paper will hopefully help to meet this need. The curves exhibit wide variation. To consider this, it is suggested that sensitivity studies could be made to examine net project benefits under different damage schedules. This would lead to more realistic project evaluation.

The writers invite discussion of this paper from individuals and agencies with experience in estimating flood damages. If enough data could be made available, comprehensive curves could be published in the discussion closure adding substantially to the curves presented here.

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## CHAPTER V

### FINANCIAL, POLITICAL AND LEGAL ASPECTS OF IMPLEMENTATION

Implementation is the most crucial phase of an UDFC project. Without the necessary approvals and funds, all of the planning, engineering and economic analysis is in vain. This point is well known in public works circles, especially regarding drainage problems. The point was made earlier that in the comprehensive APWA drainage report of 1966 [6] over half of the recommendations were for more work on implementation and financing.

Earlier in this report the point was made that benefits of UDFC projects must be identified, displayed and championed by Public Works managers during the programming and budgeting processes. It is during these phases that methods of finance (and thus implementation) must be developed.

There should be a distinction between types of projects and sources of finance because answers to the questions of incidence and equity vary with different projects. Table V-1 demonstrates some common practices regarding finance sources for different project types. Figure II-1 earlier demonstrated that major and minor UDFC projects resulted in different types of benefits and their justification must be accordingly for different reasons.

There is a rather sparse literature on financing problems of UDFC systems. A recent WRC publication covered some state ordinances on selected financing techniques [7]. There is some literature on special assessments [2,4], but very little in the way of overview documents on this subject. There does, of course, exist a well developed literature

Table V-1.

Sources of Finance for Different  
Types of UDFC Projects

Project Type Development Phase	Minor Projects	Major Projects
Existing Development	General Tax Fund Special Assessment Special Grants (for drainage) Service Charge	General Tax Fund Special Assessment Special Grants (for flood control, multi-purpose developments)
New Development	Developer's Respon- sibility Basin Fees Master Planning	Basin Fees Master Planning Dedications Anticipatory Zoning



on the subject of public finance at the federal, state and local level. This is a respectable discipline within the economics/public administration disciplines. The reader is referred to [5] for an overview of this area. Finally, there exist a number of references related to rate setting and service charges for utilities, some of which may be applicable to this problem (See [1], for example).

Whenever the questions of implementation and finance arise, legal arguments must be satisfied before a plan can proceed. In the provision of urban public services of all types, benefit-cost analyses are on shaky ground until the term *benefit* is specifically defined. For the most part, it has not been specifically defined in formal legislation, at least not for UDFC in the State of Colorado. The next chapter is devoted to a legal analysis of this problem.

There are three basic methods which can be used to raise funds for urban drainage facilities: (a) General ad valorem taxes; (b) Special assessments, and (c) Service charges or fees which users must pay. The essential elements of each method are noted in the paragraphs below.

General Ad Valorem Taxes. Most local governments are authorized to levy taxes against property within their jurisdictions for the general benefit and public health, welfare and safety. Some localities, such as Denver, also have head and sales taxes which generate revenue for a general fund. If a local government so desired, drainage projects could be funded by using monies from such general funds.

Special Assessment. In special assessments, property is assessed according to the *benefits* received from the specific drainage improvement being made. The Colorado statutes (See Chapter 89, Section 2, Colorado Revised Statutes) provide that it is lawful to construct

improvements and to assess the cost thereof upon property *especially benefitted* by such improvements. The term *specially benefitted* has been generally defined by state courts as increase or enhancement of value in property. However, at present, the Colorado statutes do not define the terms *benefit* or *especially benefitted*, so their precise meaning may be subject to interpretation.

Service Charges or Fees. Service charges should be distinguished from assessments or taxes, since the law places different requirements on each. Service charges may be generally defined as amounts imposed to defray the costs of particular services rendered for one's account. Important elements in such charges are the actual provision of some tangible service or commodity, a relation between the charges imposed and the value of the service rendered, and a specific usage of charges collected for the provision and maintenance of the particular service and service facilities. An example of such charges would be the fees paid for water and sewer services. In both cases, as with drainage facilities, a collection and distribution network is required which may involve transmission facilities and larger works at various points within the network. Although, at present, there is no specific statutory authority for service charges or fees for drainage, such a method of charging users has precedent with water, sewer, airport, etc. user fees.

The financing question for UDFC problems is an important one which has not been resolved locally or nationally. This question is intertwined with the need for better benefit-cost analyses and, in fact, a benefit-cost analysis would be useless if it did not lead to an equitable method of financing.

Financing questions have not been addressed in depth in this study. An earlier study for the Urban Drainage and Flood Control District discussed in detail the alternative measures available, but the results of this study have not yet been implemented because of certain financing constraints [3].

## CHAPTER V - REFERENCES

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## CHAPTER VI

### LEGAL PROBLEMS OF ESTABLISHING BENEFITS\*

A tunnel which, though serving no useful purpose as an isolated transportation unit, is intended to furnish an avenue or highway to be leased to public transportation agencies, is a public improvement for a public use, for which taxes may be imposed. Milheim v. Moffat Tunnel Improvement District<sup>1</sup>

Colorado has a history of finding legal justification for public improvements. The quotation above is from a famous case involving an even more famous engineering feat, that of building a railroad tunnel through the Rocky Mountains, which later also housed a 108-inch water pipe. That case has set a precedent on which proponents of urban drainage projects may also rely. In so doing, it is important to understand the distinction between "general benefits" which accrue to the community at large as contrasted with "special benefits" which must accrue directly and solely to the owner of the land in question and not to others.

#### Introduction

Most public improvements, including urban drainage projects, are financed with revenues obtained from taxes paid by the public.<sup>2</sup> Drainage improvements in rural areas have long been financed by establishing drainage districts<sup>3</sup> which assess rural lands for the cost of building and maintaining drainage facilities. Urban areas have been

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\* This chapter contains a paper entitled "What Constitutes Benefits for Urban Drainage Projects" by Joseph Shoemaker. This paper will appear later in the Denver Law Journal.

given authority to use local improvement and special improvement districts to build drainage works.<sup>4</sup>

In local improvement districts, the property owners vote on the issue of whether their property should be taxed to pay for the improvements. Whether their property will *benefit* to the extent of the additional taxes is the determinative issue.

In special improvement districts, the property owners are assessed in relation to the *benefits* bestowed upon their property by the construction of the improvement. The assessing government eventually has the burden of showing these benefits.

In the application of user fees toward the construction of drainage projects, the users are entitled to question whether the fee paid is commensurate with the cost of the facility and the *benefits* received from the use of such facility.

Any governmental builder who is responsible, will clearly delineate the *benefits* to be received by his constituents from proposed drainage projects *before* adding to the general taxation burden of those same constituents the amount necessary to derive revenues to pay for the drainage projects. Therefore, whether the urban drainage project is of "general benefit" or "special benefit," someone in government - whether administrative, legislative, or both - has to know what the judicial branch ultimately may hold to be a legal "benefit" for which taxpayers may be taxed.<sup>5</sup> The objective of this Article is to provide some background on what courts in Colorado and elsewhere may decide. Certainly, a good drainage system is indispensable to good urban living conditions.

Drainage projects have had minimal success in competition with other public improvements, such as housing, transportation, etc.

because the *benefits* of drainage projects have been narrowly construed in those cases involving "special improvement districts" as a taxing mechanism, where "special benefits" have to be proved.

This article's main undertaking is to demonstrate that the narrow "special benefit" viewpoint is to be distinguished from the "general benefit" definition so that public builders of urban drainage projects may have the justification needed to merit their use of taxpayers' dollars. The legal meaning of *benefits* as interpreted by the courts in different factual settings will be examined.

### Special Benefits

The common place problem of surface water drainage has been around for so long that some municipal officials have ignored the flood and health hazards which outmoded drainage systems pose to our growing cities.<sup>6</sup>

When the above statement was made in 1968 by this author, it was a reflection of the practical frustration inherent in trying to use the special improvement district as a funding mechanism for drainage improvements.<sup>7</sup>

The legal hurdles that have developed over the years in "special assessment" cases have been enough to discourage the most energetic public works official from ever attempting to solve drainage problems.

This brief section will review that method of financing drainage improvements, if only to show that the narrow legal interpretation of "benefits" relates to the *method* of financing, not to the *need* for urban drainage improvements.

Most statutory enactments which relate to the authority of local governments to construct drainage improvements follow this general form:

The City and County shall have the power to contract for and make local improvements, to assess the cost thereof wholly or in part upon the property especially benefited and the cost shall be assessed in proportion to benefits received.<sup>8</sup>

This method of financing an improvement follows the historical language contained in statutory authorization<sup>9</sup> allowing farmers to join together in a District to drain their lands by tiling, building drainage channels, or deepening existing natural waterways. Property owners paid the cost (usually minimal) of such projects by assessing a mill levy against properties in the district commensurate to *benefits* received.

One of the noteworthy observations of Article 4, Chapter 47, C.R.S. 1963, is the fact the statute has eighteen sections but nowhere is the word "benefits" defined. This lack of definition by legislators of "benefits" has left the job to the courts. Generally, the cases tell what "benefits" are not, and from this narrow interpretation of legislation, municipal officials interested in building drainage improvements have been discouraged. What follows is an attempt to put into perspective what appears to be the narrow meaning of "benefits" in "special assessment" cases. In each case a particular property taxpayer, *not* the general public, brought the appeal, which was based on the owner's contention that *his* property was not *specialy* benefited, meaning, it received no more benefit than any one else's property.

The foundation of the right to levy assessments for drainage improvements is the particular benefit received by the property charged.<sup>10</sup>

A landmark case (for the language the court used, because the court's decision did not grant relief to the plaintiff property owners who were appealing a special assessment) is Ferguson v. Borough



of Stamford,<sup>11</sup> where the court stated that improvements may not be assessed upon those benefited only as members of the community at large. Nor may they be assessed to an amount greater than the amount of benefits conferred. Like all other taxation, they should be apportioned as far as possible, equitably among all who are similarly interested.

General benefit alone will not support an assessment to pay the cost of a drainage project. There must be a special benefit to the property to be charged, tending to increase its value, or to relieve it from a burden, or to adapt it to a superior or more profitable use.<sup>12</sup>

Another case defining the elements of "special benefit" with more certainty is In re Drainage District No. 100,<sup>13</sup> where it was declared proper to consider whether a drain will make the land more valuable for tillage, or more desirable as a residence, or more valuable in the general market, the final test being the influence of the proposed improvement on the market value of the property.

In Hoepner v. Yellow Medicine County,<sup>14</sup> a county in Minnesota proposed to convert part of a natural waterway into a public drainage ditch and outlet. The plaintiff's land was separated from the natural waterway by about 1,000 feet, and the land had some sloughs, the largest of which drained through a private open ditch across a neighbor's land to the natural watercourse. The Minnesota Supreme Court stated: "The question presented is whether a landowner as a matter of law receives assessable drainage benefits in a drainage improvement proceeding solely by reason of the fact that the surface water on his land is drained into the public ditch involved, even though he had a right to use, in its natural condition, the outlet which is to be the public ditch and even though there is no showing that the public ditch offers a better outlet."

It was contended by the County that the deepening of the creek would facilitate tiling of plaintiff's land and give an advantage of subsurface drainage. Plaintiff contended that the open ditch presently used adequately drained the subsurface; in fact, that the open ditch had a greater capacity for drainage than any tile which could be installed.

The county also contended that plaintiff's outlet to the natural water course was only based on the oral permission given by the neighbor and that the public improvement would make the outlet more accessible.

The court, in affirming a jury trial and decision in lower court that plaintiff would not be benefited, used the language of the statute involved, Section 106.151, Minnesota Statutes, to justify its position, namely: Lands may be assessed for benefits when the construction of the drainage system "Makes an outlet more accessible, or otherwise directly benefits such lands or properties." The court held neither to be the case here.

In Cirasella v. Village of South Orange,<sup>15</sup> the question was raised whether or not a storm sewer improvement provided a peculiar benefit to the plaintiff's property which was not contiguous to the storm sewer improvement and was not contiguous to any pipe or pipes carrying surface drainage into the storm sewer. The improvement had been built to carry the surface runoff from the lands of plaintiff and others. The Court in affirming a lower court ruling that plaintiff's lands were not "benefited," stated at 155 A. 2d, 136, 137:

. . . Assessments, as distinguished from other kinds of taxation, are those special and local impositions upon the property in the immediate vicinity of municipal

improvements, which are necessary to pay for the improvement, and are laid with reference to the special benefit which the property is supposed to have derived therefrom. 14 McQuillin, Municipal Corporations (3rd ed.) sec. 38.01, pp. 11-15. The foundation of the power to lay a special assessment or a special tax for a local improvement of any character, whether it be opening, improving or paving a street or sidewalk or constructing a sewer, or cleaning or sprinkling a street, is the benefit which the object of the assessment or tax confers on the owner of the abutting property, or the owners of property in the assessment or special taxation district, which is different from the general benefit which the owners enjoy in common with the other inhabitants or citizens of the municipal corporation. Accordingly, it is not well settled in most jurisdictions that adjacent property may be specially assessed to defray, in whole or in part, the cost of local improvements by which such property is especially benefited. That doctrine, as stated is based for its final reason on enhancement of values. That is to say, the whole theory of local taxation or assessments is that the improvements for which they are levied afford a remuneration in the way of benefits. Whether the property has been specially benefited by an improvement is generally regarded a question of fact, depending on the circumstances in each case, for the determination of the proper tribunal. The broad question is whether the general value of the property has been enhanced, not whether its present owner receives advantage. McQuillan, supra.<sup>16</sup>

In Frank v. Renville County,<sup>17</sup> another Minnesota case, the factual dispute was set forth in some detail and illustrates in words the historical conflict in most "special assessment" drainage cases. The County constructed a drainage ditch across the plaintiff's land and determined benefits accrued to the land. Damages to the plaintiff's land were also established and the plaintiff appealed both on counts that benefits were assessed too high, and damages too low.

The plaintiff's position was that a 200-acre farm which produced an average annual income of \$12,500 could not be benefited to the extent of \$3,000 by any drainage system when only three or four acres of crop on this land was lost in two out of five years. He further

claimed his land was damaged substantially and materially by construction of a 40-foot ditch across his land.

The County contended the improvement would necessitate less maintenance than plaintiff's tile system; result in water moving more rapidly from the tract; and water would be cleared from several acres where it was covered most of the time. Plaintiff contended that the creation of banks caused by increasing the depth of the ditch from eight to ten feet; the loss of a crossing over the ditch and resulting inconveniences to his farming operations were damages for which he should be compensated.

The Supreme Court reversed the lower court and remanded the case for a new trial on both issues: The "benefits" assessed to the plaintiff and the damages awarded to him.

Colorado's Supreme Court has spoken decisively and consistently on the same issue.<sup>18</sup> In Santa Fe Land Improvement Co. v. City and County of Denver,<sup>19</sup> a sanitary sewer special improvement district case, the Court stated that special assessments are permitted upon the theory that the property against which they are levied derives some special, immediate, and peculiar benefit by reason of the improvement, in addition to, and different from that enjoyed by other property in the community outside of the district in which the improvement is made; in other words, that the local improvement peculiarly *enhances the value* of the property against which the assessment is levied, to an amount equal to, if not in excess of, the amount of the special assessment.

In Hildreth v. City of Longmont,<sup>20</sup> upholding a District Court ruling that property was benefited, the Court at page 114 stated that generally speaking, only such benefits may be assessed as may reasonably be

expected to benefit the property other than the general benefit to the community, and nothing is to be considered a benefit which does not enhance the value of the property. Vacant lots may have no present use for a sewerage system; but it adds to their value by giving them a sanitary *advantage* which renders them salable at a higher price which they otherwise could not command, because of their increased desirability.

Fort Lupton v. U.P.R.R. Co.<sup>21</sup> was an action by the railroad to enjoin the City of Fort Lupton from assessing railroad property for street and curb improvement. The railroad pointed out that the street improvement provided no additional access for its customer traffic, no increase in revenues to the railroad, and no physical benefit to the railroad's property. The Supreme Court affirmed a lower court's finding that "no benefit inured to the railroad," (at 156 Colo. 354) despite the city's contention that a declaration of benefits by the City Council "shall be *prima facie* evidence of the fact that the property assessed is benefited in the amount of the assessments."

It should be apparent at this point that some differences exist between the definitions of "special benefits" depending upon whether urban or rural land is involved. The cases cited herein generally agree that *urban land is specially benefited if its market value is increased* by the installation of storm or sanitary sewers. Thus even vacant urban land may be specially benefited by such improvements, as its market value and salability increase. *It should be noted that the increase in value is a benefit which may never be converted to cash by a land owner if he never sells or transfers his land, and thus may*

never be realized. In the case of a sanitary sewer, the actual use thereof is a benefit tangible enough to justify assessment.

*When rural land is involved, the cases seem to imply that a present special benefit is necessary. Rural land often seems to require some agriculturally-related benefit, such as drainage of flooded land for use as crop land, or increasing runoff to promote earlier planting. These benefits are often balanced against cost and inconvenience to the rural land owner. Increase in land value may also be a consideration in assessing rural drainage projects.*

*Special benefits, then, have at least one common denominator in economic value. If a monetary benefit can be shown to have accrued to a land owner by reason of an improvement (increased market value, increased crop production, etc.), then special assessment becomes more feasible. Difficulties may arise where no value can be assigned to an improvement by a landowner such as the drainage of land used as a refuse dump by the owner.*

*The requirement should also be remembered that an improvement must have a unique and distinguishable benefit to the land owner, apart from and beyond benefit to the public at large, in order to justify special assessment.*

#### General Benefits

It is not expected that "special benefits" will be defined in legislative enactments because of the relationship of the method of taxation to the individual property.

To the contrary, it would be most helpful to builders of drainage improvements if legislative bodies did speak to potential types of

benefits from urban drainage projects, leaving exact dollar amounts to facts of each proposed improvement.

Black's Law Dictionary, 4th Edition, defines Benefit as follows: Benefit. Advantage; profit; fruit; privilege. "Benefit" is not limited to pecuniary gains, nor to any particular kind of advantage; it refers to what is advantageous, whatever promotes prosperity or happiness, what enhances the value of the property or rights of citizens as contradistinguished from what is injurious. Hooper v. Merchants' Bank and Trust Co., 190 N.C. 423, 130 S.E. 49, 52 (1925).

Ballentine's Law Dictionary, 3d Edition, defines Benefit as follows: A contribution to prosperity; whatever adds value to property; advantage; profit; whatever promotes our prosperity, happiness, or enhances the value of our property rights, or rights as citizens, as contradistinguished from what is injurious. National Surety Co. v. Jarrett, 95 W. Va. 420, 121 S.E. 291 (1924). (An interpretation in a Will case of a power to dispose of property whenever necessary for the person's *benefit*, use, and comfort.)

The leading Colorado case of Milheim v. Moffat Tunnel, n.1 supra, goes into some detail as to what constitutes a general public benefit. A number of plaintiffs brought suit to enjoin the defendants from proceeding under a statute creating a tunnel improvement district, the ground of the action being that plaintiffs' property would be burdened by an illegal tax.

Issues of law and fact were presented as to the benefit to the property subject to assessment.

The District Court of Jefferson County heard evidence upon the question of benefits and found for the defendants. The Colorado Supreme Court affirmed.

The Improvement District was created for the construction of a transportation tunnel through the Continental Divide for communication between western and eastern portions of the state. Properties in nine counties were to be assessed. One of the contentions of the plaintiffs was that the improvement was not for public use. The Court, at 651 stated:

A use may be public though not many persons may enjoy it. This is well-established, the requirement being that the improvement be open to use by all persons who have need of it.

If the business proposed to be carried on is essentially for public *benefit* and *advantage*, then the use is public.

In determining a public use,

- (a) The physical conditions of the country,
  - (b) The needs of the community,
  - (c) The character of the benefit which a projected improvement may confer upon a locality,
- and
- (d) The necessities for such improvement in the development of the resources of a state

are to be taken into consideration.

It was further contended that the benefits are unequal. The Court, at 653, stated: "The law does not require that the benefits should be exactly equal."

The plaintiffs also objected on the grounds that no special benefits accrued to the property owners in Jefferson County because of the tunnel. The Court noted, at 654, that the tunnel would make possible the delivery of coal in Denver at a considerably lower freight rate, and hence would likely promote the growth and prosperity of the city. That being true, the lands in Jefferson County within the district would assuredly increase in value with the growth of Denver.



At page 658, a concurring opinion noted that the area of the District is cut off from intercourse with the rest of the world for many weeks in the year. The interference with, and sometimes complete lack of communication with other parts of the state interrupts and jeopardizes commercial intercourse of all kinds. Products from this vast and fertile territory cannot be marketed with any degree of assurance. The proposed improvement would benefit the district in a peculiar and local way above any possible benefit to the State at large.

In a more recent case involving the ecological impact of a proposed project, Seaside Industries v. Florida Power & Light,<sup>22</sup> a court found that since the constitution declared the policy of the state as to natural resources, the protection of resources is an appropriate matter for consideration in condemnation cases. The plaintiff maintained that the canal to be built to carry spent cooling water from a generating plant to the body of water into which it was to be discharged, was unnecessary because spent water would harm the permanent body of water. The Court found that defendant successfully showed that the discharge would be acceptable and no irreparable harm would result.

Another case distinguishing assessments for benefits to the general public from assessments to particular property not specially benefiting, is Crampton v. Royal Oak. 362 Mich. 503, 108 N.W. 2d 16 (1961).

The City of Royal Oak Created a special assessment district in a downtown area for development of pedestrian malls and plazas, among other improvements. Plaintiffs contended their property would not be "specially benefited" and that the assessor's method of assessing,

namely: One part on assessed value of the land for general tax purposes and second part based on closeness or remoteness and square footage of each parcel, was in error.

The court reversed a lower court which had upheld the assessor's method. In declaring that special assessments must be based on special benefits and not on assessed valuation, the Court referred to an earlier Michigan decision, Grand Rapids School Furniture Co. v. City of Grand Rapids, 92 Mich. 564, 52 N.W. 1028, 1029 (1892), in which it was stated that assessors "are simply to apportion a fixed amount, not with reference to values alone, but also with reference to needs, necessities, and advantages."

The Michigan court also reaffirmed an earlier principle that "future probable advantages may be considered in assessing benefits, and incidental benefits may be taken into account as well as those directly received by the land."

The court further stated: "The improvement here involved is not primarily one for the protection of property but is designed to benefit the city as a whole, and the property within the assessment district specially, by promoting the use and enjoyment thereof and enhancing its value . . . In a case of this nature, consideration must be given to the purpose to be attained by the public improvement sought."

In this case, the assessment was set aside by the Court and the municipality was given the right to substitute a new assessment based on benefits received by each parcel of land within the assessment district.

In a concurring opinion for reversal, Justice Black observed that what could be benefits for some in the assessment district could be

detrimental for others in the district. He quoted from the City's brief as follows:

It takes no great imagination to see that an area easily accessible to pedestrian and motorist alike in safety, free from fast moving through traffic and congested local traffic with its attendant noise, fumes and general commotion, systematically and conveniently planned and laid out, generously interspersed with large free parking areas, and beautified with landscaping and decorative malls and plazas, is to be preferred far and away over its opposite counterpart.

He then went on to agree with these benefits as related to some property owners, but pointed out that the diverted traffic, fumes and noise could be a detriment to others.

Such a project benefits, yes. The shopper is inconvenienced and attracted by comfortable ways of spending money, and the adjacent places of business do more business. But that business, so attracted, must be taken from other less attractive spots. Such is Confucius' law of competition. It affords no basis for compulsive contribution of those adversely affected, or at least those who receive no like benefit.

Health and sanitation improvements have been cited by several courts as a basis for assessing lands for drainage improvements.

Even though it is impossible under the circumstances to ascertain the exact monetary benefit resulting directly to land from a drain, the land may nevertheless be subject to assessment on the basis of improvement in health and sanitation.<sup>25</sup>

#### Legislative Action

"The legislature is vested with a wide discretion in imposing taxes." Bedford v. Johnson, 102 Colo. 103, 78 P.2d 373 (1938).

A state legislature, in the absence of any constitutional restriction, may fix the basis of assessment or taxation, and whenever it does so, such method must be followed to the exclusion of any other.<sup>25</sup>

As was noted previously, the Colorado Statutes use the words "benefits" and "specially benefited" but nowhere do the Statutes define the terms. Since the Legislature has seen fit to relate assessments and taxation to benefits, specifically as related drainage projects, the next step should be the establishment of criteria for determining what constitutes "benefits".

The engineers and planners who are working with urban drainage projects can provide valuable assistance to the Legislature in defining "benefits" from drainage improvements by outlining the particular benefits inherent in such projects.

#### Summary

The need for adequate urban drainage and flood control systems in metropolitan areas is clear. However, implementation of such systems is being hindered by hesitancy of local officials to act in light of the statutory requirement that assessments be made according to "benefits" received, while the meaning of "benefits" remains undefined. The following proposed statutory definition of "benefit" would help to clarify the situation, and its enactment would be a positive step toward encouraging needed urban drainage improvements.

- The term benefit, for the purposes of assessing a particular property within a drainage district (or special improvement district), shall include, but shall not be limited to, the following:
- a. Any increase in the market value of the property;
  - b. The provision for accepting the burden from specific property for discharging surface water onto servient property in a manner or quantity greater than would naturally flow because the dominant owner made some of his property impermeable;
  - c. Any adaptability of property to a superior or more profitable use;

- d. Any alleviation of health and sanitation hazards accruing to particular property or of public property in the district if the provision of health and sanitation is paid for wholly or partially out of funds derived from taxation of property owners of the district;
- e. Any reduction in the maintenance costs of particular property or of public property in the district if the maintenance of the public property is paid for wholly or partially out of funds derived from taxation of property owners of the district;
- f. Any increase in convenience or reduction in inconvenience accruing to particular property owners, including the facilitation of access to and travel over streets, roads and highways;
- g. Aesthetic, ecological or recreational improvements accruing to particular property owners as a direct result of the drainage improvement.

The United States Supreme Court has ruled that the fact that lands included in a drainage district will receive no direct benefit is not *per se* enough to exempt them from assessment.<sup>26</sup> Therefore, assessment according to the above model definition of benefit is well within judicial limits.<sup>27</sup> The Legislature should take the necessary action to enact such a provision defining benefits as a broader term than most state courts have followed as a step toward encouraging the construction of needed urban drainage improvements.

#### Footnotes

1. 72 Colo. 268, 211 P. 649 (1922), 262 U.S. 710, 43 S. Ct. 694 (1922).
2. Private funds sometimes are received. User fees are becoming more popular as a means of financing public projects, e.g., airport facilities, sewage treatment works, turnpikes, water works.
3. Colo. Rev. Stat. Ann.

4. Colo. Rev. Stat. Ann. §89-2-1 (1963): "It shall be lawful . . . to construct any of the local improvements mentioned in this article and to assess the cost thereof . . . upon the property especially benefited by such improvements." Further, "Such improvements may also consist of the construction of sewers . . ." Colo. Rev. Stat. Ann. §89-2-2 (1963).
5. Legislation is needed in Colorado to define "benefit"; a proposal will be discussed later.
6. Shoemaker, An Engineering-Legal Solution to Urban Drainage Problems, 45 Denver L. J. 381 (1968).
7. Since that article was published, and to a great extent because of the article, the Colorado Legislature in 1969 provided for the establishment in the Denver Metropolitan Area (Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson Counties) of the Urban Drainage and Flood Control District with a mill levy authority of one-tenth (.1) mill for planning purposes and authority to seek two (2) mills for construction of projects. In 1973, the Colorado Legislature added an additional authorization to the Board of four-tenths (.4) mill for construction of drainage and flood control improvements.
8. City and County of Denver, Colo., Charter, §§A 2.4, A 2.6.
9. Colo. Rev. Stat. Ann. §47-4-1 (1) (1963): "The tracts of land which will receive most and about equal benefits shall be marked one hundred, and such as are adjudged to receive less benefits shall be marked with a lesser number denoting its per cent of benefit."
10. 25 Am. Jur. 2d Drains and Drainage Districts §45 (1966).

11. 60 Conn. 432, 446, 22 A. 782, 787 (1891).
12. 25 Am. Jur. 2d Drains and Drainage Districts §46 (1966).
13. 161 Neb. 758, 74 N.W. 2d 528 (1956).
14. 241 Minn. 6, 62 N.W. 2d 80 (1954).
15. 57 N.J. Super. 522, 155 A. 2d 134 (1959).
16. For purposes of determining whether property will be benefited by creation of a parking district, "benefit" is usually considered as tending to reflect enhancement in market value of property and local zoning ordinances are matters which help determine the market values. Jeffery v. City of Salinas, 42 Cal. Rptr. 486, 493, 232 Cal. App. 2d 29 (1965).

The "benefit" for which the owner of a lot is taxed for municipal improvements is not the benefit to the public at large, or to any other person whomsoever *but the owner of the lot*. The phrases "benefits" and "increased value" are convertible terms, and, where the tax is apportioned according to the increased value of the lot, it is the same thing as the value of the benefit which the owner receives from the improvement. Garret v. City of St. Louis, 25 Mo. 505, 511, 69 Am. Dec. 475 (1857).

"Benefit" is the increment of value to land affected by improvement, and represents the difference between market value of land before improvement and market value of land immediately after improvement. Benefits to be assessed for improvements must be such special, pecuniary benefits as result to a particular landowner by reason of his ownership of land affected, as distinguished from general benefits to the public. Maywood Land Co. v. Township of Rochelle Park, 13 N.J. Misc. 841 A. 696 (1935).

The terms "benefits" and "to be benefited," as used in an act providing for organization of flood control districts, mean that a landowner has received, or will receive, by reason of the improvement, an increase in market value of his property.

Weyerhaeuser Timber Co. v. Banker, 186 Wash. 332, 58 P. 2d 285, 289 (1936).

17. 242 Minn. 172, 64 N.W. 2d 750 (1954).
18. Legal practitioners have questioned, however, whether the landmark case of Milheim v. Moffat Tunnel, supra, is a special benefit case or general benefit case. Or whether, because of the novelty of the subject matter as opposed to a sewer or street improvement case, the court came to its conclusion using both "special benefit" and "general benefit" language.
19. 89 Colo. 309, 2 P.2d 238, 240 (1931).
20. 47 Colo. 79, 105 P. 107 (1909).
21. 156 Colo. 352, 399 P.2d 248 (1965). See also District 50 Metropolitan Recreation Dist. v. Burnside, 167 Colo. 425, 448 P.2d 788 (1968), where the Colorado Supreme Court upheld a statute which excluded railroad property from levy for recreational district purposes. At page 791, the Court stated: "The section is a legislative declaration of what is obvious - that the property excluded would not benefit from or have any use for, playgrounds, golf courses and swimming pools."
22. 245 So. 2d 209, 45 A.L.R. 3d 1255 (Fla. 1971).

It would be helpful if the Legislature were to set forth what constitutes benefits, or criteria for public officials to use.



23. In a condemnation case, Backer v. Sidney, 166 Neb. 492, 89 N.W. 2d 592 (1958), a distinction between general and special benefits was made as follows:

General benefits arose from the fulfillment of the public purpose which justified the taking, and resulted in public enjoyment of the work, while special benefits arose from the peculiar relation of the land in question to the improvement, and were ordinarily incidental, arising from physical changes in the land or proximity to a desirable object.

24. In re Drainage District No. 100, 161 Neb. 758, 74 N.W.2d 528 (1956).  
Garden of Eden Drainage District v. Bartlett, 330 Mo. 554, 50 S.W.2d 627, 631 (1932).

"What is termed hill land, when contiguous to or surrounded by swampland, may be greatly benefited by draining such disease producing swamps, or the means of ingress and egress to and from such lands."

25. Clark v. City of Royal Oak, 325 Mich. 298, 38 N.W.2d 413, 38 N.W. 2d 413, 418 (1949); 261 U.S. 481, 43 S. Ct. 440 (1922); 261 U.S. 155, 43 S. Ct. 261 (1922).
26. Miller & Lux v. Sacramento Drainage Dist., 256 U.S. 129, 41 S. Ct. 404, 65 L. Ed. 859 (1921).
27. See Also:  
Morton Salt Co. v. City of South Hutchison, 159 F.2d 897 (10th Cir. 1947);  
Curtis v. Louisville & Jefferson Co. Metropolitan Sewer Dist., 311 S.W.2d 378 (Ky. 1963);  
Barten v. Turkey Creek Watershed Joint Dist. No. 32, 200 Dan. 489, 438 P.2d 732 (1968).