URBAN DRAINAGE AND FLOOD CONTROL PROJECTS ECONOMIC, LEGAL AND FINANCIAL ASPECTS

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ABSTRACT

Techniques for evaluating minor and major Urban Drainage and Flood Control (UDFC) Projects are described. Economic, political, engineering, financial and legal problems must be faced prior to implementation of proper levels of these projects. The measurement of tangible benefits is described while a literature review revealed no direct objective techniques for quantifying intangibles. Some methods for establishing the relative rankings of intangible contributions show promise for improvement of evaluation techniques, however. The legal problem of establishing benefits is described and a copy of recently enacted Colorado legislation is included. Information on the estimation of flood damages and the selection of discount rates is presented for use by the analyst. Careful coordination of land use and drainage control measures is stressed. Related recent legislation and regulations are included.

FOREWORD

by L. S. Tucker
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A major activity of the Urban Drainage and Flood Control District is the development of master plans for major drainageways in the Denver region. The purpose of the master planning process and the resulting report and plans is to define problems and provide solutions. The plans define the flood plain for regulation purposes and provide definite guidelines for managing future development affecting the drainageways and associated flood plains.

The master plans also provide the justification and basis for moving from the planning stage to acquisition of funds and eventually to construction of improvements or other forms of implementation. Since the master plans provide a basis for implementation, it is necessary that the solutions adopted be based on sound and logical procedures. A primary input to the decision making process is an analysis of the benefits and costs of various alternatives.

The procedures for evaluating the benefits and costs of urban drainage and flood control projects is not well defined. Direction for analyzing intangible benefits is particularly lacking. Recognizing this deficiency, the Urban Drainage and Flood Control District joined with Colorado State University and submitted a request to the OWRT (Office of Water Research and Technology, formerly OWRR) for federal assistance. An OWRT grant was made, and with matching funds provided by CSU and the District, a two-year research effort was initiated in 1973. This paper is the culmination of the resulting two years of activity.

An important ingredient of this research effort was the close link between the research team and the "user," the Urban Drainage and Flood Control District. An interim report was published in June 1974 and immediately tested by application to actual planning projects. The result of this real life laboratory was the modification of the interim methodology. This report will also be used by the District as a guide for the development of cost and benefit analysis for future urban drainage and flood control efforts.

Another key factor of the project was the research team. The research effort was led by Dr. Neil S. Grigg, Associate Professor of Civil Engineering at Colorado State University. Also actively involved were Leonard Rice, a practicing civil engineer, and W. J. Shoemaker, a practicing attorney and Colorado State Senator. The relationship between the research team and the "user," and the make up of the research team has resulted in a product that is a well intended marriage between theory, practice, and application.

Chapter 1
URBAN DRAINAGE AND FLOOD CONTROL PROJECT SELECTION AND IMPLEMENTATION

The primary environmental effect of urbanization is the alteration of natural drainage patterns. Public works managers, in seeking the best solution to this problem, have been confronted with twin dilemmas; first, it is difficult to formulate and select the best alternative methods to solve these complex problems and next, it is even more difficult to implement solutions because of legal and financial problems.

This paper has one primary objective: To present methodologies for evaluating the comparative benefits of minor and major urban drainage and flood control (UDFC) projects. These reflect the latest evaluation procedures from systems analysis and planning, and related tool areas such as benefit-cost analysis and environmental impact analysis. The paper has several secondary objectives. To support the methodologies, detailed information is presented on general economic evaluation of UDFC projects. Woven into the economic evaluation problem is the need to define, measure and legally establish the "benefits" from UDFC investments. If this can be properly accomplished, the evaluation and implementation problems can be more readily handled. This paper presents procedures for accomplishing this.

Specific supportive topics which are covered in the paper are: The legal basis for establishing benefits, including model benefit legislation; data on measuring benefits; data on determination of potential damages; and data on establishment of the proper interest rate.

It is hoped that this paper will be useful for public works managers, city officials and consulting engineers seeking to effectively solve UDFC problems.

Why Evaluate UDFC Projects?

Drainage and flood control improvements provide services to the people who live in cities. They are part of the urban "infrastructure." Like other services (police, library, utilities, etc.) they can be provided only to the extent of the public's willingness to pay. Often the willingness-to-pay decision is preempted by public officials because the complex issues of taxation, costs and benefits and levels of service are not grasped by the ordinary citizen. The public official assumes an additional responsibility in this case to ensure the best investment of funds available.

The problem of evaluating comparative public investments has long been of concern at the federal, state and local levels. Perhaps the most famous era of this was during the tenure of Defense Secretary McNamara, who applied "cost effectiveness analysis" to military expenditures. Evaluation techniques such as benefit-cost analysis will increasingly be applied to all kinds of public programs such as automobile safety and drug control as well as engineering programs [2].*

UDFC really encompasses several services. As pointed out by Jones [4], 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 basic services are evident for UDFC, a protection from natural hazards (flood control), and management of urban runoff, (an environmental management service). The benefits from natural hazard protection will be clearly distinct from those provided from environmental management.

Environmental management services include management of runoff *quantity* and *quality*. This paper is concerned only with management of runoff quantity but the role of UDFC in quality management must be recognized. An alarm to this effect, coupled with a recommended plan for research was sounded in 1968 by an American Society of Civil Engineers group. Since then a systematic program of research has gone forward [1].

A basic reason for evaluating UDFC projects is to measure their actual or potential effectiveness in delivering the desired service. The measurement of effectiveness is a key element in management control for all types of urban services and, as the pressure for accountability increases, accurate goal statements and measurement become more important. Reference [5] is a useful recent document on measuring effectiveness of municipal services.

Types of Evaluation Problems

An UDFC project extends from the first perception of a need through planning, programming, budgeting, design, construction and operation. The project will not reach the budgeting stage unless it satisfies the needs of a group of citizens in a manner to warrant funding from a limited financial resource base. The project must win the right to be funded in a complex evaluation process.

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.
2. The measures of effectiveness for the system.
3. The priorities needed for decision making.

In the analysis of UDFC projects, several distinct evaluation subproblems appear. They begin with the establishment of objectives and measures of effectiveness, moving into formulation of alternative solutions, evaluation and tradeoff analyses, and then to the selection or decision stage. 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.

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 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* [3].

2. Programming Stage

How to rank competing UDFC projects to determine priorities, optimum investment timing and desirable sequences of implementation. These are sometimes called *interprogram comparison studies* [3].

3. Budgeting Stage

a. How to objectively but competitively display *total* public benefits of UDFC projects to ensure adequate funding for UDFC in the annual budgeting process.

b. How to determine and quantify benefits by incidence to equitably apportion project costs between and within public and private entities. The latter are sometimes called *intergroup comparison studies* [3].

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Chapter 2
THE GENERAL ECONOMIC EVALUATION PROBLEM FOR UDFC PROJECTS

This chapter presents information on evaluating and implementing UDFC projects as background material for later chapters which present direct evaluation techniques. Basically, the evaluation problem for UDFC is the same as that for general water resources projects, but at a smaller, more concentrated urban scale. A good reference for economic evaluation of water resources projects is James and Lee [9]. For the urban service viewpoint, a good reference is Hirch' Urban Economic Analysis [6]. Economic analysis of water projects is a subject which has received wide attention. Recently, the U. S. Government adopted a uniform procedure in their "Principles and Standards for Planning" [14]. All of these references are very useful for the general problem. This paper places its focus directly on UDFC specifically.

To many, economic evaluation of water projects means Benefit-Cost Analysis (BCA). Actually, the state-of-the-art has proceeded far beyond some of the early procedures of this type.

Benefit-Cost Analysis was mandated by the Flood Control Act of 1936. Since then a number of shortcomings have been identified. An excellent review of BCA has been published by Prest and Turvey [12] while Howe [7] and James and Lee [9] demonstrate its application to water resources problems. Actually, all evaluative techniques are methods to compare benefits and costs of different policies.

In preparing the "Principles and Standards," the U. S. Water Resources Council (WRC) undertook a comprehensive study of planning and evaluation procedures. The evaluation technique they selected does not display efficiency Benefit-Cost Ratios but presents information in a set of *accounts*. 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.

Distinction Between Minor and Major UDFC Systems

The difference between minor and major UDFC systems is essentially the difference between drainage and flood control, or between convenience and damage prevention systems. The latter distinction becomes somewhat blurred, however, since minor systems sometimes prevent damage, and vice-versa.

The difference is also apparent from an engineering formulation of the UDFC problem. Consider the simple urban catchment shown on Figure II-1. The depth at the gutter flow line can be identified as a parameter to measure the extent of flooding hazard. This depth can be entered into a stage-frequency curve as shown on Figure II-2.

The information on Figure II-2 can be converted to a probability density curve as shown on Figure II-3. Basically, the transformation required is simply that the return period, T, is the reciprocal of the exceedance probability P. Then P is simply the area to the right of any selected point, such as B on Figure II-3.

Figure II-3 vividly shows the frequent occurrence of minor depths and the rare occurrence of greater depths. The curve shown is typical of the skewed distributions to be expected.

Minor flows *generally* cause inconvenience more than damage, whereas major flows often cause damage. The objectives of minor and major UDFC projects may therefore differ accordingly. Since benefits must be measured in terms of meeting objectives, an attempt to show the *spectrum* of benefits of UDFC is presented on

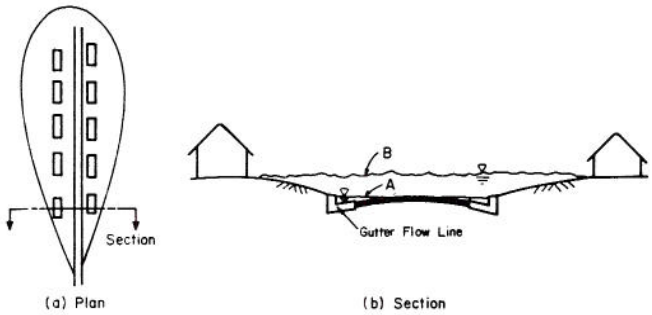

Figure II-1. Simplified Urban Catchment with Street Cross Section

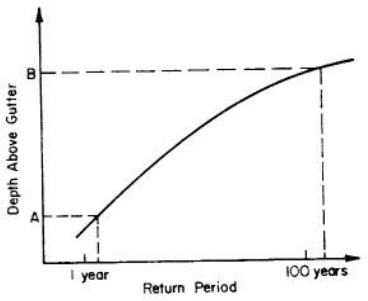

Figure II-2. Depth-Frequency Curve

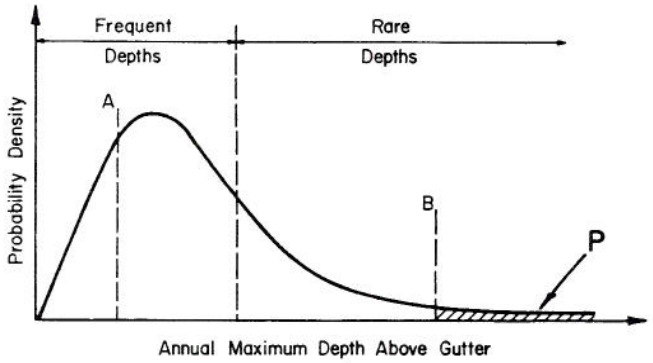

Figure II-3. Probability Density Function for Annual Maximum Gutter Depth

Figure II-4. A key point in the distinction between benefits of major and minor systems is the frequency of experience; for example, a major runoff project which prevents damage does not necessarily provide cost effective convenience, or in fact any convenience at all, because it operates less frequently at capacity than a smaller system.

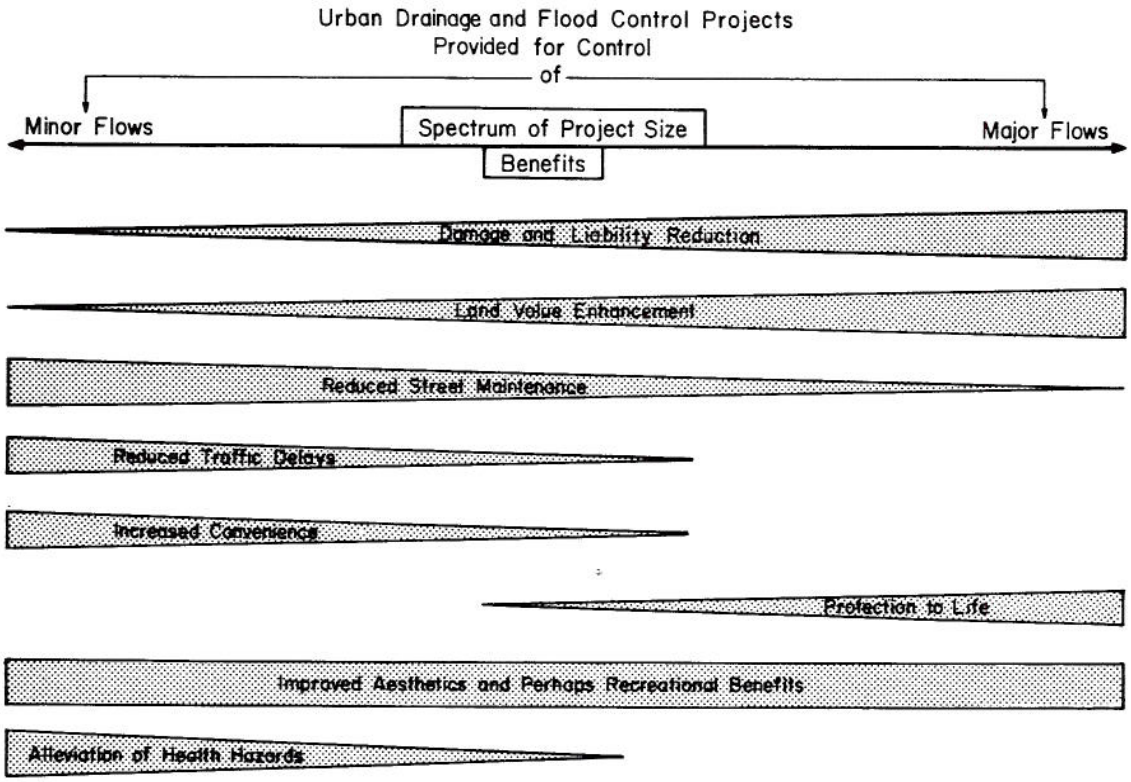

Figure II-4. Spectrum of Benefits from Urban Drainage and Flood Control Projects

State-of-the-Art of Evaluation Capability

Current practice is to design both major and minor UDFC systems based upon rather arbitrary criteria. This is also the practice for establishing most types of environmental quality standards. Minor systems are usually designed for 1 to 10 year frequencies based upon the discretion of local decision makers (often with millions of dollars of construction costs at stake). Major systems usually point to the 100-year flow because of federal pressure. This setting of standards reflects an implicit weighting of benefits and costs, but removes the flexibility of the planner and the decision maker.

The fixed-effectiveness, minimum cost appraoch does not always insure the most cost effective use of the public dollar, particularly when social, environmental and distributional effects must be considered. The alternative is to fix cost and maximize effectiveness. This may be a more economically efficient approach. Practically speaking, the realities of the land development and public investment processes often call for a cost minimization approach. The efficiency of this approach can be enhanced when *tradeoffs* are carefully considered.

In the budgeting process, urban drainage and flood control may receive an annual capital budget B according to the perceived needs for UDFC expenditures. This will depend somewhat on the manager's success in the evaluation process described earlier. If the city is committed to the fixed effectiveness approach (say 10-year design), then project D_2 would not begin until sufficient funds are allocated for D_1 at the selected effectiveness. Depending on priorities and the sizes of D_1,D_2, etc., a single project could consume several years' capital budget while other worthwhile projects go begging. If, however, the city decides to solve these drainage problems by allocating the fixed urban drainage budget between the projects; B_1 to D_1, B_2 to D_2, etc. according to the fixed cost, maximum effectiveness approach, a greater opportunity for maximum investment effectiveness exists. James [8] has presented clearly the procedure for considering the level of protection as a variable in the economic analysis of non-structural alternatives by minimizing total cost, a process roughly equivalent to maximizing net benefits.

Evaluation of Major UDFC Projects

In terms of size, the most visible UDFC problems are those associated with the major drainage system. They sometimes include risk to life, property damage and other potential severe consequences. For this reason it is easier to identify the benefits for major UDFC projects than for minor projects. Since the major category of benefits is reduction of flood damage, a great deal of useful information already exists. Flood damage benefits have been analyzed for years by federal agencies.

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 may be transferred from the taxpayers to flood plain occupants, creating incentives 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.

Table II-1 is a list of UDFC project benefits and costs. Some of these are indirect or intangible, making them more difficult to consider quantitatively.

The Problems of Estimating Direct, Indirect and Intangible Benefits

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 the following five categories of damages:

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

A good classification and description of benefit types is in James and Lee [9], pp. 163-168. Basically, a Direct Benefit accrues to those who put project outputs to direct use whereas Indirect Benefits are external effects. Secondary Benefits denote value added through economic linkages. Intangible Benefits are those which cannot be quantified.

Table II-1. Inventory of Costs and Benefits of UDFC Projects

BENEFITS	COSTS
Reduced flood damage to public and private facilities	Construction costs
Land value enhancement	Land acquisition costs
Reduced Liability to upstream land owners	Costs of non-structural programs, including flood plain zoning
Reduction in traffic delays	Evacuation and emergency program costs
Reduced income, rental, sales, and production losses	Administration costs
Reduced cleanup and maintenance costs	Insurance subsidy costs
Reduced emergency relief costs	Increased reconstruction costs due to the magnitude and extent of flood damage
Increased possibilities for recreation opportunities	Environmental and social costs
Reduced inconvenience	
Increased sense of security	
Alleviation of health hazards	
Improved aesthetic environment	
Reduced risk to life	

The prevention of potential damage by construction of a project is a benefit. The prevention of direct damages therefore becomes a direct benefit. There are, of course, many other types of benefits in all of the above categories.

Direct damages affect structures and their contents, public facilities such as roads, utilities, and associated facilities, and vehicles. Damages to property vary according to the type of property, it's value, and the cost to restore it to it's original condition. They are experienced mostly by flood plain occupants. Alternative drainage management strategies should not be compared under this benefit definition alone unless an incidence analysis is also made. The incidence analysis will indicate the most economical alternative from the points of view of the various subgroups concerned and the extent of any potential payment transfer will be identified.

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. Appendix B provides further details on this.

The inventory of benefits presented in Table II-1 includes reduced risk to life. Quantification of this benefit requires estimation of the value (or damage due to loss) of a human life and the probability of such loss for given floods. Placing a dollar value or 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. There does not appear to be a compelling reason to include such benefits directly in UDFC evaluations at the present time.

Land value enhancement benefits, where applicable, can be estimated by considering the increased value that land will have when provided with adequate UDFC facilities. Also, when a project allows the reclamation of flood prone land, the land value may increase. Such an increase benefits the property owner. If the land is public and if the reclamation provides the potential for open space recreation, the benefit accrues to the general public. There is great interest today in providing this type of benefit to the public.

Indirect benefits consider items such as: Reduction of lost business and services, elimination of the cost of alleviating hardship, safeguarding health and traffic disruption. Identification 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 indirect damages are not as readily available as for direct benefits. One set of estimates which was used in a 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%

These benefits are computed as a percentage of direct benefits. In other words, in a residential area, direct benefits are increased 15% to account for indirect 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 by hindered services may feel adverse affects. 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 to be outside the scope of UDFC project evaluation because of their complex nature.

With the recent issuance of the Water Resources Council "Principles and Standards for Water Resources Planning" intangible costs and benefits have received greater attention [14]. Among the categories of intangible damages and benefits are environmental quality, social wellbeing and aesthetic values. It is not presently feasible to estimate monetary values of intangible damages and benefits, but they should be considered as part of the analysis for project selection. There are several research projects underway which intend to present methods of quantifying intangibles but reliable consensus procedures are not anticipated within the near future. These are described further in Chapter VII.

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 abundance of literature on this topic, however. A recent comprehensive work is by Knetsch [10].

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 or subjective techniques are 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, however. 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 [2].

The occupants of flood hazard areas suffer a hardship because of the ever present uncertainty of when the next flood will occur and how serious it will be. 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. 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 but can be included with the intangibles.

The value of intangible benefits may be stressed in the narrative portion of the engineer's report. Once enumerated, proper evaluation of them can be made by the decision making body. Such benefits may be useful for distinguishing between closely ranked alternatives.

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. To illustrate the importance of implementation, over half of the recommendations in the well known APWA drainage study of 1966 were for more work on implementation and financing [11].

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 is rather sparse literature on financing problems of UDFC systems. A recent WRC publication covered some state ordinances on selected financing techniques [13]. There is some literature on special assessments [1,4], but very little in the way of overview documents on this subject. There does, of course, exist a well developed literature on the subject of public finance at the federal, state and local level. This is a separately identified discipline within the economics/public administration disciplines.

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Chapter 3
MEASURING THE TANGIBLE "BENEFITS" OF UDFC PROJECTS

Benefits from programs must be measured in terms of the *objectives* of the program. In planning, one normally seeks to identify the *programs* or *projects* that "best" meet a given set of objectives. In order to rank programs by this criteria, *indicators* are needed to measure the extent to which programs meet different objectives. These indicators can, in turn, be used to indicate the degree of benefit or cost to the parties affected by the program. The use of indicators leads directly into a need for different types of measurement *scales* which must be properly used.

Objectives of UDFC

The operational objectives of UDFC are traditionally considered to be as shown in Table III-1 Some of these objectives are interdependent, of course, and there are many other ways in which they can be classified. For the analyst, the best classification scheme would be the one that most facilitated the measurement of benefits.

When the objectives given above are reached, they become *benefits* and it becomes necessary to determine who they impact on for assessment studies.

Indicators of UDFC Benefits

The perception of many urban managers and residents is that the primary benefit from UDFC is the prevention of flood damage and/or inconvenience. This explains the emphasis on the traditional *return period* for project design, an indicator of risk involved. This ignores the fact that many important benefits are not primarily related to return period.

Table III-1. Operational Objectives of UDFC Systems

1. Protection Objectives
   a. To minimize property damage from all types of flooding
   b. To eliminate loss of life due to flooding
   c. To alleviate health hazards from water hazards caused by unsanitary conditions
   d. To reduce traffic accident hazards due to street flooding

2. Economic Objectives Other Than Reduction in Property Damage
   a. To enhance neighborhood land values by improving the urban environment
   b. To reduce street maintenance costs by prevention of runoff damage
   c. To reduce liability of property owners and land developers associated with runoff-producing land development

3. Amenity Objectives
   a. To improve the visual and aesthetic impact of the urban environment
   b. To provide recreational opportunities where possible
   c. To make urban life more convenient by the reduction of delays and other inconveniences associated with drainage problems

The realization of the objectives listed in Table III-1 are usually measured as shown in Table III-2.

Some of these measurement parameters are more amenable to quantification than others. Needless to say, the literature on economic evaluation of flood control alternatives has traditionally concentrated on those parameters which can be directly quantified, mostly on flood damage reduction.

Property Damage: Although economic analysis of flood control alternatives has traditionally relied on damage reduction as a primary benefit, quantification of potential damages is far from an exact science; in fact it requires considerable guesswork. The state-of-the-art of estimating flood damage in urban areas is given in Reference [5] where the authors showed the uncertainty involved in estimating even direct damages, not to mention indirect, secondary, intangible and other types of damages. Nevertheless, many analysts would agree that the measurement of potential flood damages is a widely practiced technique in the profession.

Other Protective Benefits: Because of transactions of the insurance industry it is possible to assign a dollar value to human life for the purpose of an economic analysis [3]. This is a rather strange procedure from the social accounting viewpoint because, even though monetary transfers accompany a death, they do not really measure the *value* to the family of the deceased of his life, nor do they necessarily have any relation to the value society would place on the potential production of the deceased. The saving lives benefit moreover probably represents either a minor benefit or one which will unnecessarily bias an analysis. Such assignments of value at the present time therefore can be viewed as surrogate measures which probably should not be directly considered in the economic analysis of UDFC alternatives.

Table III-2. Measures of UDFC Benefits

Protective	
Minimize Property Damage	Average Annual Property Damage
Eliminate Life Loss	Expected Loss of Lives
Alleviation of Health Hazards	Absence of Hazards
Reduction of Traffic Hazards	Presence (Absence) of Hazards
Other Economic	
Improve Land Values	Measured Land Values
Reduction in Maintenance	Expected Maintenance Budget
Reduction in Liability	Presence (Absence) of Potential Liability
Amenity	
Aesthetic Improvements	Scale of Aesthetic Value
Recreational	Quantity of Recreational Opportunities
Convenience	Travel Time, Cleaning Bills, etc.

The recent economic literature on air and water pollution contains some clues as to the potential for quantification of health hazard reduction benefits. The emphasis so far has been on national scale programs which seek to clean up contaminated air and water. Presumably, such programs might result in quantifiable reductions in hospital costs, work absences and other measures of changes in public health. It would not appear that microscale measurements could be made

of this effect as it might result from a single UDFC project.

The elimination of traffic hazards would appear to be a quantifiable benefit from the statistical standpoint. In the literature of transportation economics, aggregate reductions in traffic accidents will follow an improvement in roadway conditions or other positive safety changes, such as the imposition of a 55 mile per hour speed limit. Normally, the data upon which to base such estimates would not be available but such measurement should be, in theory, possible.

Other Economic Benefits: There exists substantial literature on the economics of land values. Lands which can produce a greater economic *rent* is basically a function of the land value. The parameters that determine land value have sometimes been taken to be: accessibility to economic activities, the availability of utility services, zoning, amenities, and certain cultural features (see for example, [2,10]). While no substantial empirical data exists demonstrating increases in land value after construction of UDFC projects, the suggestion of Brigham [2] could be followed whereby local brokers could serve as a panel of experts providing estimates of such increases. Such increases would be highly site specific and these opinions could not serve to provide generalized estimating curves, but they could be useful in certain cases. Soule and Vaughan [8] suggest that the increase in value of land after flood protection is provided exceeds the amount of the damage itself because of new willingness to use the land.

The question of street maintenance is an important one for the public works manager concerned with drainage. Problems such as undercutting, erosion and freezing and thawing can be mitigated by proper drainage systems. Since maintenance costs are ultimately borne by the public from the general tax fund, reductions are clearly financial benefits. It would appear that the best method to estimate these benefits would be to secure unbiased estimates of street maintenance schedules with and without drainage.

Another type of economic benefit is associated with the development of land that lies at the upper end of drainage basins. Under certain types of drainage law, the upper land owner is entitled to improve his land but not to increase the runoff hazard or burden imposed on lower lands. When upper land develops, increasing the impervious area, there may be created a simultaneous liability, associated with the flood risk to downstream properties. The removal of this liability thus becomes a benefit credited to the project under study. To this important question we will return later.

Amenity Benefits: One of the most obvious amenity benefits associated with UDFC is the aesthetic or visual benefit produced when open space is provided or enhanced as part of an UDFC project. The value of the aesthetic improvement is clearly an intangible quantity, not readily measurable in dollar terms except as an increase in land value, described elsewhere. Some literature has recently appeared which offers ordinal ranking schemes for different types of streams or water courses. Chapter VII deals further with this question. This type of information serves to guide the planner or designer in the selection of UDFC schemes but could not currently be used to reliably value benefits from alternative projects.

Recreational benefits from UDFC projects are more easily quantified due to substantial literature emerging over the past fifteen years. Much of the literature has arisen as a result of the need to evaluate larger water resources projects and, although there are many uncertainties in this type of approach, a firm precedent does exist for quantifying recreational benefits. An excellent starting point in this literature is Knetsch [6].

Although convenience benefits have not been quantified to the extent recreational benefits have, a basis for such quantification exists in the travel time due to certain UDFC projects can be theoretically determined, and dollar benefits thereby assigned.

UDFC Beneficiaries

It is important to distinguish between recipients of UDFC benefits. As the economists point out, some public benefits impact more on property while others impact more on residents, indirectly appearing as benefits to property. Some benefits are experienced frequently, others only rarely. As an example, property damage reduction from UDFC may only occur once in twenty-five years while convenience may be provided from the same system twenty-five times per year. These differences should show up in the measures of UDFC benefits.

Using the above considerations, benefits can be classified in terms of incidence as shown in Table III-3.

Using this classification scheme, benefits are separated in such a manner that more easily measured financial benefits are distinguished from the others. The latter benefits are not only more difficult to measure but are diffused over a number of persons and not easily separable.

Identification of Beneficiaries

In the 1936 U. S. Flood Control Act, Congress directed federal agencies to justify flood control projects by insuring that benefits were greater than costs regardless of "whomsoever" they accrued to. This does not help the analyst, however, when he seeks to apportion costs. Table III-3 essentially identifies beneficiaries in such a manner that special benefits can be distinguished from general benefits. To insure that total benefits exceed total costs, all benefits should be counted. To assess costs directly, however, the special benefits need to be identified separately. These are portions of the property damage, the reduction in liability and improved land values. This leads into a natural classification as given in Table III-4.

If all of the benefits shown in Table III-4 could be quantified in consistent units, the assessment procedure would be rather straight-forward:

1. Determine total benefits in dollar terms
2. Distribute benefits to
   a. Public Sector
   b. Private Sector
3. Assess Public Sector from General Fund
4. Apportion Private Sector Costs fairly across beneficiaries

Unfortunately, all of these benefits cannot be quantified in consistent dollar terms. The

special benefits can, however, be more readily quantified than the general benefits.

Table III-3. Incidence of UDFC Benefits

Benefit	Recipient
FINANCIAL BENEFITS	
Property Damage Reduction	
Residential	Homeowner
Commercial, Industrial	Business
Public (streets, channels, etc.)	Public
Reduction in Maintenance	Public
Reduction in Liability	Property Owner or Developer
Improved Land Values	Property Owner
OTHER BENEFITS	
Prevention of Life Loss	Primarily local residents and property owners but also citizens using the area or traveling through.
Alleviation of Health Hazard	
Reduction of Traffic Hazards	
Aesthetic Improvement	
Recreational	
Convenience	

Table III-4. Classification of UDFC Benefits

GENERAL BENEFITS

Reduction of Damage to Public Property
Reduction of Drainage Induced Maintenance Problems
Prevention of Life Loss
Alleviation of Health Hazards
Aesthetic Improvements
Provision of Recreational Opportunities
Improved Public Convenience

SPECIAL BENEFITS

Reduction of Damage to Private Property
Reduction of Drainage Liability Caused by Property Development
Improved Land Values

Estimating Special Benefits

The three categories of special benefits shown on Table III-4 are interrelated. Property damage potential is precisely the hazard that creates a liability for upper land owners. Improved land values are partially the result of removing the damage hazard.

The property owners of interest here should be identified as *riparian*, meaning those properties adjacent to some route of drainage waters; and *upper*, meaning those properties generally located away from any such drainage course. Obviously riparian owners stand to benefit principally from damage reduction and property value improvement whereas upper land owners will benefit from reduction in liability.

To further describe the estimation of special benefits, it is necessary to have a classification of drainage basins to refer to. A convenient method to classify urban drainage basins is into three categories, by size as shown on Figure III-1. The *drainage basin* is a well-defined watershed draining through an urban area. It is divided into *catchments* which are watersheds having defined outfall points on major receiving

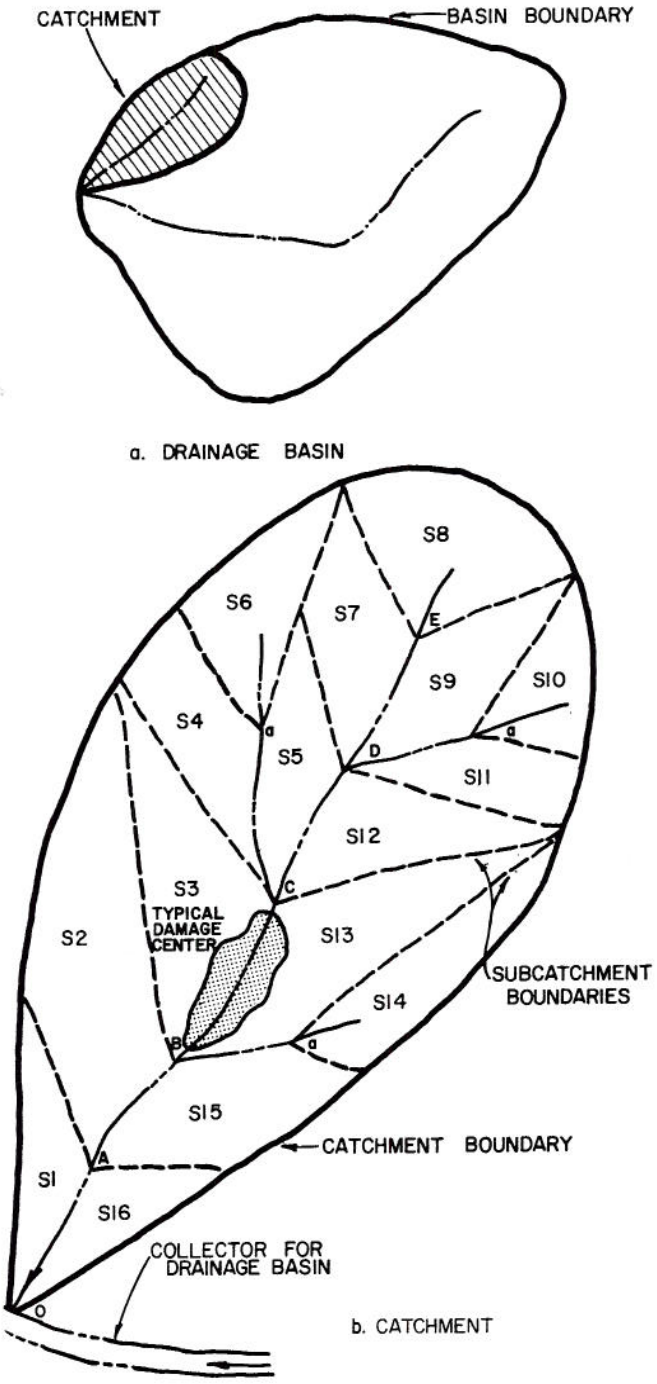

Figure III-1. Subdivision of a Drainage Basin

waters (lakes, rivers, oceans, etc.) within or bounding the urban area. These are, in turn, divided into *subcatchments* which are smaller watersheds generally of the subdivision or neighborhood scale. The subcatchment is a small enough unit so that it alone generally would not require a drainage conduit larger than, say 30 inches. The *subcatchment* thus will be on the order

of 0-200 acres; and the *catchment* on the order of 200-1000 acres; and the *drainage basin* on the order of several square miles or more.

The distinction of basin sizes is important for the definition of benefits. For example, Bullock classifies drainage lines into the categories of lateral, collector, trunk and interceptor sizes, these being related to the extent of local or general need [4]. These correspond roughly to the classification above as follows:

Bullock Classification	This Report	Basin Size
Lateral	Subcatchment	Few Blocks
Collector	Subcatchment	Up to about 0.25 Square Miles
Trunk	Catchment	Several Square Miles
Interceptor	Drainage Basin	Entire Segments of City

In Figure III-1, the riparian and upper owners can readily be identified according to location. For example, owners in the upper part of subcatchment S_3 are clearly "upper" whereas those in the damage center shown are "riparian.:

The question of variation of catchment size is discussed in an ASCE publication (see [9]). They show that for four distinctly different cities (San Francisco, Washington, Milwaukee and Houston), the median size of sewered catchments is 560, 375, 95 and 65 acres respectively.

Impact of Property Development on UDFC System: The development of property has substantial impact on the hydrological regime of a natural drainage basin. At the subcatchment level, the impact creates a need for UDFC collection and transmission facilities to convey stormwater to an outfall point. At the catchment level, a number of subcatchments drain together into a regional collection/transmission system which serves an entire drainage basin. The drainage basin would be eventually tributary to a readily identifiable stream.

In the urbanization process, the chief hydrological impact is the paving over of the natural soil cover, rendering it impervious. This naturally produces increased runoff from any given storm and urbanization therefore may require the establishment of an UDFC system to handle the additional runoff. If the system is not provided there will be adverse effects such as damage or disruption, resulting in a cost to be borne by some party involved. If the system is provided, it must be paid for and the cost must be somehow shared by the parties benefiting. The UDFC system does not, of course, have to be just regular storm sewers. Other innovative solutions are possible.

The financial impact of urbanization therefore falls on either the damaged parties or the parties paying for the UDFC systems installed. Every scheme for providing UDFC has significant implications for the incidence of the burden of the costs on the different parties.

The *benefits* received by property owners are related to the impact of property development on the natural hydrological regime of a basin. Unless this impact is countered with an effective UDFC strategy it will be detrimental to someone's property and/or public facilities such as the existing drainage channel network.

The most direct way to describe the hydrological impact of urbanization is to view a natural catchment from its virgin condition to full urbanization, with a variety of land uses. Consider Figure III-1 which shows such a catchment, divided into subcatchments. A system was established to number reaches OA, AB, BC, etc., and subcatchments $S_1, S_2, \ldots, S_{16}$.

Under the Modified Civil Rule type of drainage law, upper land owners are generally considered to have a drainage easement equivalent to the needs of the natural channels below their property. Their liability for handling drainage begins when they increase the drainage by virtue of increasing the impervious cover of their property. For more details on this, see Shoemaker [7]. The legal basis for this liability is still being established.

From Figure III-1, an example would be that Subcatchment S_{12} would be entitled to drain its natural flow through reaches CB, BA and AO (and possible further), but not to discharge additional flows without incurring a liability. The extent of this liability should be related to the potential *damages* caused by the added flow.

Determination of a Liability Benefit: Consider that in each reach R_j (j=1 is reach OA; j=2 is reach AB, etc.), there will be a damage center upon full development. Such a center is shown in reach BC on Figure III-1. The magnitude of potential damages there depends on the assumption of future development and the increased magnitude of developed flows. As an upper bound case, consider that full development is allowed to the edge of the virgin flood plain for a 100-year event, the type of development dependent on local zoning and land use plans. Such a situation is shown on Figure III-2. Damage-frequency relationships for any reach can be established as shown on Figure III-3. The area under any of these curves is the *average annual damage* which we will call D_j for reach j. In Figure III-3, the difference in the developed and virgin cases is the added average annual damage, ΔD_j, for reach R_j.

The liability for the added damages ΔD_j in any reach R_j would be shared by those owners above R_j, to the extent that they increase discharges above the virgin case. A measure of this increase is the added average annual peak flow ΔQ_i for any subcatchment S_i. This increment of added flow can be calculated for S_i from a flow-frequency relation such as shown in Figure III-4. The added average annual discharge, ΔQ_i, is the difference in area between the two curves.

It is necessary to specify *where* a subcatchment is considered to discharge to the stream. This would ordinarily be determined from a drainage master plan. For the purpose of this discussion, consider this point to be at the downstream end of the subcatchments. Using this convention, it is then possible to establish, for each reach, which subcatchments contribute to it, and for each subcatchment, which reaches it drains through.

The damage increment in any reach R_j can be spread over the flow contributions by the relationship

$$UD_j = \frac{\Delta D_j}{\sum_{i=S_o}^{S_m} \Delta Q_i}$$

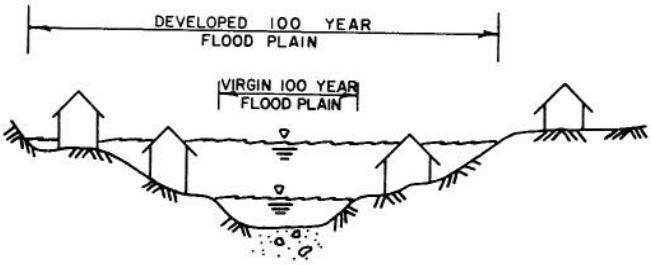

Figure III-2. Developed and Virgin Flood Plains

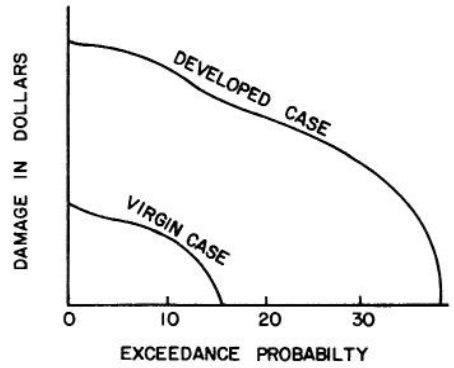

Figure III-3. Damage-Frequency Relations for a Reach

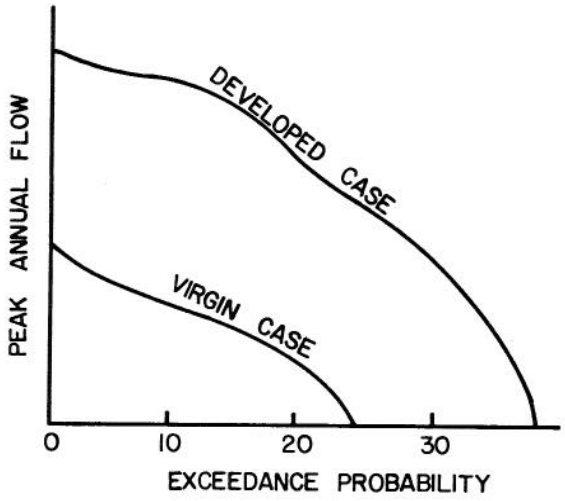

Figure III-4. Flow-Frequency Relations for a Subcatchment

where UD_j = damage in R_j per unit of flow increment; S_o = the first subcatchment tributary to R_j and S_m = the last.

For any subcatchment S_k, the liability incurred in reach j is, therefore,

$$L_{kj} = UD_j \ (\Delta Q_k)$$

where L_{kj} = the liability of subcatchment k in reach j. The total liability for any subcatchment k thus becomes

$$L_k = \Delta Q_k \sum_{j=R_o}^{R_n} \left(\frac{\Delta D_j}{\sum_{i=S_o}^{S_m} \Delta Q_i} \right)$$

The determination of the function ΔQ_i is subject to a great deal of engineering judgment and controversy. It is commonly accepted in urban hydrological practice that the chief determinant of the flow increment ΔQ is the increase in impervious cover. Call UA_i the impervious area of a subcatchment after urbanization (after U, the urbanization factor or percent impervious and A, the basin area). A surrogate relative measure for ΔQ_i is therefore UA_i and little difference should result in the calculation of L_k. No hydrological estimates are required, however, and the liability can be directly computed as

$$L_k = UA_k \sum_{j=R_o}^{R_n} \left(\frac{\Delta D_j}{\sum_{i=S_o}^{S_m} UA_i} \right)$$

It should be noted that the use of ΔUA_i as a measure of ΔQ_i eliminates any measure of drainage planning. The use of on-site detention storage, for example, would be reflected in ΔQ_i but not ΔUA_i.

Determination of Damage Reduction Benefit: In the previous section a procedure for determining the liability was presented. The benefit so determined, when summed over the entire catchment, should exactly equal the total incremental damages in the basin caused by future development. The riparian owners receive the damage removal benefits, again equal in total to the entire catchment incremental damages. A method is needed to apportion total damage reduction benefits among the flood plain occupants. This information can later be used to assess project costs.

A suggested method for damage apportionment is as follows, consider the basin whose tributary area is being developed. We speak of the present and future flood plains as being the areas inundated (for a selected return period storm) under present and future tributary basin conditions. Such flood plains are shown in Figure III-5.

To apportion damage reduction for such a case, three damage frequency curves are necessary. Figure III-6 shows these as being that for full tributary

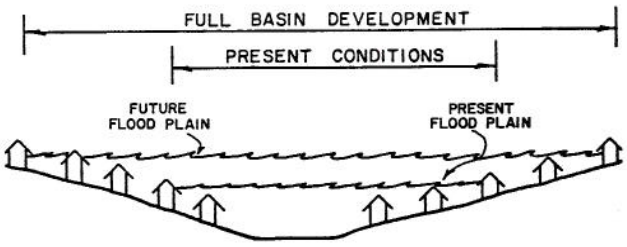

Figure III-5. Present and Full Development Flood Plains

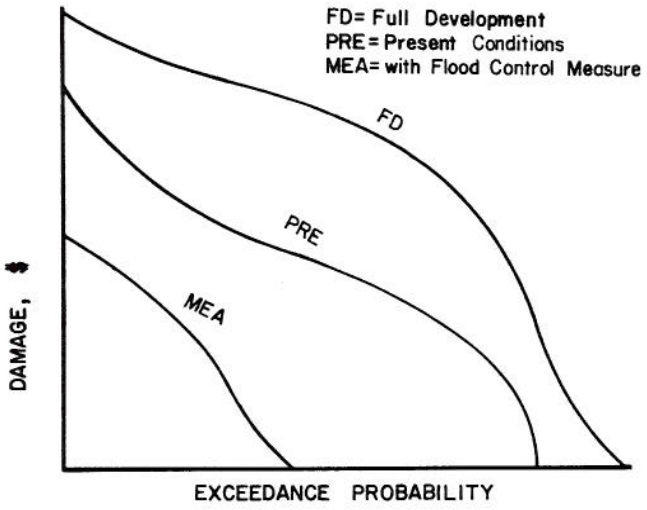

Figure III-6. Damage-Frequency Curves for Three Conditions

basin development, that for present conditions and that for the case where some flood control measure has been taken. Letting the areas under these three curves respectively be FD, PRE and MEA, the following relations apply:

Full Damage Potential = FD = Present Damage + Liability

Liability = FD - PRE

Present Damage = PRE

Residual Damage after Measure = MEA

Total Benefits = FD - MEA

$$\text{Liability Benefits} = (FD - MEA)\left(\frac{FD - PRE}{FD}\right)$$

$$\text{Riparian Benefits} = (FD - MEA)\left(\frac{PRE}{FD}\right)$$

Increase in Property Value: This is a complex benefit strongly dependent on specific locations and projects. Such increases can result from clear causes such as adaptability to higher uses (say from removal of the property from the flood plain), to more intangible cases where value increases because of greater amenities. Certainly the value of riparian property should increase due to the removal of a flood hazard.

Although this benefit is not simple to measure it appears that the best general rule would be to assemble a panel of appraisers and have them estimate the value increase, property-by-property to establish the benefit. This method would be subjective and subject to debate but, in the absence of just the right kind of market transfer data, no other approach would appear feasible.

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Chapter 4
EVALUATING MINOR UDFC SYSTEMS

As pointed out in Chapter II, the benefits from "minor" UDFC projects are mostly intangible, compared to "major" projects, where more flood damage mitigation might be expected, and where the possibility for multiple use projects with open space, recreation and the like exists. Faced with this difference, the engineer evaluating such minor projects lacks a simple tool like benefit-cost analysis upon which to base an analysis.

The problem is resolved if minor UDFC is considered a necessary service, to be provided in urban areas for much the same reasons that sanitary sewerage is provided. In fact, the benefits are very similar; convenience, sanitation and alleviation of health hazards in general.

Sanitary sewers are considered of higher priority than storm sewers because they meet a more urgen human need. By the same token, storm sewers might in some areas rate a higher priority than, say added community recreational facilities. We can empirically observe that the urgency of storm sewers is directly related to the level of nuisance and frequency of inconvenience experienced when they are absent.

Urban services such as those just described are not easy to justify using BCA; the benefits are not simple to quantify. These services are usually evaluated politically or by a community's willingness to pay, the latter being interpreted by the political judgment in the former case as well.

Although we cannot remove the political dimension from the evaluation of minor storm drainage, we can still apply evaluative economics to the selection of a best plan. It appears useless, however, at the present time to try to place dollar values on benefits such as convenience which result from drainage. In the first place, it is expensive to attempt such analyses because it adds considerably to the time required. Secondly, the results would lack any real meaning because of the completely subjective judgments involved. Actually, political judgments of desirable design frequencies can be useful and quick judgments of the value of such benefits.

The systems approach, a rational procedure for decision making, normally has the following steps:

1. Identification of problem
2. Establishment of goals and objectives
3. Specification of measures of effectiveness
4. Formulation of alternative solutions
5. Evaluation of alternative solutions
6. Selection of Best Alternative

In drainage work, it is best to work from a Master Plan. To prepare the Master Plan the engineer must follow the steps outlined above. His procedure will vary from case to case because he will be dealing with varying situations. Taking an average situation, however, he might follow the above sequence as follows:

Problem identification: Provide adequate drainage to a specified corporate area.

Solution:

1. Objectives. We can either select the procedure of fixed cost, maximum effectiveness; or fixed effectiveness, minimum cost. Let's say we are using the latter. We might then adopt legislated design standards such as the 2-year, 5-year, etc. This is frequently the approach adopted. A more realistic approach for implementation, however, is to adopt the more flexible approach where varying design standards can be considered, subject to fixed cost constraints. To illustrate how this might help, consider the case where a budget of $15,000 is available to solve a drainage problem which is estimated to require $25,000 at the predetermined design standards. By adopting flexible effectiveness criteria, the manager retains his option to maximize returns on his financial investment by investing less than $25,000 in this particular project.

2. Measures. All of the measures of effectiveness and objectives should be, of course, considered. Traditionally, the design return period and the cost of the system have been the criteria selected. They become thus surrogate, for the benefits of convenience, sanitation, etc.

3. Alternatives. The formulation of alternative solutions, as usual, relies on engineering experience to determine which of the possible solutions are feasible and likely to be promising when subjected to analysis.

4. Evaluation. At this point, the variable effectiveness question must be faced. In drainage master planning, many engineering reports have been prepared with a single frequency in mind. Consequently, the plan comes in with only one choice and one price tag. In considering variable effectiveness, one *plan* can be selected, but it must be presented for various *levels* of effectiveness. In effect, for each subsystem, a cost function rather than just a cost must be presented.

Example:

As an example, for Master Planning, consider the following case problem. Four drainage basins containing a populace of 68,000 persons are to be provided with drainage facilities. A conceptual city map is as shown in Figure IV-1. As usual, the corporate limits do not exactly coincide with the basin boundaries. According to the previous steps, it is desirable to prepare a Master Drainage Plan for the four basins shown.

1. For *objectives*, let us consider systems of variable effectiveness. The *measures* of effectiveness adopted will thus be a level of effectiveness and cost.

2. The *alternatives* formulated are all feasible drainage schemes for each basin. Typical schemes will involve combinations of pipes, swales, ponds, gutters, channels, etc. For each *level* of effectiveness, the lowest cost solution is sought. Table IV-1 shows this

part of the analysis. Note that the analysis shows the lowest cost alternative for each basin, for each return period (level of effectiveness). Plotting up the results on Figure IV-2, we get the Basin A *cost function.* Note that this function provides the lowest cost method to achieve each level of effectiveness.

3. *Selection* of an alternative plan for the basin implies that a certain funding will be provided. On the other hand, if the master plan is drawn in such a manner to reflect the *range* of possibilities (the cost function), then the level of effectiveness selected becomes a function of the *funds available.* Certain constraints must be considered, of course, and there is no doubt a *minimum acceptable* level of effectiveness.

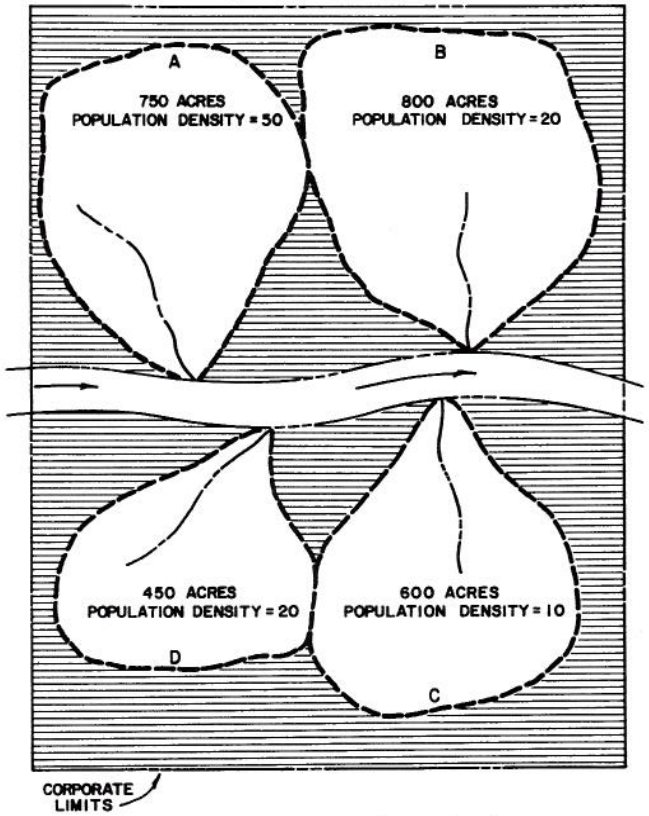

Figure IV-1. Map of Example Drainage Basins

4. The completed Master Plan can thus be prepared to show the best way to drain basins A, B, C and D for different levels of effectiveness. It would not fix the design frequency, but presents alternatives.

Considering Tradeoffs

An examination of Figure IV-2 demonstrates a simple fact. The greater the capacity of the drainage, the more it costs. But what is the optimum effectiveness level to select? This is a problem of *political economics* and is solved by a decision to invest x dollars in drainage. The public works manager can affect the magnitude of x by arguing eloquently for drainage investments as opposed to, say, greater investments in streets. Assuming that a decision has been made to provide drainage at a capital budget level of x/T , for T years, where T is the allowable development period, then each year x/T can be spent for storm drainage construction. Further, assuming no inflation or debt service costs, let us now see how the total x dollars can be "optimally" allocated over the storm drainage required.

Table IV-1. Development of Basin Cost Functions

BASIN A

EFFECTIVENESS LEVEL	ALTERNATIVE	COST ($/ACRE)
1 year	a	1630
	b	1750
	c	1500
	d	2000
2 year	a	2300
	b	1845
	c	1910
	d	2100
5 year	a	2430
	b	2450
	c	2700
	d	2600
10 year	a	3080
	b	3200
	c	3150
	d	3000
25 year	a	4400
	b	4350
	c	3930
	d	4000
100 year	a	5970
	b	6500
	c	6450
	d	6300

BASINS B, C, D

Same Procedure

Code: ALTERNATIVE	DESCRIPTION
a	Pipes Only
b	Pipes and Detention Ponds
c	Pipes, Open Channel and Ponds Mix
d	All Open Channel

Example Continued:

Consider that for drainage basins A, B, C and D a total sum of x = $3,000,000 is made available. This political decision, in a simple form, might reflect a direct decision by a governing council to allocate this sum to drainage. Rarely are decisions made this directly, of course. If T is chosen as 6 years, then x/T = $500,000 is the yearly available storm drainage budget.

Figure IV-3 shows the total cost functions for basins A, B, C and D. From this figure alternative ways to allocate the $3,000,000 can readily be seen. Four examples are given in Table IV-2. These alternatives, although simply presented, demonstrate that there are alternative ways to spread storm drainage funds over competing projects in a systematic fashion.

The next step would be to find that combination of investments that would maximize benefits, or total effectiveness, of the total sum invested. Unfortunately, there is no current or likely future practical method to assign realistic dollar benefits to the kind of intangible benefits provided for the minor

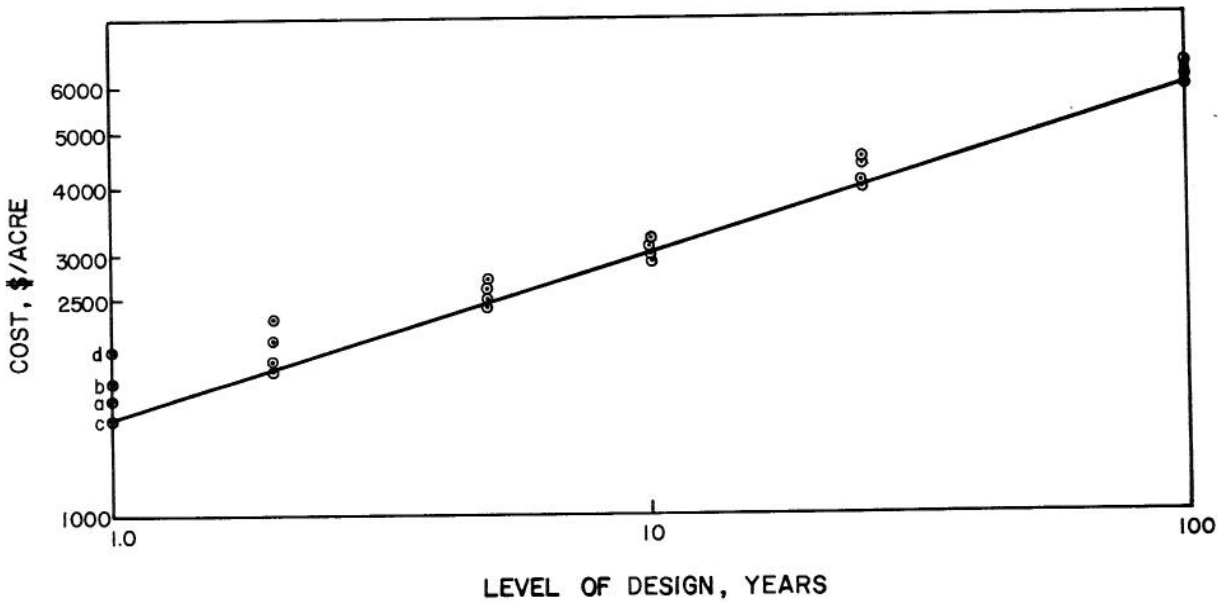

Figure IV-2. Storm Drainage Cost Function For Basin A

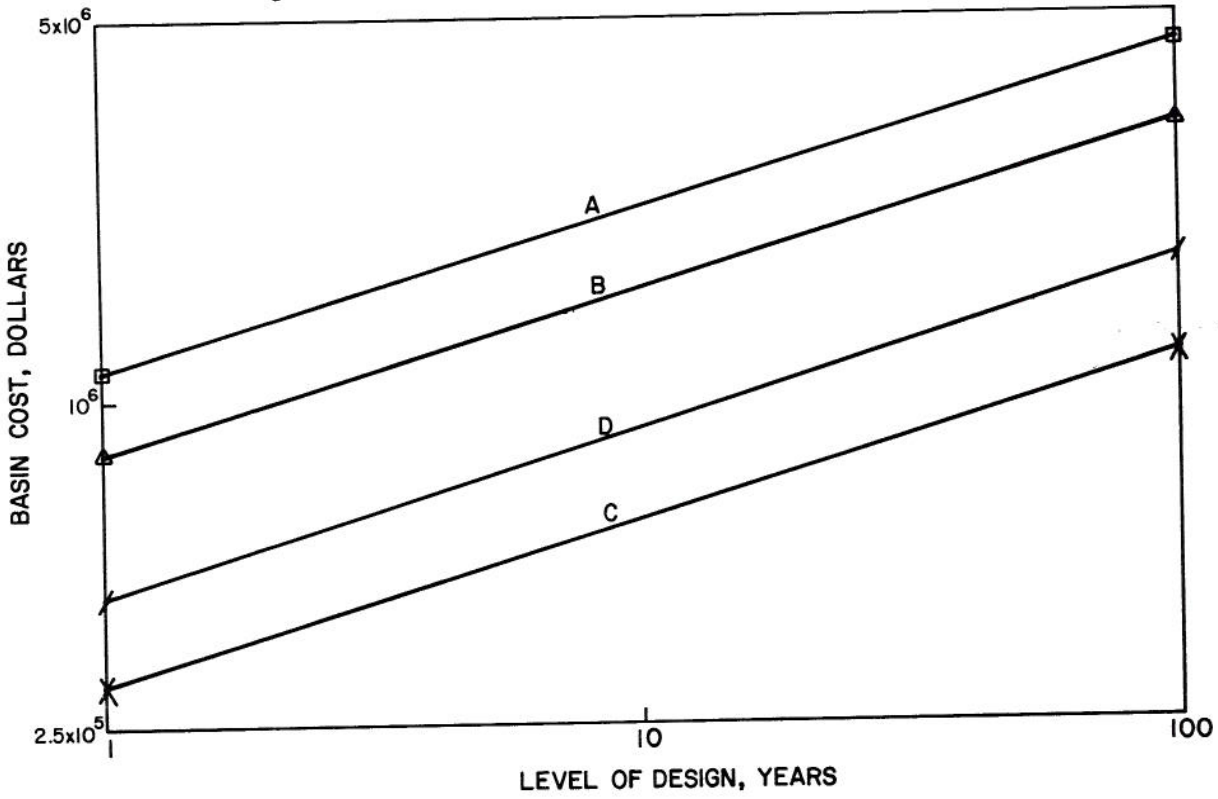

Figure IV-3. Total Basin Cost Functions

convenience storm drainage system. Consider that the City has decided that the following target storm drainage design figures are desirable:

BASIN	TARGET DESIGN (YEARS)
A	5
B	5
C	5
D	25

They further state that the optimal way to allocate the $3,000,000 in storm drainage is to provide the highest level of service to all basins, assigning penalty functions to failure to meet target levels as follows: For each resident in a zone, the failure to supply drainage is assessed a penalty of one point per person, per year of return period short of the target level. Now the data on Table IV-2 can be developed further as shown in Table IV-3. This shows that the best of the alternatives considered is No. 4 which throws most of the resources into Basin A, where most of the people are. Not shown on Table IV-2 or IV-3 is another alternative which turns out much better, as shown

BASIN	DESIGN	COST	PENALTY
A	5	1.72	0
B	2	.98	48,000
C	1	.30	24,000
D	0	0	225,000
		3.00	297,000

Table IV-2. Alternative Allocations of Storm Drainage Budget

	ALTERNATIVES							
	1		2		3		4	
	LEVEL	COST	LEVEL	COST	LEVEL	COST	LEVEL	COST
BASIN A	1.5	1.27M	1	1.13M	1	1.13M	2.4	1.46M
B	1.5	.90	1	.80	2	.98	1	.80
C	1.5	.34	1	.30	2	.37	1	.30
D	1.5	.49	6.5	.77	1.8	.52	1	.44
TOTAL		3.00M		3.00M		3.00M		3.00M

Note: LEVEL = Return Period M = Millions of Dollars

Table IV-3. Penalty Function Calculations

					ALTERNATIVE							
					1		2		3		4	
BASIN	SIZE	DENSITY	POP	TARGET	DES	PEN	DES	PEN	DES	PEN	DES	PEN
A	750	50	37500	5	1.5	131250	1	150000	1	150000	2.4	97500
B	800	20	16000	5	1.5	56000	1	64000	2	48000	1	64000
C	600	10	6000	5	1.5	21000	1	45000	2	18000	2	24000
D	450	20	9000	25	1.5	211500	6.5	166500	1.8	208800	1	216000
	2600		68000			419750		404500		424800		401500

This alternative violates the constraint that *some* drainage must be supplied to each basin; perhaps an unacceptable strategy. These methods are simply quantitative means to tradeoff possibilities searching for an optimum way to allocate resources. There is nothing magic in them but they do demonstrate that the analysis need not be limited to guesswork.

The material presented in this chapter has demonstrated some potential simple techniques for evaluating minor system plans to select a "best" plan. The criteria for selection was somewhat subjective and depended on the arbitaray set "target levels." These are values set by the decision making group. The analysis presented gives the planner a capability to demonstrate the effects of many investment alternatives.

Chapter 5
EVALUATING MAJOR UDFC SYSTEMS

The "major" UDFC project can be a large financial investment, running into millions of dollars. In many cases, however, the term "major" connotates only that the design is for a flood with an infrequent recurrence interval, and not necessarily that the scale of the project is large. The methods presented in this chapter apply to all sizes of major UDFC projects but should be especially useful for cases where the analyst needs simple straightforward techniques.

More than the "minor" UDFC system, the major system can be expected to satisfy multiple objectives, including provision of open space and recreational opportunities, as well as mitigation of flood damages. Its evaluation should therefore be carried out using multiobjective techniques. Many such techniques have been developed (see Reference [2,4]). By and large, these techniques are complex, requiring considerable effort and expertise to apply, perhaps more than is called for by the normal major UDFC system. For this reason, a simple technique is required that can be readily adapted for use by engineers lacking the specific training required to apply complex methods.

The basic need when evaluating multipurpose systems, is to consider how much each alternative project contributes toward meeting each objective. Then a method is needed to evaluate how these contributions (called "benefits") impact on different groups of persons concerned with the problem (the incidence analysis).

Approaches to Evaluation

One technique for displaying these contributions toward the different objectives is the set of "accounts" used by the Water Resources Council. Another is the "Matrix" approach which is popular with transportation planners. In the matrix approach, the benefits are simply listed by category and project, in a table. For example, the following table might result from a flood control reservoir study:

Table V-1. Matrix of Flood Control Project Benefits

OBJECTIVE / ALTERNATIVE PROJECT	FLOOD CONTROL	RECREATION	VISUAL IMPACT (max 10)	NEIGHBORHOOD DEVELOPMENT (max 10)
A	$23,000	$ 6,000	4	6
B	18,000	12,000	6	8
C	32,000	8,000	3	2
D	6,000	14,000	9	6

In this table, some of the benefits are given dollar values and others only assigned numerical values on an ordinal scale. This is because the benefits are *non-commensurate*, that is, they cannot be compared in similar units.

An interesting application of the matrix approach to UDFC analysis is reported in Reference [3]. The authors list the following eight objectives to be considered:

1. Freedom of residences from flooding damage.
2. Freedom of commercial/industrial facilities from flooding damage.
3. Freedom of public/institutional facilities and equipment from flooding damage.
4. Prevention of bank and channel erosion.
5. Protection of aquatic ecosystems.
6. Protection of wildlife habitat.
7. Freedom of parks, recreation and aesthetic areas from flooding damage.
8. Prevention of traffic interruptions.

As is evident from the list, these are not independent objectives, but are really the following three basic categories of objectives, broken into subcategories:

1. Damage Prevention (#'s 1, 2, 3, 4, 7 above)
2. Natural Ecosystem Protection (#'s 5,6)
3. Convenience, Secondary Economic Benefits (#8)

In this report, a procedure based on the matrix approach is recommended. Also, the "Goals Achievement Matrix" advocated by Hill [1] from work done in transportation planning is presented for the incidence analysis. The techniques are presented through an example, rather than in abstract fashion.

The matrix approach presented here seeks to develop a single score for each alternative so that they can be compared on a relative basis. In doing this, it takes subjective ratings and quantifies them, mixing them together with objective information. This seemingly questionable procedure is advocated for the following reasons:

1. The score so derived is not the final word but is meant to provide useful information to the decision makers.
2. The sensitivity of the scores can be examined with respect to changes in weighting factors and/or subjective ratings.
3. Such an approach appears to be the only way to coherently present a *simple* technique for multiobjective project analysis.

Additional details are spelled out in the Case Study. The reader is especially cautioned that the technique has the subtle effect of quantifying intangibles. It can only be used to examine the *relative merits* of *similar projects*. It can be misused and the results easily distorted.

Example of Project Evaluation

Description of Example Drainage Basin

The drainage basin in question is urban, its area is 25 square miles or 16,000 acres. Its channel length is 10 miles, the flood plain width averages 250 feet and takes in approximately 303 acres. The area within the existing 100-year flood plain is 30% developed (91 acres), and 70% undeveloped (212 acres). A total of 15,697 acres lie outside the flood plain limits.

Of these, 3,140 undeveloped acres located in the upper drainage basin will develop within the next 2 1/2 years. Of the remaining area outside the flood plain, 11,929 acres are completely developed and the rest currently undeveloped (628 acres). The community has a flood plain ordinance which effectively controls development within the flood plain. The 100-year flood plain was defined 10 years previously and was based on development conditions at the same time. The community is concerned about the effect that development of the upper portion of the drainage basin will have on flood peaks, flood plain area and average annual flood damages. The concept of liability for upstream land owners who increase flood peaks is already established.

Average annual flood damages under existing flooding conditions amount to $75,000 per year. Average annual flood damages will increase to $90,000 when all of the tributary basin is developed. The increased flood damages amounting to $15,000 per year represent the liability to upstream land owners. Maintenance costs attributable to drainage amount to $10,000 per year. The average annual outlay of the community attributable to drainage therefore amounts to $85,000 per year under present conditions and $100,000 per year under ultimate development conditions in current dollars.

Several regional facilities are located within the flood plain including the regional shopping center, a major elementary school, the regional sewage treatment plant and many collector streets. In recent years flooding has caused considerable inconvenience and there is public pressure for the regional flood control authority to do something about the flooding problem. The community is also concerned about the quality of their urban environment, and citizens are interested in more park space and more hiker-biker trails. The conflicting interests of preserving open space and making more land able to be developed have been expressed by different segments of the community.

A drainage management study has been undertaken and the consultant has defined four alternatives for handling the major drainage. Alternative No. 1 is a concrete channel which will require 50 feet of fenced right-of-way (ROW) for the entire 10 mile length and will take up approximately 61 acres. This alternative will make approximately 151 acres able to be developed and will cost $1,500,000. No open space or parts are planned and no trails will be provided. Alternative No. 2 is a soft-lined channel with drop structures to control stream velocities. The required ROW will be 110 feet and will not be fenced. The total ROW required will be 133 acres. Ten miles of trails will be provided although no parks or open space are planned. Seventy-nine acres will be made to be developed and the cost will be $1,300,000. Alternative No. 3 will combine detention storage with soft-lined channels and drop structures. A five acre detention dam will be located in a 15 acre regional park to be located in the upper portion of the drainage basin. The channel ROW will be 60 feet for the entire 10 mile length and the total ROW requirement will be 75 acres. An area of 137 acres will be able to be developed and 10 miles of hiker-biker trails will be provided. The total cost will be $1,100,000. Alternative No. 4 will utilize detention storage, soft-lined channels with drop structures and open flood plain. A five acre detention dam will be located in a 15 acre regional park, similar to Alternative No. 3. Channel ROW will be 60 feet for approximately 6 miles. Four miles of existing flood plain will be purchased as open space. Total ROW requirements amount to 44 acres for channel, 15 acres for park and 121 acres for flood plain. An area of 32 acres will be able to be developed and 10 miles of trails will be provided. The cost will be $850,000. (Stated costs are the present worth of all project costs).

For short titles, we will call the alternatives the following:

Alternative 1: Hard Channel
2: Soft Channel
3: Storage Mix A
4: Storage Mix B

The features of these alternatives are given in Table V-2.

The analyst began his study by evaluating project costs and damage-related benefits. Reduced flood damages, reduced maintenance costs and reduced liability were identified as the chief benefits, and construction land and operation maintenance were identified as the principal costs.

Benefit-Cost Analysis

The results of the analysis are tabulated in Table V-3. A glance at the table will indicate that from a net benefit viewpoint, Alternative No. 2 is the most efficient investment. The dollars and cents approach does not, however, reveal how each of the proposed alternatives affect community objectives which cannot be assigned dollar figures.

To examine the performance of the project alternatives toward meeting the project objectives, a clear statement of objectives is needed. These are formulated as follows. The formulation of objectives can result from either public participation or policy guidelines.

Objectives

1. Reduction in flood damage (DAMAGE)
2. Reduce liability from upstream development (LIABILITY)
3. Increase recreational opportunities and open space (RECREATION)
4. Encourage quality neighborhood development (DEVELOPMENT)
5. Improve visual impact of City (VISUAL)
6. Improve drainage service from convenience viewpoint (DRAINAGE)

Using appropriate techniques (public participation or policy guidelines), the engineer determines that for the UDFC problem at hand, and from the community point of view, the objectives are considered to have the following priorities: (0-10)

	OBJECTIVE	PRIORITY	NUMERICAL PRIORITY RATING
1.	DAMAGE	HIGHEST	10
2.	LIABILITY	LOW	3
3.	RECREATION	HIGH	7
4.	DEVELOPMENT	HIGH	7
5.	VISUAL	MEDIUM	6
6.	DRAINAGE	HIGH	7

Table V-2. Summary of Indicators

	Cost	ROW Required	Increased Development Potential	Trails	Park
1. Hard Channel	$1,500,000	50' (61 Ac)	151 Ac	-	-
2. Soft Channel	1,300,000	110' (133 Ac)	79 Ac	10 miles	-
3. Storage Mix A	1,100,000	60' (75 Ac)	137 Ac	10 miles	15 Ac
4. Storage Mix B	850,000	Note *	32 Ac	10 miles	15 Ac 121 Ac 136 Ac

Note * ROW = 60' (59 acres) for 6 miles. Four miles of existing flood plain (121 acres) purchased as open space.

Table V-3. Selection of Project by Net Benefit Method

Alt. No.	Present Worth of Total Cost ($)	Annual* Cost ($/yr.)	Reduced Flood Damages ($/yr.)	Reduced Maintenance Cost ($/yr.)	Reduced Liability ($/yr.)	Total Benefits ($/yr.)	Net Benefits ($/yr.)
1	1,500,000	95,160	65,000	9,000	14,000	88,000	-7,160
2	1,300,000	82,472	70,000	8,500	14,000	92,500	10,028
3	1,100,000	69,784	55,000	7,000	14,000	76,000	6,216
4	850,000	53,924	45,000	6,000	12,000	63,000	9,076
			235,000				

*Based on 6% at 50 years for illustration

The most significant groups of persons (publics) who are affected by the projects are considered to be the following:

AFFECTED GROUPS

1. Flood plain Residents (FP Residents)
2. Flood plain Businesses (FP Businesses)
3. Owners of Undeveloped Flood Plain Property (FP Undev)
4. Owners of Undeveloped Tributary Property (Upstream)
5. Owners of Businesses and Property Adjacent to Flood Plain (Adj FP)
6. Other Residents of City (Other City)

The information in Table V-2 can now be expanded to identify the indicators of performance for each alternative project as related to each goal. This is shown on Table V-4.

Table V-4 provides much of the same information as Table V-2. Now we are putting the information in the format of performance indicators, for use in selecting between projects. The performance indicators need to be converted to consistent units for comparison purposes. This is accomplished by allowing an arbitrary total score of 100 points for meeting each objective O_j. Each Alternative A_i will end up with an Indicator Score of I_i from this procedure, determined by

$$I_i = \Sigma \alpha_j G_{ij}$$

where α_j is the weighting factor for objective O_j and G_{ij} is the basic score for Alternative i toward meeting Objective j. Since an arbitrary total score of 100 is to be allocated to any Objective j, then

$$\sum_i G_{ij} = 100$$

and the maximum possible points to be allocated to all G_{ij} together are

$$\text{Max Points} = 100\sum_j \alpha_j$$

With this background in mind, it is possible to develop uniform scores for the different alternatives, as follows:

1. Damages. In Table V-3, the basic damage reduction figures are given. To distribute 100 points over these we first sum the damage reductions,

$$\sum \text{damage} = \$235{,}000$$

and by allocating the 100 points proportionally, we get 28, 30, 23 and 19 points for the alternatives respectively.

2. Liability. This is the same procedure as for damages. The resulting points are 26, 26, 26, and 22.

3. Recreation. Here we are allocating on the basis of park acreage rather than dollars but the procedure is the same. The points are 0, 23, 25 and 52.

4. Development, Visual Impact and Drainage. These were all provided with subjective point scales. To distribute the 100 points, we follow the same procedure as with the other categories. The points are, respectively: 8, 23, 39, 30; 7, 29, 35, 29; 25, 25, 25, 25.

These point assignments lead to Table V-5 which displays the points in Matrix form. From this display we see that Alternative 4 shapes up most favorably from the community point of view with 1150 points. The basic reason for this is its high mark in the recreational category caused by the flood plain park it provides.

The sensitivity analysis can be carried out relatively easily by varying the desired parameters. An example of this is provided by deciding that perhaps recreation was of minor importance compared to visual impact and development. To arrange this the weighting factors for the latter two are changed from 7 and 5 to 10 each and that for recreation reduced from 7 to 4. The results are shown on Table V-6. This rearranges the point total so that Alternative 3 is highest. Other variations can, of course, be considered.

The Goals-Achievement Matrix (GAM)

A separate GAM is required for each alternative to demonstrate the incidence of benefits on different population groups. To demonstrate the use of the GAM for this example, we return to the information in Table V-5. It is necessary now to calculate or estimate the extent to which the different groups will benefit from the projects in terms of each objective. In the case of Damage, Liability and Drainage, this distribution damage estimates over the groups. The Liability is all a benefit to upstream land owners. Drainage benefits are shared rather equally among persons working, living or owning property in the flood plain. Recreation, Development and Visual benefits are not so easy to estimate. Estimates of these benefits should not be used at this stage to assess costs, but they can be used to select among projects.

A table of distribution factors can thus be prepared for the different groups. These factors show the fractions of benefits received for each group, for each objective. For the case at hand, Table V-7 presents this information.

Using this information, the GAM can be prepared for the Alternatives and the weighting factors shown in Table V-5. In fact, this next step is a simple exercise in matrix multiplication which can be set up easily for the computer. The results are shown on Tables V-8, V-9, V-10, and V-11.

Table V-4. Performance Indicators

CATEGORY / ALTERNATIVE	OBJECTIVE: DAMAGE	LIABILITY		RECREATION	DEVELOPMENT	VISUAL	DRAINAGE
	INDICATOR: Damage Reduction	Liability Reduction	Total Financed	Acres of Park[1]	Subjective Rating	Subjective Rating	Performance Rating
1. Hard Channel	$65,000	$14,000	$79,000	-	2	2	10
2. Soft Channel	70,000	14,000	84,000	100	6	8	10
3. Storage Mix A	55,000	14,000	69,000	115	10	10	10
4. Storage Mix B	45,000	12,000	57,000	236[3]	8	8	10
TOTALS[2]	$235,000	$54,000	$289,000	451	26	28	40

NOTES:

1. A mile of trail is given the same value as one 10 acre regional park.
2. The totals are for the purpose of calculating "scores" later.
3. The 121 acres of purchased open space is considered as a park.

Table V-5. Alternatives-Objectives Matrix

OBJECTIVE / ALTERNATIVE	DAM		LIAB		RECR.		DEV		VIS		DRA		TOTAL
	Weighting Factors												
	10		3		7		7		5		7		39
1	28	280	26	78	-	-	8	56	7	35	25	175	624
2	30	300	26	78	23	161	23	161	29	145	25	175	1020
3	23	230	26	78	25	175	39	273	35	175	25	175	1106
4	19	190	22	66	52	364	30	210	29	145	25	175	1150*
	100	1000	100	300	100	700	100	700	100	500	100	700	3900

* = Best Score

Table V-6. Alternatives-Objectives Matrix
Changed Priorities

OBJECTIVE / ALTERNATIVE	DAM		LIAB		RECR		DEV		VIS		DRA		TOTAL
	Weighting Factors												
	10		3		4		10		10		7		44
1	28	280	26	78	-	-	8	80	7	70	25	175	683
2	30	300	26	78	23	92	23	230	29	290	25	175	1165
3	23	230	26	78	25	100	39	390	35	350	25	175	1323*
4	19	190	22	66	52	208	30	300	29	290	25	175	1229
	100	1000	100	300	100	400	100	1000	100	1000	100	700	4400

* = Best Score

Table V-7. Distribution Factors for Benefits

OBJECT. / GROUP	DAM	LIAB	RECR	DEV.	VIS.	DRA.
FP Res	.60	-	.22	.12	.22	.34
FP Bus	.30	-	.22	.30	.18	.33
FP Undev	.04	-	.22	.30	.22	.33
Upstr	-	1.00	-	-	-	-
Adj. FP	-	-	.22	.28	.22	-
Other	.06	-	.12	-	.16	-
	1.00	1.00	1.00	1.00	1.00	1.00

Table V-8. GAM for Alt. No. 1 (Scores, Distr. Tables 6,8)

	OBJECTIVES						
	DAM	LIAB	RECR	DEV	VIS	DRA	
	TOTAL SCORES						
	280	78	-	56	35	175	
FP Res	168	-	-	7	8	59	242
FP Bus	84	-	-	17	6	58	165
FP Undev	11	-	-	17	8	58	94
Upstr	-	78	-	-	-	-	78
Adj. FP	-	-	-	15	8	-	23
Other	17	-	-	-	5	-	22
	280	78	-	56	35	175	624

To examine how the benefits distribute across the publics for all projects, Table V-12, the "Publics-Alternatives Matrix" is presented. This shows that Alternative 4 is best for all groups except flood plain residents and upstream land owners. For these groups, however, Alternative No. 4 is close to the best. This could be a logical argument for its selection.

It should be pointed out that the assignment of points in the manner of this chapter has the appearance of quantifying intangible benefits. The value of a unit of visual impact, for example, comes out in terms as a dollar of damage reduction. The assignment of priorities effectively accomplishes this and serious errors can be introduced by improper use of this tool.

Table V-9. GAM for Alt. No. 2

	OBJECTIVES						
	DAM	LIAB	RECR	DEV	VIS	DRA	
	TOTAL SCORES						
	300	78	161	161	145	175	
FP Res	180	-	36	20	32	59	327
FP Bus	90	-	35	48	26	58	257
FP Undev	12	-	35	48	32	58	185
Upstr	-	78	-	-	-	-	78
Adj. FP	-	-	35	45	32	-	112
Other	18	-	20	-	23	-	61
	300	78	161	161	145	175	1020

Table V-10. GAM for Alt. No. 3

	DAM	LIAB	RECR	DEV	VIS	DRA	
FP Res	138	-	39	33	39	59	308
FP Bus	69	-	39	82	31	58	279
FP Undev	9	-	39	82	39	58	227
Upstr	-	78	-	-	-	-	78
Adj. FP	-	-	39	76	39	-	154
Other	14	-	19	-	27	-	60
	230	78	175	273	175	175	1106

Table V-11. GAM for Alt. No. 4

	DAM	LIAB	RECR	DEV	VIS	DRA	
FP Res	114	-	81	25	32	59	311
FP Bus	57	-	81	63	26	58	285
FP Undev	8	-	81	63	32	58	242
Upstr	-	66	-	-	-	-	66
Adj. FP	-	-	81	59	32	-	172
Other	11	-	40	-	23	-	74
	190	66	364	210	145	175	1150

Table V-12. Publics-Alternatives Matrix

	Alt. 1	Alt. 2	Alt. 3	Alt. 4
FP Res	242	327*	308	311
FP Bus	165	257	279	285*
FP Undev	94	185	227	242*
Upstr	78*	78*	78*	66
Adj. FP	23	112	154	172*
Other	22	61	60	74*
	624	1020	1106	1150*

The analyst is cautioned not to suggest that in so doing he has *accurately* quantified the intangibles.

In asking for priorities, he is in effect asking for the indifference point of preferences -- that is, how much visual impact would you give up for a dollar of damage reduction? this area requires a great deal of additional investigation.

CHAPTER V REFERENCES

1. Hill, Morris, "Goals Achievement Matrix for Evaluating Alternative Plans," Journal AIP, July 1968.

2. INTASA, Inc., "Multiobjective Planning for Multiple Purpose Water Resource Systems," Report for OWRR, November 1973, PB 230/619.

3. Michel, H. L. and W. P. Henry, "Flood Control and Drainage Planning in the Urbanizing Zone: Fairfax County, Virginia," in Urban Runoff, Quantity and Quality, ASCE, 1974.

4. U. S. Water Resources Council, "Principles and Standards for Planning Water and Related Land Resources," 1973.

Chapter 6
BENEFIT-COST ANALYSIS FOR COMPARING PROJECT COSTS AND FLOOD DAMAGE BENEFITS

In the previous chapter, a decision matrix approach was described for evaluating the comparative merits of major UDFC systems on a multi-objective basis. The reduction of flood damage was recognized as one of several economic benefits. Other, intangible benefits should also be considered. In this chapter, a methodology is presented for evaluating major UDFC systems using well-established Benefit-Cost Analysis (BCA) techniques. The methodology is basically limited to the consideration of the reduction of flood damage as a benefit. When other project objectives are to be considered, a procedure such as that given in Chapter V should be considered. Since damage benefits play a relatively insignificant role in the evaluation of minor UDFC projects, this methodology is not considered applicable to them.

There are strong precedents for the application of "traditional" benefit-cost techniques to the analysis problem. The federal government has been using them under the authority of the Flood Control Act of 1936 for many years, and although many problems have been identified with the approach, it does represent a straightforward process which can be replicated. Recently the Corps of Engineers issued revised regulations for implementation of the 1936 Act. These are enclosed as Appendix D [6].

The benefit-cost analysis is a part of the total economic evaluation process which is included in the development of the engineering plan. The following steps demonstrate the place of the BCA in the engineering planning process:

1. Identification of problem
2. Statement of objectives
3. Determination of effectiveness measures
4. Formulation of alternatives
5. Evaluation of alternatives
6. Display of results of evaluation process

The BCA is mostly carried out as step 5, but it relies on all of the steps for the development of data and criteria.

For BCA applied to UDFC problems, more specific steps can be developed, particularly to put the problem in the BCA format. For a given flood-prone area, the following steps would be appropriate, once a planning study is initiated:

1. Divided the study area into reaches
2. Examine flood hazard area and classify by land use
3. Determine conditions under which each flood plain management alternative will be evaluated
4. Obtain stage-frequency curves for each reach from hydrologic/hydraulic analysis
5. Determine flood damage categories by land use
6. Eliminate unlikely damage categories
7. Obtain and develop appropriate depth-damage relationships
8. Array alternatives to be considered and develop cost and performance data
9. Compute flood damages for the Base Line Condition
10. Compute the average annual flood damage potential for each alternative
11. Compute the costs for the alternatives
12. Discount benefits and costs appropriately
13. Display Benefit-Cost Information

Case Study

The case study presented demonstrates the application of benefit-cost analysis to a major UDFC problem. The analysis does not present detailed strategies for calculating B-C ratios, comparative discount rates or other material better left to economists. Rather it presents a direct method for identifying and calculating the traditional damage-related benefits, and the project costs for UDFC projects. The conclusion of the case study is a display of results, complete with an explanation of the biases introduced. The next step would be a debate, at the policy level, of the comparative merits of projects given these "net benefits" as one input. Other inputs would be community preferences and intangibles, material described in Chapters V and VII.

The example is based upon the Little Dry Creek Master Plan project located in Douglas and Arapahoe Counties, Colorado. The project was undertaken for the Urban Drainage and Flood Control District by the engineering firm of McCall-Ellingson & Morrill, Inc., and assisted by the firm of Lyon, Collins & Co., Inc., local governmental consultants [5]. The basin, shown in Figure VI-1, was chosen as the case study because of the varied conditions encountered and the detail of the analysis conducted. To broaden the scope of the example, certain hypothetical elements and conditions not found in the Little Dry Creek basin have been added.

It should be emphasized that each project will present unique hydrology, development characteristics, alternative solutions and other features, and the step-by-step procedure given here must be considered only as a guide. More than in routing design, this type of analysis requires considerable engineering judgment.

The Little Dry Creek Master Plan involves several entities as well as the Urban Drainage and Flood Control District. The basin incudes a fully urbanized area with a large regional shopping center (Reach A-B, Figure VI-1) as well as urbanizing farmland. It lies in the section of the metropolitan area experiencing very rapid growth. The area has a history of severe flooding caused by intense summer rainstorms.

Step 1 -- 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. Figure VI-1 illustrates the reaches selected.

Step 2 -- 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 (Reach A-B).

Step 3 -- Determine the Conditions under which the Flood Plain Management Alternatives will be Evaluated

It is extremely important that the base line conditions and future growth projects of land use in the flood plain be accurate and in accordance with the prevailing policies in the area. The Corps has decided to evaluate alternative plans under the assumption that land use requirements of the Flood Disaster Protection

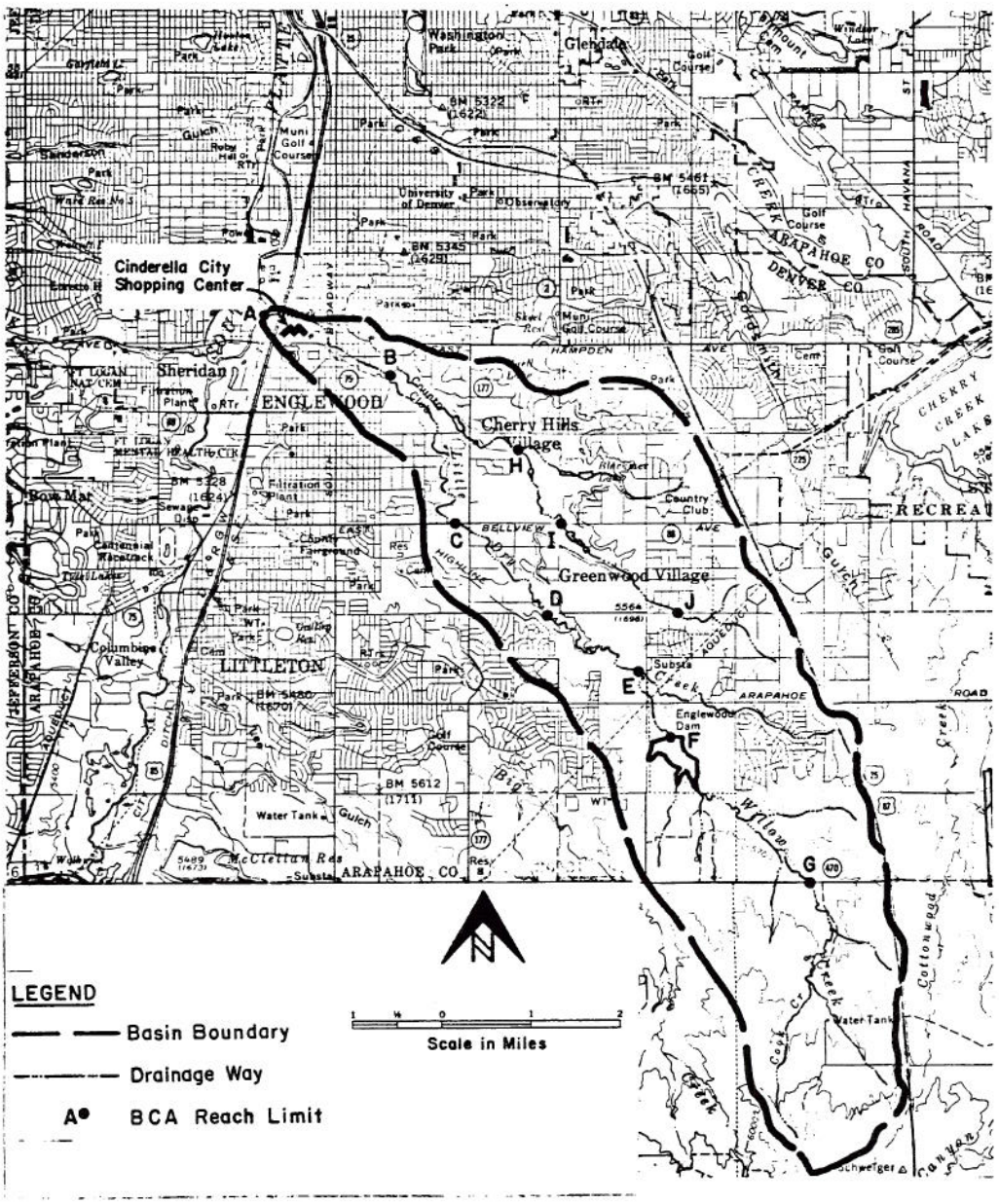

Figure VI-1. Little Dry Creek Drainage Basin

Act of 1973 (PL 93-234) will be met [6] (see Appendix D). This constraint on flood plain land development is important for the development of alternative flood plain management strategies.

In the State of Colorado, and particularly in the Urban Drainage and Flood Control District, flood plain regulation is, or will be, essentially universal; therefore, the normal base line condition will be with regulation.

In a general sense, the evaluation procedure should include a determination of the appropriate base line and growth conditions. A decision tree analysis such as is shown in Figure VI-2 will be appropriate for this.

On Figure VI-2 a shaded route is shown as that which will be appropriate for projects within the Urban Drainage and Flood Control District (UDFCD), and probably throughout most of the U.S. when regulation takes hold. In fact, in the UDFCD, several pieces of legislation back up the regulation. They are included as Appendix E and include the Flood Disaster Prevention Act of 1973, Colorado HB 1041 and a recent regulation promulgated by the Colorado Water Conservation Board.

The procedure for analysis recommended by the Corps [6] recognizes the importance of correct land use projections in the affected area. They point out the following five steps:

1. Delineation of Affected Area
2. Projection of Anticipated Activities within the Affected Area
3. Estimation of Land Use Demand
4. Determination of Flood Plain Characteristics
5. Projection of Land Use

In the Little Dry Creek example, a flood plain regulation is in effect, and the land use projection must proceed accordingly.

Step 4 -- Obtain Stage-Frequency Curves for Each Reach from Hydrologic/Hydraulic Analysis

As an input to BCA, flood hazard areas under existing and projected future development conditions must be defined. Because of the extent of flooded land, the magnitude of potential damage and the cost of preventive and corrective measures all depend on the estimates of flood flows and flood plain limits, the most reliable techniques consistent with the scope of the project and the basic data available should be utilized in the hydrologic and hydraulic analyses.

The BCA requires the computation of the flood hydrology for existing and future tributary basin conditions for a range of recurrence intervals. The recurrence intervals should be chosen to give a representative spread in the peak flows, i.e., low, medium and high. The difference between existing and future hydrology reveals the hydrologic effect of urbanization. The future hydrology will be used as the base line to evaluate alternatives.

Development of the future hydrology will require estimation of the future land development in the tributary basin. Existing land use plans should be consulted. If they are not available, the engineer must make his own prediction, perhaps with the help of local planners who are familiar with the existing development, local subdivision regulations, community preferences and other factors that will affect the type of development.

It must be recognized that the flood hazard for each year is a function of the tributary basin and flood plain development for that year. The most accurate assessment of the future hazards will therefore discount to present year-by-year development of both the tributary basin and the flood plain area.

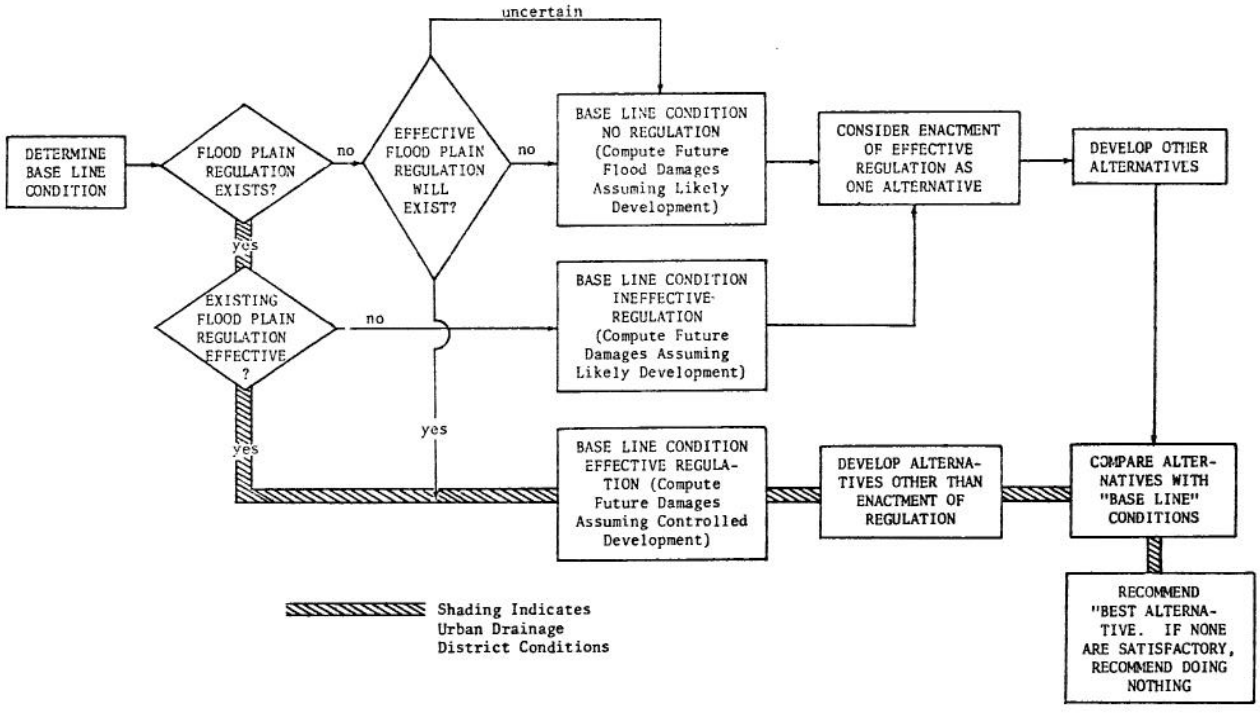

Figure VI-2. Decision Tree for Determining Base Line Conditions, and Developing and Comparing Drainage Management Alternatives

It is not normally practical, however, to make this assessment for each year of the planning period.

The use of present tributary basin conditions to estimate future flood hazards is clearly inadequate. The use of fully developed conditions is conservative. If development is proceeding slowly, this approach may be unduly conservative.

For the purposes of UDFC planning, especially in rapidly developing areas, the use of fully developed tributary basin hydrology is reasonable, especially if the conservative nature of the approach is considered.

In special cases, a year-by-year analysis can be used, or alternative growth rates can be considered.

For the case of Little Dry Creek, the hydrologic/hydraulic analysis is not presented. It is available in the basic engineering report, however [5].

Step 5 -- Determine Flood Damage Categories by Land Use

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

Land Use	Potential Damage Description
A. Public streets, bridges, culverts and utilities	1. Wash-outs damaging structures and necessitating repair or replacement, including structure damage or failure due to debris pile up. 2. Interrupted traffic or services 3. Removal of debris and cleaning
B. Public unimproved open space	1. Erosion 2. Removal of debris and cleaning
C. Public improved open space	1. Damage to facilities 2. Erosion 3. Removal of debris and cleaning
D. Private unimproved open space (grazing)	1. Erosion 2. Loss of livestock
E. Private improved open space (farming)	1. Erosion 2. Loss of livestock 3. Damage to farm equipment 4. Damage to stored goods
F. Single family residential	1. Structural damage 2. Content damage 3. Removal of debris and cleaning 4. Erosion 5. Missed work 6. General inconvenience
G. Multi-family residential	1. Structural damage 2. Content damage 3. Removal of debris and cleaning 4. Loss of renters, increased vacancies, or reduced rental income 5. Erosion 6. Missed work 7. General inconvenience
H. Trailer and mobile home parks	1. Structural damage 2. Content damage 3. Removal of debris and cleaning 4. Loss of renters, increased vacancies, or reduced rental income 4. Erosion 6. Missed work 7. General inconvenience
I. Commercial	1. Structural damage 2. Content damage 3. Inventory loss/damage 4. Removal of debris and cleaning 5. Loss of business income 6. Loss of sales taxes 7. Loss of salaries to employees 8. Special police protection
J. Industrial	1. Structural damage 2. Content damage 3. Inventory loss/damage 4. Removal of debris and cleaning 5. Operating loss-days idle 6. Loss of salaries to employees
K. Special Situations-- such as underground parking	1. Vehicular damage
L. Other	

Step 6 -- 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:

Land Use/Damage Category	Elimination Reasons
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 hazard area
D. Private unimproved open space (grazing)	Insufficient land in hazard area
E. Private improved open space (farming)	Insufficient land in hazard area
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 made 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 value

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 7 -- Obtain and Develop Appropriate Depth-Damage Relationships

Flood damages are calculated with the use of depth of flooding versus dollar damage tables or curves for various types of residential, commercial or industrial 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). It is felt that currently FIA has the most applicable data for estimating flood damages for residential structures because they have made a specific effort to generalize a great deal of data [1]. FIA has only presented such data for residential and small business structures. Generalized curves for commercial and industrial areas do not currently exist. These must be handled on a case-by-case basis.

Tables VI-1 and VI-2 give FIA depth-damage data as

used in the example problem. These were current until recently when FIA re-issued the curves and revised them downward. The most current relationships are in Appendix B.

Table VI-1

FEDERAL INSURANCE ADMINISTRATION

SEPTEMBER 1970
Depth Damage Curves*
Set A

STRUCTURES-RESIDENTIAL AND SMALL BUSINESS

	Curve No.						
	01	03	05	10	13	18	23
Depth in Feet	Damage in % of Total Value						
-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.	21.	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.

Classification	Curve No.
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.

Step 8 -- Array Alternatives to be Considered and Develop Cost and Performance Data

The formulation of alternative management strategies is a creative process and depends on engineering judgment and innovation. It is a necessary input to the BCA. For each alternative to be evaluated it is necessary to know the costs and the performance data so that these can be input into the analysis.

Data must be collected to allow computation of the following costs for each drainage management alternative:

1. Right-of-way acquisition
2. Construction and engineering
3. Fiscal and administrative
4. Discount rate
5. Annual operation and maintenance
6. Insurance

A table reflecting the annual costs over the life of the improvement will be constructed later.

The performance data will be necessary to determine the benefits for each alternative at the selected levels of investment. In the case of Little Dry Creek, five basic alternatives are considered:

Table VI-2

FEDERAL INSURANCE ADMINISTRATION

SEPTEMBER 1970
Depth Damage Curves*
Set A

CONTENTS-RESIDENTIAL

	Curve No.								
	27	29	46	51	31	41	33	56	38
Depth in Feet	Damage in % of Total Value								
-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.					

Location	Curve No.
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 - Depth Damage Curves, Elevation-Frequency Curves, Standard Rate Tables, Federal Insurance Administration, September 1970.

1. Do Nothing (Alt. #0)
2. Detention Dams (Alt. #1)
3. Channelization (Alt. #2)
4. Conduits (Alt. #3)
5. Dams with Channelization (Alt. #4)

In addition, various nonstructural mixes could have been formulated, but are not for the example. These are not the actual alternatives considered but have been modified somewhat for illustration.

For each alternative it is necessary to know all associated costs and the residual flood damages remaining after the alternative is implemented.

Step 9 -- Compute Flood Damages for the Base Line Condition

A. Establish Base Line Conditions

The "Base Line" condition defines what is likely to happen if no UDFC alternative plan is implemented. It is the datum against which the effectiveness of alternative flood control schemes will be measured. The effectiveness of each alternative is measured by how much it reduces the flood damages from the "Base Line" case considered. It is important that existing flood plain land use policies and regulations be

accounted for accurately. A key question is whether existing zoning policies will allow future development of the flood plain. In Colorado, the presence of flood plain regulation as a policy renders this question relatively simple. In other countries, it may not be so simple. Figure VI-2 gives the decision path which should be used.

If there is no flood plain regulation, the "Base Line" condition might assume that future development within the flood plain will not be controlled. If the present flood plain is largely undeveloped, this could mean a steadily increasing flood damage potential, a condition which could be prevented with appropriate regulation.

If an effective flood plain regulation is in effect, the "Base Line" condition will assume that future flood plain development will be "controlled," and the future flood damage estimates will be less.

The decision tree in Figure VI-2 essentially provides for three Base Line conditions. Each of these is dependent on the status of the flood plain regulation; effective, ineffective or nonexistent. Table VI-3 summarizes the types of alternatives and Base Line conditions which might be encountered.

The computation of flood damages in a reach requires that the land use conditions and the topography in the flood plain be known.

B. Identify Damage Categories (Benefits and Collect Supporting Data)

For this case, benefits are limited to direct and indirect flood damage reduction. To establish them, engineering data are required from the hydrologic and hydraulic analyses which include:

1. Tributary basin flood hydrographs for several recurrence intervals for future basin development conditions.
2. Delineation of the corresponding flood plains on adequate topographic mapping.
3. Estimates of flood depths and velocities.

Other data necessary for the damage analysis are:

1. 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 flood plain. The data obtained for each property were:

   Legal description
   Property address
   Assessed valuation of structure

   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. This technique is only valid if the assessments realistically reflect market conditions.

2. 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 warranted. Instead, a factor of 50% of the structure value is used. This factor corresponds to practices within the insurance industry and represents a reasonable estimate considering the accuracy of the data. See Appendix B.

3. Content and Inventory Data -- Commercial

   In the Little Dry Creek Basin two major commercial areas exist in portions of the flood plain. 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 the 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.

4. Structural and Content Data -- 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.

5. 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 were made and the average per hour rate of the public employees who would be involved in the work multiplied by 2.25 to cover overhead. This estimate is based upon the personal experience of the analyst (former municipal finance official).

6. 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 flood plain. This calculation also was designed to cover lost income from missed work.

7. 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 a retail clerk was used to price the employees' time.

8. 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 flood plain. Recent unit cost data from various public projects were used in these estimates.

9. 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.

10. Loss of Business Sales and Sales Tax

In the Englewood portion of 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.

11. 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.

12. Vehicular Damage

A large underground parking facility exists at Cinderella City Shopping Center in Englewood. The egress from that area can become impossible should many 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.

13. 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.

For areas of uniform flood damage potential (i.e., a residential area of uniformly valued homes), per acre damage factors can be developed for a range of flood depths. During the analysis, the flood plain can be divided into areas of similar flood depth, i.e., 0 to 1 foot, 1 to 2 feet, etc. 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 VI-4 summarizes the procedure for obtaining area damage factors for 3 and 4 foot flood depths for a sample low density residential area. Damages for the other depths would be determined in a similar manner. The data can also be presented graphically as in Figure VI-3.

For areas that are not homogeneous with respect to land use or damage potential, a more detailed analysis must be performed. For each land use category the value of property exposed to flooding must be known. The exposure is multiplied by the damage factor taken from an appropriate depth versus damage curve. Dollar damage is estimated and tabulated for each damage category, as in Table VI-5.

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 and flotation are possible if the velocities are significant. Data for estimating this type of damage are not readily available. It is recommended that at least the velocity head be added to the flood depth when velocities exceed 8 fps, to account for some of the damage that might occur. The depth-damage relationships previously presented account somewhat for the velocity phenomena by predicting 100% damage at some depths.

C. Compute Base Line Average Annual Damages

Total the flood damages for each reach and recurrence interval as shown in Table VI-6 for Reach A-B.

Table VI-3. UDFC Alternatives and Base Line Conditions

Existing Situation	No Flood Plain Regulation in Force	Ineffective Flood Plain Regulation in Force	Effective Flood* Plain Regulation in Force
Alternative:			
Enact "Effective" Flood Plain Regulation	X	X	-
Structural Mix	X	X	X
Non-Structural Mix	X	X	X
Mix of Structural and non-structural	X	X	X
Other	X	X	X
Base Line Condition Defined	Future Tributary basin hydrology, uncontrolled development in flood plain	Future tributary basin hydrology, semi-controlled development in flood plain	Future tributary basin hydrology, controlled development in flood plain

* Colorado Conditions

For each reach, construct a graph of flood damage versus probability of exceedance in any given year. The graph will be similar to Figure VI-4. Since the rarest flood calculated may be the 1% event (100-year), the 0% event must be estimated and plotted. It can be extrapolated from the slope at the end of the curve. The zero damage point must also be established. Caution must be exercised since determination of these points will affect the computation of the average annual flood damage. In this example, flood damages are high for the "Base Line" condition even though an effective flood plain regulation has been assumed. The damages are largely due to existing development within the flood plain, including a portion of completely urbanized area.

The damages for Reach A-B shown on Table VI-6 amount to more than half the total Little Dry Creek damages shown on Figure VI-4. The high ratio is due to the comparably extensive development in Reach A-B.

Table VI-4

EXAMPLES OF HOW TO COMPUTE PER ACRE FACTORS FOR ESTIMATING FLOOD DAMAGES IN HOMOGENEOUS AREAS(a)

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

Damage Category	Exposure Per Acre	3 Foot Flood Depth		4 Foot Flood Depth	
		Damage Factor	Damage Per acre (b)	Damage Factor	Damage Per Acre (b)
1 Story Structure	$85,800	.35	$30,030	.39	$33,462
1 Story Content	42,900	.60	25,740	.68	29,172
Streets	6,000	.40	2,400	.80	4,800
Utilities	12,600	.20	2,520	.50	6,300
Lawns, Open Space	3,520	1.00	3,520	1.00	3,520
Vehicles	13,500	.68	9,180	.75	10,125
Cleanup	250/day	6 days	1,500	8 days	2,000
Total Damages:			$74,890 Per Acre		$89,379 Per Acre

(a) Follow similar procedure for other flood depths.

(b) Multiply estimated exposure and damage factor.

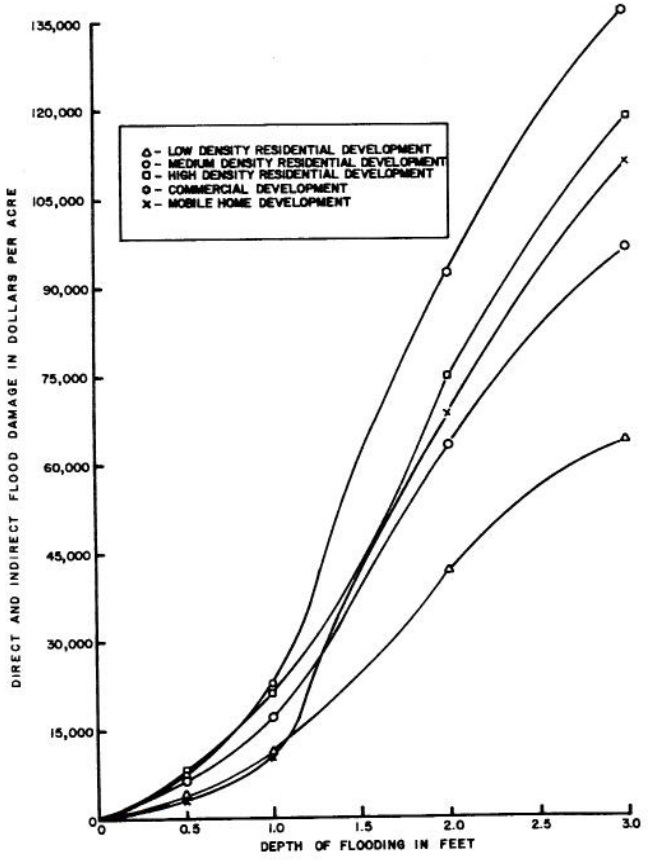

Figure VI-3. Per Acre Flood Damage

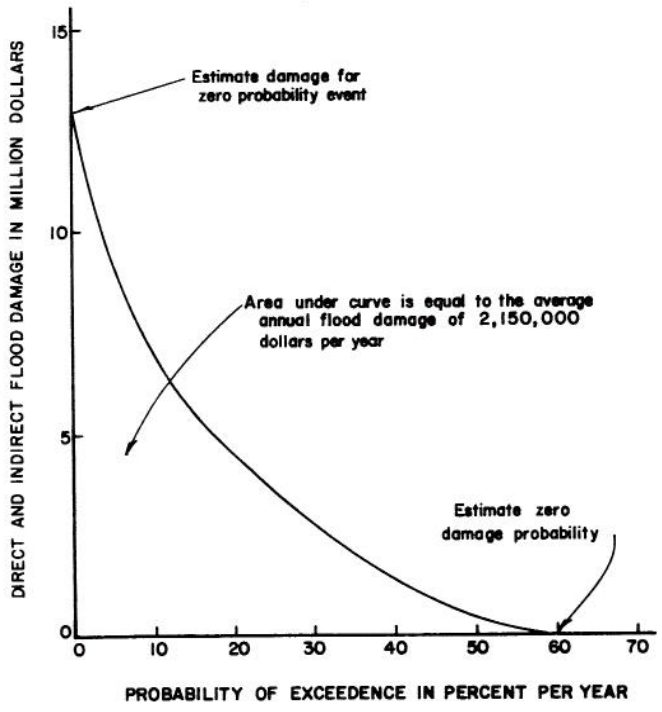

Figure VI-4. Flood Damage Versus Probability of Exceedance Curve for Little Dry Creek Base Line Condition

Table VI-5

DAMAGE TABULATION SHEET FOR NON-HOMOGENEOUS AREAS

Reach:

Frequency: 100 years

Type of Damage: One Story Residential Structure

Condition: Developed Basin, Controlled Development in Flood Plain

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.	6-7 ft.	
$30,000	15	5	1					$177,300
$40,000	6	1						$ 74,000
$50,000	1							$ 12,500
Number of Structures	22	6	1					
Total Value	$740,000	$190,000	$30,000					
% Total Value Damaged (a)	25	35	41	46	49	52		
Total Flood Damage	$185,000	$ 66,500	$12,300					$263,800

(a) From appropriate depth versus damage table or curve.

Table VI-6

SUMMARY OF BASE LINE FLOOD DAMAGES FOR A REACH

Stream: Little Dry Creek

Reach: A to B

Frequency: 100 years

Conditions: Developed tributary basin, controlled future development in flood plain.

Direct Damages	Amount of Damage
Residential Structure and Content	$420,000
Commercial Structure and Content	623,000
Indirect Damages	
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 Rentals	4,000
Total:	$1,280,000

The indirect damages were directly estimated rather than taken as a percentage of direct damages. They amount to the following:

$$\text{Residential} - {}^{6000}/_{420,000} = 1\%$$

$$\text{Commercial} - {}^{216,000}/_{623,000} = 35\%$$

The comparable data given in Chapter II by the Corps is therefore exactly the same for commercial (35%) but far different for residential (15% vs. 1%).

Step 10 -- Compute the Average Annual Flood Damage Potential for Each Alternative

Repeat the flood damage computation parts of Step 9 for each flood control alternative under consideration. There will generally be residual flood damages for each alternative, due to flood events larger than the design event. The residual damage is the area under the damage-frequency curve after the alternative is implemented. Figure VI-5 shows such a curve for Alternative 1, plotted alongside the Base Line curve.

The reduction in the annual flood damage potential is the principal benefit realized if the flood control improvement is constructed. The average annual benefit is illustrated graphically in Figure VI-5 as the area between the two curves.

Make a list of the benefits of the alternatives, as in Table VI-7. A discussion of the present worth factor shown will follow.

Step 11 -- Compute the Costs for the Alternatives

Prepare a table that reflects end-of-the-year costs over the project life. The table would resemble

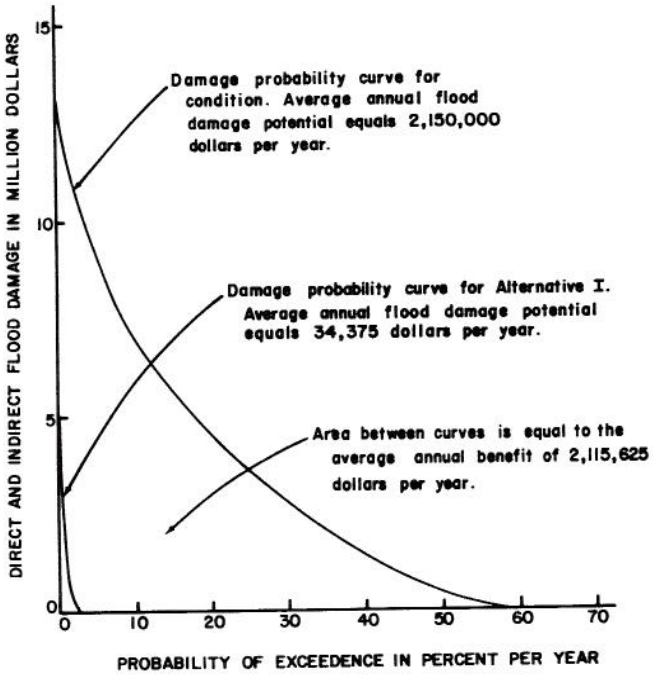

Figure VI-5. Flood Damage Versus Probability of Exceedance Curves for Little Dry Creek

Table VI-8, prepared for Alternative 1.

Step 12 -- Discount Benefits and Costs Appropriately

Selection of an appropriate discount rate is important. The discount rate will bias the analysis and may change the recommended alternative [2]. Selection should reflect at least the cost of borrowed capital for the entities involved. In this example, the recommended value of the Water Resources Council of 5 7/8% per year for fiscal year 1975 was used. Appendix C provides additional information on the selection.

The selection of time horizon or planning period should be based upon the physical life of the improvements which will prevent or control flooding. If the improvements have a useful life which is less than the design recurrence interval of the level of protection and the analyst wishes to extend the BCA to that point, it is necessary to show replacement of the facilities as a project cost. High inflation makes this procedure uncertain. For this example a 50-year project life was chosen. This corresponds to Corps procedures.

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 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 or annual amounts before comparison, using appropriate 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 VI-7 and VI-8. The use of present worth or annual amounts biases the analysis somewhat. The reader is referred to engineering economics texts for a discussion of this phenomena.

Step 13 -- Display Benefit-Cost Information

Display of alternatives is possible with a number of methods, including the benefit-cost ratio, net benefit, incremental rate-of-return [2,4], and

Table VI-7

FLOOD CONTROL BENEFITS FOR ALTERNATIVES

Alternatives	Average Annual Flood Damage	Average Annual Flood Damage Reduction*	Present Worth Factor**	Present Worth of Benefits @ 5 7/8%
Do Nothing = Base Line Condition	$2,150,000	$ 0	16.04106	$ 0
Alt. #1 - Detention Dams	$ 34,375	$2,115,625	16.04106	$33,936,868
Alt. #2 - Channelize	$ 22,150	$2,127,850	16.04106	$34,132,970
Alt. #3 - Conduits	$ 11,050	$2,138,950	16.04106	$34,311,025
Alt. #4 - Dams With Channelization	$ 15,275	$2,134,725	16.04106	$34,243,252

* Flood Damages reduced from the Base Line condition.

** P. W. Factor = $\frac{(1 + i)^n - 1}{(i)\ (1 + i)^n}$, where i = 5 7/8% and n = 50 years

minimization of total costs [3].

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 decision makers 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. The net benefit is simply the value of the benefits minus the value of the costs, both expressed in present or annual worth dollars. Table VI-9 is an example of the procedure for displaying net benefit information. If this case study had assumed a maximum cost constraint, then some of the projects might be eliminated due to excessive cost.

Table VI-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	Present Worth of Costs @ 5 7/8%
Site Acquisition	$ 530,000	0	0	.94451*	$ 500,590
Construction	$3,500,000	0	0	.94451*	$3,305,785
Engineering	$ 875,000	0	0	.94451*	$ 826,446
Fiscal and Administrative	$ 2,000	$2,000	$2,000	16.04106**	$ 32,082
Maintenance and Operation	0	$2,000	$2,000	(.94451)* (15.98347)**	$ 30,193
Other	$ 1,500	$1,500	$1,500	16.04106**	$ 24,062
Present Worth Total @ 5 7/8%					$4,719,158

* PW Factor for fixed future cost = $\frac{1}{(1 + i)^n}$, where n = number of years and i = discount rate = .05875

** PW Factor for equal annual costs = $\frac{(1 + i)^n - 1}{i(1 + i)^n}$, where n and i are defined above.

Table VI-9

DISPLAY OF NET BENEFITS

Alternatives*	Present Worth of Costs @ 5 7/8%	Present Worth of Benefits @ 5 7/8%	Net Benefit (Benefits-Costs)
Do Nothing = Base Line Condition	$ 2,150,000***	$ 0	-$ 2,150,000
Alt. #1 - Detention Dams	$ 4,719,158	$33,936,868	+$29,217,710**
Alt. #2 - Channelize	$ 9,764,850	$34,132,970	+$24,368,120
Alt. #3 - Conduits	$18,216,000	$34,311,025	+$16,095,025
Alt. #4 - Dams With Channelization	$ 6,305,100	$34,243,252	+$27,938,152

* These are not the alternatives presented in the Little Dry Creek UDFC study.

** The most economical alternative has the largest positive net benefit.

*** Base Line condition flood damages.

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Chapter 7
THE EVALUATION OF SOCIAL AND ENVIRONMENTAL BENEFITS

The array of UDFC costs and benefits presented earlier (Table VI-9) included a number listed as "Intangible." Basically, intangible benefits and costs are those to which no monetary value can be assigned [1]. For UDFC projects, the primary intangibles to be considered are social, aesthetic and environmental, all of which are interrelated. A primary social benefit is convenience, which can be quantified under certain assumptions, in much the same manner as the effect of traffic disruptions on travel time.

Since UDFC is water based development, the intangibles to be considered are basically the same as those provided by other water projects. Some similarities also exist between intangible benefits of UDFC projects and transportation corridors since both may involve the linear development of space.

The "Principles and Standards for Water Resources Planning" of the Water Resources Council provides a description of the categories of benefits to be considered [2]. Those falling into the categories of "social well-being" and "environmental quality" are generally considered to be intangible. These include the following:

1. Environmental Quality
   a. Open and green space, wild and scenic rivers, lakes, beaches, shores, mountains wilderness areas, estuaries, and other areas of natural beauty;
   b. Archeological historical, biological and geological resources and selected ecological systems;
   c. The quality of water, land, and air resources; and
   d. Irreversible commitments of resources to future uses.
2. Social Well-Being
   a. Real income distribution;
   b. Life, health and safety;
   c. Educational, cultural and recreational;
   d. Emergency preparedness.

The "Principles and Standards for Water Resources Planning" requires or encourages that beneficial and adverse effects of proposed projects on these parameters be displayed. This is tantamount to asking for a statement of benefits and costs from these categories, descriptively rather than quantitatively because they cannot be quantified.

In spite of the difficulty in quantification, it is known that the public generally prefers certain views or values highly certain social parameters. It is therefore possible that methods could be established to quantitatively consider intangible benefits for decision making purposes.

It should be clearly stated at this point that this report does not present a firm finished technique for the evaluation of social and environmental benefits. Such a technique has not been forthcoming even at the most sophisticated levels of project analysis including projects with significant impacts such as the siting of nuclear power plants. Rather, a review of methods in use is presented in this chapter so that the reader can formulate his own impression of the state-of-the-art of the evaluation of intangibles. He can then use his own judgment in formulating descriptions and displays of the intangible benefits and costs of the UDFC projects he proposes in the most effective manner consistent with the state-of-the-art of evaluating these intangibles.

A number of recent state-of-the-art reports have been produced concerning the evaluation of social and environmental intangibles. A recent OWRR report [3] evaluated the social dimensions of water resources planning. In this report, the researchers present 42 social factors that were identified as being significant for water resources decision making. Using the statistical survey techniques, the relative importance of these 42 social factors was determined and they were ranked into a priority list accordingly. This list is reporduced as Table VII-1. As seen from Table VII-1, hygienic tap water is of high priority, whereas water sounds for people to enjoy is last priority. The factors that are significant for UDFC are distributed throughout the list, but it is noteworthy that flood control is relatively high.

A recent report by the U.S. Environmental Protection Agency [4] reviewed current methodologies for evaluating aesthetics and environmental planning. This comprehensive report presents a review of methods for measuring and quantifying aesthetics. The review is up to date as the report was published in late 1973. The methods fall into two general categories. First, visual analysis, which is a method to be used by planning staff to identify aesthetic attributes in the environment and to describe the implications of changes in terms of potential uses of environmental resources. The second category, user analyses, is a body of techniques for evaluating individual preferences for various aesthetic stimuli. According to the report, both methodologies are intended to provide information to assist decision makers and the general public when considering the advantages and disadvantages of proposed planning activities. In this report, a number of the best known methodologies are reviewed. This includes the environmental quality rating system, prepared by the Bureau of Outdoor Recreation, the Environmental Evaluation System (EES) the Water Resources Planning devised for the Bureau of Reclamation, the procedure for evaluating environmental impact devised by Leopold for the U.S. Geological Survey, and a number of others. Most of these methodologies have great potential when used properly. They all attempt to measure the very complex interactions between the human and the natural environment. As an example of the complexities to be considered, Figure VII-1 which gives an overview of the environmental evaluation system is presented [5]. All of the impacts listed presumably would fall into one of the categories of the Water Resources Council.

A recent Corps of Engineers publication, reported on a symposium which was directed toward a technique for quantifying aesthetic qualities of water resources [6]. This document contains six independent papers and a summary paper presented at the colloquium. In the summary paper, the participants agreed that any method for aesthetic quality quantification must meet the following criteria:

1. Be based on the theoretical framework
2. Be generated from public experience and not the developers biases.

3. Be adaptable to diverse planning methodologies (i.e., have usable outputs and be budget-realistic)
4. Be functional for both regional and site analysis
5. Be predictive of change
6. Be designed to deal with both cognitive and physical aspects of aesthetic experience
7. Be adaptive to consider the situational state of the area user
8. Be capable of identifying unique aesthetic opportunities
9. Be built to eliminate response bias and deal with uncertainty judgments
10. Be designed utilizing cardinal scaling
11. Be reliable and valid.

Table VII-1. Rated Value of Each of 42 Social Factors

VALUE		FACTOR
12.05*	1**	Hygienic tap water
11.91	27	Bodies of water free from sewage
11.29	28	Bodies of water free from radioactive waste products
10.90	9	Water for farming
10.24	13	People not wasting water
10.14	26	Bodies of water free from oil
10.10	40	Public informed about water uses, resources, and problems
10.07	2	Water that is pleasant to drink
9.81	34	Flood control
9.52	23	Drinkable stream and lake water
9.50	11	Water for electrical power
9.27	36	Fair rationing, if water rationing is necessary
9.20	38	Water costs fairly allocated among the people
8.92	18	Natural watery habitats for wild life
8.78	10	Water for industrial uses
8.53	5	Plenty of tap water for people to use as they wish
8.36	22	Clear, beautiful stream and lake water
8.15	12	Recycled water
7.85	41	Public participation in water-management decisions
7.67	6	Water to keep things green
7.58	31	No offensive odors from water or wastewater treatment
7.25	14	Water rationed, to prevent waste or conserve supply
6.99	15	Native planting, to reduce need for watering
6.76	16	Bodies of water for recreation
6.61	37	Fair allocation of water resources for recreation
6.58	21	Scenic beauty of bodies of water
6.57	17	Bodies of water for transportation
6.54	4	Fluoridated public drinking water
6.52	24	Streams and bodies of water free from excessive vegetation
6.20	20	Building-developments kept away from bodies of water
5.98	35	Fish farms
5.89	42	Local population density controlled through water supply
5.52	25	Stream bottoms unsealed, not concreted
5.35	39	Water-resources personnel having good community relations
5.17	19	Natural rivers, free of dams
4.84	3	Water that is not too hard
4.45	30	Visually inoffensive water facilities or plants
4.17	33	Opportunity to live conveniently near to bodies of water
4.07	29	Bodies of water free from excessive noise
3.65	7	Water to keep the streets clean
3.54	8	Water for private or public swimming pools
2.46	32	Water sounds for people to enjoy

* Preference ratings
** Original list number

One of the papers, that by Gum [7], actually presented a technique for quantifying aesthetic opportunities. In the summer session, the participants agreed that this approach had possible merit. It is not described in detail in this report, but the reader is referred to the original publication.

Another interesting approach to the quantificatior of these intangibles was presented by Battelle Laboratories, for the Atomic Energy Commission [8]. This document, which was basically prepared to present a methodology for evaluating social and aesthetic values associated with nuclear power plants, contains a methodology which might be useful for water resources projects. They examined a number of data sources, and determined that eight criteria were significant for use in analyzing nuclear plant options. These were: economics, water quality, air quality, animal/plant life, cultural/recreational, health/safety, aesthetics and land use. In the case of aesthetics, a method was developed to express relationships between viewscape quality and the basic components of the impactness, vividness and unity. The analysis can be complex up to the point where it becomes burdensome, according to the report. They identified three major weaknesses in the methodology for evaluating alternatives. These were: 1) lack of quantification of most effects, 2) lack of measure of community social values, 3) lack of methods for integrating social values with techno-economic ones. This report should be of significant interest to landscape planners and members of the interdisciplinary teams most interested in the visual impact of their designs. It is felt that the methodology is too detailed and complex for engineers working on UFDC projects.

In summary, a great deal of literature is becoming available on the quantification of intangible costs and benefits. These have been recognized as important for the evaluation of water resources projects at the federal level. The emergence of the new federal "Principles and Standards for Water Resources Planning," which puts environmental quality in as an objective, essentially equal with national economic development, signals that intangible benefits are to be considered in a significant fashion. The only appropriate methods to display them at the present time appear to be through a descriptive approach with none of the quantification methodologies yet being adaptable at the practical level. Some additional literature is sighted in the references for this chapter, for those readers who would like to investigate this question further.

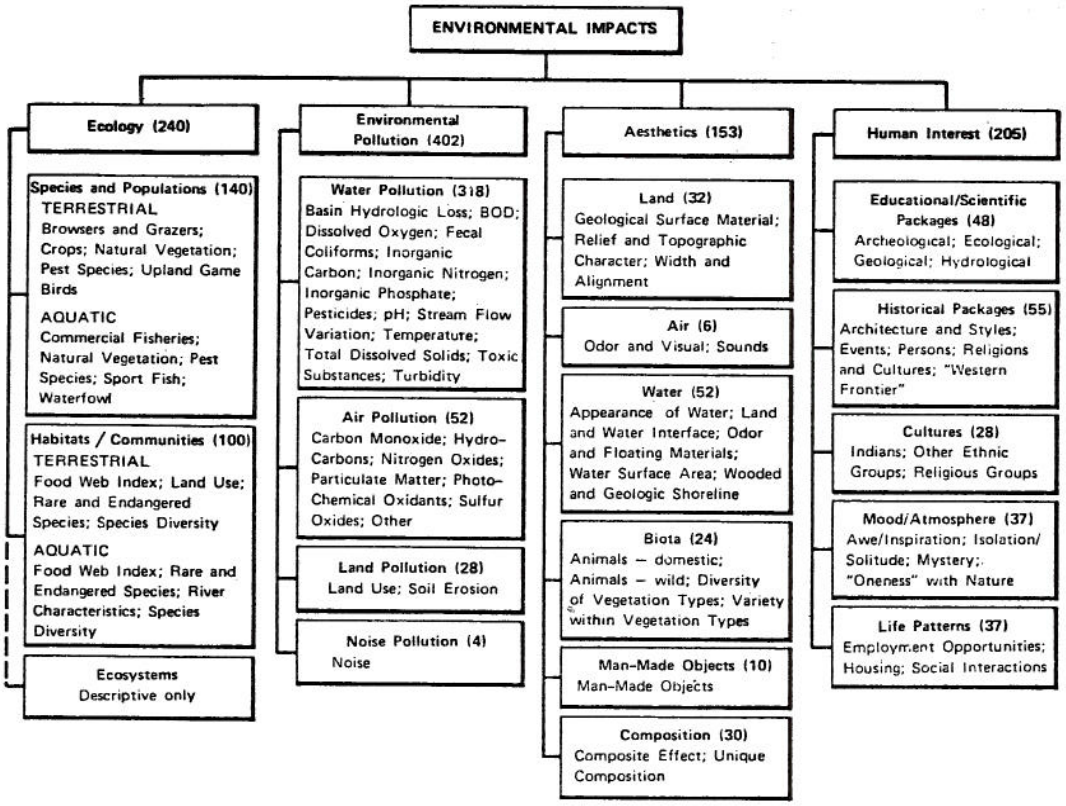

Figure VII-1. The Environmental Evaluation System (EES) Applied to a Specific Study [5]

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Chapter 8
REALITIES OF IMPLEMENTATION

Implementation is the most crucial and difficult 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 previously in this report that over half of the recommendations contained in the comprehensive APWA drainage report of 1966 [6] were for more work on implementation and financing.

Implementation is a deliberate and phased process tempered by political pressures. In metropolitan areas, implementation is complicated by multi-jurisdictional problems.

The initial step in the implementation phase is the master planning process, which consists of definition of the problems and solutions, development of facts, and preparation of a preliminary design for an agreed-upon solution. It is during the master planning process that benefits and costs are identified for the various solutions available. Benefits and costs are an important aspect of alternative selection, which in some cases is very difficult, particularly when several entities are involved.

Benefit and cost facts serve as input for decision making and should be considered in this perspective. The alternative with the highest benefit-cost ratio may be unacceptable because of high capital costs or adverse environmental effects. However, benefit-cost analysis may be used to optimize a given design using storm frequency as the variable. Another possibility may be to select an alternative with a favorable benefit-cost ratio (but not necessarily the highest) but with a low capital cost. In any event, benefit and cost facts provide the information necessary for public works officials and political bodies to compare, consider, evaluate, and select desirable and cost effective solutions to drainage and flooding problems.

The completion of a preliminary design does not guarantee implementation. However, it is difficult to implement without a preliminary design. There is typically a limited amount of general funds available for drainage improvements, and a critical problem is how to allocate the available monies. This is where the political process plays a critical role, with the general criterion being the distribution of funds over a period of time to benefit all constituencies in a manner similar to their contribution. This is generally true regardless of the level of government involved. At the local government level, councilmen or county commissioners try to get things done for the districts they represent. At the state level, legislators must keep those that elected them happy. At the federal level, the "pork barrel" projects championed by legislators from local areas are common.

To a large extent, implementation depends on political pressure which in turn, is generated by the affected public. The public works official is usually aware of the problems and is generally not surprised by political pressure. If he has prepared well, he may have a master plan on hand that can provide a basis for implementation. If a solution is defined, and costs and benefits identified, the professional and his process and the political representative and his process can join forces to attack the problem.

With the technical background and political support, the public works official attempts to develop ways to finance the proposed improvements. There is a distinction between types of projects and sources of finance because the beneficiaries vary with different projects. It is difficult to justify using general tax funds to finance a project of obviously localized benefit. It is not impossible, however, if it can be shown that general funds will be distributed equally throughout the region over a reasonable period of time. The time frame is usually a problem, however, and pressure develops to solve problems in a more rapidly responsive manner.

Politically, elected policy makers will be more inclined to work toward financing drainage solutions if they have received adequate information as to the problem, who is affected, and costs and time of potential solutions.

The concept of incidence and equity can provide a basis for a method for addressing problems in a time frame consistent with political pressures. If the relationship between project cost and those who benefit can be identified, then funding schemes can be developed based on equity. If the people who benefit do not want to pay, then the general public cannot be expected to pay, and that problem can be dropped for the time being. Some common practices regarding finance sources for different type projects are listed in Table VIII-1. It was shown earlier in Figure II-1 that major and minor UDFC projects result in different types of benefits, which necessitates justifying each effort on a project-by-project basis.

There is a rather sparse literature on the specific problems of financing UDFC systems. A recent Water Resources Council 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 exist, however, considerable literature on the subject of public finance at the federal, state, and local level. Public finance is a respectable discipline within the economics/public administration disciplines. The reader is referred to Reference [5] for an overview of this area. Finally, there exists 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. The Colorado State Legislature, however, did pass legislation in 1975 to define what benefits may be accrued to a drainage or flood control project. Appendix A is devoted to a legal analysis of this problem and includes a copy of the legislation.

There are three basic methods which can be used to raise funds for urban drainage facilities: (a) general ad valorem taxes and/or sales 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 and Sales 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 and many other cities in Colorado, also have head and sales taxes which generate revenue for general funds. 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 benefited" by such improvements. The term "especially benefited" has been generally defined by state courts as increase or enhancement of value in property. However, the Colorado State Legislature recently defined the term "benefit" but the new law has not yet been tested.

Service Charge 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. At present, there is specific authority in Colorado statutes for service charges or fees for drainage. Such a method of charging users has operational precedent with water, sanitary sewer, airport, parking, turnpike, park, 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, which is the necessity to be able to relate benefits to beneficiaries.

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].

Table VIII-1. Sources of Finance for Different Types of UDFC Projects

Development Phase \ Project Type	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) Service Charge
New Development	Developer's Responsibility Basin Fees Master Planning	Basin Fees Master Planning Dedications Anticipatory Zoning

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Appendix A
LEGAL BASIS FOR ESTABLISHING DRAINAGE BENEFITS INCLUDING MODEL LEGISLATION

1. "What Constitutes 'Benefits' for Urban Drainage Projects"

2. Senate Bill No. 52

As part of this project a paper was prepared by W. J. Shoemaker, a Denver attorney and Colorado State Senator, on the legal problems of establishing drainage benefits. Subsequently, Senator Shoemaker introduced Senate Bill 52 into the legislature to provide for the establishment of these benefits, dependent upon sound technical analysis.

Senator Shoemaker's background paper appeared in the Denver Law Journal, Vol. 51, No. 4, 1974, and is reproduced here. Senate Bill 52, which can serve as model legislation, appears afterwards.

WHAT CONSTITUTES "BENEFITS" FOR URBAN DRAINAGE PROJECTS

BY W. JOSEPH SHOEMAKER*

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.[1]

INTRODUCTION

Colorado has a history of finding legal justification for public improvements as the holding above witnesses. *Milheim v. Moffat Tunnel Improvement District*, a famous Colorado case, involved an even more famous engineering feat, that of boring a railroad tunnel, with provisions for a 108-inch water pipe, through the Rocky Mountains. That case has set a precedent upon which proponents of urban drainage projects may also rely. In order to use the *Milheim* precedent to advocate such a cause, however, it is important to understand the distinction between assessing property for *general benefits* which accrue to the community at large as contrasted with assessing property for the *special benefits* which must accrue directly and solely to the owner of the land in question and not to others. *Milheim* approved of the former method of assessing, although most of its language related to the special benefits the property owners would receive.

Most public improvements, including urban drainage projects, are financed with revenues obtained from taxes paid by the public.[2] Drainage improvements in rural areas have long been financed by establishing drainage districts[3] which assess rural lands for the cost of building and maintaining drainage facilities, while urban areas have been given authority to use local improvement and special improvement districts to build drainage works.[4]

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[1] *See* Milheim v. Moffat Tunnel Improvement Dist., 262 U.S. 710 (1923), *aff'g* 72 Colo. 268, 211 P. 649 (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, because such fees relate to services received as opposed to the value of one's property.

[3] COLO. REV. STAT. ANN. § 47-1-1 (1963).

[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 . . . ." *id.* § 89-2-2(1)(a) (1963).

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 be *generally benefited* to the extent of the additional taxes is the determinative issue. In special improvement districts, the property owners are assessed in relation to the *special 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 urban 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 responsible governmental builder will clearly delineate the *benefits* to be received by his constituents from proposed drainage projects *before* adding to the 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.[5] One objective of this article is to provide some background on what courts may decide on urban drainage projects as to *special* versus *general* benefits.

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, in which *special benefits* have to be proved. The main undertaking of this article 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. Additionally, the legal meaning of *benefits* as interpreted by the courts in different factual settings will be examined.

I. SPECIAL BENEFITS

The commonplace problem of surface water drainage has been around for so long that some municipal officials have ignored the

[5] Legislation is needed in most jurisdictions to define "benefit"; see proposal presented in CONCLUSION *infra*.

flood and health hazards which outmoded drainage systems pose to our growing cities.[6]

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.[7] 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. A brief review of this method of financing *special* drainage improvements will 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 the benefits received.[8]

This method of financing an improvement follows the historical language contained in the statutory authorization[9] allowing farmers to join together in a district to drain their lands by tiling, building drainage channels, or deepening existing natural waterways. Property owners pay the cost of such projects by assessing a mill levy against properties in the district commensurate to *benefits* received.

[6] Editorial preface to Shoemaker, *An Engineering-Legal Solution to Urban Drainage Problems*, 45 DENVER L.J. 381 (1968).

[7] *Id.* 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 mill for planning purposes and authority to seek 2 mills for construction of projects. COLO. REV. STAT. ANN. § 89-21-22(4) (Supp. 1969), *as amended*, § 89-21-22(4) (Supp. 1971). In 1973, the Colorado Legislature added an additional authorization to the Board of four-tenths mill for construction of drainage and flood control improvements. Ch. 286, § 1, [1973] Colo. Sess. Laws 996.

[8] CITY AND COUNTY OF DENVER, COLO., CHARTER § A2.4.

[9] *Id.* at A2.6.

[10] 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 less number denoting its per cent of benefit."

It is noteworthy that nowhere in the entire 18 sections of the Colorado statute[11] is the word *benefits* defined. This legislative failure to define *benefits* has delegated the duty to the courts. The cases do not directly define *benefits*, but rather tell what *benefits* are not. This narrow negative interpretation of *benefit* legislation discourages municipal officials interested in building drainage improvements. What follows is the putting into perspective of 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 based on the owner's contention that *his* property was not *specially* benefited, essentially meaning that it received no more benefit than anyone else's property. All of the following factual situations are matched against the special improvement financing theory that the basis of the right to levy an assessment for an improvement is the particular benefit received by the property charged.[12]

A landmark case is *Ferguson v. Borough of Stamford*,[13] 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, improvements should be apportioned, as far as possible, equitably among all who are similarly interested. Stated another way, a general benefit alone will not support a special assessment to help pay the cost of a drainage project. There must be a special benefit to the specific property to be charged which increases its value, relieves it from a burden, or adapts it to a superior or more profitable use.[14]

Another case defining the elements of *special benefit* with greater certainty is *Peterson v. Thurston*,[15] where it was declared proper to consider whether a drain would make 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*,[16] 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

[11] COLO. REV. STAT. ANN. § 47-4-1 (1963).
[12] 25 AM. JUR. 2d *Drains and Drainage Districts* § 45 (1966).
[13] 60 Conn. 432, 22 A. 782 (1891).
[14] 25 AM. JUR. 2d *Drains and Drainage Districts* § 46 (1966).
[15] 161 Neb. 708, 74 N.W.2d 528 (1956).
[16] 241 Minn. 6, 62 N.W.2d 80 (1954).

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:

> [T]he 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.[17]

The county contended 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; and, in fact, that the open ditch had a greater capacity for drainage than any tile which could be installed. The county further 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 Minnesota Supreme Court found the plaintiff *not* to be *specially* benefited and based its finding on the language of the statute involved.[18] "'[L]ands 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.' "[19] The court held neither to be the case here.

In *Cirasella v. Village of South Orange*,[20] 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 storm-sewer improvement had been built to carry the surface runoff from the lands of plaintiff and others. The New Jersey court, in affirming a lower court ruling that plaintiff's lands were not *benefited*, stated:

> 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

[17] *Id.* at 9, 62 N.W.2d at 83.
[18] MINN. STAT. § 106.151 (1971).
[19] Hoepner v. Yellow Medicine County, 241 Minn. 6, 10, 62 N.W.2d 80, 84 (1954).
[20] 57 N.J. Super. 522, 155 A.2d 134 (1959).

> which the property is supposed to have derived therefrom . . . . 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 of 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 now 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.[21]

In *Frank v. Renville County*,[22] 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 that benefits accrued to the land.

[21] *Id.* at 525, 155 A.2d at 137 *citing In re* Public Service Elec. & Gas Co., 18 N.J. Super. 357, 363, 87 A.2d 344, 346 (App. Div. 1952). For purposes of determining whether property will be benefited by creation of a parking district, "[b]enefit is usually considered as tending to reflect enhancement in the market value of property . . . . Local zoning ordinances are matters which help determine market values . . . ." Jeffery v. City of Salinas, 232 Cal. App. 2d 29, 37, 42 Cal. Rptr. 486, 493 (1965).

When the owner of a lot is taxed for municipal improvements, the *benefit* is not the benefit to the public at large *but to the owner of the lot*. The phrases *benefits* and *increased value* are interchangeable terms since, where tax is apportioned according to the increased value of a lot, they are 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, 478 (1857).

Benefit is the increment of value to land affected by improvement and represents the difference between market value of land before improvement and immediately after improvement. Assessments 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. Rochelle Park T., 13 N.J. Misc. 841, 181 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 improvement, an increase in market value of his property. Weyerhaeuser Timber Co. v. Banker, 186 Wash. 332, 342, 58 P.2d 285, 289 (1936).

[22] 242 Minn. 172, 64 N.W.2d 760 (1954).

Damages to the plaintiff's land were also established and the plaintiff appealed both 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 3 or 4 acres of crop on his land was lost in 2 out of 5 years because of inadequate drainage. He further claimed his land was substantially and materially damaged 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 further contended that the creation of the banks (caused by increasing the depth of the ditch from 8 to 10 feet), the cost of a bridge crossing over the ditch, and resulting inconveniences to his farming operations were damages for which he should be compensated. The Minnesota 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.[23] In *Santa Fe Land Improvement Co. v. City & County of Denver*,[24] a sanitary sewer special improvement district case, the court found support for special assessments under 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. That is, 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*,[25] upholding a district court ruling that property was benefited, the Colorado Supreme Court stated:

> Generally speaking, only such benefits are to be assessed as it is

[23] Milheim v. Moffat Tunnel Improvement Dist., 72 Colo. 268, 211 P. 649 (1922). Legal practitioners have questioned, however, whether the landmark case of *Milheim* 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 conclusions using both *special benefit* and *general benefit* language.
[24] 89 Colo. 309, 313, 2 P.2d 238, 239 (1931).
[25] 47 Colo. 79, 105 P. 107 (1909).

> reasonably apparent the property will receive 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 price which otherwise they could not command, because of their desirability . . . ."[26]

Town of Fort Lupton v. Union Pacific Railroad Co.[27] 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 Colorado Supreme Court affirmed a lower court's finding that no benefit inured to the railroad 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.[28]

It should be apparent at this point that some differences exist among the various definitions of *special benefits*, depending upon whether urban or rural land is involved. The above cases are in general agreement 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 landowner 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 above 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

[26] *Id.* at 86, 105 P. at 114 (emphasis added).

[27] 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). In *Burnside*, the Colorado Supreme Court upheld a statute which excluded railroad property from levy for recreational district purposes. 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." *Id.* at 431, 448 P.2d at 791. It would be helpful if the legislature were to set forth what constitutes benefits, or criteria for public officials to use.

[28] *Id.* at 354, 399 P.2d at 249.

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 landowner 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.

In all cases where the special improvement assessment has been upheld, the burden was on the assessing government to show that the improvement had a unique and distinguishable benefit to the particular land owner assessed, apart from and beyond benefit to the public at large.

II. General Benefits

It would be most helpful to builders of urban drainage improvements if legislative bodies defined potential types of benefits from urban drainage projects, leaving exact dollar amounts to the facts of each proposed improvement. Thus, if a special improvement district were determined the best method of financing the improvement, the types of benefits would have to be evaluated with respect to each piece of property assessed. On the other hand, if property were to be assessed generally for the cost of the improvement, the types of benefits would only have to be evaluated for the total area covered by the district to answer the general question of whether benefits equalled or exceeded the cost of the improvement.

There are several resources to assist legislators in drafting types of benefits. Benefit has been defined as "[a]dvantage; profit; fruit; privilege,"[29] and also as:

> [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.[30]

Moreover,

> "[b]enefit" 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.[31]

[29] BLACK'S LAW DICTIONARY 200 (4th ed. 1951).

[30] BALLENTINE'S LAW DICTIONARY 131 (3d ed. 1969). See National Surety Co. v. Jarret, 96 W. Va. 420, 121 S.E. 291 (1924) for a testamentary definition of benefit.

Benefit has also been defined in general terms in cases. The leading Colorado case of *Milheim* goes into some detail as to what constitutes a *benefit*.[32] 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 Tunnel Improvement District in *Milheim* was created for the construction of a transportation tunnel through the continental divide for transportation between the 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 Colorado Supreme Court 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.[33]

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, the criteria followed by the court consisted of (a) the physical conditions of the country; (b) the needs of a 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.[34]

It was further contended by the plaintiffs that the benefits were unequal. The court stated: "The law does not require that the benefits should be exactly equal."[35] The plaintiffs further objected on the grounds that no special benefits accrued to the property owners in Jefferson County because of the tunnel. The court noted:

> [T]he tunnel will make possible the delivery of coal in Denver at a considerably lower freight rate, and hence make it probable that the growth and prosperity of the city will be materially promoted. That being true, the lands in Jefferson County within this district will assuredly increase in value with the growth of Denver.[36]

[31] A. Booth & Co. v. Weigand, 30 Utah 135, 83 P. 734 (1906).

[32] Milheim v. Moffat Tunnel Improvement Dist., 72 Colo. 268, 211 P. 649 (1922).

[33] *Id.* at 270, 211 P. at 651.

[34] *Id. citing* Tanner v. Treasury Tunnel, Mining & Reduction Co., 35 Colo. 593, 596, 83 P. 464, 465 (1906).

[35] *Id.* at 273, 211 P. at 653.

A concurring opinion in *Milheim* further observed that:

> The area of the district is one which is cut off from intercourse with the rest of the world for many weeks in the year . . . . The lack of easy communication, and, for some periods during the year, of any communication at all, 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 is needed and will benefit the district in a peculiar and local way above any possible benefit to the state at large.[37]

The broad interpretation of *benefit* by the Colorado Supreme Court lends credence to a possible effort by the Colorado Legislature to define *benefit*.

Courts in other jurisdictions have also expanded upon the meaning of benefits for purposes of justifying taxation of property to defray the costs of improvements. In a recent Florida case involving the ecological impact of a proposed project, *Seadade Industries v. Florida Power & Light Co.*,[38] it was held 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. In *Seadade*, the plaintiff maintained that the proposed canal to carry spent cooling water from a generating plant to the body of water into which it was to be discharged, was unnecessary because the spent water would harm the permanent body of water. The Florida Supreme Court found that the defendant successfully showed that the discharge would be acceptable and no irreparable harm would result. The type of benefit under consideration related to preservation of a permanent body of water.

A case distinguishing assessment for benefits to the general public from assessments to particular property not specially benefited, is *Crampton v. City of Royal Oak*.[39] Royal Oak had 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 bene-

[36] *Id.* at 278, 211 P. at 654.

[37] *Id.* at 290-91, 211 P. at 658.

[38] 245 So. 2d 209 (Fla. 1971).

[39] 362 Mich. 503, 108 N.W.2d 16 (1961).

fited" and that the city's method of assessing, *i.e.*, one part on assessed value of the land for general tax purposes and the second part based on closeness or remoteness and square footage of each parcel, was in error.

The Michigan Supreme Court in *Crampton* reversed a lower court decision which had upheld the assessor's method. In declaring that special assessments must be based on special benefits to particular parcels of property and not on assessed valuation, the court referred to an earlier Michigan decision, *Grand Rapids School Furniture Co. v. City of Grand Rapids*,[38] 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."[39] The Michigan Supreme Court also reaffirmed an earlier principle that "future probable advantages may be considered in assessing benefits, and that incidental benefits may be taken into account as well as those directly received by the land."[40] 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.[41]

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 dissenting opinion, 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.[42]

[38] 92 Mich. 564, 52 N.W. 1028 (1892).
[39] *Id.* at 569, 52 N.W. at 1029.
[40] 362 Mich. at 522, 108 N.W.2d at 24.
[41] *Id.* at 523, 108 N.W.2d at 25-26.
[42] *Id.* at 532, 108 N.W.2d at 29.

Justice Black 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 convenienced 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.[43]

This case is particularly important because it establishes types of benefits that may be present. The special assessments were set aside as a mechanism for financing the proposed improvement because there was inadequate evidence to support the types of benefits as related to specific parcels.

Health and sanitation improvements have also been cited by several courts as a type of benefit for assessing lands for drainage improvements.[44] As related to this type of benefit, the cases seem to indicate that even though it is impossible under the circumstances to ascertain the exact monetary benefit resulting directly to land from an urban drainage project relieving a health and sanitation problem, the land may nevertheless be subject to assessment on the basis of the improvement to health and sanitation.

III. Legislative Action

"[T]he Legislature is . . . invested with a wide discretion . . . [in] imposing a tax . . . ."[45] 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.[46] As was noted previously,[47] the Colorado statutes use the word *benefits*, but nowhere do the statutes define the term.[48] Since the legislature has seen fit to relate assessments and taxation to benefits, specifi-

[43] *Id.* at 533-34, 108 N.W.2d at 30.
[44] Garden of Eden Drainage Dist. v. Bartlett Trust Co., 330 Mo. 554, 562, 50 S.W.2d 627, 631 (1932): "What is termed hill land, when contiguous to or surrounded by swamp-land, may be greatly benefited by draining such disease producing swamps, or the means of ingress and egress to and from such lands . . . ." *See also* Dean v. Wilson, 267 Mo. 268, 183 S.W. 611 (1916).
[45] Bedford v. Johnson, 102 Colo. 203, 210, 78 P.2d 373, 377 (1938).
[46] Clark v. City of Royal Oak, 325 Mich. 298, 38 N.W.2d 413, *cert. denied*, 338 U.S. 890 (1949).
[47] *See* text accompanying note 11 *supra*.
[48] No statutory definition of benefit in other jurisdictions has been discovered.

cally as related to drainage projects, the next step should be the establishment of criteria for determining what constitutes types of *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.

Conclusion

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 purpose of assessing a particular property within a drainage district (or special improvement district), may include any one or more of 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.
> h. The dollar value or values of any one or more of the above a. through g. accruing to a specific parcel of property or the total property of a taxing entity shall be determined as related to the cost of the specific 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.[51] erefore, assessment according to the above types of benefit is well within judicial limits.[52] The legislature should take the necessary action to enact such a provision defining types of benefits. It is a broader definition than most state courts have followed and is a step toward encouraging the construction of needed urban drainage improvements, while at the same time affording protection to property to be assessed from irresponsible charges.

[51] Miller & Lux, Inc. v. Sacramento Drainage Dist., 256 U.S. 129 (1921).
[52] *See also* Morton Salt Co. v. City of S. Hutchinson, 159 F.2d 897 (10th Cir. 1947); Barten v. Turkey Creek Joint Dist., 200 Kan. 489, 438 P.2d 732 (1968); Curtis v. Louisville & Jefferson County Metropolitan Sewer Dist., 311 S.W.2d 378 (Ky. 1958).

Colorado Legislation Defining "Benefits"

Colorado's progressive Legislature was presented with the SB 52 in January, 1975. After passing the Senate, it passed the House on June 6, 1975. Both Houses and the respective Local Government Committees were presented copies of the preceding paper.

The Legislators were generally unaware that previous legislatures had used the word "benefits" in eighteen sections of Colorado Statutes, but nowhere defined the term. Legislators were also eager to expand upon the norrow definition given to "benefits" by Courts. Finally, the references in SB 52 to (1) dominant owners discharging excess water on to servient property; (2) alleviation of health and sanitation hazards; (3) reduction in maintenance costs; (4) increase in convenience to property owners; and (5) recreational improvements resulting from some drainage improvements, were persuasive arguments to the legislators, as developed by the previous phase of this research project.

SB 52 amends with the same language five separate sections of Colorado Statues.

1975

An Act

SENATE BILL NO. 52. BY SENATORS Shoemaker and Sandoval; also REPRESENTATIVE Strahle.

PROVIDING FOR ASSESSMENT OF BENEFITS ACCRUING TO PROPERTY WITHIN VARIOUS TYPES OF IMPROVEMENT DISTRICTS WHICH PROVIDE FOR WATER DRAINAGE.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Part 5 of article 20 of title 30, Colorado Revised Statutes 1973, is amended BY THE ADDITION OF A NEW SECTION to read:

30-20-512.5 Determination of special benefits - factors considered. (1) The term "benefit", for the purposes of assessing a particular property within a public improvement district, particularly with respect to storm sewer drainage and to drainage improvements to carry off surface waters, includes, but is not limited to, the following:

(a) Any increase in the market value of the property;

(b) The provision for accepting the burden from specific dominant 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 accruing to public property in the improvement 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 improvement district;

(e) Any reduction in the maintenance costs of particular property or accruing to public property in the improvement 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 improvement 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) Recreational improvements accruing to particular property owners as a direct result of drainage improvement.

SECTION 2. Part 6 of article 20 of title 30, Colorado Revised Statutes 1973, is amended BY THE ADDITION OF A NEW SECTION to read:

30-20-605.5. Determination of special benefits - factors considered. (1) The term "benefit", for the purposes of assessing a particular property within an improvement district, particularly with respect to drainage improvements to carry off surface waters, includes, but is not limited to, the following:

(a) Any increase in the market value of the property;

(b) The provision for accepting the burden from specific dominant 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;

Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

(d) Any alleviation of health and sanitation hazards accruing to particular property or accruing to public property in the improvement 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 improvement district:

(e) Any reduction in the maintenance costs of particular property or accruing to public property in the improvement 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 improvement 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) Recreational improvements accruing to particular property owners as a direct result of drainage improvement.

SECTION 3. Part 5 of article 25 of title 31, Colorado Revised Statutes 1973, as amended by House Bill No. 1089, enacted at the First Regular Session of the Fiftieth General Assembly and approved by the Governor on May 1, 1975, is amended BY THE ADDITION OF A NEW SECTION to read:

31-25-506.5. Determination of special benefits - factors considered. (1) The term "benefit", for the purposes of assessing a particular property within a storm sewer improvement district, includes, but is not limited to, the following:

(a) Any increase in the market value of the property;

(b) The provision for accepting the burden from specific dominant 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 accruing to public property in the improvement 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 improvement district;

(e) Any reduction in the maintenance costs of particular property or of public property in the improvement 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 improvement 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;

(g) Recreational improvements accruing to particular property owners as a direct result of drainage improvement.

SECTION 4. Article 5 of title 37, Colorado Revised Statutes 1973, is amended BY THE ADDITION OF A NEW SECTION to read:

37-5-104.5. Determination of special benefits - factors considered. (1) The term "benefit", for the purposes of assessing a particular property within a conservancy district particularly with respect to regulating stream flow to control floods includes, but is not limited to, the following:

(a) Any increase in the market value of the property;

(b) The provision for accepting the burden from specific dominant 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 accruing to public property in the improvement 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 improvement district;

(e) Any reduction in the maintenance costs of particular property or of public property in the improvement 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 improvement 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) Recreational improvements accruing to particular property owners as a direct result of drainage improvement.

SECTION 5. Article 23 of title 37, Colorado Revised Statutes 1973, is amended BY THE ADDITION OF A NEW SECTION to read:

37-23-101.5. Determination of special benefits - factors considered. (1) The term "benefit", for the purposes of assessing a particular property within a drainage system improvement district, includes, but is not limited to, the following:

(a) Any increase in the market value of the property;

(b) The provision for accepting the burden from specific dominant 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 accruing to public property in the improvement 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 improvement district;

(e) Any reduction in the maintenance costs of particular property or of public property in the improvement 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 improvement 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) Recreational improvements accruing to particular property owners as a direct result of drainage improvement.

SECTION 6. Effective date. This act shall take effect July 1, 1975.

SECTION 7. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

Fred E. Anderson
PRESIDENT OF
THE SENATE

Ruben A. Valdez
SPEAKER OF THE HOUSE OF
REPRESENTATIVES

Comfort W. Shaw
SECRETARY OF THE
SENATE

Evelyn T. Davidson
CHIEF CLERK OF THE HOUSE
OF REPRESENTATIVES

APPROVED _____

Richard D. Lamm
GOVERNOR OF THE STATE OF COLORADO

Appendix B
DAMAGE ESTIMATION DATA

1. Table B-1. 1975 Revised Depth-Damage Curves for FIA Residential and Samll Business Structures.

2. Table B-2. 1975 Revised Depth-Damage Curves from FIA Residential Contents

3. "State-of-the-Art of Estimating Flood Damage in Urban Areas"

Earlier in this research project, an analysis was made of the state-of-the art of estimating flood damages. It was found that although estimation procedures were widespread in federal agencies, little information was available in the engineering literature.

A paper was prepared and published in the Water Resources Bulletin (Vol. 11, No. 2, April 1975), which presented some information on this topic. Other information has since been identified in other publications. The above paper is reproduced here for the information of the reader.

The Federal Insurance Administration has been active in studying depth-damage data. They recently prepared revised, generally reduced relationships for residential and small business structures. These are given as Tables B-1 and B-2.*

Table B-1

1975 REVISED DEPTH-DAMAGE CURVES FROM FIA RESIDENTIAL AND SMALL BUSINESS STRUCTURES

	Curve No.						
	01	03	05	10	13	18	23
Depth, ft.	Damage in % of Market Value						
-3					0	0	0
-2					4	3	3
-1	0	0	0	0	8	5	5
0	7	5	3	8	11	7	6
1	10	9	9	45	18	11	16
2	14	13	13	64	20	17	19
3	26	18	25	74	23	22	22
4	28	20	27	79	28	28	27
5	29	22	28	80	33	33	32
6	41	24	33	81	38	35	35
7	43	26	34	82	44	38	36
8	44	31	41		49	40	44
9	45	36	43		51	44	48
10	46	38	45		53	46	50
11	47	40	46		55	48	52
12	48	42	47		57	50	54
13	49	44	48		59	52	56
14	50	46	49		60	54	58
15		47	50			56	59
16		48				58	60
17		49				59	
18		50				60	

*Furnished by Mr. Sam Brugger, FIA, April, 1975.

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

Table B-2

1975 REVISED DEPTH-DAMAGE CURVES FROM FIA RESIDENTIAL CONTENTS

	Curve No.						
	27	29	31	38	41	46	51
Depth, ft.	Damage in % of Total Value						
-4					0	0	0
-3					45	5	5
-2	0	0	0	0	50	7	6
-1					55	8	9
0	10	7	1	3	60	15	11
1	17	9	2	27		20	17
2	23	17	3	50		22	22
3	29	22	4	65		28	28
4	35	28	5	71		33	33
5	40	33	6	76		39	39
6	45	39	6	78		44	44
7	50	44	6	49		50	49
8	55	50	6	81		55	55
9	60	55	10	83		60	61
10		58	17				64
11		65	23				71
12		72	29				76
13		78	35				78
14		79	40				79
15		80	45				80
16		81	50				81
17			55				
18			60				

Classification	Curve No.
All on first floor	27
All on first two floors	29
All above first floor	31
Mobile home on foundation	38
All in basement	41
All on first floor and basement	46
All on first two floors and basement	51

WATER RESOURCES BULLETIN
VOL. 11, NO. 2 AMERICAN WATER RESOURCES ASSOCIATION APRIL 1975

STATE-OF-THE-ART OF ESTIMATING FLOOD DAMAGE IN URBAN AREAS[1]

Neil S. Grigg and Otto J. Helweg[2]

ABSTRACT: With implementation of the Flood Insurance Act of 1968 many additional local flood protection projects are being considered. Consulting engineers and local agencies need consistent methods to estimate flood damage in order to perform feasibility studies. Federal agencies have a great deal of data and long experience in making damage estimates but no comprehensive guides are available at the local level. Curves of flood damages to different residential structure types are presented. The relationships in use by the U. S. Federal Insurance Administration are shown to be reasonable and are recommended for use as approximate guides. Additional research is recommended and discussion of the paper is invited in order to make additional data available in the literature.
(KEY TERMS: damages; drainage; flood control; land use; management; planning; zoning.)

INTRODUCTION

When flood 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 [Breaden, 1973]

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 damages which should be considered. Damages to property vary according to the type of

[1] Paper No. 74065 of the *Water Resources Bulletin*. Discussions are open until August 1, 1975.
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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 [Grigg and Helweg, 1974] 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 [Breaden, 1973]. 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 [Kates, 1965] 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 [Breaden, 1973]. 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 [Breaden, 1973]. It has been shown that people are willing to pay annual insurance premiums

exceeding the expected annual losses to avoid financial disaster or even the financial inconvenience of irregular budgeting [Breaden, 1973]. 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. 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 projects 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." [Ackermann, et al., 1968]

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 [1969]. 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 [1964].

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 source 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 [Ackermann, 1968]. 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 [Homan and Waybur, 1960; USDA, 1970] 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 [White, 1964]. 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 [1973] and James [1972] have published examples of the aggregate formula approach. For example, James [1972] suggests that for estimation purposes,

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

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 structure 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 [1958]. As shown on Figure 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.

Where:

- D_i = the damage for the i^{th} flood selected
- P_i = exceedance probability of the i^{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 [Cornell et al., 1972; TVA, 1959]. 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.

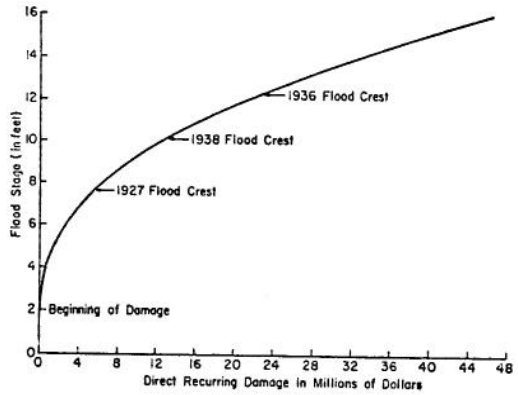

Figure 1. Historical Depth-Damage Curve.

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 structure (with contents) in the flood plain. This is illustrated in Figure 2. Structures can include roads and other

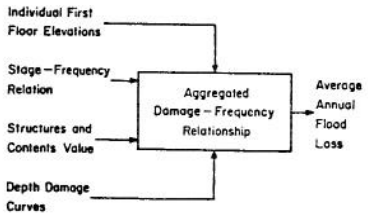

Figure 2. Computational Procedure for Average Annual Flood Loss.

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 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) [1960]. From their data, a regression equation was developed with the following results:

$$100\frac{V_c}{V_s} = 42.0818 - .00072\,V_s \qquad (2)$$

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% or $5,000. 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,

$$V_t = V_s + V_c \qquad (3)$$

$$D_t = D_s V_s + D_c V_c \qquad (4)$$

$$\frac{D_t}{V_t} = \left[\frac{D_s}{1.3} + \frac{D_c}{4.33}\right] \qquad (5)$$

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 [TVA, 1960; USACE, 1970; USDA, 1974; FIA, 1970]. 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.

Figures 3 through 6 show depth-damage curves for four main types of residential structures. Figure 7 shows a comparison between one type of house with and without a basement. Figure 8 is the result of a study conducted by the TVA [1969], 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 3 through 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 assuracy 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.

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 [Cornell, 1972].

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.

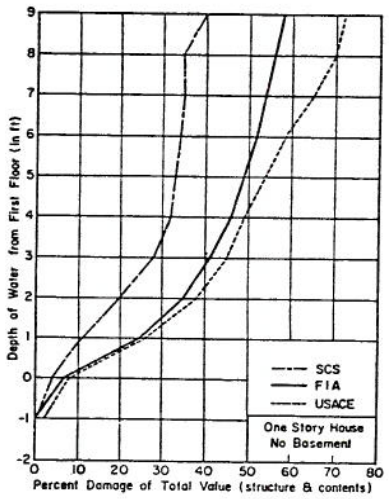

Figure 3. Depth-Damage Curves
One Story House, No Basement.

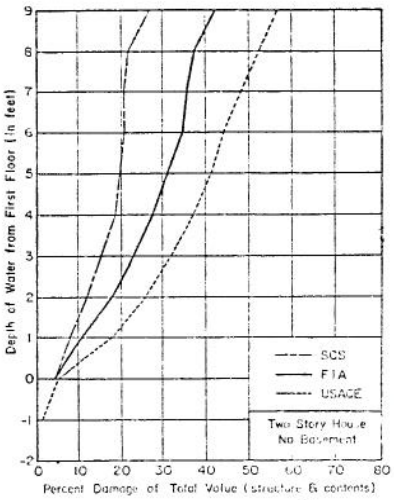

Figure 4. Depth-Damage Curves Two Story House, No Basement.

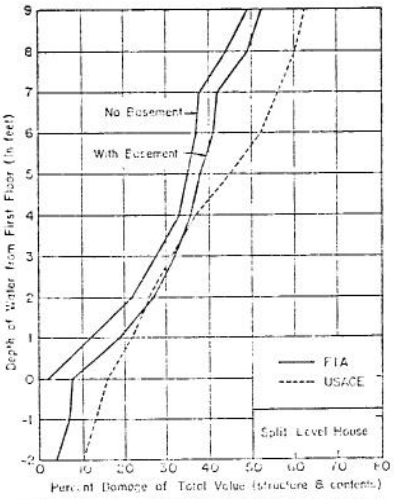

Figure 5. Depth-Damage Curves Split Level House.

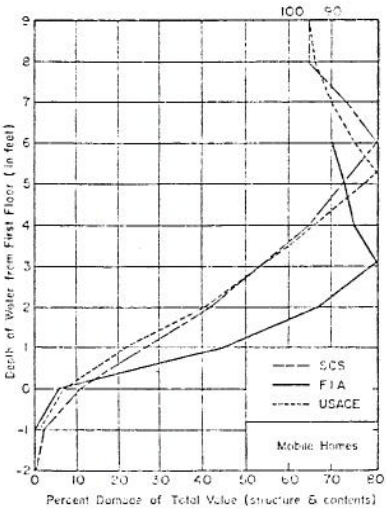

Figure 6. Depth-Damage Curves Mobile Homes.

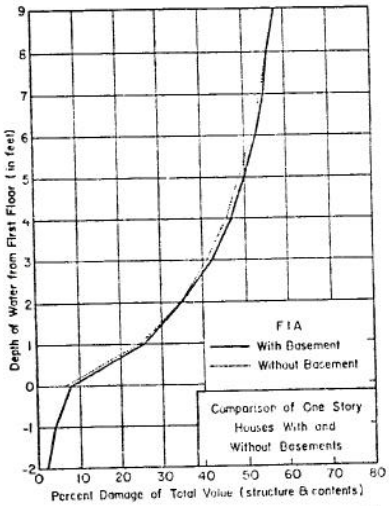

Figure 7. Comparative Depth-Damage Curves With/Without Basements.

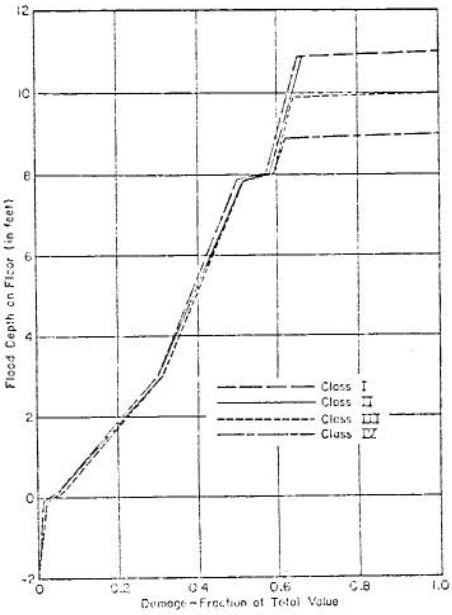

Figure 8. Depth-Damage Curves for One Structure, Four Value Classes [12].

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Appendix C
DETERMINATION OF THE DISCOUNT RATE

1. Water Resources Council, Standards for Planning Water and Related Land Resources

Great controversies have arisen over the selection of the discount rate to be used in engineering-economic studies. These have mostly arisen because the federal government was using rates regarded by some as too low for the evaluation of water resources projects.

Generally, in economic studies, the rate to be used should reflect a value judgment on the part of the public served of their willingness to forego consumption for the formation of capital. James and Lee* list five specific approaches for deriving a proper rate.

We cannot solve here an insolvable problem. A great deal of thought has gone into recent federal thinking on the subject and we are recommending specifically that the Water Resources Council recommended rate be used.

The Water Resources Council's "Principles and Standards for Water Resources Planning," approved October 25, 1973 established a rate of 6 7/8%. The Water Resources Development Act of 1974 rescinded this, returning back to an earlier procedure which linked the interest rate to the government's yield rates of bonds within duration 50 years or longer. This includes certain specified categories of bonds. The Water Resources Council procedures are explained in their Rules and Regulations, which are reproduced below. The procedure is one where the Water Resources Council attempts to tie their recommended rate to these long term yield rates. The approved value for the FY 1975 is 5 7/8%. The calculated value for FY '75 according to their rules and regulations was 6 1/2%. Due to the constraint that not more than a quarter percent movement in a given year is allowable, they were only to raise from the FY '74 value of 5 5/8% to 5 7/8% in FY '75. The indication would therefore be that the rate will be 6 1/8% in FY '76 assuming that the 6 1/2% computation made in FY '75 will approximate the computation for FY '76.

*James, L. D. and R. R. Lee, Economics in Water Resources Planning, McGraw-Hill, 1971, pp. 126-127.

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UNITED STATES WATER RESOURCES COUNCIL

29242 SUITE 800 • 2120 L STREET, N.W. WASHINGTON, D.C. 20037 NOTICES

WATER RESOURCES COUNCIL
Standards for Planning Water and Related Land Resources

Change in Discount Rate Formula and Currently Applicable Rate.

1. Notice is hereby given that the interest rate formula established by the U. S. Water Resources Council, September 10, 1973, in Chapter IV, D., "Standards for Planning Water and Related Land Resources" was amended by section 80 of the Water Resources Development Act of 1974, Public Law 93-251, March 7, 1974. The full text of section 80 is as follows:

Section 80. (a) The interest rate formula to be used in plan formulation and evaluation for discounting future benefits and computing costs by Federal officers, employees, departments, agencies, and instrumentalities in the preparation of comprehensive regional or river basin plans and the formulation and evaluation of Federal water and related land resources projects shall be the formula set forth in the "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources" approved by the President on May 15, 1962, and published as Senate Document 97 of the Eighty-seventh Congress on May 29, 1962, as amended by the regulation issued by the Water Resources Council and published in the FEDERAL REGISTER on December 24, 1968 (33 FR 19170; 18 CFR 704.39), until otherwise provided by a statute enacted after the date of enactment of this Act. Every provision of law and every administrative action in conflict with this section is hereby repealed to the extent of such conflict.

(b) In the case of any project authorized before January 3, 1969, if the appropriate non-Federal interests have, prior to December 31, 1969, given satisfactory assurances to pay the required non-Federal share of project costs, the discount rate to be used in the computation of benefits and costs for such project shall be the rate in effect immediately prior to December 24, 1968, and that rate shall continue to be used for such project until construction has been completed, unless otherwise provided by a statute enacted after the date of enactment of this Act.

(c) The President shall make a full and complete investigation and study of principles and standards for planning and evaluating water and related resources projects. Such investigation and study shall include, but not be limited to, consideration of enhancing regional economic development, the quality of the total environment including its protection and improvement, the well-being of the people of the United States, and the national economic development, as objectives to be included in federally-financed water and related resources projects and in the evaluation of costs and benefits attributable to such projects, as intended in section 209 of the Flood Control Act of 1970 (84 Sta 1818, 1829), the interest rate formula to be used in evaluating and discounting future benefits for such projects, and appropriate Federal and non-Federal cost sharing for such projects. He shall report the results of such investigation and study, together with his recommendations to Congress not later than one year after funds are first appropriated to carry out this subsection.

2. The "Principles and Standards for Planning Water and Related Land Resources," established by the U. S. Water Resources Council pursuant to section 103 of the Water Resources Planning Act (Pub. L. 89-80), were published in the FEDERAL REGISTER on September 10, 1973, (38 FR 24778) and became effective October 25, 1973.

3. Pursuant to the provisions of Section 80 of Pub. L. 93-251 and the authority delegated in Section 2 of Executive Order 11747, November 7, 1973, Chapter IV, D., "The Discount Rate" in the "Standards" is hereby amended to read as follows:

The discount rate will be established in accordance with the concept that the Government's investment decisions are related to the cost of Federal borrowing.

(a) The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs, or otherwise converting benefits and costs to a common time basis, shall be based upon the average yield during the preceding fiscal year on interest-bearing marketable securities of the United States which, at the time the computation is made, have terms of 15 years or more remaining to maturity. Provided, however, that in no event shall the rate be raised or lowered more than one-quarter of 1 percent for any year. The average yield shall be computed as the average during the fiscal year of the daily bid prices. Where the average rate so computed is not a multiple of one-eighth of 1 percent, the rate of interest shall be the multiple of one-eighth of 1 percent nearest to such average rate.

(b) The computation shall be made as of July 1 of each year, and the rate thus computed shall be used during the succeeding 12 months. The Director shall annually request the Secretary of the Treasury to inform the Water Resources Council of the rate thus computed.

(c) Subject to the provisions of paragraphs (d) and (e) of this section, the provisions of paragraphs (a) and (b) of this section shall apply to all Federal and federally assisted water and related land resources project evaluation reports submitted to the Congress, or approved administratively, after the close of the second session of the 90th Congress.

(d) In the case of any project authorized before January 3, 1969, if the appropriate non-Federal interests have, prior to December 31, 1969, given satisfactory assurances to pay the required non-Federal share of project costs, the discount rate to be used in the computation of benefits and costs for such project shall be the rate in effect immediately prior to December 24, 1968, and that rate shall continue to be used for such project until construction has been completed, unless otherwise provided as a statute enacted after the date of enactment of the Water Resources Development Act of 1974, Public Law 93-251, March 7, 1974.

(e) Notwithstanding the provisions of paragraphs (a) and (b) of this section, the discount rate to be used in plan formulation and evaluation for the fiscal year 1969 shall be 4 5/8 percent except as provided by paragraph (d) of this section.

4. The Treasury Department on July 13, 1973, informed the Water Resources Council pursuant to 3.(b) above, that the interest rate would be 5 5/8 percent based upon the formula set forth in 3.(a):

the average yield during the preceding fiscal year on interest-bearing marketable securities of the United States which, at the time the computation is made, have terms of 15 years or more remaining to maturity

This rate was used for plan formulation and evaluation during the periods July 1, 1973-October 24, 1973, and March 7, 1974-June 30, 1974, of the Fiscal Year 1974 consistent with a further provision of 3.(a) which provides:

***[t]hat in no event shall the rate be raised or lowered more than one-quarter of 1 percent for any year.

Since the rate in Fiscal Year 1973 was 5 1/2 percent (37 FR 14445), the rate for Fiscal Year 1974 was 5 5/8 percent.

5. The Treasury Department on July 17, 1974, informed the Water Resources Council pursuant to 3.(b) above, that the interest rate would be 6 1/2 percent based upon the formula set forth in 3.(a):

***the average yield during the preceding fiscal year on interest-bearing marketable securities of the United States which, at the time the computation is made, have terms of 15 years or more remaining to maturity ***

This higher rate, however, cannot be used for plan formulation and evaluation for Fiscal Year 1975 because a further provision of 3.(a) provides:

***[t]hat in no event shall the rate be raised or lowered more than one-quarter of 1 percent for any year.

Since the rate in Fiscal Year 1974 was 5 5/8 percent (38 FR 20119), the rate for Fiscal Year 1975 is 5 7/8 percent.

Dated: August 7, 1974.

Rogers C. B. Morton,
Chairman

[FR Doc. 74-18624 Filed 8-13-74; 8:45 a.m.)

Appendix D
U.S. ARMY CORPS OF ENGINEERS GUIDE ON
EVALUATION OF FLOOD CONTROL BENEFITS

federal register

THURSDAY, AUGUST 15, 1974

WASHINGTON, D.C.

Volume 39 ■ Number 159

PART II

DEPARTMENT OF DEFENSE

Department of the Army

■

EVALUATION OF ECONOMIC BENEFITS FOR FLOOD CONTROL AND WATER RESOURCE PLANNING

General Principles and Standards of Benefit Evaluation

No. 159—Pt. II——1

Title 33—Navigation and Navigable Waters

CHAPTER II—CORPS OF ENGINEERS, DEPARTMENT OF THE ARMY

PART 341—EVALUATION OF ECONOMIC BENEFITS FOR FLOOD CONTROL AND WATER RESOURCE PLANNING

General Principles and Standards of Benefit Evaluation

Notice is hereby given that the regulation set forth below by the Secretary of the Army (acting through the Chief of Engineers) prescribes revised implementing policy and procedures pursuant to section 1 of the Flood Control Act of 22 June 1936 (Pub. L. 74-738). Specifically, the regulation emphasizes the procedures and measurement techniques for evaluating benefits under the national economic development objective for flood control and related water resources planning.

Since this regulation prescribes a general policy statement and specific evaluation procedures and measurement techniques designed primarily for internal use by Corps professional staff, notice of proposed rulemaking and the procedures thereto is considered unnecessary. This regulation will become effective August 15, 1974. It does not apply to planning reports submitted to the Office of the Chief of Engineers (OCE) prior to the effective date. It applies fully to all planning reports submitted to OCE after December 31, 1974. It will be applied partially to planning reports submitted between August 15, 1974 and December 31, 1974.

Dated: 5 August 1974.

JAMES L. KELLY,
Brigadier General, USA,
Acting Director of Civil Works.

Subpart A—Introduction

AUTHORITY: Flood Control Act of 1936, Pub. L. 74-738 (33 U.S.C. 701a), June 22, 1936; Water Resources Council, Principles and Standards for Planning Water and Related Land Resources, 38 FR 24778-24869, September 10, 1973.

Subpart A—Introduction

§ 341.10 Purpose.

This regulation outlines the principles, standards, procedures and measurement techniques for evaluating benefits under the national economic development objective for flood control and related water resources planning. This is one of the objectives contained in the Principles and Standards of 10 September 1973.

§ 341.11 Authority.

(a) Flood Control Act of 1936, Pub. L. 74-738, 33 USC 701a, June 22, 1936;

(b) Water Resources Council, *Principles and Standards for Planning Water and Related Land Resources*, 38 FR 24778-24869, September 10, 1973.

§ 341.12 Definitions.

"Activity." Any firm, household or public service entity, be it governmentally sponsored, private, profit making, quasi-public, charitable, etc.; sometimes used in text to mean all activities of a similar type; e.g. (residential, agricultural, manufacturing, or commercial).

"Activity decisions." A choice by an activity based upon maximization of its net income (economic rationality, net income).

"Alternative site, available alternative, alternative location." (a) Broadly, any location where a given activity might locate outside of the flood plain; (b) specifically, the best available non-flood plain location at a given point in time, as measured by maximization of net income to the activity. As a rule the site is not available if it is already occupied by a similar activity type or it will be occupied by a similar activity type both with and without the project. If an already occupied site is to be considered as the alternative, the costs of moving, including any unrecovered sunk costs, lost interest and profits during moving and any diseconomies to employees must be fully accounted for. As a practical matter, these costs will usually preclude use of occupied sites unless the useful life of the structures is near zero.

"Area affected." The area affected by a proposed plan is the flood plain plus other areas likely to serve as alternate sites for activities which might use the flood plain if it were protected.

"Associated costs." The cost necessary to make one site equally valuable as another. Value is measured either as gross income (revenues) or as other total output for non-monetary activities, such as schools (value, activity, development costs, site development costs, site operating costs, locational advantages).

"Average annual flood damages." See "Flood damages."

"Base year." The first year in which the plan is expected to become operational.

"Benefit." An NED benefit means an increase in the Nations' output of goods and services and/or an improvement in economic efficiency caused by a project. NED benefits are categorized according to their effect on activity decisions as inundation reduction benefit, location benefit, or intensification benefit.

"Benefit standard." The willingness of users (benefiting activity) to pay for a proposed plan (user, activity).

"Benefiting activity." An activity which realizes an increase in net income because of a proposed plan (user, activity).

"Costs." The amount expended by an activity in order to generate output, normally excluding the rental value of the land. In this regulation, costs usually segregate those due to flood damages in order to facilitate analysis. However, flood damages are conceptually a cost of doing business. (NOTE: Project "costs" are a separate item).

"Damage susceptibility." The relationship between total value of a type of activity in a flood plain and the flood damages sustained by that activity. The relationship is a function of the characteristics of the flooding itself (depth, velocity, duration, etc.) and the objects flooded (dwelling, materials, etc.), and their location.

"Damages." Often used in text to mean flood damages (flood damages).

"Damages reduced." Often used in text to mean flood damages reduced (flood damages reduced).

"Depreciation." A loss from the upper limit of value. An effect caused by deterioration and/or obsolescence. Deterioration is reflected by wear and tear, decay or structural defects, obsolescence occurs in two forms: functional and economic.

"Development costs." The cost of preparing land for use by an activity (site development costs) plus, when applicable, cost necessary to make one site as valuable as another (associated costs). The difference in development costs is a component of changed net income.

"Economic benefit." Synonymous with benefit, for purpose of the economic development objective.

"Economic development objective." The objective of increasing the value of the Nation's output of goods and services and improving national economic efficiency.

"Economic efficiency." The objective of producing goods and services at the lowest possible cost per unit of output for a given level of output (economic development objective, economic rationality, economic benefit).

"Economic rationality." The assumption that activities having full knowledge of the flood hazard will attempt to maximize returns, and will not externalize their flood losses.

"Efficiency." Synonymous with economic efficiency for purposes of the economic development objective.

"Exceedence frequency (frequency of flooding)." The percentage of values that exceed a specified magnitude, and occur as the most extreme event within specified sequential time periods; the exceedence probability times one hundred. A 100 year exceedence interval corresponds to an exceedence frequency of 1.00.

"Exceedence interval (of flooding)." Also, sometimes the less desirable terms, recurrence interval and/or return period have been used. The average interval of time between values that exceed a specified magnitude; reciprocal of the exceedence frequency per 100 years. In an annual flood series, the average interval in which a flood of a given size is exceeded as an annual maximum. In a partial duration series, the average interval between floods exceeding a given size regardless of their relationship to any period of time. It should be noted that a flood corresponding to a 100 year average exceedence interval is not expected to be equaled only once during a 100 year period. A 100 year exceedence interval flood magnitude can be expected to be exceeded one or more times one out of four periods of 30 years length, one out of two periods of 70 years length, and about two out of three periods of 100 years length. The total period of time under consideration must exceed 1,000 to 10,000 years before the 100 year exceedence interval flood magnitude can be expected to be exceeded on an average of once for each 100 years.

"Existing benefits (and damages)." Average annual benefits (and damages) to activities affected by flooding at the time the study is completed.

"Exceedence probability (probability of flooding)." A probability that an event selected at random, the most extreme event within each sequential time period of a specified length, will exceed a specified magnitude. A 100 year exceedence interval corresponds to an exceedence probability of 0.01.

"Externality." Synonymous with external effect. An effect on parties other than users of the outputs of a plan; specifically, increased damages to activities outside the protected area under the with—as compared to the without—condition.

"Flood." Inundation arising from stream overflow, overland water flow, high lake stages, high tides and inadequate drainage plus stream related erosion, gullying, flood plain scouring, streambank cutting, shore or beach erosion and sedimentation.

"Flood characteristics." The physical properties of floods are an important variable in determining and projecting flood damages.

"Flood control project." (a) Broadly, a synonym for flood plain management

plan; (b) Narrowly, a structural project by whomsoever undertaken.

"Flood damages." (a) Broadly, damages caused by a flood; (b) often "flood damages" mean "average annual damages." Floods vary in size and frequency. Average annual damages are yearly damages, on average, at any point in time, assuming one set of conditions and are independent of the interest rate used for project evaluation; (c) flood damages are a cost of doing business; reduction of the damage is therefore a reduction in costs which contributes to economic efficiency (synonymous with inundation damages).

"Flood damages prevented." Flood damages with a plan or project deducted from damages without the plan or project.

"Flood damages reduced." Synonym for flood damages prevented.

"Flood plain." Land physically inundated by a flood.

"Flood plain management plan." A plan for responding to the adverse effects of flooding (flood). This plan may envision structural measures, flood proofing, zoning, management, or a combination. This regulation provides for choosing plans on the basis of the economic development objective.

"Gross income." Total return to an activity. Usually expressed in dollars (synonym for gross or total revenues). Gross income, less costs, rent, and flood damages, equals net income for a given activity (revenues, costs, rent, flood damages, net income).

"Index." The relation or proportion of one amount to another; an indicator, e.g., density is an index of urbanization. The proper choice and use of an index is often critical to the accuracy of projections. Therefore, use of one item to indicate changes in another item should be based upon (1) establishing empirical relationship between the two items; (2) confirming a logical relationship between the two items, and (3) determining the likelihood that the relationships will continue over time and the nature of possible variances.

"Infrastructural locational advantage." See locational advantage.

"Intensification benefit." Benefit which arises because a plan or project induces an activity to modify its operation on the flood plain.

"Intensification of land use." An increase in the gross output of an existing activity at an existing site, due to a change in the factors of production.

"Inundation reduction benefit." The flood control benefit to those activities whose location decisions are unaffected by a proposed plan. It is the value of those flood losses prevented to those activities which would use the flood plain even without the proposed plan.

"Inundation damages." Synonym for flood damages.

"Land use." A description as to how land is utilized within the affected area. A change in land use is based upon affected area requirements and the ability of the flood plain to better meet these requirements given various levels of protection. A major source and starting point are land use maps, with support data, determined by responsible local, regional and Federal agencies. The detail number of levels of protection and number of years land use need be projected will vary with the plans being considered and the area being studied. The level of detail should be based upon the criteria of whether formulation and justification are affected.

"Location advantage." For any given demand for land, the desirability one parcel of land may possess over another; and advantage may be physical, aesthetic, infrastructural or a combination thereof. The former includes slope, foundation, potential for flooding, availability of water; infrastructural locational advantages are primarily psychological, such as nearness to existing population, accessibility to highways, civil stability, and proximity to market. Most physical advantages do not change significantly over time and are generally measured in terms of site development costs or in terms of hazard damage sustained. Infrastructural advantages will change over time as an area develops, depreciates or redevelops. It is most difficult to quantify infrastructural advantages. Measuring associated costs is one way, where it is possible to make two parcels of land equivalently valuable for an activity by a measurable expenditure (e.g., by putting in a road, by evaluating commuter costs between two sites, etc.). Where this is not possible, a direct estimate of the value of the location may be made. A starting point is to state the advantage(s) quantitatively; e.g., water supply available. A second step would be to attempt to measure the market value of comparable land and activities with and without the advantage. The purpose is to isolate unique advantages. Interviews with experts may also be helpful. Where the infrastructural advantage cannot be measured either directly or by associated devlopment costs, the advantage should be listed qualitatively by the reporting planner.

"Location benefit." Changes in net income to those activities whose decisions as to where to locate are affected by the proposed plan.

"Market value." Synonym for value.

"Net income." For firms, the difference between the gross income and costs (or expenses). For households or public service activities, the difference between the value (market or simulated) of the good or service supplied and the alternative cost of providing that same service. The difference is net income for users and is the benefit attributable to a flood control project. It is emphasized that net income merely defines the benefit; it does not indicate how the benefit is to be measured. Costs exclude land rent except when specified otherwise in the regulation (costs, revenues, benefit).

"Period of analysis." The period of analysis is that time horizon over which needs shall be assessed and is the basis for the NED benefit-cost ratio. The period of analysis is 100 years for major reservoirs, major long-term urban protection and main-line levees. It is 50 years for all other flood control measures.

"Physical locational advantage." See locational advantage.

"Productivity." (a) The ability to produce or increase output; (e.g.) normally expressed as a rate of output over time; (b) economic efficiency.

"Profit." Synonymous with net income, as used in this regulation.

"Project." See flood control project.

"Protection." A measure of the level of a flood protection or plan, generally measured by the exceedence frequency protected against (e.g., Standard project protection, 50-year protection). (exceedence frequency, threshold level)

"Rationality." See economic rationality.

"Rent." The value to, or the amount paid, a landowner for use of his raw land; a component of location benefit. Economic rent equals the net income of the occupying activity.

"Remaining flood damages." Flood damages which will occur even with a flood plain management plan (flood damages, flood damages prevented).

"Sensitivity analysis." The calculation of the rate of change of the objective function with respect to a particular parameter. An analysis of the components of a plan based upon alternative assumptions and/or projections to determine if a change in a measure would appreciably affect plan choice, design or schedule.

"Site operating costs." The costs of operating a given activity on a given parcel of land. The difference is a component of location advantage. (site development costs, associated costs, development costs, location benefit)

"Standard project flood." A large and improbable flood, usually simulated by placing the largest storm of record in a given region over a specific basin or sub-basin.

"Threshold level." For a given activity and year, the protection level at which the activity is indifferent to locating on or off the flood plain. The activity is indifferent when net incomes, on and off the flood plain, are equal. Threshold levels are crucial to location benefit measurement and to land use analysis.

"Uneconomic." An event which is not economically rational (economic rationality.)

"User." Synonym for benefiting activity.

"Value." In this regulation, value means market value; i.e., what a willing buyer will pay a willing seller for a good or service assuming full knowledge by both parties of the pertinent market characteristics of the good or service. The market may be simulated.

"Willingness to pay." The benefit standard for National Economic Development benefits attributable to a flood plain management plan.

"With project condition." The condition of having a specific flood control plan, regardless of sponsorship or operation.

"Without project condition." The condition of not having the specific flood control plan in operation. It is described in terms of what is most likely to occur within an area under evaluation without the specific action, regardless of sponsorship.

"Zoning." Authoritative restriction of uses to which land may be put. A form of land use regulation.

Subpart B—General Principles and Standards of Benefit Evaluation

§ 341.20 Definition and examples of national economic development objective.

This regulation applies where national economic development, providing for an increase in the value of the Nation's output of goods and services and improving national economic efficiency, is an objective. When this is the case, the development of water and related land resources results in increased production of goods and services which can be measured in terms of their value to the user. Increases in crop yields, expanding recreational use, and peaking capacity for power systems are examples of direct increases in national output which result from water and land resource developments. Such developments often result in an increase in the productivity of labor and capital used with these resources. Increases in earnings through changes in land use, reduced disruption of economic activity due to droughts, floods and inadequate water supplies, and removal of constraints on production through improved water quality are additional examples of direct increases in productivity from water and land development that further contribute to national output.

§ 341.21 Relationship of flood control programs to national economic development objective.

A variety of programs, such as flood plain management (including flood control and prevention), drainage, reduction of sedimentation, land stabilization and erosion control, contribute to the national economic development objective by improving the net productivity of flood prone land resources. This occurs either by a direct increase in total output or by reducing the costs for activities using land resources. In the latter case, the resources released are available for use elsewhere in the economy to further increase national economic output. These programs affect land resources and consequently the output of activities in the following manner:

(a) Prevention or reduction of inundation arising from stream overflow, overland waterflow, high lakes stages, high tides, and prevention of damage from inadequate drainage.

(b) Prevention or reduction of soil erosion, including sheet erosion, gullying, and flood plain scouring; streamback cutting, shore or beach erosion, and prevention of sedimentation.

(c) Removal or reduction of limitations on uses of specified land resources.

(d) Adjustments in the manner and mode of flood plain use in recognition of the flood hazard.

§ 341.22 General benefit standard for national economic development.

The benefit standard is the willingness of users (benefiting activities) to pay for each increment of output from a plan.

(a) *Willingness to pay* determines the values of the increase in output from a plan where total value is defined as the willingness of users to pay for each increment of output from a plan. The output of flood control plans is the increase in the productivity of land or the reduction in the cost of using land resources. When users are producers, willingness to pay is determined by the difference in net income accruing to users of land resources benefiting from the flood control plan compared with what the users would earn in the absence of such a plan. When users are consumers (as opposed to producers), willingness to pay is defined as the difference between the cost of obtaining a site of equivalent value in an alternative manner and the cost of using the protected flood plain. If the additional output from a plan is not expected to have a significant effect on the price of land of comparable quality to the protected site, these prices may be used in the estimation of plan benefits.

(b) *Users.* Users may be individuals, households, landowners, firms, or public entities.

(c) *Net income.* Net income is defined as the difference between the value (market or simulated) of output (goods or services) and the cost of (excluding land rent) of producing the output.

(d) *Non-national business and financial losses.* Losses to benefiting commercial activities which are compensated through increased business off flood plain are not national losses.

(e) *Externalities* are effects on parties other than users of the outputs of a plan. Flood damages may result from a plan beyond the area it is designed to protect. When plan induced damages occur to non-protected areas, they must be subtracted from the benefits to the protected area when calculating final benefits of a plan.

§ 341.23 Application of general benefit standards to flood control programs.

While there is only one benefit standard, there are three benefit categories thereunder reflecting different activity decisions made in response to the reduction of flood flows or hazards which result from a flood control plan; namely:

(a) *Inundation reduction benefit.* An activity uses the flood plain exactly the same with and without a plan. The benefit is the increase in net income to the flood plain activity. For activities not now on the flood plain, this benefit will occur only when it can be demonstrated that the activity will have a larger net income at the flood plain site than at the next most efficient available alternative site (as defined in § 341.3 of this part) without the plan.

(b) *Intensification benefit.* A commercial, industrial or agricultural activity on the flood plain modifies its operation because the reduction in potential flood damages makes it profitable to do so. The benefit is the increased net income to the activity and landowner comparing the current and previous methods of operation. This benefit will occur when the increased output can be produced most efficiently under project conditions by intensified operation on the existing acreage as opposed to increasing production elsewhere or bringing new areas into production.

(c) *Location benefit.* An activity uses the flood plain with a plan but not without, as a result of the reduction in potential flood damages. The benefit is the difference in net income to the new activity comparing the flood plain site to the alternative off-flood plain site which would be used without the plan less the difference in net income for the activity displaced by the new activity.

Subpart C—Evaluation Procedure

§ 341.30 Prerequisites to evaluation procedure.

The following provides a description of those elements which are common to a consideration of all flood control in the plan formulation and evaluation process. Special consideration should be given these elements during the study, and they should be described in the final study report.

(a) *Description of flood plain management plans.* A flood plain management plan is a strategy contributing to appropriate use of flood plains principally by reducing potential flood damage. Such plans will normally involve a combination of measures, regardless of sponsorship, for modifying flood flows and/or reducing damage susceptibility. Each specific plan under consideration will be described in that portion of the report dealing with evaluation and measurement.

(b) *With and without analysis.* Each plan will be evaluated under strict adherence to the principle of with and without analysis. The with condition will be specific in terms of a plan, regardless of sponsorship or level of protection, rather than general terms, such as a flood control program. The without condition will be defined in terms of what is most likely to occur within an area under evaluation without a specific plan. The four cases that follow illustrate and clarify the appropriate without condition.

(1) *No alternative action in the absence of a Corps plan of action.* In this case, the appropriate without situation is that which will exist in the absence of any Corps action.

(2) *Alternative action already taken by other parties.* In this case some flood protection has already been provided. The appropriate without situation includes existing flood protection but without further action by the Corps or any other party.

(3) *Alternative action is anticipated to be taken before Corps action.* In this case, the appropriate without situation includes such anticipated protection but without further action by the Corps or other parties. For example, flood protection has not yet been provided but there are assurances that it will be provided before a Corps plan could be started.

(4) *Alternative action will be taken in the absence of a Corps plan, but if the Corps undertakes a plan no alternative action will be taken by other parties.* In this case, the appropriate without situation is that which will exist in the absence of action by any party, as in (b)(1) of this section. The rationale for this is that in formulating plans, evaluation of available alternatives (structural, non-structural and mixed) must be undertaken. Likewise a choice must be made from among these alternatives, including those which could be undertaken by other parties in the absence of a Corps project.

(c) *Application of Flood Disaster Protection Act to with and without conditions.* The adoption and enforcement of land use regulations pursuant to the Flood Disaster Protection Act of 1973 (Pub. L. 93-234) will be assumed, both with and without a Corps plan. This is to insure that Corps evaluation procedures conform to Federal policy.

(1) *Regulation certified or near certification.* The Corps office will assure itself that the land use regulation has been or will be certified by the Flood Insurance Administration (FIA) as adequate under 24 CFR 1910.3(c) and/or (d) and 24 CFR 1910.5. In such cases, the without conditions are developed pursuant to the regulation. Further structural, non-structural and mixed alternatives will be considered in Corps plan formulation. The with condition will assume a zoning ordinance compatible with the without condition ordinance in those cases where the 100 year flood is not contained by the Corps plan. Where the flood is contained, it may be assumed that no zoning ordinance will be in effect. This is consistent with FIA policy.

(2) *Regulation not yet certified.* It will be assumed that the local jurisdiction will adopt land use regulations certifiable to FIA in the near future under the without condition as a datum, and for the with condition when a residual hazard will remain. This applies to flood plains regulated pursuant to 24 CFR 1910.3 (a) and (b); to flood plains presently regulated by local ordinances independent of FIA; and to flood plains with no flood regulation presently in effect. The regulation assumed will include the following two crucial features: No further development of the flood plain unless the first floor of the building is elevated to the 100-year level for residences or flood proofed to that level for non-residences; and no occupancy of the floodway which when taken with other developments raises the height of the 100-year flood by greater than one foot anywhere in the flood plain. The possibility of a 24 CFR 1910.5 exemption will not be considered. In those cases where application of this sub-paragraph results in significantly higher benefits to the Corps plan than would be the case under an assumption of no land use regulations, the District will report this finding and the reasons therefore.

(3) *Exceptions.* In certain cases the prior provisions of this paragraph will not apply. These cases will involve situations where private, non-federally related financing of future development is likely. Such cases will be extremely rare and should be fully supported in the report by an adequate explanation of the unusual circumstances.

(4) *Other applications.* The impact of Pub. L. 93-234 on evaluation has not been fully determined. The use of reduction in premium rates as a benefit category is an example. For the time being, no further changes in evaluation procedure will be made.

(d) *Economic rationality.* The with and without conditions are defined as those which are most likely to occur under each condition. However, for purposes of evaluating structural components of a plan economic rationality will be assumed. (This assumption is necessary since it is contrary to Corps policy to encourage or perpetuate irrational flood plain use.) Economic rationality assumes that activities attempt to maximize returns, have full knowledge of the flood hazard, and will not externalize their flood losses. For those flood plains where a local zoning ordinance forms part of the with and without conditions, the basic test of economic rationality for occupancy is: Do the advantages of the flood plain exceed the cost of complying with the zoning ordinance plus remaining flood losses? For the few other flood plains, the basic test for occupancy is: Do the advantages of the flood plain exceed the expected flood damages or the cost of flood-proofing plus remaining flood losses, whichever is less?

(e) *Base Year Definition.* The base year is defined as the first year in which the recommended plan is expected to be operational. The choice of the base year should allow for the practical minimum time required for authorization, funding, construction and/or implementation, with no attempt made to account for unforeseen delays or unusual expeditithg in any procedural phase. The selection of the base year should be estimated on as realistic a basis as possible; the following is recommended as a guide:

Procedural phase	*Time allowance*
Submission of feasibility report to date of plan authorisation.	2 years
Plan authorization to date of receipt of initial construction or implementation funds.	2 years
Receipt of initial funds to date plan becomes operational.	Variable depending upon scope and complexity of the plan; shall be identical to period during which interest during construction is charged under current directives.

(f) *Period of analysis.* The period of analysis is 100 years for major reservoirs, major long-term urban protection and main-line levees. It is 50 years for all other flood control measures. The period of analysis is the time horizon over which needs shall be assessed and is the basis for the NED benefit-cost ratio.

(g) *Amortization.* Benefits and costs for each flood plain management plan shall be brought to present worth as of the base year and amortized for 50 and 100 year periods. Projections beyond 50 years are difficult to support. Therefore, neither increases or decreases in flood control benefits for project years 50 to 100 will be assumed or accepted.

(h) *Benefit display.* Benefits shall be displayed in undiscounted average annual values for the current year, the base year, and by decade thereafter. Account will be taken of projected hydrologic, demographic, and economic changes. Average future hydrologic conditions shall not be used.

(i) *Price levels.* Benefits and costs shall be evaluated under prices existing at the time of submission of the report to OCE. In the case of agriculture, apply Water Resources Council (WRC) Guideline #2, *Agricultural Price Standards for Water and Related Land Resources Planning,* Feb. 1974, and subsequent revisions, for all projects covered by the Principles and Standards and related guidance.

§ 341.31 Evaluation procedure.

There are five major steps necessary to evaluate a flood plain management plan. These five steps are: Delineation of affected area; projection of anticipated activities within the affected area; estimation of land use demand; determination of flood plain characteristics; and projection of land use. The level of detail and presentation of each step will vary with the area being studied and should be based upon the criteria of whether plan formulation or evaluation are affected. For example, a stable economic setting, where existing damages justify or nearly justify the proposed plan, will normally require less detail in assessing future benefits than a plan justified primarily on future conditions.

(a) *Delineation of affected area.* The area affected by a proposed plan consists of the flood plain plus all other areas likely to serve as alternative sites for any activity which might use the flood plain if it were protected. A functional approach to delineating the affected area requires obtaining insight as to potential future uses of the flood plain. There are several methods of accomplishing this, such as simply observing current uses of the flood plain, holding public hearings, reviewing local plans, consulting influential citizens, community officials, private firms and utility companies, reviewing economic base studies, Standard Metropolitan Statistical Areas (SMSA) and other large area studies. Potential future uses should first be specified by broad categories including: Industrial (manufacturing), commercial, residential, open space, recreation, agriculture and other. Working circumferentially from the flood plain, alternative available areas for each such use must be specified. Sufficient areas must be included to insure that the affected area is large enough to accommodate at least these major categories of potential future use. When the potential use of the flood plain includes industrial use within an SMSA, the entire SMSA is the affected area; for residential use, even within an SMSA, a much smaller area may be envisioned. In the case of agriculture, it is normally sufficient to specify alternative areas in more general terms.

(b) *Projection of anticipated activities within the affected area.* Projections of demographic and economic activity within the affected area are seldom influenced, in the aggregate, by a plan for flood control. A single set of projections should be developed, therefore, to serve as a basis for the entire analysis. Exceptions to the general rule will be supported by a special explanation of why a plan is likely to cause a different level of aggregate activity. Economic and demographic projections should be made for at least the following characteristics: Population, personal income, manufacturing employment and output, and agricultural output. For any given area, additional projections may be necessary depending upon the potential uses of the flood plain and the sensitivity of the plan to these projections. Projections should be made for the planning period (normally 50 years from the base year) at least by 10 year increments. Demographic projections should be based upon historical trends for the affected area, upon larger area trends or projections such as those put out by the Office of Business Economics, U.S. Department of Commerce and the Economic Research Service, U.S. Department of Agriculture (OBERS), and upon local master plans and projections. However, growth in the flood plain is not likely to be the same as for larger areas. The influence of applicable constraints such as quality of land available, environmental impact and local zoning ordinances must be made explicit in the analysis.

(c) *Estimation of land use demand.* Land use demand within the affected area is obtained by converting demographic projections (e.g., population) to acres. Such conversion factors will normally be derived from published secondary sources, from Corps studies of similar areas, or from empirical data available in the affected area. The categories of land use demand should be only as detailed as is necessary to reflect the incidence of the flood hazard and to establish the benefits derived from a plan. For example, if the affected area has considerable potential for high-rise apartments, then the population projection should be carefully converted to acres which include high-rise densities factors. Conversely, where residential use is small, detailed analysis of the residential sector is of lesser importance.

(d) *Determination of flood plain characteristics.* The existing characteristics of the flood plain must be delineated before it is possible to determine its potential uses. Therefore, an inventory of the flood plain will be undertaken in order to determine those characteristics which make it attractive or unattractive for the land use demands established in paragraph c of this section. Emphasis will be placed upon those characteristics which which distinguish the flood plain from other portions of the affected area. The following categorization should be used as a guide.

(1) *Inherent characteristics of a flood plain.* All or most flood plains have the following characteristics: Flooding; floodway, natural storage; open space, recreation, wildlife, wetlands; transportation; and other.

(i) *Flooding.* A description of the flood situation will be presented, including a designation of high hazard areas. This description will include the characteristics of the flooding such as depths, velocity, duration, debris content, area flooded by flood of selected frequencies, including 100 year frequency, historical floods and Standard Project Flood (SPF). See also § 341.41(c)(1) of this part.

(ii) *Floodway, natural storage.* A description and delineation of those areas which, if urbanized or structurally protected, would affect natural storage, velocity or stage, or in any way affect flood flows elsewhere will be presented.

(iii) *Open space, recreation, wildlife, wetlands.* Many flood plains are potential recreation, open space, wetland, or wildlife preserves, particularly those proximate to an urban area. The potential of the flood plain for these purposes must be recognized and presented.

(iv) *Transportation.* Flood plains near navigable streams have inherent attractiveness for industries which demand water-oriented transportation. Flood plains also often serve as sites for railroads, highways, pipelines, and related facilities which are not susceptible to serious flood damage yet tend to attract industry to the area.

(v) *Other attributes.* Other inherent attributes include: Soil fertility, reliability of water supply, waste disposal, sand, mineral and gravel deposits.

(2) *Physical characteristics.* The existence of certain physical characteristics may effectively preclude use by some activities likely to compete for flood plain land. For example, it may not be feasible for certain types of heavy manufacturing activity to locate in areas possessing unfavorable soil foundation characteristics. Therefore pertinent physical characteristics should be described, including slope, soil types, water table, among others.

(3) *Available services.* Most activities require some or all of the following services: Transportation facilities (highways and rail), power, sewerage, water, availability of labor force, and the like. The availability of such services in or near the flood plain will be indicated, including comparisons with other portions of the affected area. Future planned services for the affected area will also be presented.

(4) *Existing activities.* The inventory of the flood plain will include a list of existing activities, the number of acres and density of each. The total acreage of the flood plain should thus be accounted for; vacant or unused acreage should be separately categorized.

(e) *Projection of land use.* Given the existing characteristics of the flood plain and the remainder of the affected area previously designated, land use demand must be allocated to flood plain and non-flood plain lands, with and without each specific flood plain management plan.

(1) *Basic factors.* The allocation shall be based upon a comparison of three sets of factors. These are: (i) The flood plain characteristics; (ii) the characteristics sought by potential occupants; and (iii) the availability of sought-after characteristics in the non-flood plain portions of the affected area.

(2) *Criteria.* The principle of economic rationality shall be applied. The flood plain will not be used unless it possesses characteristics which give it a significant economic advantage over all other available sites within the affected area. If such advantages exist, the analyst must determine whether they overcome potential flood losses. Flood losses include those to the benefiting activity and to those additional activities induced to use the flood plain; e.g., residential use, induced neighborhood commercial and public facilities. Flood losses will be specific to the zone of the flood plain being considered. A zone is delineated by frequency of flooding, (See § 341.13, "Exceedence Frequency" of this part), under "without plan" conditions, from which the incidence of all benefits shall be specified. This should include flood magnitudes with exceedence intervals of 25, 50, 100 years, the standard project flood and the design flood.

(3) *Procedure.* A consistent procedure will be applied to every plan and protection level under consideration, and to the without plan condition. The appropriate procedure is:

(i) Determine whether future benefits are likely to affect the design, formulation or justification of a flood plain management strategy. If so, proceed to next step.

(ii) Eliminate all uses for which the flood plain offers no advantages and all activities which cannot tolerate flooding or flooding of a certain type (e.g., high velocity).

(iii) For uses attracted to the flood plain, a list of advantages in comparison to alternative sites in the affected area will be presented. For each advantage, the analyst will indicate the importance of the advantage in location choice (e.g., essential, important, desirable, or of marginal advantage). Special attention should be paid to minimum characteristic requirements of each activity type (e.g., ground surface slope may not exceed 15 percent for "X" activity. type). Where applicable, the advantage will be explicitly quantified.

(iv) For advantaged uses, an estimate of potential flood losses should be presented. Often economic losses are minimal; e.g., green belts, municipal parks, game refuge or the use of simple open space. In such cases, continued flood plain use may be assumed. Often a high

level of protection will reduce potential losses for any activity in all areas of the flood plain to negligible amounts. In such cases, those activities for which there is a maximum absolute advantage will use the flood plain.

(v) The advantages of the flood plain to related flood hazard will be compared in order to determine whether, for low levels of protection or under the without condition, the advantages exceed the potential flood losses. Historical experience in the flood plain or in nearby or similar flood plains; the ratio of losses to approximate net returns or capital investment; guidelines by Federal and private lending authorities; local master plans which explicitly take flood hazards into account; WRC guidelines; residential interviews; and business interviews are all methods by which such a determination can be made short of detailed quantification.

§ 341.32 Irrational use.

While allocation of land use will proceed under the assumption of economic rationality, there will be instances where occupancy of flood plains in the general area exists, but is not apparently rational; e.g., single family residential use in frequently flooded areas. This should be confirmed in several ways. One is by direct interview of occupants; e.g., did the occupant know he was in a flood plain? What degree of hazard did he anticipate? Another is by discussion with local authorities. A third is by observing historical occupancy and sequence of development to determine whether high hazard flood plain occupancy is common. If deliberate high hazard occupancy is observed, the location decision may be assumed to be rational. Once the existence of irrational use is verified, and the probable increased future irrational use confirmed, the report should (a) base future benefits to structural protection only on rational use, (b) if possible, assist the local entity in devising sound regulatory ordinances to prevent continued irrational use, and (c) claim the prevention of irrational use as a benefit to such regulation, flood plain information, land purchase and other similar non-structural plans or plan components.

§ 341.33 Presentation.

For the recommended plan and for the without condition, there should be presented a map or other graphic display clearly indicating existing and projected land use for the affected area, with appropriate exceedence intervals as indicated in § 341.31(e)(2) of this part.

Subpart D—Benefit Measurement

§ 341.40 Characteristics of flood plain management benefits.

The use of a flood plain is likely to change even in the absence of a flood plain management plan. This change may result in an increase or decrease of economic activity. A benefit accrues by reducing or modifying the flood hazard to such economic activity. This benefit is referred to as an "inundation reduction benefit." In addition, activities which would use the flood plain even without a project may be encouraged to intensify their use because of a plan (e.g., where a shift from lower to higher value crops occurs). This is referred to as an "intensification benefit." Finally, a plan may induce new economic activity into the flood plain (e.g., where a shift from agricultural to industrial use occurs). This benefit is referred to as a "location benefit".

§ 341.41 Flood damages without project.

The determination of the level of existing and future flood damages without a plan leads directly to computation of the inundation reduction benefit.

(a) *Types of flood damage.* Flood damages can be classified as physical damages or losses, emergency costs, and business or financial losses. Each activity affected by a flood experiences losses in one or more of these classes. Such classification assists in identifying and evaluating the losses and in relating variations in their magnitude to the range of flood conditions expected with and without the project.

(1) *Physical damages* include the damages to or loss of buildings or parts thereof; loss of contents, including furnishing, equipment, decorations, stock of raw materials, materials in process and completed products; cost of cleanup; loss of roads, sewers, bridges, power lines, and so forth.

(2) *Business and financial losses* include the various economic losses other than direct physical damages and emergency costs resulting from a flood, such as net loss of normal profits and return to capital, labor and management in the readily identifiable zone of flood influence. Such losses bear no consistent relation to physical damages and must be derived from specific independent economic data for the interests and properties affected. To the extent that such losses cannot be compensated by postponement of an activity or through transfer of the activity to business establishments not affected, prevention of such loss results in a contribution to national economic development.

(3) *Emergency costs* will include those additional expenses resulting from a flood that would not otherwise be incurred, such as evacuation and reoccupation, flood fighting, disaster relief, increased expense of normal operations during the flood, increased costs of police, fire or military patrol, and abnormal depreciation. Emergency costs should be determined by specific survey or research and may not be estimated by applying arbitrary percentages to the physical damage estimates.

(b) *Existing flood damages without project.* Existing flood damages are potential average annual damages to activities affected by flooding at the time the study is completed. Existing damages are those either expressed for a given magnitude of flooding or as computed in the damage frequency process. No projection is involved. The basis for the determination of existing damages shall be losses actually sustained in historical floods. Therefore, the analyst should specify the year and month for all significant discharges above zero point of damage and indicate damages actually sustained by reach or zone and type of property and activity. Data on historical flood losses must be supplemented by appraisals and an inventory of the capital investment (including structures and contents) within the flood plain. Estimates of damages under existing conditions for floods of magnitude which have not historically occurred must be computed. Average annual losses will be estimated by using standard damage-frequency integration techniques.

(c) *Future flood damages without project.* These are damages to economic activities which are expected to use the flood plain in the future in the absence of a plan. Future includes any time period after the year in which the study is submitted to OCE. In order to ultimately relate costs to benefits, however, future damages must be discounted to the base year.

(1) *Hydrologic changes.* Changes in basin land use may result in major alteration of the drainage characteristics, particularly surface run-off; such hydrologic changes must be projected for the planning period. Average future hydrologic conditions shall not be used; such techniques obscure situations where a project level of protection may be totally unacceptable by the end of the planning period.

(2) *Economic changes.* Economic changes can be expected to result in a change in the level of flood losses in the future. The following three paragraphs discuss the projection of future flood damages. The level of detail in projecting future flood losses should be based on the effect of the analysis on plan formulation and evaluation. A benefit-cost ratio for existing condition will always be shown. If it is greater than unity, the projection of future benefits may be accomplished in abbreviated form, unless it would distort the comparison of alternatives or the cost allocation and cost sharing in multiple purpose projects. In the latter situation the detail and accuracy of the estimates of flood control benefits should be comparable to benefit estimates for other purposes (e.g., water supply).

§ 341.42 Measurement and projection of physical flood losses.

Measurement and projection of flood damages must be based upon the establishment of actual, observed relationships between damages, flood characteristics, and those indicators used for measurement and projection. Thus, projections of flood damages should be made on the basis of the actual regression coefficients as modified by consideration of constraints which change the historically derived relationship between flood damages and a given independent variable. Basically, damages are a function of the number and value of each physical unit of property in the flood plain adjusted for the damage susceptibility at each stage of flooding. All of these interrelationships must not only be made explicit in the analysis, but their accuracy and representativeness supported by empirical evidence. There are three steps to be used in measuring flood damages for a future year: Estimating the number and size of physical units; estimating the future value of units; and determining damage susceptibility of units.

(a) *Physical units.* The first step in measuring flood damages for a future year, is to determine from the land use analyses the number and size of physical units in the flood plain by hazard zones for each of the following categories:

(1) *Residential.* The number of physical units can be obtained by relating the number of acres to density, persons per dwelling unit and similar ratios. These ratios can be expected to change over time; however, major shifts would be improbable. Several ratios should be tried to test for consistency, accuracy and sensitivity of any one estimate. Extreme care must be taken to subdivide the residential category into single family and mutliple dwelling units since damage per unit of value vary widely for each. Multiple dwelling units should be further subdivided; e.g., into high rises, garden apartments, and low density multiple. Single family residences should be classified as conventional or mobile home units. Type of construction is also important, as discussed below under damage susceptibility.

(2) *Commercial.* The number of commercial establishments can be estimated by relating sales to population, output to sales, acres to output, square footage to gross sales, or by a similar technique. Again, extreme care must be taken to subdivide commercial categories; e.g., retail, wholesale, warehouse, professional and administrative, highway commercial, and other appropriate subcategories affecting the value and damage susceptibility of the physical unit. A causal relationship must be demonstrated between the activity projected (e.g., warehouse), and the independent variable (e.g., manufacturing output within affected area). The interdependence between commercial activity and related socio-economic indicators should be closely checked for consistency and dependability.

(3) *Industrial.* The number of industrial establishments is estimated less readily than commercial or residential. This is because broad regional or national needs will usually dictate the demand for most industrial products. It is not reasonable to assume that the aggregate industrial output of an affected area will be influenced by a flood control program. However, the location of these activities within the area could easily be affected. Direct interviewing of existing industries and consultation with a responsible land use planning entity as to possible shifts in industrial location patterns is usually feasible due to the relatively small number of industries likely to occupy a given flood plain. Indices of physical units which may be appropriate include capital to output ratios, output per employee, sales to output ratio, capital investment per unit of output, value added per gross sales, and rolling stock per ton-

mile. Land available for industry as indicated by local zoning and land use plans may act as a constraint upon development but does not determine the amount of industry which will locate in the flood plain. Recognized projections such as OBERS, McGraw-Hill, National Planning Association, the Federal Reserve, and Resources in America's Future, among others, should also be utilized.

(4) *Public facilities.* These cover a wide range of different types of physical units; e.g., roads and bridges, schools, government offices, sewage treatment facilities, water treatment plants, and parks. Many of these can be projected in the future by determining physical requirements as a function of the population and industrial mix of the affected area. It is noted that some types of public facilities, such as streets and schools will increase virtually in direct proportion to population. Other types, such as junior colleges, will appear for the first time only when a high regional population density is reached. Other types of public facilities do not vary with the population of the local area but rather with regional or national demands; e.g., major freeways, state office buildings, and major universities. As with the industrial category, maximum use should be made of accepted published projections, direct interviews and established land use plans.

(5) *Agriculture.* Acres of land under production, types of crops, and changes in yields per acre are the principal physical units of agricultural measurement. As a rule physical structures on agricultural lands are limited to farmhouses, barns, and related buildings. The number is generally a function of farm type and size. Estimates of physical equipment, such as irrigation equipment, and tractors, in the flood plain may be based upon regional characteristics and trends in farm capital/output ratios or farm capital/land ratios as well as model farm data. Capital equipment for agricultural production is often mobile and can be removed from the hazard of most floods. Farm residence and personal property can also be advantageously located outside of the flood plain in many instances. Information specifying the types of agricultural damages is to be displayed. Additional information should be included to provide details on the time of year and the stage of the growing cycle in order that the origin of the flood damages associated with each of the historical floods can be explained.

(b) *Value per physical unit.* (Not available at this time.)

(c) *Damage susceptibility.* Once the number of physical units and the value associated with each unit are known, damage susceptibility relationships must be established as a function of total value of each physical unit and the flood characteristics of the stream, such as velocity, depth, duration, volume, debris control and salinity. Some of the determinates of damage susceptibility are:

(1) *Location within the flood plain.* An industry located between the 50 and 100 exceedence interval of a flood plain is less flood prone than the same one located within the fifteen year flood plain.

(2) *Type of activity.* Certain types of activity are more susceptible to damages than others. For example, single family residences usually sustain greater damage per unit value than high-rises. Another example is in comparison of damage to crops and single family residences. The latter are usually built to allow for rapid lot drainage; hence, major damage often does not begin unless depth of flooding exceeds one or two feet above natural ground level. Flood duration similarly affects alternative activities in different ways. The calculation of remaining damages should be particularly cognizant of activity type. Plans should consider the implications of elevation, flood proofing, evacuation and relocation, and all other management options.

(3) *Vertical development.* As the value of each physical unit increases, historical trends indicate that the number of stories in buildings increases because of land scarcity. For most streams, flood waters do not reach second stories or above. In some areas basements are traditional and in other areas slab foundations predominate; both affect damage susceptibility.

(4) *Material used.* Some materials are inherently less prone to flood damage than others. For instance, cinder block is normally less prone to flood damage than wood.

(5) *Individual response.* As property value increases, owners may be expected to take individual actions to reduce damage susceptibility, such as keeping valuable household items on the second story. The cost of flood proofing serves as a limit on the level of damages which a rational activity is willing to accept. The rational action of an average individual should apply when trying to anticipate the response to a flood hazard situation.

(6) *Unknown commodities and materials.* Increases in damages will not be assumed where the nature of commodities and materials projected in the future are unknown. This is because the susceptibility of such commodities and materials to flood damages cannot be known, and many aspects of "known" projected activity cannot be accurately perceived.

§ 341.43 Projection of business and financial losses.

Business losses can be projected to increase in the future only under special circumstances. The special circumstances are when it can be shown that future losses cannot be compensated through a transfer of sales to other establishments. Such a showing will require a determination of the number and location of similar businesses in the general area. In no event will increases in physical losses be used to directly project business losses.

§ 341.44 Projection of emergency costs.

Emergency costs encompass a wide variety of programs. Some, such as emergency shelter and food, are primarily a function of the occupancy of the flood plain, but not of the value of development in the flood plain itself. In no event will emergency costs be projected to increase as a direct function of physical losses.

§ 341.45 Inundation reduction benefit.

The inundation reduction benefit is the value of reducing flood losses to activities which would use the flood plain without any plan. Structural measures directly reduce flood flows. Evacuation reduces flood losses without modifying flood flows. Early warning systems reduce flood losses. Flood plain regulations governing flood proofing and building materials also reduce damage susceptibility.

(a) *Flood damages reduced.* Inundation reduction benefits are measured as the reduction in the amount of flood damages or related costs. Related costs are those which would be voluntarily undertaken by economically rational individual activities to reduce flood damages. An important example is where flood proofing is expected without a plan. In such cases the benefit is the cost of flood proofing plus damages assuming flood proofing, less residual damages.

(b) *Market value of land.* The difference in the market value of land with and without a project reflects the capitalized increase in net income associated with the project. This proxy is not perfect and in some instances, such as flood plain evacuation, is meaningless. Therefore, the reduction in flood damages often provides a more practical and representative measure of inundation benefits than does increase in land value. However, the land value approach is a useful check on benefits, especially in a stable agricultural situation. The influence of externalities must be carefully considered whenever land values are used in the benefit algorithm.

§ 341.46 Location benefit.

The location benefit is the value of making flood plain land available for new uses by reducing flood hazards to activities which would use the flood plain only with protection. An example is when a plan permits industrial use of a flood plain which would be in agricultural use or vacant without the plan. Any flood plain management strategy which reduces potential flood losses can potentially give rise to a location benefit. Location benefits are narrowly defined in this regulation. The benefit for producers is the difference in the net income accruing to users of land resources which would locate on the protected flood plain when compared to what these users would earn in the absence of a plan. For consumers, the benefit standard is defined as the difference between the cost of obtaining a site of equivalent value in an alternative manner and the cost of locating on the protected flood plain. Three techniques are available to measure location benefits. These are: Net income differences, threshold levels, and changes in the market value of land. These techniques represent a compromise between theory and the time and data limitations facing Districts. Because they are not equivalent, two methods will be used in each calculation of location benefits. The choice of values for location benefits used in the final benefit calculation should be based on an explicit evaluation of the reliability of the alternative estimates. Finally, the reduction of flood related expenses is an upper bound on location benefit, no matter which method is used.

(a) *Net income differences.* The benefit is derived in six steps:

(1) For a displacing activity, calculate the net income difference for the activity (where costs exclude land rent and flood damages) between the alternative site and the flood plain site.

(2) For a displaced activity (if any), calculate the net income difference (where costs exclude land rent and flood damages) between the alternative site and the flood plain site. This step is primarily designed to insure that the loss of agricultural productivity on a fertile flood plain is not overlooked.

(3) Add the increases in net income of the displacing activities less the decreases in net income of the displaced activities.

(4) As with all evaluation categories, residual damages to induced development must be substracted from gross location benefits. Note that induced development includes activities which locate on the protected flood plain solely because another activity locates there. For example, if residential development occurs on the flood plain, schools, commercial businesses and other activities will locate there also. This reduces the benefit attributable to the flood control plan because residual damages to such activities must be deducted from location benefits.

(5) Flood damages reduced to activities which have been displaced by the induced activities should be subtracted if such reductions have already been counted as part of an inundation benefit.

(6) External flood damages must be deducted. Taken together, steps 4, 5 and 6 call for a thorough analysis of induced and remaining flood damages.

The net income approach will have greatest practical application where the advantages of the flood plain relative to alternative sites are specifically identifiable and quantifiable, and the displaced activity is agricultural (or vacant).

(b) *Threshold levels.* The threshold level is that level of protection at which a new activity is economically indifferent between location on the flood plain and off the flood plain. Viewed from a flood frequency perspective, for example, an activity may be indifferent to moving onto the flood plain if a 50-year level of protection were assured. Any level of protection above 50 years, therefore, would induce the activity onto the protected flood plain. The benefit above this level may be quantified in terms of flood damages reduced to the new activities. Flood damages reduced to the old activity must be subtracted to avoid double counting of benefits if they have been claimed as inundation benefits. Finally, external flood damages must be deducted (similar to paragraph (a)(6) of this section.

(1) *Rationale.* The method is analogous to the use of flood damages reduced to measure the inundation benefit. It will be noted that in the case of inundation benefits, the threshold level of protection is no protection.

(2) *Some suggested methods of measurement.* The following are suggested as aids in quantifying threshold levels:

(i) *Direct interview with potential flood plain users.* Because of the limited number of interviews necessary, this ap-

proach would be particularly useful in intensification situations and for industrial, commercial, and home construction firms which are already in the general area.

(ii) *Institutional sources.* Various sources on information include: local flood control districts, local zoning ordinances and Federal flood plain management offices.

(iii) *Flood damages per acre.* Where the flood plain is fairly homogenous except for the flood hazard, the flood damages per acre (or other unit) on the portion of the flood plain which is expected to experience the same development pattern with or without the plan approximate an acceptable level of flood hazard. Every advantage should be taken of statistical sampling techniques under these conditions.

(iv) *Similar projects.* The effect of Federal or local projects along the same stream or other similar streams may indicate the threshold level. For example, if 50-year channel works induced residential development in a nearby area, the 50-year protection threshold level for the study area would probably be similar.

(v) *Location within the flood plain.* Low levels of protection may induce development of only those areas of the flood plain which are not subject to large damages.

(vi) *Prior determinations.* Where a detailed analysis (subsequent paragraphs) of development and operating costs has established a given threshold level for a stream, the same level may apply for other streams in the area or other streams with similar characteristics.

(vii) *Shape of damage curve.* For example, where potential damages occur primarily in larger floods, a high level of protection will be necessary to induce activities to locate in the flood plain.

(c) *Changes in the market value of land.* Changes in market value of land can be used to measure location benefits. The value of land is established through market transactions and is influenced by buyers and sellers considering the estimated effects of risk, uncertainty, probability of higher use, and the time lapse before particular land parcels are expected to shift into a higher order of use. Consequently, market land value represents the present capitalized value of the anticipated future income stream (rents) associated with the expected uses of the land. Changes in the market value of land can be used to measure the benefits to activities which would locate in the flood plain when there are important externalities associated with a plan. Thus, there are two uses of changes in the market value of land.

(1) *Location benefit to users.* The benefit is the difference in the market value of flood plain land with and without a plan.

(i) *With plan value.* If the plan does not result in a major addition to the supply of land in the area, the value with protection is the market value of comparable flood free land. If the plan results in a major addition to the supply, the effect on the general price of land should be taken into account in estimating the value of flood plain lands with protection. The flood free land must be comparable in terms of physical and infrastructural characteristics, e.g., water availability, transportation, soil stability, utilities, amenities, and so forth.

(ii) *Without plan value.* The value of nearby flood plain sites should be used or, where reasonable, the current value of the flood plain. In either case, the current and, where available, past market values of the flood plain will be reported. Actual market values will be used, not capitalized income values. Hence, it must not be assumed that the value of land being used for agriculture in an urban or urbanizing situation is the capitalized value of agricultural returns and that any value higher than that is due to (*a*) speculation on a Corps' project or (*b*) lack of knowledge. On the contrary, without values in excess of agricultural values are to be expected, reflecting the probability of future use as well as existing and anticipated infrastructural investments (e.g., highways, water supply, etc.). In addition, the comparable without project sites should not be flood free agricultural sites.

(iii) *Projection of market value of land.* Projected increases in the market value of land with and without a plan may not be used to measure flood control benefits. This is because the current market value of land theoretically captures the expected stream of benefits over time.

(iv) *Data problems, sources and display.* Comparable sites should always be specified both as to location and as to sales data utilized for establishing the price. In addition, the comparable sites should be displayed on a map. The number of observations and an analysis of the range of values must be based on sound statistical procedures. In addition, the difference in with and without values must be net of differences due to zoning and to parcel size. Market values may be obtained from reports of land transactions, appraisals and assessments and other sources depending upon data availability and reliability.

(v) *Computation of benefits from market value data.* The Federal rate of return will be used in converting market values to average annual benefits. This is because of the difficulties in converting a nominal private rate of return to a real rate of return by adjusting for inflation. Of course, residual damages to induced activities must be deducted. Increased flood damages to areas outside the protected area must also be deducted and inundation benefits to displaced activities must be deducted if these were claimed as inundation benefits.

(2) *Effects from externalities.* In addition to its effects on flood damages outside the protected area, a plan may have other effects on activities near the flood plain. For example, when a plan permits the development of a flood plain which otherwise would be open or green space, nearby activities may suffer losses. These losses would be reflected in a decline in land values in the nearby areas. Conversely, open or green space as a component of a flood plain management plan may raise surrounding land values. When such externalities are expected to be important and can be estimated, they should be included in the location benefit calculation.

§ 341.47 Intensification benefit.

The intensification benefit is the value of a plan to activities which are thus enabled to utilize their land more intensively. An example is where the reduction of the risk of flooding permits a user to invest additional labor or capital in the land, thereby producing higher crop yields or converting woodland or pasture to crops. This same type of benefit can accrue in urban settings. For example, homeowners may decline to renovate older homes due to a flood threat or properly utilize land available for expansion; the removal of the threat results in an intensification benefit. A flood plain management plan which embodies preservation or enhancement of open space, parks or historic sites may also result in large intensification benefits in urban settings where a high demand for such uses exists. Residual flood losses to these intensified activities must also be considered when calculating net flood damages.

(a) *Direct measurement.* Revenues and costs are usually available for agricultural activities. Direct measurement of net income changes is therefore possible. Net agricultural income for future years may be obtained by estimating anticipated net productivity gains in agriculture for the area under analysis. Factors of production should be made explicit. The analyst should utilize expert opinion, past trends and data from "model" farms such as those run by agricultural experiment stations. Net productivity is the increased yields and commodity price per acre adjusted for the change in costs, including inundation damages associated with the new operation. Under the majority of circumstances, it may be assumed that no individual project is likely to influence the productive practices of agricultural activity elsewhere. Although extremely difficult to measure, the cumulative effect of agricultural intensification benefits for each project should reflect the net reduction in agricultural income lost elsewhere because of the project. This means that the benefit is limited to the savings in cost for induced production when compared to production on upland areas, and must be so calculated whenever possible. In no case may this exceed the savings in the cost for induced production in the flood plain itself.

(b) *Threshold levels.* Similar to the measurement approach for location benefits, intensification benefit can be measured by those flood damages reduced above the threshold level.

(c) *Market value of land.* As discussed under inundation reduction and location benefits, market value is normally not preferred as a measure of benefits; although it does provide a useful check upon other techniques and may serve as a parameter of benefit worth.

§ 341.48 Remaining flood damage situation: Categorization.

The remaining damages are those which are expected to occur even with a flood plain management plan in operation. Categories of remaining damages are:

(a) Damages to activities which would occupy the flood plain with as well as without the plan. Damages to these activities may be increased by the presence of induced activities because the induced activities reduce the natural storage area of the flood plain (e.g., by floodway encroachment). Such effects are a part of the remaining damages.

(b) Damages to activities which would occupy the flood plain only with the plan. Again effects of increased flood heights resulting from induced development are a part of the remaining damages.

(c) Increased damages to activities outside the protected area under the with—as compared to the without—condition. For example, the plan itself or the development induced by a plan may cause increased or new flooding on the fringe of the flood plain or up and downstream. Such external effects are a part of the remaining damages.

§ 341.49 Remaining flood damage situation: Display.

The quantity and nature of remaining flooding, particularly for large and infrequent floods, will have an important bearing on plan formulation, evacuation and recommendation as already indicated §§ 341.44–341.46 of this Part. Benefits resulting from a plan must be net of residual damages. Therefore, the benefit evaluation and measurement part of any report shall separately describe and quantify remaining flooding. In order that an unacceptably large remaining loss condition does not remain under any given plan, and in order that plan induced losses are not overlooked, it is most important that remaining losses are carefully and explicitly presented. The remaining flood situation should be described by at least the following parameters:

(a) *Average annual equivalent residual flood losses.* Such losses are to be presented in average annual equivalent flood losses, existing and projected, brought to present worth, and amortized.

(b) *Residual average annual losses for selected years.* Annual losses, on an undeferred basis, shall be presented for the current year, the base year, and by decade thereafter. Full account will be taken of projected hydrologic demographic and economic changes. Average future hydrologic conditions shall not be used.

(c) *Standard project flood.* Flood losses with project are an extremely important factor in plan choice in urban situations, especially where the possibility of a catastrophic flood remains. A catastrophe occurs when an urban area is crippled for a sustained period, where a substantial infusion of Federal, state or regional rehabilitation funds (disaster relief) is necessary, or where it could be expected to be deemed a Federal or state disaster area. Likewise, a catastrophe oc-

curs when a serious danger to life exists or extensive property damage results. It is possible that a plan may be effective in reducing average annual flood losses but ineffective against large (SPF) floods; e.g., thus levees may be overtopped and far upstream reservoirs may not effectively reduce damaging stages at the downstream damage center. A plan could actually increase the disaster potential of an area by inducing unwise use of the flood plain unless land use is regulated with full recognition of the remaining hazard. Therefore, remaining flooding in a SPF flood, with the plan, must be fully described. With plan, SPF damages will be presented on an undeferred basis for the selected years listed in the prior subparagraph. The number of structures and acres by land use type, the disruption of essential services (water, power, fire protection and sanitary services) and the distance to unaffected essential services, the depth of flooding, and anticipated warning time, the velocity, duration, typical debris content and any other pertinent descriptors of the residual flood situation will be presented. Similarly, damages and descriptors under without plan conditions will be presented for comparative purposes. The presentations of SPF losses will clearly distinguish between losses to plan induced or intensified development, losses to development which would locate in the flood plain with and without the plan, and increased losses to development off the flood plain.

Subpart E—Validation of Benefit Evaluation

§ 341.50 Methods for adding validity to benefit evaluation.

The following is a brief discussion of several methods by which the planner can improve the credibility of the results of a proposed plan. The suggested techniques are not all-inclusive, and many may not be applicable in the majority of analyses. The inclusion of such tests may be required under certain conditions and will be expected whenever there is any significant question regarding the validity of the underlying analysis.

(a) *Sensitivity analysis.* Sensitivity analysis is a necessary feature of any good, multivariable analysis. The planner cannot be satisfied with the definition of a plan for resource (e.g., land, water, recreation, etc.) allocation that is optimal for a specific set of conditions if the plan is particularly sensitive to changes in the model. Water and land resource allocation models require the planner to predict both the rate of changes in the assumed values of the model parameters and the range of conditions over which any particular plan is recommendable; these data are obtained by sensitivity analysis. In cases where a solution is found to be particularly sensitive to a given variable or parameter, such information must be made explicit in the plan formulation and evaluation report.

(b) *Utilization of sampling techniques and statistical testing.* This method can be applied whenever practical, statistically sound sampling techniques can be utilized in the collection of data on flood plains and their affected areas. Sampling is not only an excellent means of reducing the cost of the study effort, but can often result in data which are statistically superior to a total survey approach in terms of accuracy and consistency. In addition, the planner is in a position to predetermine a sample size which will produce results of a comparable accuracy (and cost) with the remaining study elements. This is possible by choosing a sample size whose level of confidence (probability) is no greater nor less than that of the study as a whole. Except when a true sample is utilized, statistical measures of probability cannot be accurately quantified. Likewise, knowledge of data characteristics such as distribution and mean variation can assist the planner substantially in the design of sensitivity tests, optimal solutions and overall estimates of study result probability for further plan formulation and evaluation.

(c) *Quantifying variable relationships.* Whenever a cause and effect relationship is assumed to exist between a study (dependent) variable and one or more independent variables, a coefficient of correlation and determination must be cited prior to its introduction into plan formulation and evaluation. Whenever this same relationship is projected into the future, the source of the projected, independent variable must be cited and the final regression coefficients conspicuously displayed in the final report. In addition, an indication of how well the regression equation described the assumed relationship must also be stated; e.g., a measure of the dispersion of the actual values of Y about the regression line, similar to the variance or the standard deviation for the mean average of the previously discussed sample. There are numerous standard analytical computer routines which the planner can utilize for this task, including those available within the Corps System of Information Retrieval and Analysis for Planners (SIRAP) program.

§ 341.51 Assumptions and hypotheses.

A summary of study assumptions and hypotheses to be utilized in a study effort should precede the presentation of the analysis. An indication of the sensitivity of study results (direct or indirect) to changes in each study assumption, hypothesis or variable should be noted at the time of its introduction into the analytical process; (e.g., a hypothetical example might read, "the study assumed a fertility rate of 2.7 percent by the year 2000. Alternative assumptions of 3.1 percent and 2.45 percent were also tested and resulted in less than 5 percent change in aggregate water supply requirements and a 3 percent change in total benefits, with no change in project design implied."). It should be noted that many assumptions possess a certain consistency. These interdependenci
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Appen
LEGISLATION AFFECTI
FLOOD PLAINS I

Act of 1973 (PL 93-234)

cerning Land Use

gulation of the Colorado Water

w 93-234
H. R. 8449
31, 1973

Act

program by substantially increasing
insurance authorized to be outstanding
communities to participate in the pro-

House of Representatives of the
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'rotection Act of 1973".

Flood Disaster
Protection Act
of 1973.

RATION OF PURPOSE

: the Nation from floods and mud-
rming rate, largely as a result of
, and concentration of population
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87 STAT. 975

87 STAT. 976

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234 - 2 - December 31, 1973

DEFINITIONS

sed in this Act, unless the context otherwise requires,

nunity" means a State or a political subdivision
has zoning and building code jurisdiction over a
a having special flood hazards;
al agency" means any department, agency, corpora-
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sociation and the Federal Home Loan Mortgage

cial assistance" means any form of loan, grant, guar-
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neral or special revenue sharing or formula grants
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Appendix E
LEGISLATION AFFECTING REGULATION OF FLOOD PLAINS IN COLORADO

1. U. S. Flood Disaster Act of 1973 (PL 93-234)

2. Colorado HB 1041 Concerning Land Use

3. Model Flood Plain Regulation of the Colorado Water Conservation Board

Public Law 93-234
93rd Congress, H. R. 8449
December 31, 1973

An Act

To expand the national flood insurance program by substantially increasing limits of coverage and total amount of insurance authorized to be outstanding and by requiring known flood-prone communities to participate in the program, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Flood Disaster Protection Act of 1973". Flood Disaster Protection Act of 1973.

FINDINGS AND DECLARATION OF PURPOSE

SEC. 2. (a) The Congress finds that—

(1) annual losses throughout the Nation from floods and mudslides are increasing at an alarming rate, largely as a result of the accelerating development of, and concentration of population in, areas of flood and mudslide hazards;

(2) the availability of Federal loans, grants, guaranties, insurance, and other forms of financial assistance are often determining factors in the utilization of land and the location and construction of public and of private industrial, commercial, and residential facilities;

(3) property acquired or constructed with grants or other Federal assistance may be exposed to risk of loss through floods, thus frustrating the purpose for which such assistance was extended;

(4) Federal instrumentalities insure or otherwise provide financial protection to banking and credit institutions whose assets include a substantial number of mortgage loans and other indebtedness secured by property exposed to loss and damage from floods and mudslides; 87 STAT. 975

(5) the Nation cannot afford the tragic losses of life caused annually by flood occurrences, nor the increasing losses of property suffered by flood victims, most of whom are still inadequately compensated despite the provision of costly disaster relief benefits; and 87 STAT. 976

(6) it is in the public interest for persons already living in flood-prone areas to have both an opportunity to purchase flood insurance and access to more adequate limits of coverage, so that they will be indemnified for their losses in the event of future flood disasters.

(b) The purpose of this Act, therefore, is to—

(1) substantially increase the limits of coverage authorized under the national flood insurance program;

(2) provide for the expeditious identification of, and the dissemination of information concerning, flood-prone areas;

(3) require States or local communities, as a condition of future Federal financial assistance, to participate in the flood insurance program and to adopt adequate flood plain ordinances with effective enforcement provisions consistent with Federal standards to reduce or avoid future flood losses; and

(4) require the purchase of flood insurance by property owners who are being assisted by Federal programs or by federally supervised, regulated, or insured agencies or institutions in the acquisition or improvement of land or facilities located or to be located in identified areas having special flood hazards.

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DEFINITIONS

SEC. 3. (a) As used in this Act, unless the context otherwise requires, the term—

(1) "community" means a State or a political subdivision thereof which has zoning and building code jurisdiction over a particular area having special flood hazards;

(2) "Federal agency" means any department, agency, corporation, or other entity or instrumentality of the executive branch of the Federal Government, and includes the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation;

(3) "financial assistance" means any form of loan, grant, guaranty, insurance, payment, rebate, subsidy, disaster assistance loan or grant, or any other form of direct or indirect Federal assistance, other than general or special revenue sharing or formula grants made to States;

87 STAT. 976
87 STAT. 977

(4) "financial assistance for acquisition or construction purposes" means any form of financial assistance which is intended in whole or in part for the acquisition, construction, reconstruction, repair, or improvement of any publicly or privately owned building or mobile home, and for any machinery, equipment, fixtures, and furnishings contained or to be contained therein, and shall include the purchase or subsidization of mortgages or mortgage loans but shall exclude assistance for emergency work essential for the protection and preservation of life and property performed pursuant to the Disaster Relief Act of 1970 or any subsequent Act of Congress which supersedes or modifies the Disaster Relief Act of 1970; 84 Stat. 1744. 42 USC 4401 note.

(5) "Federal instrumentality responsible for the supervision, approval, regulation, or insuring of banks, savings and loan associations, or similar institutions" means the Board of Governors of the Federal Reserve System, the Federal Deposit Insurance Corporation, the Comptroller of the Currency, the Federal Home Loan Bank Board, the Federal Savings and Loan Insurance Corporation, and the National Credit Union Administration; and

(6) "Secretary" means the Secretary of Housing and Urban Development.

(b) The Secretary is authorized to define or redefine, by rules and regulations, any scientific or technical term used in this Act, insofar as such definition is not inconsistent with the purposes of this Act.

TITLE I—EXPANSION OF NATIONAL FLOOD INSURANCE PROGRAM

INCREASED LIMITS OF COVERAGE

SEC. 101. (a) Section 1306(b)(1)(A) of the National Flood Insurance Act of 1968 is amended to read as follows: 82 Stat. 575. 42 USC 4013.

"(A) in the case of residential properties—

"(i) $35,000 aggregate liability for any single-family dwelling, and $100,000 for any residential structure containing more than one dwelling unit,

"(ii) $10,000 aggregate liability per dwelling unit for any contents related to such unit, and

"(iii) in the States of Alaska and Hawaii, and in the Virgin Islands and Guam, the limits provided in clause (i) of this sentence shall be: $50,000 aggregate liability for any single-family dwelling, and $150,000 for any residential structure containing more than one dwelling unit;".

87 STAT. 978

(b) Section 1306(b)(1)(B) of such Act is amended by striking out "$30,000" and "$5,000" wherever they appear and inserting in lieu thereof "$100,000". 82 Stat. 575. 42 USC 4013.

(c) Section 1306(b)(1)(C) of such Act is amended to read as follows: 85 Stat. 775.

"(C) in the case of church properties and any other properties which may become eligible for flood insurance under section 1305— 83 Stat. 397. 42 USC 4012.

"(i) $100,000 aggregate liability for any single structure, and

"(ii) $100,000 aggregate liability per unit for any contents related to such unit; and."

REQUIREMENT TO PURCHASE FLOOD INSURANCE

SEC. 102. (a) After the expiration of sixty days following the date of enactment of this Act, no Federal officer or agency shall approve any financial assistance for acquisition or construction purposes for use in any area that has been identified by the Secretary as an area having special flood hazards and in which the sale of flood insurance has been made available under the National Flood Insurance Act of 1968, unless the building or mobile home and any personal property to which such financial assistance relates is, during the anticipated economic or useful life of the project, covered by flood insurance in an amount at least equal to its development or project cost (less estimated land cost) or to the maximum limit of coverage made available with respect to the particular type of property under the National Flood Insurance Act of 1968, whichever is less: *Provided*, That if the financial assistance provided is in the form of a loan or an insurance or guaranty of a loan, the amount of flood insurance required need not exceed the outstanding principal balance of the loan and need not be required beyond the term of the loan. 82 Stat. 572. 42 USC 4001 note.

(b) Each Federal instrumentality responsible for the supervision, approval, regulation, or insuring of banks, savings and loan associations, or similar institutions shall by regulation direct such institutions not to make, increase, extend, or renew after the expiration of sixty days following the date of enactment of this Act any loan secured by improved real estate or a mobile home located or to be located in an area that has been identified by the Secretary as an area having special flood hazards and in which flood insurance has been made available under the National Flood Insurance Act of 1968, unless the building or mobile home and any personal property securing such loan is covered for the term of the loan by flood insurance in an amount at least equal to the outstanding principal balance of the loan or to the maximum limit of coverage made available with respect to the particular type of property under the Act, whichever is less.

(c) Notwithstanding the other provisions of this section, flood insurance shall not be required on any State-owned property that is covered under an adequate State policy of self-insurance satisfactory to the Secretary. The Secretary shall publish and periodically revise the list of States to which this subsection applies. State-owned property, exemption.

ESTABLISHMENT OF CHARGEABLE RATES

SEC. 103. Section 1308 of the National Flood Insurance Act of 1968 is amended by striking out subsection (c) and inserting in lieu thereof the following new subsection: 82 Stat. 576. 42 USC 4015.

"(c) Notwithstanding any other provision of this title, the chargeable rate with respect to any property, the construction or substantial improvement of which the Secretary determines has been started after

82 Stat. 587. 42 USC 4101.

December 31, 1974, or the effective date of the initial rate map published by the Secretary under paragraph (2) of section 1360 for the area in which such property is located, whichever is later, shall not be less than the applicable estimated risk premium rate for such area (or subdivision thereof) under section 1307(a)(1).".

42 USC 4014.

FINANCING

82 Stat. 577. 42 USC 4016.

SEC. 104. Section 1309(a) of the National Flood Insurance Act of 1968 is amended by striking out all after the semicolon and inserting in lieu thereof the following: "except that the total amount of notes and obligations which may be issued by the Secretary pursuant to such authority (1) without the approval of the President, may not exceed $500,000,000, and (2) with the approval of the President, may not exceed $1,000,000,000. The Secretary shall report to the Committee on Banking and Currency of the House of Representatives and the Committee on Banking, Housing and Urban Affairs of the Senate at any time when he requests the approval of the President in accordance with the preceding sentence.".

Report to congressional committees.

PROGRAM EXPIRATION

82 Stat. 581. 42 USC 4026.

SEC. 105. Section 1319 of the National Flood Insurance Act of 1968 is amended to read as follows:

"PROGRAM EXPIRATION

"SEC. 1319. No new contract for flood insurance under this title shall be entered into after June 30, 1977.".

EMERGENCY IMPLEMENTATION OF PROGRAM

83 Stat. 396; 85 Stat. 775. 42 USC 4056.

SEC. 106. Subsection (a) of section 1336 of the National Flood Insurance Act of 1968 is amended by striking the date "December 31, 1973" and inserting in lieu thereof "December 31, 1975".

DEFINITION OF FLOOD

82 Stat. 588; 83 Stat. 397. 42 USC 4121.

SEC. 107. Section 1370(b) of the National Flood Insurance Act of 1968 is amended by inserting "proximately" before "caused".

EXTENSION OF FLOOD INSURANCE PROGRAM TO COVER LOSSES FROM EROSION AND UNDERMINING OF SHORELINES

42 USC 4001.

SEC. 108. (a) Section 1302 of the National Flood Insurance Act of 1968 is amended by adding at the end thereof the following new subsection:

"(g) The Congress also finds that (1) the damage and loss which may result from the erosion and undermining of shorelines by waves or currents in lakes and other bodies of water exceeding anticipated cyclical levels is related in cause and similar in effect to that which results directly from storms, deluges, overflowing waters, and other forms of flooding, and (2) the problems involved in providing protection against this damage and loss, and the possibilities for making such protection available through a Federal or federally sponsored program, are similar to those which exist in connection with efforts to provide protection against damage and loss caused by such other forms of flooding. It is therefore the further purpose of this title to make available, by means of the methods, procedures, and instrumentalities which are otherwise established or available under this title for purposes of the flood insurance program, protection against damage and loss resulting from the erosion and undermining of shorelines by waves

or currents in lakes and other bodies of water exceeding anticipated cyclical levels.".

(b) Section 1370 of such Act is amended by adding at the end thereof the following new subsection:

82 Stat. 588; 83 Stat. 397. 42 USC 4121.

"(c) The term 'flood' shall also include the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels, and all of the provisions of this title shall apply with respect to such collapse or subsidence in the same manner and to the same extent as with respect to floods described in paragraph (1), subject to and in accordance with such regulations, modifying the provisions of this title (including the provisions relating to land management and use) to the extent necessary to insure that they can be effectively so applied, as the Secretary may prescribe to achieve (with respect to such collapse or subsidence) the purposes of this title and the objectives of the program.".

"Flood."

ESTIMATES OF PREMIUM RATES

82 Stat. 576. 42 USC 4014.

SEC. 109. Section 1307 of the National Flood Insurance Act of 1968 is amended by adding at the end thereof the following new subsection:

"(d) Notwithstanding any other provision of law, any structure existing on the date of enactment of the Flood Disaster Protection Act of 1973 and located within Avoyelles, Evangeline, Rapides, or Saint Landry Parish in the State of Louisiana, which the Secretary determines is subject to additional flood hazards as a result of the construction or operation of the Atchafalaya Basin Levee System, shall be eligible for flood insurance under this title (if and to the extent it is eligible for such insurance under the other provisions of this title) at premium rates that shall not exceed those which would be applicable if such additional hazards did not exist.".

Ante, p. 975.

APPEALS

82 Stat. 587. 42 USC 4101.

SEC. 110. Chapter III of the National Flood Insurance Act of 1968 is amended by adding at the end thereof the following new section:

"APPEALS

42 USC 4102. Publication in Federal Register.

"SEC. 1363. (a) In establishing projected flood elevations for land use purposes with respect to any community pursuant to section 1361, the Secretary shall first propose such determinations by publication for comment in the Federal Register, by direct notification to the chief executive officer of the community, and by publication in a prominent local newspaper.

Flood elevation determinations, publication.

"(b) The Secretary shall publish notification of flood elevation determinations in a prominent local newspaper at least twice during the ten-day period following notification to the local government. During the ninety-day period following the second publication, any owner or lessee of real property within the community who believes his property rights to be adversely affected by the Secretary's proposed determination may appeal such determination to the local government. The sole basis for such appeal shall be the possession of knowledge or information indicating that the elevations being proposed by the Secretary with respect to an identified area having special flood hazards are scientifically or technically incorrect, and the sole relief which shall be granted under the authority of this section in the event that such appeal is sustained in accordance with subsection (e) or (f) is a modification of the Secretary's proposed determination accordingly.

Appeals by private persons.

"(c) Appeals by private persons shall be made to the chief executive officer of the community, or to such agency as he shall publicly designate, and shall set forth the data that tend to negate or contradict the Secretary's finding in such form as the chief executive officer may specify. The community shall review and consolidate all such appeals and issue a written opinion stating whether the evidence presented is sufficient to justify an appeal on behalf of such persons by the community in its own name. Whether or not the community decides to appeal the Secretary's determination, copies of individual appeals shall be sent to the Secretary as they are received by the community, and the community's appeal or a copy of its decision not to appeal shall be filed with the Secretary not later than ninety days after the date of the second newspaper publication of the Secretary's notification.

Review.

"(d) In the event the Secretary does not receive an appeal from the community within the ninety days provided, he shall consolidate and review on their own merits, in accordance with the procedures set forth in subsection (c), the appeals filed within the community by private persons and shall make such modifications of his proposed determinations as may be appropriate, taking into account the written opinion, if any, issued by the community in not supporting such appeals. The Secretary's decision shall be in written form, and copies thereof shall be sent both to the chief executive officer of the community and to each individual appellant.

Publication in Federal Register.

"(e) Upon appeal by any community, as provided by this section, the Secretary shall review and take fully into account any technical or scientific data submitted by the community that tend to negate or contradict the information upon which his proposed determination is based. The Secretary shall resolve such appeal by consultation with officials of the local government involved, by administrative hearing, or by submission of the conflicting data to an independent scientific body or appropriate Federal agency for advice. Until the conflict in data is resolved, and the Secretary makes a final determination on the basis of his findings in the Federal Register, and so notifies the governing body of the community, flood insurance previously available within the community shall continue to be available, and no person shall be denied the right to purchase such insurance at chargeable rates. The Secretary shall make his determination within a reasonable time. The community shall be given a reasonable time after the Secretary's final determination in which to adopt local land use and control measures consistent with the Secretary's determination. The reports and other information used by the Secretary in making his final determination shall be made available for public inspection and shall be admissible in a court of law in the event the community seeks judicial review as provided by this section.

Information, availability.

"(f) Any appellant aggrieved by any final determination of the Secretary upon administrative appeal, as provided by this section, may appeal such determination to the United States district court for the district within which the community is located not more than sixty days after receipt of notice of such determination. The scope of review by the court shall be as provided by chapter 7 of title 5, United State Code. During the pendency of any such litigation, all final determinations of the Secretary shall be effective for the purposes of this title unless stayed by the court for good cause shown.".

80 Stat. 392. 5 USC 701.

FLOOD INSURANCE PREMIUM EQUALIZATION PAYMENTS

82 Stat. 583. 42 USC 4054.

SEC. 111. Section 1334 of the National Flood Insurance Act of 1968 is amended by striking out subsection (b) and by redesignating subsection "(c)" as subsection "(b)".

TITLE II—DISASTER MITIGATION REQUIREMENTS

NOTIFICATION TO FLOOD-PRONE AREAS

82 Stat. 587. 42 USC 4101.

SEC. 201. (a) Not later than six months following the enactment of this title, the Secretary shall publish information in accordance with subsection 1360(1) of the National Flood Insurance Act of 1968, and shall notify the chief executive officer of each known flood-prone community not already participating in the national flood insurance program of its tentative identification as a community containing one or more areas having special flood hazards.

Public hearing.

(b) After such notification, each tentatively identified community shall either (1) promptly make proper application to participate in the national flood insurance program or (2) within six months submit technical data sufficient to establish to the satisfaction of the Secretary that the community either is not seriously flood prone or that such flood hazards as may have existed have been corrected by floodworks or other flood control methods. The Secretary may, in his discretion, grant a public hearing to any community with respect to which conflicting data exist as to the nature and extent of a flood hazard. If the Secretary decides not to hold a hearing, the community shall be given an opportunity to submit written and documentary evidence. Whether or not such hearing is granted, the Secretary's final determination as to the existence or extent of a flood hazard area in a particular community shall be deemed conclusive for the purposes of this Act if supported by substantial evidence in the record considered as a whole.

(c) As information becomes available to the Secretary concerning the existence of flood hazards in communities not known to be flood prone at the time of the initial notification provided for by subsection (a) of this section he shall provide similar notifications to the chief executive officers of such additional communities, which shall then be subject to the requirements of subsection (b) of this section. Notifications to other communities officers.

(d) Formally identified flood-prone communities that do not qualify for the national flood insurance program within one year after such notification or by the date specified in section 202, whichever is later, shall thereafter be subject to the provisions of that section relating to flood-prone communities which are not participating in the program. Supra.

EFFECT OF NONPARTICIPATION IN FLOOD INSURANCE PROGRAM

SEC. 202. (a) No Federal officer or agency shall approve any financial assistance for acquisition or construction purposes on and after July 1, 1975, for use in any area that has been identified by the Secretary as an area having special flood hazards unless the community in which such area is situated is then participating in the national flood insurance program.

(b) Each Federal instrumentality responsible for the supervision, approval, regulation, or insuring of banks, savings and loan associations, or similar institutions shall by regulation prohibit such institutions on and after July 1, 1975, from making, increasing, extending, or renewing any loan secured by improved real estate or a mobile home located or to be located in an area that has been identified by the Secretary as an area having special flood hazards, unless the community in which such area is situated is then participating in the national flood insurance program.

REPEAL OF DISASTER ASSISTANCE PENALTY

SEC. 203. Section 1314 of the National Flood Insurance Act of 1968 is repealed. Repeal. 82 Stat. 579. 42 USC 4021.

87 STAT. 983

ACCELERATED IDENTIFICATION OF FLOOD-RISK ZONES

SEC. 204. (a) Section 1360 of the National Flood Insurance Act of 1968 is amended by inserting the designation "(a)" after "SEC. 1360." and adding at the end thereof the following new subsections: 82 Stat. 587. 42 USC 4101.

"(b) The Secretary is directed to accelerate the identification of risk zones within flood-prone and mudslide-prone areas, as provided by subsection (a)(2) of this section, in order to make known the degree of hazard within each such zone at the earliest possible date. To accomplish this objective, the Secretary is authorized, without regard to sections 3648 and 3709 of the Revised Statutes, as amended (31 U.S.C. 529 and 41 U.S.C. 5), to make grants, provide technical assistance, and enter into contracts, cooperative agreements, or other transactions, on such terms as he may deem appropriate, or consent to modifications thereof, and to make advance or progress payments in connection therewith. Grants, technical assistance, etc., authorization.

"(c) The Secretary of Defense (through the Army Corps of Engineers), the Secretary of the Interior (through the United States Geological Survey), the Secretary of Agriculture (through the Soil Conservation Service), the Secretary of Commerce (through the National Oceanic and Atmospheric Administration), the head of the Tennessee Valley Authority, and the heads of all other Federal agencies engaged in the identification or delineation of flood-risk zones within the several States shall, in consultation with the Secretary, give the highest practicable priority in the allocation of available manpower and other available resources to the identification and mapping of flood hazard areas and flood-risk zones, in order to assist the Secretary to meet the deadline established by this section.".

AUTHORITY TO ISSUE REGULATIONS

SEC. 205. (a) The Secretary is authorized to issue such regulations as may be necessary to carry out the purpose of this Act.

(b) The head of each Federal agency that administers a program of financial assistance relating to the acquisition, construction, reconstruction, repair, or improvement of publicly or privately owned land or facilities, and each Federal instrumentality responsible for the supervision, approval, regulation, or insuring of banks, savings and loan associations, or similar institutions, shall, in cooperation with the Secretary, issue appropriate rules and regulations to govern the carrying out of the agency's responsibilities under this Act.

CONSULTATION WITH LOCAL OFFICIALS

SEC. 206. In carrying out his responsibilities under the provisions of this title and the National Flood Insurance Act of 1968 which relate to notification to and identification of flood-prone areas and the application of criteria for land management and use, including criteria derived from data reflecting new developments that may indicate the desirability of modifying elevations based on previous flood studies, the Secretary shall establish procedures assuring adequate consultation with the appropriate elected officials of general purpose local governments, including but not limited to those local governments whose prior eligibility under the program has been suspended. Such consultation shall include, but not be limited to, fully informing local officials at the commencement of any flood elevation study or investigation undertaken by any agency on behalf of the Secretary concerning the nature and purpose of the study, the areas involved, the manner in which the study is to be undertaken, the general principles to be applied, and the use to be made of the data obtained. The 82 Stat. 572. 42 USC 4001 note.

Secretary shall encourage local officials to disseminate information concerning such study widely within the community, so that interested persons will have an opportunity to bring all relevant facts and technical data concerning the local flood hazard to the attention of the agency during the course of the study.

TO PERMIT NATIONAL BANKS TO INVEST IN AGRICULTURAL CREDIT CORPORATIONS

SEC. 207. That paragraph "Seventh" of section 5136 of the Revised Statutes (12 U.S.C. 24) is amended by adding at the end thereof the following: "Notwithstanding any other provision in this paragraph, the association may purchase for its own account shares of stock issued by a corporation organized solely for the purpose of making loans to farmers and ranchers for agricultural purposes, including the breeding, raising, fattening, or marketing of livestock. However, unless the association owns at least 80 per centum of the stock of such agricultural credit corporation the amount invested by the association at any one time in the stock of such corporation shall not exceed 20 per centum of the unimpaired capital and surplus of the association.".

FLEXIBLE INTEREST RATE AUTHORITY FOR MOBILE HOME LOANS

SEC. 208. Section 3(a) of the Act entitled "An Act to amend chapter 37 of title 38 of the United States Code with respect to the veterans' home loan program, to amend the National Housing Act with respect to interest rates on insured mortgages, and for other purposes", approved May 7, 1968, as amended (12 U.S.C. 1709-1), is amended by adding at the end thereof the following new sentence: "Notwithstanding the provisions of section 2(b) of the National Housing Act regarding the maximum interest rate which may be established for obligations with respect to which insurance is granted to financial institutions under section 2 of such Act, the Secretary of Housing and Urban Development is also authorized, until the date specified in the preceding sentence, to set the maximum interest rate for obligations with respect to which insurance is granted under such section, and which represent loans and advances of credit made for the purpose of financing purchases of mobile homes, at such level as he finds necessary to meet the loan market.". 82 Stat. 113; 86 Stat. 405. 12 USC 1703.

Approved December 31, 1973.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 93-359 (Comm. on Banking and Currency).
SENATE REPORT No. 93-583 (Comm. on Banking, Housing and Urban Affairs).
CONGRESSIONAL RECORD, Vol. 119 (1973):
Sept. 5, considered and passed House.
Dec. 1, considered and passed Senate, amended.
Dec. 3, motion vacated; bill restored to calendar.
Dec. 18, considered and passed Senate, amended.
Dec. 20, House agreed to Senate amendment with an amendment; Senate concurred in House amendment.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 10, No. 1 (1974):
Dec. 31, 1973, Presidential statement.

An Act

HOUSE BILL NO. 1041. BY REPRESENTATIVES Dittemore, Buechner, Herzberger, Miller, Pettie, Eaker, Eckelberry, Friedman, Gustafson, Hamlin, Koster, O'Brian, Ross, Sack, Sonnenberg, and Tempest; also SENATORS Allshouse, Darby, Johnson, Plock, H. Brown, DeBerard, L. Fowler, Garnsey, Jackson, Klein, McCormick, Schieffelin, Stockton, and Strickland.

CONCERNING LAND USE, AND PROVIDING FOR IDENTIFICATION, DESIGNATION, AND ADMINISTRATION OF AREAS AND ACTIVITIES OF STATE INTEREST, AND ASSIGNING ADDITIONAL DUTIES TO THE COLORADO LAND USE COMMISION AND THE DEPARTMENT OF LOCAL AFFAIRS, AND MAKING APPROPRIATIONS THEREFOR.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Chapter 106, Colorado Revised Statutes 1963, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 7

Areas and Activities of State Interest

PART 1

GENERAL PROVISIONS

106-7-101. Legislative declaration. (1) In addition to the legislative declaration contained in section 106-4-1 (1), the general assembly further finds and declares that:

(a) The protection of the utility, value, and future of all lands within the state, including the public domain as well as privately owned land, is a matter of the public interest;

(b) Adequate information on land use and systematic methods of definition, classification, and utilization thereof are either lacking or not readily available to land use decision makers;

(c) It is the intent of the general assembly that land use, land use planning, and quality of development are matters in which the state has responsibility for the health, welfare, and safety of the people of the state and for the protection of the environment of the state.

(2) It is the purpose of this article that:

(a) The general assembly shall describe areas which may be of state interest and activities which may be of state interest and establish criteria for the administration of such areas and activities; Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

(b) Local governments shall be encouraged to designate areas and activities of state interest and, after such designation, shall administer such areas and activities of state interest and promulgate guidelines for the administration thereof; and

(c) Appropriate state agencies shall assist local governments to identify, designate, and adopt guidelines for administration of matters of state interest.

106-7-102. General definitions. As used in this article, unless the context otherwise requires:

(1) "Development" means any construction or activity which changes the basic character or the use of the land on which the construction or activity occurs.

(2) "Local government" means a municipality or county.

(3) "Local permit authority" means the governing body of a local government with which an application for development in an area of state interest or for conduct of an activity of state interest must be filed or the designee thereof.

(4) "Matter of state interest" means an area of state interest or an activity of state interest or both.

(5) "Municipality" means a home rule or statutory city, town, or city and county or a territorial charter city.

(6) "Person" means any individual, partnership, corporation, association, company, or other public or corporate body, including the federal government, and includes any political subdivision, agency, instrumentality, or corporation of the state.

106-7-103. Definitions pertaining to natural hazards. As used in this article, unless the context otherwise requires:

(1) "Aspect" means the cardinal direction the land surface faces, characterized by north-facing slopes generally having heavier vegetation cover.

(2) "Avalanche" means a mass of snow or ice and other material which may become incorporated therein as such mass moves rapidly down a mountain slope.

(3) "Corrosive soil" means soil which contains soluble salts which may produce serious detrimental effects in concrete, metal, or other substances that are in contact with such soil.

(4) "Debris-fan floodplain" means a floodplain which is located at the mouth of a mountain valley

tributary stream as such stream enters the valley floor.

(5) "Dry wash channel and dry wash floodplain" means a small watershed with a very high percentage of runoff after torrential rainfall.

(6) "Expansive soil and rock" means soil and rock which contains clay and which expands to a significant degree upon wetting and shrinks upon drying.

(7) "Floodplain" means an area adjacent to a stream, which area is subject to flooding as the result of the occurrence of an intermediate regional flood and which area thus is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Mainstream floodplains;

(b) Debris-fan floodplains; and

(c) Dry wash channels and dry wash floodplains.

(8) "Geologic hazard" means a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Avalanches, landslides, rock falls, mudflows, and unstable or potentially unstable slopes;

(b) Seismic effects;

(c) Radioactivity; and

(d) Ground subsidence.

(9) "Geologic hazard area" means an area which contains or is directly affected by a geologic hazard.

(10) "Ground subsidence" means a process characterized by the downward displacement of surface material caused by natural phenomena such as removal of underground fluids, natural consolidation, or dissolution of underground minerals or by man-made phenomena such as underground mining.

(11) "Mainstream floodplain" means an area adjacent to a perennial stream that is subject to periodic flooding.

(12) "Mudflow" means the downward movement of mud in a mountain watershed because of peculiar characteristics of extremely high sediment yield and occasional high runoff.

(13) "Natural hazard" means a geologic hazard, a wildfire hazard, or a flood.

(14) "Natural hazard area" means an area containing or directly affected by a natural hazard.

(15) "Radioactivity" means a condition related to various types of radiation emitted by natural radioactive minerals that occur in natural deposits of rock, soil, and water.

(16) "Seismic effects" means direct and indirect effects caused by an earthquake or an underground nuclear detonation.

(17) "Siltation" means a process which results in an excessive rate of removal of soil and rock materials from one location and rapid deposit thereof in adjacent areas.

(18) "Slope" means the gradient of the ground surface which is definable by degree or percent.

(19) "Unstable or potentially unstable slope" means an area susceptible to a landslide, a mudflow, a rock fall, or accelerated creep of slope-forming materials.

(20) "Wildfire behavior" means the predictable action of a wildfire under given conditions of slope, aspect, and weather.

(21) "Wildfire hazard" means a wildfire phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Slope and aspect;

(b) Wildfire behavior characteristics; and

(c) Existing vegetation types.

(22) "Wildfire hazard area" means an area containing or directly affected by a wildfire hazard.

106-7-104. Definitions pertaining to other areas and activities of state interest. As used in this article, unless the context otherwise requires:

(1) "Airport" means any municipal or county airport or airport under the jurisdiction of an airport authority.

(2) "Area around a key facility" means an area immediately and directly affected by a key facility.

(3) "Arterial highway" means any limited-access highway which is part of the federal-aid interstate system or any limited-access highway constructed under the supervision of the state department of highways.

(4) "Collector highway" means a major thoroughfare serving as a corridor or link between municipalities, unincorporated population centers or recreation areas, or industrial centers and constructed under guidelines and standards established by, or under the supervision of, the state department of highways. Collector highway does not include a city street or local service road or a county road designed for local service and constructed under the supervision of local government.

(5) "Domestic water and sewage treatment system" means a wastewater treatment plant, water treatment plant, or water supply system, as defined in section 66-38-2 (6), (7), and (8), C.R.S. 1963, and any system of pipes, structures, and facilities through which wastewater is collected for treatment.

(6) "Historical or archaeological resources of statewide importance" means resources which have been officially included in the national register of historic places, designated by statute, or included in an established list of places compiled by the state historical society.

(7) "Key facilities" means:

(a) Airports;

(b) Major facilities of a public utility;

(c) Interchanges involving arterial highways;

(d) Rapid or mass transit terminals, stations, and fixed guideways.

(8) "Major facilities of a public utility" means:

(a) Central office buildings of telephone utilities;

(b) Transmission lines, power plants, and substations of electrical utilities; and

(c) Pipelines and storage areas of utilities providing natural gas or other petroleum derivatives.

(9) "Mass transit" means a coordinated system of transit modes providing transportation for use by the general public.

(10) "Mineral" means an inanimate constituent of the earth, in either solid, liquid, or gaseous state which, when extracted from the earth, is usable in its natural form or is capable of conversion into usable form as a metal, a metallic compound, a chemical, an energy source, a raw material for manufacturing, or construction material. This definition does not include surface or ground water subject to appropriation for domestic, agricultural, or industrial purposes, nor does it include geothermal resources.

(11) "Mineral resource area" means an area in which minerals are located in sufficient concentration in veins, deposits, bodies, beds, seams, fields, pools, or otherwise, as to be capable of economic recovery. The term includes but is not limited to any area in which there has been significant mining activity in the past, there is significant mining activity in the present, mining development is planned or in progress, or mineral rights are held by mineral patent or valid mining claim with the intention of mining.

(12) "Natural resources of statewide importance" is limited to shorelands of major publicly-owned reservoirs and significant wildlife habitats in which the wildlife species, as identified by the division of wildlife of the department of natural resources, in a proposed area could be endangered.

(13) "New communities" means the major revitalization of existing municipalities or the establishment of urbanized growth centers in unincorporated areas.

(14) "Rapid transit" means the element of a mass transit system involving a mechanical conveyance on an exclusive land or guideway constructed solely for that purpose.

106-7-105. Effect of article - public utilities. (1) With regard to public utilities, nothing in this article shall be construed as enahncing or diminishing the power and authority of municipalities, counties, or the public utilities commission. Any order, rule, or directive issued by any governmental agency pursuant to this article shall not be inconsistent with or in contravention of any decision, order, or finding of the public utilities commission with respect to public convenience and necessity. The public utilities commission and public utilities shall take into consideration and, when feasible, foster compliance with adopted land use master plans of local governments, regions, and the state.

(2) Nothing in this article shall be construed as enhancing or diminishing the rights and procedures with respect to the power of a public utility to acquire property and rights-of-way by eminent domain to serve public need in the most economical and expedient manner.

106-7-106. Effect of aritcle - rights of property owners - water rights. (1) Nothing in this article shall be construed as:

(a) Enhancing or diminishing the rights of owners of property as provided by the state constitution or the constitution of the United States;

(b) Modifying or amending existing laws or court decrees with respect to the determination and administration of water rights.

106-7-107. Effect of article - developments in areas of state interest and activities of state interest meeting certain conditions. (1) This article shall not apply to any development in an area of state interest or any activity of state interest which meets any one of the following conditions as of the effective date of this article:

(a) The development or activity is covered by a current building permit issued by the appropriate local government; or

(b) The development or activity has been approved by the electorate; or

(c) The development or activity is to be on land:

(I) Which has been conditionally or finally approved by the appropriate local government for planned unit development or for a sue substantially the same as planned unit development; or

(II) Which has been zoned by the appropriate local government for the use contemplated by such development or activity; or

(III) With respect to which a development plan has been conditionally or finally approved by the appropriate governmental authority.

106-7-108. Effect of article - state agency or commission responses. (1) Whenever any person desiring to carry out development as defined in section 106-7-102 (1) is required to obtain a permit, to be issued by any state agency or commission for the purpose of authorizing or allowing such development, pursuant to this or any other statute or regulation promulgated thereunder, such agency shall establish a reasonable time period, which shall not exceed sixty days following receipt of such permit application, within which such agency must respond in writing to the applicant, granting or denying said permit or specifying all reasonable additional information necessary for the agency or commission to respond. If additional information is required, said agency or commission shall set a reasonable time period for response following the receipt of such information.

(2) Whenever a state agency or commission denies a permit, the denial must specify:

(a) The regulations, guidelines, and criteria or standards used in evaluating the application;

(b) The reasons for denial and the regulations, guidelines, and criteria or standards the application fails to satisfy; and

(c) The action that the applicant would have to take to satisfy the state agency's or commission's permit requirements.

(3) Whenever an application for a permit as provided under this section contains a statement describing the proposed nature, uses, and activities in conceptual terms for the development intended to be accomplished and is not accompanied with all additional information, including, without limitation, engineering studies, detailed plans and specifications, zoning approval, or where a hearing is required by the statutes, regulations, rules, ordinances, or resolutions thereof prior to the issuance of the requested permit, the agency or commission shall, within the time provided in this section for response, indicate its acceptance or denial of the permit on the basis of the concept expressed in the statement of the proposed uses and activities contained in the application. Such conceptual approval shall be made subject to the applicant filing and completing all prerequisite detailed additional information in accordance with the usual filing requirements of the agency or commission within a reasonable period of time.

(4) All agencies or commissions authorized or required to issue permits for development shall adopt rules and regulations, or amend existing rules and regulations, so as to require that such agency or commission respond in the time and manner required in this section.

(5) Nothing in this section shall shorten the time allowed for responses provided by federal statute dealing with, or having a bearing on, the subject of any such application for permit.

(6) The provisions of this section shall not apply to applications approved, denied, or processed by a unit of local government.

PART 2

AREAS AND ACTIVITIES DESCRIBED -

CRITERIA FOR ADMINISTRATION

106-7-201. Areas of state interest - as determined by local governments. (1) Subject to the procedures set forth in part 4 of this article, a local government may designate certain areas of state interest from among the following:

(a) Mineral resource areas;

(b) Natural hazard areas;

(c) Areas containing, or having a significant impact upon, historical, natural, or archaeological resources of statewide importance; and

(d) Areas around key facilities in which development may have a material effect upon the facility or the surrounding community.

106-7-202. Criteria for administration of areas of state interest. (1) (a) Mineral resource areas designated as areas of state interest shall be protected and administered in such a manner as to permit the extraction and exploration of minerals therefrom, unless extraction and exploration would cause significant danger to public health and safety. If the local government having jurisdiction, after weighing sufficient technical or other evidence, finds that the economic value of the minerals present therein is less than the value of another existing or requested use, such other use should be given preference; however, other uses which would not interfere with the extraction and exploration of minerals may be permitted in such areas of state interest.

(b) Areas containing only sand, gravel, quarry aggregate, or limestone used for construction purposes shall be administered as provided by article 36 of chapter 92, C.R.S. 1963.

(c) The extraction and exploration of minerals from any area shall be accomplished in a manner which causes the least practicable environmental disturbance, and surface areas disturbed thereby shall be reclaimed in accordance with the provisions of article 13 or article 32 of chapter 92, C. R. S. 1963, whichever is applicable.

(d) Unless an activity of state interest has been designated or identified or unless it includes part or all of another area of state interest, an area of oil and gas or geothermal resource development shall not be designated as an area of state interest unless the state oil and gas conservation commission identifies such area for designation.

(2) (a) Natural hazard areas shall be administered as follows:

(I) Floodplains shall be administered so as to minimize significant hazards to public health and safety or to property. The Colorado water conservation board shall promulgate a model floodplain regulation no later than September 30, 1974. Open space activities such as agriculture, recreation, and mineral extraction shall be encouraged in the floodplains. Any combination of these activities shall be conducted in a mutually compatible manner. Building of structures in the flood plain shall be designed in terms of the availability of flood protection devices, proposed intensity of use, effects on the acceleration of floodwaters, potential significant hazards to public health and safety or to property, and other impact of such development on downstream communities such as the creation of obstructions during floods. Activities shall be discouraged which, in time of flooding, would create significant hazards to public health and safety or to property. Shallow wells, solid waste disposal sites, and septic tanks and sewage disposal systems shall be protected from inundation by floodwaters. Unless an activity of state interest is to be conducted therein, an area of corrosive soil, expansive soil and rock, or siltation shall not be disignated as an area of state interest unless the Colorado soil conservation board, through the local soil conservation district, identifies such area for designation.

(II) Wildfire hazard areas in which residential activity is to take place shall be administered so as to minimize significant hazards to public health and safety or to property. The Colorado state forest service shall promulgate a model wildfire hazard area control regulation no later than September 30, 1974. If development is to take place, roads shall be adequate for service by fire trucks and other safety equipment. Firebreaks and other means of reducing conditions conducive to fire shall be required for wildfire hazard areas in which development is authorized.

(III) In geologic hazard areas all developments shall be engineered and administered in a manner that

will minimize significant hazards to public health and safety or to property due to a geologic hazard. The Colorado geological survey shall promulgate a model geologic hazard area control regulation no later than September 30, 1974.

(b) After promulgation of guidelines for land use in natural hazard areas by the Colorado water conservation board, the Colorado soil conservation board through the soil conservation districts, the Colorado state forest service, and the Colorado geological survey, natural hazard areas shall be administered by local government in a manner which is consistent with the guidelines for land use in each of the natural hazard areas.

(3) Areas containing, or having a significant impact upon, historical, natural, or archaeological resources of statewide importance, as determined by the state historical society, the department of natural resources, and the appropriate local government, shall be administered by the appropriate state agency in conjunction with the appropriate local government in a manner that will allow man to function in harmony with, rather than be destructive to, these resources. Consideration is to be given to the protection of those areas essential for wildlife habitat. Development in areas containing historical, archaeological, or natural resources shall be conducted in a manner which will minimize damage to those resources for future use.

(4) The following criteria shall be applicable to areas around key facilities:

(a) If the operation of a key facility may cause a danger to public health and safety or to property, as determined by local government, the area around the key facility shall be designated and administered so as to minimize such danger; and

(b) Areas around key facilities shall be developed in a manner that will discourage traffic congestion, incompatible uses, and expansion of the demand for government services beyond the reasonable capacity of the community or region to provide such services as determined by local government. Compatibility with nonmotorized traffic shall be encouraged. A development that imposes burdens or deprivation on the communities of a region cannot be justified on the basis of local benefit alone.

(5) In addition to the criteria described in subsection (4) of this section, the following criteria shall be applicable to areas around particular key facilities:

(a) Areas around airports shall be administered so as to:

(I) Encourage land use patterns for housing and other local government needs that will separate uncontrollable noise sources from residential and other noise-sensitive areas; and

(II) Avoid danger to public safety and health or to property due to aircraft crashes.

(b) Areas around major facilities of a public utility shall be administered so as to:

(I) Minimize disruption of the service provided by the public utility; and

(II) Preserve desirable existing community patterns.

(c) Areas around interchanges involving arterial highways shall be administered so as to:

(I) Encourage the smooth flow of motorized and nonmotorized traffic;

(II) Foster the development of such areas in a manner calculated to preserve the smooth flow of such traffic; and

(III) Preserve desirable existing community patterns

(d) Areas around rapid or mass transit terminals, stations, or guideways shall be developed in conformance with the applicable municipal master plan adopted pursuant to section 139-59-6, C.R.S. 1963, or any applicable master plan adopted pursuant to section 106-2-7. If no such master plan has been adopted, such areas shall be developed in a manner designed to minimize congestion in the streets; to secure safety from fire, flood waters, and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements. Such development in such areas shall be made with reasonable consideration, among other things, as to the character of the area and its peculiar suitability for particular uses, and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout the jurisdiction of the applicable local government.

106-7-203. Activities of state interest as determined by local governments. (1) Subject to the procedures set forth in part 4 of this article, a local government may designate certain activities of state interest from among the following:

(a) Site selection and construction of major new domestic water and sewage treatment systems and major extension of existing domestic water and sewage treatment systems;

(b) Site selection and development of solid waste disposal sites;

(c) Site selection of airports;

(d) Site selection of rapid or mass transit terminals, stations, and fixed guideways;

(e) Site selection of arterial highways and interchanges and collector highways;

(f) Site selection and construction of major facilities of a public utility;

(g) Site selection and development of new communities;

(h) Efficient utilization of municipal and industrial water projects; and

(i) Conduct of nuclear detonations.

106-7-204. Criteria for administration of activities of state interest. (1) (a) New domestic water and sewage treatment systems shall be constructed in areas which will result in the proper utilization of existing treatment plants and the orderly development of domestic water and sewage treatment systems of adjacent communities.

(b) Major extensions of domestic water and sewage treatment systems shall be permitted in those areas in which the anticipated growth and development that may occur as a result of such extension can be accommodated

within the financial and environmental capacity of the area to sustain such growth and development.

(2) Major solid waste disposal sites shall be developed in accordance with sound conservation practices and shall emphasize, where feasible, the recycling of waste materials. Consideration shall be given to longevity and subsequent use of waste disposal sites, soil and wind conditions, the potential problems of pollution inherent in the proposed site, and the impact on adjacent property owners, compared with alternate locations.

(3) Airports shall be located or expanded in a manner which will minimize disruption to the environment of existing communities, will minimize the impact on existing community services, and will complement the economic and transportation needs of the state and the area.

(4) (a) Rapid or mass transit terminals, stations, or guideways shall be located in conformance with the applicable municipal master plan adopted pursuant to section 139-59-6, C.R.S. 1963, or any applicable master plan adopted pursuant to section 106-2-7. If no such master plan has been adopted, such areas shall be developed in a manner designed to minimize congestion in the streets; to secure safety from fire, flood waters, and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements. Activities shall be conducted with reasonable consideration, among other things, as to the character of the area and its peculiar suitability for particular uses, and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout the jurisdiction of the applicable local government.

(b) Proposed locations of rapid or mass transit terminals, stations, and fixed guideways which will not require the demolition of residences or businesses shall be given preferred consideration over competing alternatives.

(c) A proposed location of a rapid or mass transit terminal, station, or fixed guideway that imposes a burden or deprivation on a local government cannot be justified on the basis of local benefit alone, nor shall a permit for such a location be denied solely because the location places a burden or deprivation on one local government.

(5) Arterial highways and interchanges and collector highways shall be located so that:

(a) Community traffic needs are met;

(b) Desirable community patterns are not disrupted; and

(c) Direct conflicts with adopted local government, regional, and state master plans are avoided.

(6) Where feasible, major facilities of public utilities shall be located so as to avoid direct conflict with adopted local government, regional, and state master plans.

(7) When applicable, or as may otherwise be provided by law, a new community design shall, at a minimum, provide for transportation, waste disposal, schools, and other governmental services in a manner that will not overload facilities of existing communities of the region. Priority shall be given to the development of total communities which provide for commercial and industrial activity, as well as residences, and for internal transportation and circulation patterns.

(8) Municipal and industrial water projects shall emphasize the most efficient use of water, including, to the extent permissible under existing law, the recycling and reuse of water. Urban development, population densities, and site layout and design of storm water and sanitation systems shall be accomplished in a manner that will prevent the pollution of aquifer recharge areas.

(9) Nuclear detonations shall be conducted so as to present no material danger to public health and safety. Any danger to property shall not be disproportionate to the benefits to be derived from a detonation.

PART 3

LEVELS OF GOVERNMENT INVOLVED AND THEIR FUNCTIONS

106-7-301. Functions of local government. (1) Pursuant to this article, it is the function of local government to:

(a) Designate matters of state interest after public hearing, taking into consideration:

(I) The intensity of current and foreseeable development pressures; and

(II) Applicable guidelines for designation issued by the applicable state agencies;

(b) Hold hearings on applications for permits for development in areas of state interest and for activities of state interest;

(c) Grant or deny applications for permits for development in areas of state interest and for activities of state interest;

(d) Receive recommendations from state agencies and other local governments relating to matters of state interest;

(e) Send recommendations to other local governments and the Colorado land use commission relating to matters of state interest; and

(f) Act, upon request of the Colorado land use commission, with regard to specific matters of state interest.

106-7-302. Functions of other state agencies. (1) Pursuant to this article, it is the function of other state agencies to:

(a) Send recommendations to local governments and the Colorado land use commission relating to designation of matters of state interest on the basis of current and developing information; and

(b) Provide technical assistance to local governments concerning designation of and guidelines for matters of state interest.

(2) Primary responsibility for the recommendation and provision of technical assistance functions described in subsection (1) of this section is upon:

(a) The Colorado water conservation board, acting in cooperation with the Colorado soil conservation board, with regard to floodplains;

(b) The Colorado state forest service, with regard to wildfire hazard areas;

(c) The Colorado geological survey, with regard to geologic hazard areas, geologic reports, and the identification of mineral resource areas;

(d) The Colorado division of mines, with regard to mineral extraction and the reclamation of land disturbed thereby;

(e) The Colorado soil conservation board and soil conservation districts, with regard to resource data inventories, soils, soil suitability, erosion and sedimentation, floodwater problems, and watershed protection; and

(f) The division of wildlife of the department of natural resources, with regard to significant wildlife habitats.

(3) Pursuant to section 106-7-202 (1) (d), the oil and gas conservation commission of the state of Colorado may identify an area of oil and gas development for designation by local government as an area of state interest.

PART 4

DESIGNATION OF MATTERS

OF STATE INTEREST - GUIDELINES FOR ADMINISTRATION

106-7-401. Designation of matters of state interest. (1) After public hearing, a local government may designate matters of state interest within its jurisdiction, taking into consideration:

(a) The intensity of current and foreseeable development pressures; and

(b) Applicable guidelines for designation issued by the Colorado land use commission after recommendation from other state agencies, if appropriate. In adopting such guidelines, the Colorado land use commission shall be guided by the standards set forth in this article applicable to local governments.

(2) A designation shall:

(a) Specify the boundaries of the proposed area; and

(b) State reasons why the particular area or activity is of state interest, the dangers that would result from uncontrolled development of any such area or uncontrolled conduct of such activity, and the advantages of development of such area or conduct of such activity in a coordinated manner.

106-7-402. Guidelines - regulations. (1) The local government shall develop guidelines for administration of the designated matters of state interest. The content of such guidelines shall be such as to facilitate administration of matters of state interest consistent with sections 106-7-202 and 106-7-204.

(2) A local government may adopt regulations interpreting and applying its adopted guidelines in relation to specific developments in areas of state interest and to specific activities of state interest.

(3) No provision in this article shall be construed as prohibiting a local government from adopting guidelines or regulations containing requirements which are more stringent than the requirements of the criteria listed in sections 106-7-202 and 106-7-204.

106-7-403. Technical and financial assistance. (1) Appropriate state agencies shall provide technical assistance to local governments in order to assist local governments in designating matters of state interest and adopting guidelines for the administration thereof.

(2) (a) The department of local affairs shall oversee and coordinate the provision of technical assistance and provide financial assistance as may be authorized by law.

(b) The department of local affairs shall determine whether technical or financial assistance or both are to be given to a local government on the basis of the local government's:

(I) Showing that current or reasonably foreseeable development pressures exist within the local government's jurisdiction; and

(II) Plan describing the proposed use of technical assistance and expenditure of financial assistance.

106-7-404. Public hearing - designation of an area or activity of state interest and adoption of guidelines by order of local government. (1) The local government shall hold a public hearing before designating an area or activity of state interest and adopting guidelines for administration thereof.

(2) (a) Notice, stating the time and place of the hearing and the place at which materials relating to the matter to be designated and guidelines may be examined, shall be published once at least thirty and not more than sixty days before the public hearing in a newspaper of general circulation in the county. The local government shall send written notice to the Colorado land use commission of a public hearing to be held for the purpose of designation and adoption of guidelines at least thirty days and not more than sixty days before such hearing.

(b) Any person may request, in writing, that his name and address be placed on a mailing list to receive notice of all hearings held pursuant to this section. If the local government decides to maintain such a mailing list, it shall mail notices to each person paying an annual fee reasonably related to the cost of production, handling, and mailing such notice. In order to have his name and address retained on said mailing list, the person shall resubmit his name and address and pay such fee before January 31 of each year.

(3) Within thirty days after completion of the public hearing, the local government, by order, may adopt, adopt with modification, or reject the particular designation and guidelines; but the local government, in any case, shall have the duty to designate any matter which has been finally determined to be a matter of state interest and adopt guidelines for the administration thereof.

(4) After a matter of state interest is designated pursuant to this section, no person shall engage in development in such area and no such activity shall be conducted until the designation and guidelines for such area or activity are finally determined pursuant to this article,

(5) Upon adoption by order, all relevant materials relating to the designation and guidelines shall be forwarded to the Colorado land use commission for review.

106-7-405. Report of local government's progress. (1) Not later than one hundred eighty days after the effective date of this article, each local government shall report to the Colorado land use commission, on a form to be furnished by the Colorado land use commission, the progress made toward designation and adoption of guidelines for administration of matters of state interest.

(2) Upon the basis of the information contained in such reports and any information received pursuant to any other relevant provision of this article, the Colorado land use commission may take appropriate action pursuant to section 106-4-3(2)(a).

106-7-406. Colorado land use commission review of local government order containing designation and guidelines. (1) Not later than thirty days after receipt of a local government order designating a matter of state interest and adopting guidelines for the administration thereof, the Colorado land use commission shall review the contents of such order on the basis of the relevant provisions of part 2 of this article and shall accept the designation and guidelines or recommend modification thereof.

(2) If the Colorado land use commission decides that modification of the designation or guidelines is required, the Colorado land use commission shall, within said thirty-day period, submit to the local government written notification of its recommendations and shall specify in writing the modifications which the Colorado land use commission deems necessary for compliance with the relevant provisions of part 2 of this article.

(3) Not later than thirty days after receipt of the modifications recommended by the Colorado land use commission, a local government shall:

(a) Modify the original order in a manner consistent with the recommendations of the Colorado land use commission and resubmit the order to the Colorado land use commission; or

(b) Notify the Colorado land use commission that the Colorado land use commission's recommendations are rejected.

106-7-407. Colorado land use commission may initiate identification, designation, and promulgation of guidelines for matters of state interest. (1) (a) The Colorado land use commission may submit a formal request to a local government to take action with regard to a specific matter which said commission considers to be of state interest within the local government's jurisdiction. Such request shall identify the specific matter and shall set forth the information required in section 106-7-401 (2) (a) and (2) (b). Not later than thirty days after receipt of such request, the local government shall publish notice and hold a hearing within sixty days pursuant to the provisions of section 106-7-404, and issue its order thereunder.

(b) After receipt by a local government of a request from the Colorado land use commission pursuant to paragraph (a) of this subsection (1), no person shall engage in development in the area of conduct the activity specifically described in said request until the local government has held its hearing and issued its order relating thereto.

(c) If the local government's order fails to designate such matter and adopt guidelines therefor, or, after designation, fails to adopt guidelines therefor pursuant to standards set forth in this article applicable to local governments, the Colorado land use commission may seek judicial review of such order or guidelines by a trial de novo in the district court for the judicial district in which the local government is located. During the pendency of such court proceedings, no person shall engage in development in the area or conduct the activity specifically described in said request except on such terms and conditions as authorized by the court.

PART 5

PERMITS FOR DEVELOPMENT IN AREAS OF STATE INTEREST AND FOR CONDUCT OF ACTIVITIES OF STATE INTEREST

106-7-501. Permit for development in area of state interest or for conduct of an activity of state interest required. (1) (a) Any person desiring to engage in development in an area of state interest or to conduct an activity of state interest shall file an application for a permit with the local government in which such development or activity is to take place. The application shall be filed on a form prescribed by the Colorado land use commission. A reasonable fee determined by the local government sufficient to cover the cost of processing the application, including the cost of holding the necessary hearings, shall be paid at the time of filing such application.

(b) The requirement of paragraph (a) of this subsection (1) that a public utility obtain a permit shall not be deemed to waive the requirements of article 5 of chapter 115, C.R.S. 1963, that a public utility obtain a certificate of public convenience and necessity.

(2) (a) Not later than thirty days after receipt of an application for a permit, the local government shall publish notice of a hearing on said application. Such notice shall be published once in a newspaper of general circulation in the county, not less than thirty nor more than sixty days before the date set for hearing, and shall be given to the Colorado land use commission. The Colorado land use commission may give notice to such other persons as it determines not later than fourteen days before such hearing.

(b) If a person proposes to engage in development in an area of state interest or for conduct of an activity of state interest not previously designated and for which guidelines have not been adopted, the local government may hold one hearing for determination of designation and guidelines and granting or denying the permit.

(c) The local government may maintain a mailing list and send notice of hearings relating to permits in a manner similar to that described in section 106-7-404 (2) (b).

(3) The local government may approve an application for a permit to engage in development in an area of state interest if the proposed development complies with the local government's guidelines and regulations governing such area. If the proposed development does not comply with the guidelines and regulations, the permit shall be denied.

(4) The local government may approve an application for a permit for conduct of an activity of state interest if the proposed activity complies with the local government's regulations and guidelines for conduct of such activity. If the proposed activity does not comply with the guidelines and regulations, the permit shall be denied.

(5) The local government conducting a hearing pursuant to this section shall:

(a) State, in writing, reasons for its decision, and its findings and conclusions; and

(b) Preserve a record of such proceedings.

(6) After the effective date of this article, any person desiring to engage in a development in a designated area of state interest or to conduct a designated activity of state interest who does not obtain a permit pursuant to this section may be enjoined by the Colorado land use commission or the appropriate local government from engaging in such development or conducting such activity.

106-7-502. Judicial review. The denial of a permit by a local government agency shall be subject to judicial review in the district court for the judicial district in which the major development or activity is to occur.

SECTION 2. Article 3 of chapter 106, Colorado Revised Statutes 1963, as amended, is amended BY THE ADDITION OF A NEW SECTION to read:

106-3-9. Statewide program for identification of matters of state interest as part of local land use planning. (1) The department of local affairs shall conduct a statewide program encouraging counties and municipalities to prepare, as a part of the comprehensive plan provided for in section 106-2-5 and article 59 of chapter 139, C.R.S. 1963, a complete and detailed identification and designation of all matters of state interest within each county by June 30, 1976. The general assembly shall appropriate funds for this purpose to the department of local affairs for distribution to participating counties. Each county desiring to participate in the identification and designation of matters of state interest program established by this section shall be allocated an equal amount by the department of local affairs from the funds so appropriated, to be expended by each county separately or through an organized group of counties or counties and municipalities. The department of local affairs, in cooperation with applicable state agencies, shall establish reasonable standards relative to the scope, detail, and accuracy of the program and shall insure that all information is comparable for each county. Each county shall, after consultation with the municipality, prepare such identification and designation for territory located within these municipalities which request such preparation and in any municipality which fails to undertake an identification and designation program. Each county shall, upon request of the municipality, assist the municipality in its identification and designation program.

(2) The general assembly shall appropriate to the department of local affairs funds to assist counties and municipalities participating in the identification and designation of matters of state interest program, where additional assistance is deemed by the department of local affairs to be necessary. The department of local affairs shall also allocate such funds upon request of any county participating in the identification and designation of matters of state interest program under subsection (1) of this section for implementation of supplemental planning in that county, or to any municipality, based upon priorities established by the department of local affairs and on the need and capabilities of each county and municipality.

SECTION 3. 106-4-3 (2) (a), Colorado Revised Statutes 1963 (1971 Supp.), is amended to read:

106-4-3. Duties of the commission - temporary emergency power. (2) (a) Whenever in the normal course of its duties as set forth in this article the commission determines that there is in progress or proposed a land development activity which constitutes a danger of injury, loss, or damage of serious and major proportions to the public health, welfare, or safety, the commission shall immediately give written notice to the board of county commissioners of each county involved of the pertinent facts and dangers with respect to such activity. If the said board of county commissioners does not remedy the situation within a reasonable time, the commission may request the governor to review such facts and dangers with respect to such activity. If the governor grants such request, such review shall be conducted by the governor at a meeting with the commission and the boards of county commissioners of the counties involved. If, after such review, the governor shall determine that such activity does constitute such a danger, the governor may direct the commission to issue its written cease and desist order to the person in control of such activity. Such order shall require that such person immediately discontinue such activity. If such activity, notwithstanding such order, is continued, the commission may apply to any district court of this state in which such activity is located for a temporary restraining order, preliminary injunction, or permanent injunction, as provided for in the Colorado rules of civil procedure. Any such action shall be given precedence over all other matters pending in such district court. The institution of such action shall confer upon said district court exclusive jurisdiction to determine finally the subject matter thereof.

SECTION 4. Article 4 of chapter 106, Colorado Revised Statutes 1963, as amended, is amended BY THE ADDITION OF A NEW SECTION to read:

106-4-5. Commission staff to assist counties and municipalities. The commission, within available appropriations, shall assign full-time professional staff members to assist counties and municipalities in the program established under article 7 of this chapter and to monitor progress in the same. No later than February 1, 1975, the commission shall issue its report to the general assembly as to progress being made in such program and shall include in its report those items required by section 1-6-4-4 (4) (b) and (4) (c).

SECTION 5. Appropiration. (1) There is hereby appropriated to the department of local affairs, out of any moneys in the state treasury not otherwise appropriated, the sum of two million seventy-five thousand dollars ($2,075,000), or so much thereof as may be necessary, to implement the provisions of section 106-3-9, C.R.S. 1963, which moneys shall become available upon passage of this act and remain available until June 30, 1975, to be allocated as follows: Identification and designation of matters of state

interest program - one million five hundred seventy-five thousand dollars ($1,575,000); supplemental planning - five hundred thousand dollars ($500,000).

(2) There is hereby appropriated out of any moneys in the state treasury not otherwise appropriated, to the Colorado land use commission, for the fiscal year beginning July 1, 1974, the sum of three hundred thousand dollars ($300,000), or so much thereof as may be necessary, to provide assistance to counties and muncipalities pursuant to section 106-4-5, C.R.S. 1963 (10.0 FTE, five of which shall be full-time professional staff pursuant to said section 106-4-5).

SECTION 6. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

John D. Fuhr
SPEAKER OF THE HOUSE
OF REPRESENTATIVES

Ted L. Strickland
ACTING PRESIDENT
OF THE SENATE

Lorraine F. Lombardi
CHIEF CLERK OF THE HOUSE
OF REPRESENTATIVES

Comfort W. Shaw
SECRETARY OF THE SENATE

APPROVED _____

John D. Vanderhoof
GOVERNOR OF THE STATE OF COLORADO

COLORADO WATER CONSERVATION BOARD
102 Columbine Building
1845 Sherman Street
Denver, Colorado 80203

February 26, 1975

MODEL FLOODPLAIN REGULATION

Section 1. Statutory authorization, findings of fact, statement of purpose and definitions.

1.1 Statutory authorization. This (regulation) (ordinance) for flood prevention and control is adopted pursuant to the authority contained in Title 24, Article 65, Colorado Revised Statutes 1973, as amended, and Title 30, Article 28, Colorado Revised Statutes 1973, (counties), or Title 31, Article 23, Colorado Revised Statutes 1973, (towns and cities).

1.2 Findings of fact. The (board of county commissioners) (city council) finds that there are within the (county) (city) of _____ various floodplains constituting natural hazards of state and local interest, the occupation of which (has already resulted in) (is likely to cause) the loss of human life and the destruction of property, and that the imprudent occupation of these floodplains will pose a continuing and greater future danger to life and property, unless proper regulations are adopted concerning their use and occupation.

1.3 Statement of purpose. It is the purpose of this (regulation) (ordinance) to promote the public health, safety and general welfare by provisions designed to:

(1) Permit only such uses within the designated floodplains as will not endanger life, health, public safety or property in times of flood.
(2) Prohibit the placement of fill, materials and structures which would significantly obstruct flood flows to the potential damage of others or cause potentially damaging debris to be carried downstream.
(3) Protect the public from the burden of avoidable financial expenditures for flood control projects and flood relief measures.
(4) Prevent avoidable business and commerce interruptions.
(5) Minimize damages to public utilities, streets and bridges.
(6) Minimize victimization of unwary home and land purchasers.
(7) Minimize the pollution of water by prohibiting the disposal of garbage and other solid waste materials in floodplains.

1.4 Definitions. As used in this (regulation) (ordinance) the following words or phrases are defined as follows:

(1) "Designated floodplain" means the area designated as a floodplain by official action of the (board of county commissioners) (city council) with the prior concurrence of the Colorado Water Conservation Board.
(2) "Floodplain" means an area in and adjacent to a stream, which area is subject to flooding as the result of the occurrence of an intermediate regional flood and which area thus is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property.
(3) "Floodproofing" means a combination of structural provisions, changes, or adjustments to lands, properties and structures subject to flooding primarily for the reduction or elimination of flood damages to lands, properties, structures, and contents of buildings in a flood hazard area.
(4) "Floodway zone" is the channel of a stream and those portions of the adjoining floodplain which are reasonably required to carry and discharge the floodwaters of an intermediate regional flood. In the context of this (ordinance) (regulation), it is the designated floodplain less the low hazard zone, if any such low hazard zone has been identified. If no low hazard zone has been identified, then the terms "designated floodplain" and "floodway zone" shall be considered as being synonymous.
(5) "Intermediate regional flood" means a type of flood, including the water surface elevation and territorial occupation thereof, which can be expected to occur at any time in a given area based upon recorded historical precipitation and other valid data, but with an average statistical one percent chance of being equalled or exceeded during any one year. The term is used interchangeably with a one percent flood or one hundred year flood.
(6) "Low hazard zone" means that area of the floodplain in which the waters of an intermediate regional flood will not attain a maximum depth greater than one and one-half feet.
(7) "Stream" means any natural channel or depression through which water flows either continuously, intermittently or periodically, including any artificial modification of the natural channel or depression.

Section 2. Designation of floodplains - subdivisions thereof - identification.

2.1 Designation. The floodplains of the (county) (city) of _____ are hereby defined as encompassing all those land areas of the (county) (city) in and adjacent to a stream which lies within the area which would be inundated by an intermediate regional flood as heretofore or hereafter approved by the Colorado Water Conservation Board, and as heretofore or hearafter designated by the (board of county commissioners) (city council) of _____ in the manner prescribed by (regulation) (ordinance number _____.

2.2 Floodplain subdivisions. Where sufficient data are available to determine the effect thereof on existing or foreseeable land uses, the designated floodplain may be subdivided into a floodway zone and a low hazard zone as defined in subsections 1.4(4) and (6) of this (ordinance) (regulation).

2.3 Identification. True and official copies of maps of floodplains so designated by the (board of county commissioners) (city council) shall be kept and maintained for public inspection in the offices of the (county) (city) clerk and the (county) (city) planning commission. Such maps shall be in sufficient detail and scale so as to permit ready identification of the flood hazard

area, including the low hazard zone, if any, by ground inspection or survey. Copies of such maps shall be available for public sale at a charge of $_____ per section.

2.4 Interpretation. Where interpretation is needed as to the exact location of the boundaries of designated floodplains or subdivisions thereof, the (designated county or city official or agency) shall make the necessary interpretation. The intermediate regional flood elevation for the point or points in question shall be the governing factor in determining the actual boundaries.

2.5 Official zoning map. Any official zoning map or maps of the (county) (city) shall incorporate the floodplains designated by the (board of county commissioners) (city council), including the low hazard zone, if such has been identified.

Section 3. Use of designated floodplains.

3.1 General. No development, use, fill, construction or alteration on or over any portion of a designated floodplain shall be permitted which alone, or cumulatively with other such activities, would cause or result in any of the following:

(1) The storage or processing of materials that in times of flooding are buoyant, flammable, explosive or otherwise potentially injurious to human, animal or plant life.
(2) The disposal of garbage or other solid waste materials.
(3) The human occupation of structures, either fixed or mobile, for residential purposes, either permanent or temporary.
(4) Substantial solid debris being carried downstream by floodwaters.
(5) Any obstruction which would adversely affect the efficiency of or restrict the flow capacity of a designated floodplain so as to cause foreseeable damage to others, wherever located.

3.2 Exceptions permitted in low hazard zones. Except as prohibited by subsections 3.1(1) and (2), the low hazard zone of a designated floodplain, if any such low hazard zone has been identified, may be used for any lawful purpose; provided that:

(1) Such use shall not cause an enlargement of the floodplain so as to cause damages to or on lands other than those owned by the user.
(2) Any building or structure, whether fixed or mobile, designed for human occupancy or the storage of property, and occupying a space greater than one hundred square feet, shall be constructed or located so that any external wall shall be not less than fifteen feet from the stream side of the low hazard zone.
(3) The lowest floor of any such building or structure shall be not less than one foot above the maximum water elevation of the computed intermediate regional flood, unless such building or structure has been adequately floodproofed to or over one foot above said maximum water elevation.
(4) In the event that the floodwaters in a low hazard zone can be expected to attain a velocity greater than three feet per second, additional floodproofing shall be required sufficient to withstand such greater velocity.

3.3 Non-conforming uses. The provisions of this section shall not apply to or affect:

(1) Any fixed building or structure already lawfully in place or the terms or conditions of any lawful permit already granted at the time of the enactment of this (regulation) (ordinance); provided that, in the event of the discontinuance of use or destruction or damage in major part of a non-conforming building or structure, its reconstruction or replacement shall be considered a new use and be governed by the other applicable provisions of this section.
(2) Any device or structure reasonably necessary for the diversion or storage of water or for flood control or prevention.

Section 4. Administration - publication - hearing - appeal.

4.1 Permits. It shall be unlawful to develop, fill or occupy; or to construct, reconstruct or alter any building or structure; within a designated floodplain without the property owner or his authorized representative first obtaining a permit from the (designated county or city official or agency), in accordance with the following procedures;

(1) Application for a permit shall be made to and in the form and containing the information prescribed by the (designated county or city official or agency), accompanied by a fee of $_____ plus the estimated publication costs.
(2) No later than thirty days after receipt of an application for a permit, notice of such application and the time and place of hearing thereon shall be published once in a newspaper of general circulation in the (city) (county) of _____, which said publication shall be not less than thirty nor more than sixty days before the date set for hearing. A copy of such notice shall be forwarded to the Colorado Land Use Commission not later than the date of publication. Copies of such notice shall also be made available for public dissemination in the office of (county) (city) clerk.
(3) After the conclusion of the public hearing, the (designated county or city official or agency) shall grant or deny the permit according to the criteria set forth in section 3 of this (regulation) (ordinance); provided that if the (designated county or city official or agency) shall find that there is not sufficient information concerning the boundaries and other characteristics of the designated floodplain upon which a sound decision can be based, it shall continue such hearing until sufficient information is obtained.
(4) The applicant or any person claiming to be affected by the granting or denial of any such permit may appeal such granting or denial to the (Board of Adjustment) (other designated local agency) by filing a notice of appeal with the (Board of Adjustment) (other designated local agency) within thirty days of the granting or denial of such permit.
(5) The applicant or any person claiming to

be affected by the decision of the (Board of Adjustment) (other designated local agency) may appeal such decision for trial de novo to the district in and for the county in which the decision was rendered by filing a notice of appeal with said district court within thirty days of the issuance of a final decision by the (Board of Adjustment) (other designated local agency).

4.2 Inspection.
(1) The (county or city official or agency) or its authorized representatives (is) (are) hereby empowered and directed to inspect and examine the use, occupation or development of designated floodplains within the (county) (city) of _____ for the purpose of determining from time to time whether or not such use, occupation or development is in violation of any of the provisions of section 3 of this (regulation) (ordinance) or of any permit issued or required pursuant to this section 4.
(2) If a violation shall be found to exist, the (designated agency) or its authorized representatives shall by written order direct that such remedial action be taken forthwith as will result in full compliance with the applicable provisions of this (regulation) (ordinance); provided, however, that the issuance of such order shall in no way or manner be deemed a prerequisite to the institution of such enforcement proceedings as are hereinbelow set forth; and provided further, that compliance with such order shall not necessarily be deemed to be a defense to any alleged violation of this (regulation) (ordinance) in any court action instituted seeking full compliance therewith, but evidence of compliance with such order may be introduced as pertinent to mitigation and extenuation.

4.3 Violations and remedial actions.
(1) Any person, firm or corporation, whether as principal, agent, employee or otherwise, who shall use, occupy or develop any portion of any designated floodplain in violation of any provision of this (regulation) (ordinance) shall be fined an amount not to exceed one hundred dollars ($100.00) for each violation, such fine to inure to the (county) (city) of _____. Each day during which such illegal use, occupation or development continues shall be deemed a separate offense.
(2) If any such use, occupation or development shall occur in violation of any provision of this (regulation) (ordinance), or the applicable statutes of the State of Colorado, the (board of county commissioners) (city council) or any person who may be injured by such violation, in addition to other remedies provided by law, may institute injunction, mandamus, abatement or any other appropriate action or proceeding to prevent, enjoin, abate or remove such unlawful use, occupation or development, and the fine hereinabove provided for may be recovered in that same civil action wherein such injunction, mandamus or abatement is sought, or separate and distinct proceedings may be instituted seeking varying forms of relief, as the law may allow.

Section 5. Interpretation, disclaimer or liability and severability.

5.1 Interpretation.

(1) It is not intended by this (regulation) (ordinance) to repeal, abrogate or impair any existing easements, covenants, or deed restrictions. However, where this (regulation) (ordinance) imposes greater restrictions, the provisions of this (regulation) (ordinance) shall prevail. All other (regulations) (ordinances) inconsistent with this (regulation) (ordinance) are hereby repealed to the extent of the inconsistency only.
(2) In their interpretation and application, the provisions of this (regulation) (ordinance) shall be held to be minimum requirements and shall not be deemed a limitation or repeal of any other powers granted by the state constitution or statutes.

5.2 Disclaimer of liability. The degree of flood protection required by this (regulation) (ordinance) is considered reasonable for the protection of life and property and is based on engineering and scientific methods of study. Larger floods may occur on rare occasions or the flood height may be increased by man-made or natural causes, such as ice jams and bridge or culvert openings being restricted by debris. This (regulation) (ordinance) does not imply that areas outside the designated floodplains or land uses permitted within such floodplain will be free from flooding or flood damages. This (regulation) (ordinance) shall not create liability on the part of the (county) (city) of _____ or any officer or employee thereof for any flood damages that result from reliance on this (regulation) (ordinance) or any administrative decision lawfully made thereunder.

5.3 Severability. If any section, clause, provision or portion of this (regulation) (ordinance) is adjudged unconstitutional or invalid by a court of competent jurisdiction, the remainder of this (regulation) (ordinance) shall not be affected thereby.

C E R T I F I C A T E

I certify that the foregoing is a true and correct copy of a model floodplain regulation adopted by a majority vote of the members of the Colorado Water Conservation Board in regular session assembled at Denver, Colorado, on the 26th day of February, 1975.

_____

FELIX L. SPARKS, Secretary

KEY WORDS: Benefits, Budgeting, Cities, Drainage, Drainage Practices, Drainage Programs, Economic Justification, Feasibility, Financial Feasibility, Flood Plains, Project Benefits, Runoff, Storm Drains, Urban Drainage

ABSTRACT: Techniques for evaluating minor and major Urban Drainage and Flood Control (UDFC) Projects are described. Economic, political, engineering, financial and legal problems must be faced prior to implementation of proper levels of these projects. The measurement of tangible benefits is described while a literature review revealed no direct objective techniques for quantifying intangibles. Some methods for establishing the relative rankings of intangible contributions show promise for improvement of evaluation techniques, however. The legal problem of establishing benefits is described and a copy of recently

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enacted Colorado legislation is included. Information on the estimation of flood damages and the selection of

discount rates is presented for use by the analyst. Careful coordination of land use and drainage control measures is stressed. Related recent legislation and regulations are included.

Reference: Neil S. Grigg, Colorado State University, Leslie H. Botham, Leonard Rice, Leonard Rice Consulting Water Engineers, Inc., W. J. Shoemaker, Shoemaker & Whan, Attorneys at Law, Denver, L. Scott Tucker, Urban Drainage and Flood Control District, Denver, Hydrology Paper No. 85 February (1976), Urban Drainage and Flood Control Projects Economic, Legal and Financial Aspects.

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