FLOODS AND FLOOD CONTROL IN MARATHON, NEW YORK

by

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November 1973 No. 73-21

PREFACE

This year the Federal government has budgeted $3.2 billion for water resources and generally related power programs: $60 for an average family of four. The stream channelization project proposed for the Marathon area by the U. S. Army Corps of Engineers is a common form of small water resource project. However, the careful attention given to the problem by Granastein and Roberts is unusual.

Five points made by them seem to me to be of particular interest. First, ground water flooding is an important part of the overall flooding problem, but it would be unaffected by a channelization project. Second, they note that the actual flood damages recorded by the citizens of Marathon bear little resemblance to the Corps' computer simulation analysis. Third, they suggest that increased flooding reported by Marathon residents is not attributable to climatic conditions, but is in part due to increased upstream development around Cortland and the development of Interstate Highway 81. Fourth, as is true for all Federal project evaluations, the interest rate employed in the Agency analysis is 5.5% per year, substantially below the 7%-10% most economists believe is appropriate to government investment. Fifth, the economic benefits as estimated by Granastein and Roberts with this 5.5% interest rate nevertheless are far below the estimated costs.

Considering the size of the Federal expenditures on water programs and our share in this expense, it is worthwhile for us all to consider solutions to water problems other than construction, concrete, and channelization too often favored by the construction agencies. The analysis offers a realistic evaluation of these solutions.

Granastein and Roberts began their study as part of an undergraduate course at Cornell University. It should be of value to our area, and it may be of interest to other communities facing similar problems.

-- Duane Chapman

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Introduction

Flooding as a natural phenomenon is not "bad"; it becomes a problem to man when human interests are damaged. Basically man has created the flood problems of today by virtue of his own actions. The flat, well-drained valley lands along rivers provide excellent building sites for settlements as well as transportation and water power, and have attracted human development. Unfortunately, these same lands describe the flood plain area. The problem of flooding has grown over the years as the development and monetary value of the development in the flood plain have increased. In recent times, the Federal government has provided "public benefit" to those suffering from flooding by implementing flood-control projects and dispensing emergency aid. Hurricane Agnes of 1972 is a stunning example of this situation. The notion of "social cost" has been maturing of late as a response to the once unchallenged "public benefit". Social cost tries to encompass both monetary and nonmonetary values and goes beyond the often narrow scope of the purported public benefit. With a tightening of fiscal allotment and increasing concern for the environment, a more equitable approach is being sought with a broader basis of responsibility to the public for dealing with the flood problem. The situation prevailing in Marathon, New York, should be examined in this context.

The village of Marathon is located on the Tioughnioga River at its confluence with Hunt's Creek, 25 miles north of Binghamton and 15 miles south of Cortland, New York. Glacial scour and stream erosion formed the hills and valleys characteristic to this area. The main land feature is the Tioughnioga River Valley. The floor of this valley (the site of most human development) is composed of flat, pasture-type land. Unfortunately most of the valley floor is covered by the Tioughnioga's flood plain. The Valley's relatively steep sides inhibit development and the rolling terrain of the uplands is developing somewhat slower than the valley floor.

Marathon lies on the Appalachian Plateau and is underlain by shale, siltstone and sandstone bedrock. These rocks, along with glacial deposits, have produced Middlebury-Tioga soils. The very well-drained soil produces silage, corn, oats and hay which are used in dairy operations. Some cash crops of potatoes and corn also are grown. An increase in forest products has been the recent trend in the area. Along with a decrease in the number of farmers, residential development has increased.

Most of the village residents commute to Binghamton or Cortland for employment. This makes economic growth very slow and, in fact, few persons of child-bearing age remain in the village. Marathon is expected to continue as a rural commuter community, but potential for developing the recreational aspects of the area exists.

Yearly flooding is common, but usually not severe. The most consistent water problem is basement flooding. This problem is due partially to the very porous soils and high spring groundwater tables. No flood control project would alleviate this situation. Two major floods, in 1935 and 1964, caused substantial damage. Highest flows were recorded in the 1964 flood, but damages were highest in 1935. This was due to a log jam on Hunt's Creek which flooded areas not usually subjected to flooding problems.

In 1968, the village attempted some flood prevention, and on September 12 an application was filed with the New York Department of Environmental Conservation for a permit to remove certain islands and sandbars in the stream. The application was refused for two reasons. First, the contemplated action was insufficient to substantially reduce the flooding problem. Second, it would decrease the habitat for desirable game fish including bass, brown trout, and rainbow trout. The Department of Environmental Conservation suggested that the town obtain expert help.

Thus, the Army Corps of Engineers became involved. Their original study determined that standard (1 in 100 years) flood protection would not generate a favorable benefit:cost ratio. Due to a recent policy change, a study of projects offering less protection (1 in 50 years) was initiated and four alternative projects were designed. After a public hearing on December 12, 1972, these alternatives were modified and five additional alternatives were added to the list of possible projects (see Table 1). Presently, work is being done on these nine alternatives to determine the best solution to the flooding problem in Marathon.

Our study evolved from the feeling that Marathon offers a good example for a comprehensive evaluation of the approach to a flooding problem. The situation there is current, and certainly any contribution toward a solution for the greatest social benefit is valuable. An assembly of all the

Table I

NUMERICAL COMPARISON ANALYSIS

ALTERNATE	0	1	2	3	4	5	6	7	8	9	COMMENTS
DESCRIPTION	EXISTING CONDITION; NO ACTION	DEEPEN 100% CHANNEL MIN. DOUBLE BANK CUT	DEEPEN 100% CHANNEL MAX. DOUBLE BANK CUT	MAX. DEEPEN 50% CHANNEL, MAX. SINGLE BANK CUT	STRAIGHT CHANNEL UP AND DOWNSTREAM	EXCAVATE FLOODWAY	WIDEN BRIDGE	STEEPEN CHANNEL SLOPE AND WIDEN CHANNEL	LEVEE WALL SYSTEM, PUMPS, AND DEEPEN CHAN. UNDER BRIDGE	STRAIGHT STEEP CHANNEL 225 FEET UPSTREAM 170 FEET DOWNSTREAM	MAIN ITEMS OF ALTERNATE PLANS OF IMPROVEMENT
TOTAL INVESTMENT (RATING)	$ 0.00 (1)	$1,640,000 (3)	$1,800,000 (6)	$1,980,000 (7)	$2,200,000 (8)	$1,720,000 (4)	$ 850,000 (2)	$2,400,000 (9)	$1,740,000 (5)	$2,700,000 (10)	JULY 1972 BASIS
ANNUAL COST (RATING)	$ 0.00 (1)	$ 113,000 (3)	$ 124,000 (4)	$ 137,000 (6)	$ 152,000 (7)	$ 127,000 (5)	$ 56,000 (2)	$ 161,000 (8)	$ 213,000 (10)	$ 183,000 (9)	INTEREST PLUS AMORTIZATION AT 5½% FOR 50 YRS. & MAINT.
ANNUAL BENEFITS (RATING)	$ 0.00 (9)	$ 185,000 (7)	$ 195,000 (4)	$ 202,000 (2)	$ 188,000 (5)	$ 0.00 (10)	$ 104,000 (8)	$ 187,000 (6)	$ 220,000 (1)	$ 197,000 (3)	DETERMINED FROM FREQUENCY-DAMAGE CURVE; DIFFERENCE IN DAMAGES
BENEFIT-COST RATIOS (RATING)	0.00 (9)	1.64 (2)	1.57 (3)	1.47 (4)	1.24 (5)	0.00 (10)	1.86 (1)	1.16 (6)	1.03 (8)	1.08 (7)	BENEFITS DIVIDED BY COST
NET BENEFITS ANNUALLY (RATING)	$ 0.00 (9)	$ 72,000 (1)	$ 71,000 (2)	$ 65,000 (3)	$ 36,000 (5)	$ 0.00 (10)	$ 48,000 (4)	$ 26,000 (6)	$ 7,000 (8)	$ 14,000 (7)	DIFFERENCE OF (BENEFITS - COST)
CHANNEL CAPACITY CFS — UPSTRM. (RATING) DNSTRM.	8,000 (10) 6,200	16,200 (6) 10,000	17,200 (4) 12,600	20,000 (2) 11,600	16,300 (5) 11,000	8,500 (9) 9,500	9,100 (8) 6,200	16,200 (6) 9,300	20,500 (1) 6,200	18,500 (3) 9,500	DERIVED FROM STAGE-DISCHARGE CURVE FOR UPSTREAM
DEGREE OF PROTECTION UPSTREAM YRS. (RATING)	1.7 (10)	16 (6)	21 (4)	50 (2)	16 (5)	1.9 (9)	2.2 (8)	16 (6)	56 (1)	33 (3)	DERIVED FROM FREQUENCY-DISCHARGE CURVE AT SECTION NO 7
AGNES FLOOD 1972 — EXISTING DAMAGES	$77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	$ 77,000	Q = 9,600 CFS DAMAGES BASED ON STAGE-DAMAGE CURVE
AGNES FLOOD 1972 — MODIFIED DAMAGES (RATING)	$77,000 (10)	$ 1,000 (6)	$ 0.0 (1)	$ 0.0 (1)	$ 500 (5)	$ 54,500 (9)	$ 45,000 (8)	$ 2,000 (7)	$ 0.0 (1)	$ 0.0 (1)	DAMAGES AFTER ALTERNATE IMPLEMENTATION
PHYSICAL	NO FLOOD PROTECTION	MODERATE FLOOD PROTECTION	MODERATE FLOOD PROTECTION	HIGH FLOOD PROTECTION	MODERATE FLOOD PROTECTION	NO FLOOD PROTECTION	MINIMUM FLOOD PROTECTION	MODERATE FLOOD PROTECTION	HIGH FLOOD PROTECTION	HIGH FLOOD PROTECTION	BASED ON DEGREE OF PROTECTION
ENVIRONMENT (ECOLOGY) (RATING)	NO EFFECT (1)	SUBSTANTIAL ADVERSE EFFECT (5)	SUBSTANTIAL ADVERSE EFFECT (5)	LEAST ADVERSE EFFECT (2)	MOST ADVERSE EFFECT (7)	MOST ADVERSE EFFECT (7)	LEAST ADVERSE EFFECT (2)	MOST ADVERSE EFFECT (7)	MODERATE ADVERSE EFFECT (4)	MOST ADVERSE EFFECT (7)	INCLUDES CONSIDERATION FOR ENVIRONMENTAL RECREATION BENEFITS
ECONOMIC INDEX	0	.26	.33	.74	.20	0	.04	.18	.58	0.36	DEGREE OF PROTECTION X B-C RATIO ÷ 100
SUM — ECONOMIC	29 (5)	16 (1)	19 (3)	22 (4)	30 (6)	39 (10)	17 (2)	35 (8)	32 (7)	36 (9)	ALL 3 AREAS ARE GIVEN EQUAL BALANCE
SUM — SAFETY	30 (10)	18 (6)	9 (4)	5 (2)	15 (5)	27 (9)	24 (8)	19 (7)	3 (1)	7 (3)	
SUM — ENVIRONMENTAL	1 (1)	5 (5)	5 (5)	2 (2)	7 (7)	7 (7)	2 (2)	7 (7)	4 (4)	7 (7)	
RATING SUMMATION	16	12	12	8	18	26	12	22	12	19	TOTAL OF RATING
RANKING	6	3	2	1	7	10	5	9	4	8	
COMMENTS	SMALL ISLANDS LOCATED IN MAIN CHANNEL; FLOOD WAY CONTAINS MINIMAL RACEWAY	OPTIMUM USE OF AUXILIARY RACEWAY FOR HIGH FLOW CONDITIONS; PRESERVATION OF ALL ISLANDS - INCLUDES RECREATIONAL AND ENVIRONMENTAL IMPROVEMENTS FOR STREAM AREA USE.			EXCAVATE COMPLETE CHANNEL BOTTOM AND ISLANDS; RACEWAY NOT UTILIZED	ALL TREES AND VEGETATION REMOVED IN MILLRACE AREA	BRIDGE SPAN INCREASED FROM 170' TO 225'; WIDEN RIVER IN VACINITY OF BRIDGE	225' CHANNEL UP. STREAM AND 170' CHANNEL DOWNSTREAM; UTILIZE RACEWAY	6' HIGH WALL; PROJECT AMORTIZED IN 100 YEARS - PUMPS 10 YEARS	EXCAVATE COMPLETE CHANNEL BOTTOM AND ISLANDS; RACEWAY NOT UTILIZED	

information relating to the problem is crucial for a comprehensive and wholistic decision. We have had personal contact with most of the parties involved and hope to develop some objective conclusions that will be useful in solving Marathon's problem.

Public Attitudes

The people of Marathon are actively concerned with the flooding problem. Lively public hearings have been held, the dominant tenor being a call for direct action. Most of the local opinions expressed the sole desire to protect life and property in the village through implementation of a project. Strong statements supporting this (rejecting the values of the fish populations) received much strong audience support. A conflict between the concern of the people and the welfare of the fish represented the typical view of the problem. Two people's approach to the situation considered various aspects, giving priority to human values. A minimum of project maintenance was cited as desirable to keep down expenses to the village. David Light of the Village Planning Board said that the people do not want levees, impoundments or high walls, as they want to preserve as much of the natural state as possible. Several others made reference to the value of aesthetics to the village.

Colonel Prentiss of the Corps, conducting the public hearing, asked the people to consider the trade-offs between a flood solution (structural) and environment values. Five local requirements for receiving a Federal project were described: 1) provision of lands, easements, rights-of-way 2) relocation of utilities, highways, bridges where necessary 3) non-liability of the Federal government 4) maintenance and operation of the project and prevention of encroachment on it 5) flood plain management. The last item is more of an emphatic recommendation; it is not legally binding.

There seemed to be a lack of direct interest about the actual benefits residents would receive from the project. It is likely that most people equated a project with total alleviation of their flood problems. The 50-year design protection was mentioned, but no questions were asked about this until Brad Griffin of the Department of Environmental Conservation requested elucidation of the physical benefits in more tangible terms. We doubted that most residents fully comprehended the type of protection that was being proposed.

Flooding still will occur, except at the lowered frequency of one chance in 50 years. Thus, a project does not represent license to disregard future flooding and further development of the flood plain area. Basement flooding due to high groundwater levels in very permeable soil will not be ended, and the river flows that would overtop a project could come next year or in one hundred years.

The illusory idea of complete protection was reflected in other statements concerning the need for a project. The beneficial effect on the village economy and viability were cited. Frank Taylor of the Cortland County Board of Supervisors referred to the "highest and best use of low-lying lands" being impeded by flooding. This implies a desire to develop this land and further increase flood damage potential. The Cortland County Planning Board supported the project on the basis of its potentially beneficial effect on the economy and living conditions of southern Cortland County. J. Martin White, the town supervisor, cited the need for a project in order for Marathon to remain a prosperous community with opportunity for growth in residential, recreational or industrial areas. The Village Plan presents the idea of developing the unoccupied flood plain by filling and rip-rapping the area. This could be used for business, housing and industry. No future recreational uses are planned for the flood plain and no reference to flood plain management is made.

In effect, a project's increase of the development potential of the flood plain in Marathon is a key factor in public support of it. John Gustafson of the Eastern Susquehanna Water Resource Development Board, responding to this notion, states: "Flood protection is not going to be provided so that new development not present now can be moved into the flood plain. Long range plans are needed to eliminate gradually use of flood plains. This will have repercussions on economic viability, but must be planned. Society cannot be expected to keep bailing people out of flood situations that are created by their unwise use of these areas." This approach is gaining wider support among planning and development agencies as the favorable policy for dealing with flooding problems. It is part of a more wholistic view and represents a long-term attitude rather than the traditional short-term measures used in the past. Most of the public attitudes have supported the latter, especially at the local level. This situation is evident in the attitudes present in Marathon and is probably the crucial issue to be resolved in any solution that is implemented.

Flood Dynamics in General

The proposed solution to Marathon's flooding problems is a structural one, based on the long engineering history of the Corps of Engineers. A complex methodology is used in designing the structural proposals. Basic to an understanding of a flood problem is the dynamics of a watershed. For any point on a watercourse, its watershed can be described as consisting of the total area of land that feeds water to that point either through runoff or subsurface seepage. Numerous factors, such as soils, vegetation, slope and land use, will determine the amount of surface runoff versus infiltration into the soil. Surface runoff reaches water courses much faster than slow subsurface flow. Several methodologies have been devised to approximate the flow of a channel at some point under various meteorologic conditions. Storm intensities have been calculated for most regions and depict the probability of occurrence of these in years, such as 1 in 50 years.

From these various techniques, one can predict the probability of a particular channel for flooding, this being dependent on the watershed runoff and the channel capacity at a particular point. Both factors are affected by man's activities which tend to slowly increase flooding problems. Surface runoff is increased by denuding the land of vegetation. Impermeable surfaces like roofs, roads, and parking lots, cause 100% surface runoff of rain. These effects increase the amount of water reaching a point in a channel in a given time above the natural condition. This raises the flooding frequency from the natural state. Also, constrictions in the channel and flood plain caused by man impede the movement of water, raising water levels and causing channel overflowing sooner.

Since man's activity often increases surface runoff and decreases channel capacity, he must make deliberate efforts to counteract these forces. One approach was to build upstream impoundments to retain potential flood waters and release them gradually as the flood threat abates. Increasing channel capacity through levees of channelization was the other tack. Smaller channels have their capacity more efficiently increased by channel excavation, whereas levees are more practical on the larger rivers. These structural approaches are designed for some frequency of protection, usually for once-in-100 years or longer. These frequencies reflect just a probability, and the flood control project could be overtopped by a large storm at any particular moment. A false sense of security is often prompted by such projects, as people assume they cannot be flooded in the next 100 years or more. It is essential that this aspect of all flood control projects be fully understood by those people receiving "protection". Flood damages may be increased by projects if a dam breaks or water becomes trapped behind levees for extended periods. Thus, flood control projects are not the cure-all for this conflict between man and the physical environment.

Evaluation of the Proposed Project

Engineering Aspects

An evaluation of the Marathon situation includes a critical assessment of the engineering involved, the general knowledge of flooding problems and the specifics of Marathon's case. The latter information is more useful when utilized with a knowledge of the former, which was presented in the preceding section. A stream channelization project is the solution to the flooding prolem in Marathon favored by the Corps of Engineers. As of April 1, 1973, their planning office in Baltimore, Maryland, had nine alternatives for the situation. These are summarized in Table I. The actual work on the Marathon project is being done under contract by Green Associates, architects-engineers, of Towson, Maryland. Data generated by them is the basis for proposals and decisions at the planning level made by the Corps office. During our visit to the Baltimore office, it was stated several times by Corps personnel that much of the work by Green Associates was inadequate, and many of their data and conclusions are basically unsound. No alternative source was mentioned for the information to be used in decision making by the Corps. Thus, the project analysis presented here must be considered in this tenuous manner.

Though our physical understanding tells us much about the dynamics of rivers, the implications of these processes are often not considered when man changes a system. A river can be a stubborn entity, often persistently trying to return to some condition prior to man's disturbance of it. Removal of a gravel bar in a river will witness only its eventual replacement. Straightening a channel will increase its gradient and can cause severe erosion. In channelization, water velocities are increased frequently, requiring extensive protection of the bank to prevent erosion. This may lead to a concrete flue if the problems become extreme. New problems of erosion and deposition can occur both at the upstream and downstream ends of the affected stretch. Channelization causes a slight incremental increase in flood stage for the area just below the project. This becomes more insignificant the further downstream one goes (L. Royston, Corps). Instances have occurred where the channelization has been continued progressively downstream to ameliorate the problems caused by the original alteration.

With channelization as the preferred engineering solution, a number of possible approaches are proposed by the Corps of Engineers for Marathon. Through excavation, both widening and deepening the channel, a new channel would be created that would contain the capacity for a once-in-50 year flow, or about 15,000 cfs. One or both banks might be excavated, and deepening could be done over the entire bottom or only a part. The varying disturbance will affect the ecological impact, which will be described later. In any case, creating enough cross-section area of channel, with a specified gradient, is the means for gaining some desired degree of flood protection with a project. Earth moving machinery would operate along the banks or in the stream itself to shape the channel. Spoil areas must be designated for depositing the excavated material. The banks would be shaped to a certain side slope and rock rip-rap or concrete would be necessary to protect critical areas from erosion. Enough flushing capacity must be maintained to prevent siltation of the channel during low flow. Siltation impedes the flood protection ability and requires maintenance, a cost born by the local community.

Another solution recognized by the Corps is the construction of a levee wall system with pumps. Earthen walls six feet above the present bank height would be constructed around the entire area to be protected and tied into the hillsides. This would contain the flow for a 56-year frequency protection. Pumping stations would be built to pump out water trapped inside the levees during normal rain and for any time that the levees overtopped. The relative merits of this approach can be found in Table 1.

Crucial to the viability of the entire project is the proposed capacity translated into a meaningful description of the degree of flood protection being offered. Capacity for a proposed channel can be calculated readily through several standard engineering formulas. From this, a discharge-frequency relationship can be figured which will estimate the degree of protection provided. But in Marathon, the bridge for Route 221 across the Tioughnioga River creates a complication. The opening under the bridge is narrower than the existing channel and presents a significant constriction for high water flow. Widening the bridge is not being considered seriously, for it would make a project in Marathon economically unfeasible. When flood waters reach the bottom of the bridge, they start to back up and then overtop the banks. This floods most of the settled parts of the village. Downstream of the bridge, most of the susceptible land is undeveloped and retains an active capacity as flood plain. Most of the proposed changes call for widening the existing channel, thus making the bridge a more serious constriction. To get around this, increasing downstream capacity and deepening the channel under the bridge are cited as solutions. This is based on the backwater concept, which describes influences on a point derived from a downstream location. Thus, by moving the water downstream faster, downstream levels would be lower, causing lower levels upstream as well, and allowing all the water to get under the bridge. Theoretically, this would eliminate the bridge as a constriction. Both we and Brad Griffin of the Department of Environmental Conservation feel that more attention should be paid to this aspect, for a major constriction in a channelization project would null the beneficial effects of the effort. If this were the case in Marathon, widening the bridge would be a likely sequel, with this expense separate from the original benefit-cost analysis. In this way, an originally unfavorable project might be authorized and built.

A potential constriction would question the purported degree of protection designated for a project. A 50-year flood frequency is cited by the Corps of Engineers for the local project in Marathon. Implications of this change from the previously standard level of 100-year frequency protection can be drawn by the individual. In Table 1, alternatives 3 and 8 meet the protection cited for the Marathon project. Since the amortization of the costs is for 50 years, a project working life of less than that does not seem reasonable. From this, it appears that alternatives 3 and 8 are the only viable ones in terms of Corps protection policy, or possibly that the level of protection can be modified in accordance with other considerations. The level of protection is the key to a flood control project, and compromising this value ought not to occur if flood control is being pursued seriously. When a project alternative is finally chosen, the degree of protection cited for it and its origin should be closely scrutinized. This facet is of prime importance to the residents of Marathon, and they need a clear and accurate understanding of the positive and negative potentials of a channelization project.

Environmental Considerations

A look at the environmental effects of a proposal is vital to understanding its full meaning. Today, such a consideration is required for Federal projects in the form of an environmental impact statement described in the National Environmental Policy Act of 1969. The preliminary statement for the Marathon project is, in our estimation, necessarily inadequate. Its hasty preparation is also recognized by the Corps personnel themselves.*

The river habitat will receive the brunt of the impact of the project. Excavation in the channel will destroy the bottom habitat which supports the sport fishery in this stretch of the river. Disturbance to the river bottom varies with the different project alternatives. Another problem is the uniform shape of the channel, which includes a flat bottom. This would preclude most fish life during low flows in the summer. To prevent this, a low flow channel could be added to concentrate enough water for fish to survive. Any of the proposed channels should have this feature included. Also, construction of artificial potholes and riffles to promote trout have been proposed by the Corps. Several fishery biologists expressed the opinion that these would be destroyed in a short period of time, creating no real benefit. Maintaining a rocky bottom for trout is also mentioned by the Corps. It is estimated to take 2-3 years following construction for the bottom to return to viable habitat. The Department of Environmental Conservation reports small-mouth bass as the major sport fish in the area, with brown and rainbow trout occurring less frequently. Thus the impact on fish habitat will depend on the project alternative chosen and the post-project restoration efforts made. Some loss of recreational potential will occur in Marathon, to be regained only after fish populations return to harvestable levels. This should occur rapidly once suitable habitat has returned since fish reside in the river at both ends of the project area.

The Tioughnioga River represents a sizeable recreational feature within

* As related to us by Captain Rust of the Baltimore office.

the village of Marathon. Water pollution at Marathon is preventing use of the full recreational potential of the river. Untreated sewage is added from the village. A treatment plant has been required by the State, but funds have not been made available. Recent improvements in sewage treatment in Cortland should help the situation and enhance canoeing, swimming, and fishing. Turbidity from upstream development has caused formation of sand and silt bars in the river, often constricting the channel and increasing local flooding. Turbidity would be increased during construction, but the project is predicated to lower sediment levels in the long run.

The Corps contends that recreation is a major factor in the future economy of the village. An increase in recreational activity is predicted from a project due to flood control and environmental "improvements". The importance of this increase seems exaggerated. An annual canoe race from Cortland to Marathon is a main event. A channelized stream is not likely to be very enticing for a canoeist. The loss of fishing for several years will decrease recreational use. Increased swimming due to better water quality cannot be credited as a project benefit. Thus, we feel that the project will have either an insignificant or slightly negative effect on recreation.

Aesthetics is a fairly new, albeit important, environmental consideration. Improved aesthetics will result from the project by Corps evaluation. The relative values of a natural versus artificial channel are personal, and we prefer the natural. Loss of about 50 mature trees along the banks is expected. These are to be replaced by some 200 new ones. The value of mature trees over saplings seems apparent, and many years are needed to regain the original scenic level. The excavated spoil from the channel will need to be deposited nearby. The preliminary spoil sites were determined on the basis of least cost. Hopefully, aesthetic judgement will be used in the final plan. Our estimation of aesthetic impact is a negative one.

A list of the aternatives to the proposed channelization project is required by law. These include: no action, flood plain management, flood management, concrete channel, earthen levee. Some of these will be discussed in a later section. In general, environmental impacts are not the most significant point of controversy for the project. Loss of fish habitat is the most serious impact and represents the basis for opposition to the project by fishery personnel of the Department of Environmental Conservation and Fish and Wildlife Service. This problem has been recognized by the Corps in their planning, but these ideas need incorporation into a final action. Claims of significant environmental improvements from the project seem unfounded to us. The environment rating in Table 1 was described as "very subjective" by the Corps and is of little use in evaluating the alternatives.

Economics

All Federally funded public works projects are required by law to have benefits greater than the costs, expressed monetarily. The factors involved in such a determination often seem to us to be obscurely formulated. Much controversy has arisen over the economic justification of many projects. We find our greatest criticism of the proposals for Marathon in this realm. To assess the viability of the project alternatives in Table 1, the Corps used the standard benefit-cost ratio analysis. The derivation of benefits and costs will be investigated to determine what the annual economic effects of a project in Marathon might be.

The first, and perhaps most important, element in this kind of analysis is the determination of average annual flood damages. To estimate this figure reliably, the Corps has developed a methodology which we feel is very good. Appendix 1 has been given to us by the Corps' Baltimore office and explains the process in more detail than will be presented here. The method focuses on the construction of a four-part graph relating, stage-damage, stage-discharge, discharge-frequency and damage-frequency. By generating a damage-frequency curve, a relationship between monetary damage and the expected frequency (in percent) of that damage is produced. Integrating that curve sums all the percentages, thereby estimating the monetary damages expected in an average year.

The methdology itself seems adequate to determine average annual flood damages. The reliability of any mathematical process depends also on the information used in that process. Thus, a discussion of how the Corps found the data to generate the four-part graph is important in assessing the accuracy of their estimate for average annual flood damages. The two areas of concern to this study are the discharge figures and the stage-damage figures used by the Corps.

To estimate river discharge, extrapolations were necessary. No gauging station is present in Marathon and, therefore, figures obtained in Cortland (upstream) and Whitney Point (downstream) were used to estimate the river flow in cubic feet per second. The results then were related to river stage and discharge, or stage-frequency. Extrapolations of this kind are done by use of standard formulas and it is felt that these figures are to that degree reliable.

The stage-damage graph is an attempt to estimate the magnitude of damage that will occur if the river reaches a certain elevation. Usually the flood of record is used as the base elevation and stages are stated in feet, plus or minus, from the base flood. To estimate the damage at the various stages, a field check is made in which residential structures are categorized as mansions or homes of high, medium, and low value. Estimations of commercial, industrial and public structures are made separately. The results of the field work are put into a computer program which, by using averages developed for the Susquehanna River Basin, generates the figures of expected monetary damages at the various stages of flooding.

In reviewing these figures, the atypical qualities of Marathon as a Susquehanna River Basin village become important. The economic and population expectations of Marathon are radically different from those of many towns in the Basin, and therefore a computer program using average characteristics might produce figures that do not accurately reflect flood damages. Therefore, we studied the 1964 flood in detail. A survey made by the editor of the town's paper provided us with a direct source of information as to local flood damages that year. By reviewing this survey and adding to it damages experienced by the school, roads, and utilities, an estimate of the damages experienced in 1964 was made. This figure, when compared with the figure generated by the computer, gave us a measure of the reliability of figures used by the Corps to estimate the average annual flood damages. Table II shows the procedure for our estimate of 1964 flood damages.

The discrepancy between the computer estimate of $215,000 and our $76,200 figure is seen by us as typical throughout the computer figures. Therefore, a ratio was used to re-adjust the figures obtained by the computer and a new average annual flood damage figure of $45,500 was used in our revision of the benefit-cost analysis. Table III shows this revision for

Table II

Evaluation of 1964 Flood Damage

39 respondents to questionnaire

$19,080 - total financial loss reported by residents

There were approximately 65 structures affected in the 1964 flood. Thus, the response to the questionnaire represents about 39/65 of the flood damage.

$19,080 x 1.67 = $32,000 - This represents estimated damage to residences, businesses or churches, as determined by the type and proportion of respondents to the questionnaire.

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$32,000	-	damage to residential, commercial and religious structures
$ 4,606	-	damage reported by school
$13,800	-	Corps estimate of transportation and utility damage
$25,000	-	non-physical losses (wages, profits, etc.)
$ 800	-	emergency relief costs
$76,200	-	total 1964 flood damage - our estimate
$215,500	-	total 1964 flood damage - Corps estimate

Table III

Benefits and Costs of Alternative 3

	Corps Figures	Revised Figures
Annual flood damages		
- without project	$127,600	$ 45,500
- with Alternative 3	12,000	4,250
Annual flood protection	115,600	41,250
Average annual benefits	202,000	41,250
Expected first cost	1,980,000	1,980,000
Project life	50 years	50 years
Interest rate	5.5%	5.5%
Annual equivalent	$116,820	$116,820
Annual maintenance costs	20,000	20,000
Total annual costs	136,820	136,820
Benefit/cost ratio	1.47	.30

alternative 3 (ranked as the most desirable alternative by the consulting agency).

Annual flood damage prevention is not always the only benefit which an area may receive due to the construction of a flood control project. Thus, the annual benefits from a project may be greater than the annual flood protection figure alone. In this case, the Corps' estimate of total annual benefits (for alternative 3) is $202,000 or $86,400 more than the estimate for flood protection alone. The explanation of this figure hinges on recreational, aesthetic, property value and growth increases to the Marathon area as a result of the project. It is our conviction that recreation and aesthetics will not benefit from the project. It is not likely that a flood control project will change significantly the present economic trend in Marathon. Therefore, no economic advantages other than flood protection are included in the revision of average annual benefits from the project. Our final average annual benefit estimate is $41,250.

Estimating construction and maintenance costs of a possible project involves pricing and quantifying the materials and labor needed to build and maintain that project. Due to our inability to estimate project costs, we have used the first cost and maintenance estimates calculated by the Corps. Assuming that their figures would not reflect an overestimate of costs (for this would lessen the project benefit-cost ratio), our conclusions would remain valid if further costs were encountered during construction. Alternative 3 is expected to cost $1,980,000 to build. Assuming a project life of 50 years, the annual equivalent of this figure is $116,820 at 5.5% interest rate. Maintenance costs are estimated by the Corps to be $20,000 per year. Therefore, total yearly project costs are $136,820.

With average annual benefits of $41,250, the revised benefit-cost ratio for alternative 3 is $41,250/$136,820 or .30. This revised appraisal of a flood control project for Marathon reveals an annual social cost of $95,570. Thus, we feel that there is no economic justification for the construction of a project of this type.

To emphasize the non-viable nature of the project, another economic check can be done. Without our reduction of the average annual damage figure, we could accept the Corps estimate of $115,600 for alternative 3. Still, there are no further benefits that we feel are justified to be credited to the project. This equates the above damage figure to the average annual benefits. Using the annual cost for alternative 3, a benefit-cost ratio of .85 results, and the project is still not acceptable from an economic point of view.

Since Congressional approval of a flood control project requires a benefit-cost ratio of over 1, our analysis judges this type of project as an undesirable solution to Marathon's flooding problem. The Corps estimates a benefit-cost ratio of 1.47 for the same alternative 3. If their figures are accepted, which is usually the case, approval of a structural solution is very possible. We presently can do little to officially contest the Corps figures. We will, though, discuss possible alternative solutions to the flooding problem existing in Marathon to encourage a non-structural approach.

Alternative Solutions

Although the list of alternative methods for solving flood problems is long, a quick look at some can be helpful. Flood protection structures are currently the most popular method for alleviating flooding in problem areas. They include channelization projects like Marathon's, along with levees, dikes, flood walls, dams and reservoirs. Despite the 9 billion dollars spent on such structures in 1972, increased development in the flood plain has caused an increase in flood damages (Fox, 1973). This problem was recognized locally by the New York State Water Resources Commission: "Many physical protection projects have been built. More will be built, but these alone are not the answer. The rate of new development in the flood plain exceeds any possible plan for complete physical protection " (Raymond, 1972).

Emergency actions, such as removing vulnerable goods to high levels or evacuation are usually helpful in minimizing danger to human life and reducing the amount of flood damage. Accurate flood predictions, not yet possible, are a must for this sort of action. Flood proofing is "a combination of structural changes and adjustments to properties subject to flooding in order to reduce flood damages" (Fox 1973). There are two major goals when attempting flood proofing: 1) to keep water out of the structure entirely and/or 2) to allow water to enter the structure, but minimize damage to contents. Bulkheads, hydrostatic cement, special sewer valves, plastic covers, and all sorts of techniques can be used to successfully flood proof a structure. This equipment, though, is most effectively designed into a structure rather than added on.

As stated in the introduction, flooding becomes a problem when man builds in flood prone areas. Therefore, adequately managing flood plain use should help solve the flooding problem. This does not mean that these areas should be forever left undeveloped, but they should be used for things that are less susceptible to damage due to flooding. Parks, golf courses, and parking lots are the types of uses that are not severely damaged when inundated by water. Perhaps a zoning ordinance could limit flood prone areas to these uses; or if a particular structure seems especially desirable, it could be designed (flood proofed) to withstand the probable flooding that might occur on the chosen site. J. H. Fox cites several ways in which flood plain management can be instituted. Building codes, subdivision regulations, public ownership of flood prone lands, adjusting lending policies all effectively can limit the use of certain areas, while encouraging the use of others. In this way, relocation of flood susceptible structures to areas which have very low flooding frequencies is possible. In a long range sense, this would eliminate the flooding problem.

As none of these alternatives claims to immediately eliminate flood damage, especially in an area where development has already occurred, some method of helping affected persons or businesses is necessary. Flood insurance, mortgage attachments and disaster relief attempt this. The National Flood Insurance Act of 1968 implemented assistance to eligible communites. The program operates under an insurance industry pool by means of a Federal subsidy to make up the difference between actuarial rates and customer rates. In many cases, this is as high as 90% of the cost of the insurance. To qualify, a community must have effective and adequate land use and control measures consistent with Federal criteria that are aimed at reducing or avoiding future damages. Development must be controlled in the 100-year flood plain unless it is determined for good cause that such a standard would not be economically and socially desirable and would unreasonably curtail future growth and viability. A problem lies in the accuracy and meaningfulness of such a determined 100-year flood plain. These regulations must be enforced continually, or the program will be withdrawn from the community.

In an emergency, Federal disaster funds may become available if an area is declared a disaster area. This often results from extensive flooding. These funds are an outright grant with no intentions of altering future occurrences of the same situation. The potential for damage thus remains and usually increases, as there is no inducement to move out of the flood prone area. A clause in the National Flood Insurance Act deals with this: no Federal disaster assistance shall be made available to any persons for the physical loss, destruction or damage of real or personal property to the extent that such loss could have been covered by flood insurance made available under the Act, and provided that the loss occurred more than one year from the date of availability of the program in the area where the damage occurred. This does not apply to low-income persons, as defined by law. Also, this clause is to be deleted in proposed new Federal legislation. Finally, Federal aid policy is attempting to reduce this disaster expenditure rather than sustain it over time by encouraging relocation outside of the flood prone lands.

An approach more difficult to implement involves compensation by those actively altering land use. It is a fact that development in the Basin can increase flooding frequency downstream. This seems to be occurring in Marathon, according to both local opinion and hydrographic records. A paragraph from the Preliminary Environmental Impact Statement refers to this:

> Whereas it is obvious that if an upstream community speeds storm water run-off and/or impedes ground water recharge by the development of previously natural vegetated land, it is their moral and legal obligation to store the run-off, protect its quality, and allow for normal recharge and normal storm water release rates. (p. 24)

This is basically a justification for upstream impoundments. We see the obligation as a possible monetary one, organized on either a local or a county level. A tax on developers per area of impermeable surface, or for the degree of erosion hazard, could be levied. The difficulties would be in designating the recipients, the amount of payment, and the extent of responsibility. Consideration of Marathon's responsibility to those downstream would be necessary if a project speeded flow through the village and increased downstream flooding. More important than devising a workable system is our desire to highlight the connection of upstream actions with downstream events. Those adversely changing conditions in a watershed must bear the responsibility for their actions.

Recommendations:

Certainly the choices for a solution to the flooding problem in Marathon are numerous. Some of these are partial, some short-term, long-term, unfeasible, or unsuitable. A "total" solution in both the short - and long-term sense would be most desirable. The impacts of an action in Marathon must be examined with reference to the village itself and our society as a whole. Situations like this no longer can be considered as local interest only, particularly where Federal participation is involved.

The short-term approaches in Marathon are inappropriate to the village situation. Flood-proofing the existing structures is impractical since most of the buildings are fairly old. Emergency actions to remove damage susceptible goods and to safeguard life depend on a good system of flood prediction, which does not exists. The structural measure for flood control is favored as a solution by the villagers and by the Corps. This is only a partial solution, giving a 50-year frequency degree of protection. Also, no policy of flood plain management will be tied to the project: it will merely be suggested by it. Future development in the flood plain is sought by the village and would increase potential damages. This is not an acceptable situation to society, as Federal monies would be promoting the increase of potential flood damages. This project is refuted on economic grounds as well, since a benefit-cost ratio of over unity is not present by our analysis. We oppose the above alternative as it does not represent the long-term policy of flood plain management and damage potential reduction.

A more satisfactory solution includes an integration of flood plain management with the flood insurance program. By instituting regulations on flood plain use, damage susceptible uses can be discouraged. Those now present can be encouraged to relocate elsewhere at the appropriate opportunity. Since recreation is cited by the Corps as a major economic goal of the village, use of the flood plain for this purpose would seem desirable.[1] The reduction of damage potential would have to occur over a long period. Meanwhile the flood plain regulations should be designed to make Marathon eligible for inclusion in the Federal flood insurance program. This coverage could protect the financial security of the residents if they took the initiative to purchase policies. At present, lack of interest in eligible communities is hampering the effectiveness of the program (L. Raymond, personal comment). The inconvenience of flooding to the villagers would not be altered. Unfortunately, based on past experience, this factor does not appear to be a deterrent to occupation of the flood plain, even when the risks are known.

1. p. 19, Preliminary Draft, Environmental Impact Statement, Marathon Local Flood Protection Project, U. S. Army Engineers, November, 1972.

This is true especially with the various opportunities for relief that are presently available (L. Raymond, personal comment). That rebuilding in the flood plain is perceived as advantageous (and is, in an economic sense) is a reality in need of change.

An added impetus to relocate out of the flood prone areas might arise from the combination of inconvenience and remuneration for damages suffered. Monies for purchase of flood plain property might be available from the State under the Environmental Bond of 1972. By combining the above two approaches, the flooding problem in Marathon could be phased out gradually in a permanent sense. Since the core of the village is built on the flood plain, total relocation would be a difficult and costly endeavor. Most of the land on the valley floor is flood plain, making most relocation necessary on the upland areas, although the western half of the village has some potential for building sites. Attrition of structures over time is the only practical method of phasing out of the flood prone area unless large amounts of money are made available. Possibly the nearly $2 million proposed for the project could be procured for relocation, thus providing a permanent solution. Converting flood prone land to recreation would hopefully stimulate this aspect of the village economy.

Our proposals for a non-structural solution to Marathon's flooding problem are basically long-term approaches. They do not provide the immediate action that the villagers desire. The villagers are apt to experience a sense of security more readily from a channelization project than to perceive the benefits of regulation of the flood hazard area (see Appendix 2). The entire system for dealing with flooding problems within our society is a self-sustaining and highly inefficient mechanism. People are encouraged to take the risk of flood plain development, and are given help to pick up the pieces after a disaster. The cycle continues itself with a resultant social cost that is born by those not affected. Rather than making a determined effort to end flooding problems, we seem to prefer subsidizing them. This is another example of a short-term outlook in the face of an obvious need for a hard look ahead at our goal in this endeavor, and development of the proper responses now to take us there. We feel that, although the residents of Marathon may face some short-term problems, the long-term solution is the necessary action for the good of the village and for the society of which we are all part.

Acknowledgements

Several sources of information were utilized in this study, although written material was not as important to the overall analysis. In most cases, we attempted to speak directly with those persons or agencies involved with a particular question. This included trips to the Corps of Engineers District Office in Baltimore, the Cortland regional office of the Department of Environmental Conservation, and the village of Marathon itself. We deeply appreciate the help given to us by the numerous people we contacted, those being Mr. L. Royston, Mr. K. Hartzell, and Mr. S. Rust of the Corps Baltimore Office; Mr. Brad Griffen of the Department of Environmental Conservation Cortland office; Mr. J. M. White and Mr. Walter Grunfeld of Marathon. They provided us with the bulk of information used in this study. Our guidance in preparing the entire study came from Assistant Professor Duane Chapman whose criticism and patience played an important role in the development of a complete study.

Appendix 1

Determination of Average Annual Damages

A. General

Average annual damages are an economic tool used by the Corps of Engineers to evaluate the relative seriousness of flood problems. They are used also to compare the cost of flood reduction versus the reduced damages (benefits) that could be expected from a project.

B. Existing Conditions

Estimated average annual damages for a given reach are calculated by combining the stage-damage values for that reach with the stage-discharge and discharge-frequency relations developed for the appropriate gaging station or index point. These stage-damage relationships are shown in Table 1 along with the corresponding discharge in thousands of cubic feet per second and the frequency of occurrence expressed in years, as taken from the appropriate rating and frequency curves shown as Exhibits 3 and 18. The average annual damages are computed as the mean ordinate of a curve of damage plotted against frequency in percent chance of occurrence in any one year. See Figure 1 for a graphic illustration of the procedure for developing the damage-frequency curve. Since the total scale of frequencies is 100 percent, or unity, the mean ordinate is equivalent numerically to the area under the curve, which can be integrated mathematically. See Table IV for the mathematical computations for average annual damages. The total accumulated average damage represents conditions reflecting the following three variables: the stream capacity reflected by the stage-discharge curve; the present level of flood plain development as indicated by the stage-damage table; and the effects of any flood control reservoirs shown as modifications to the frequency curve.

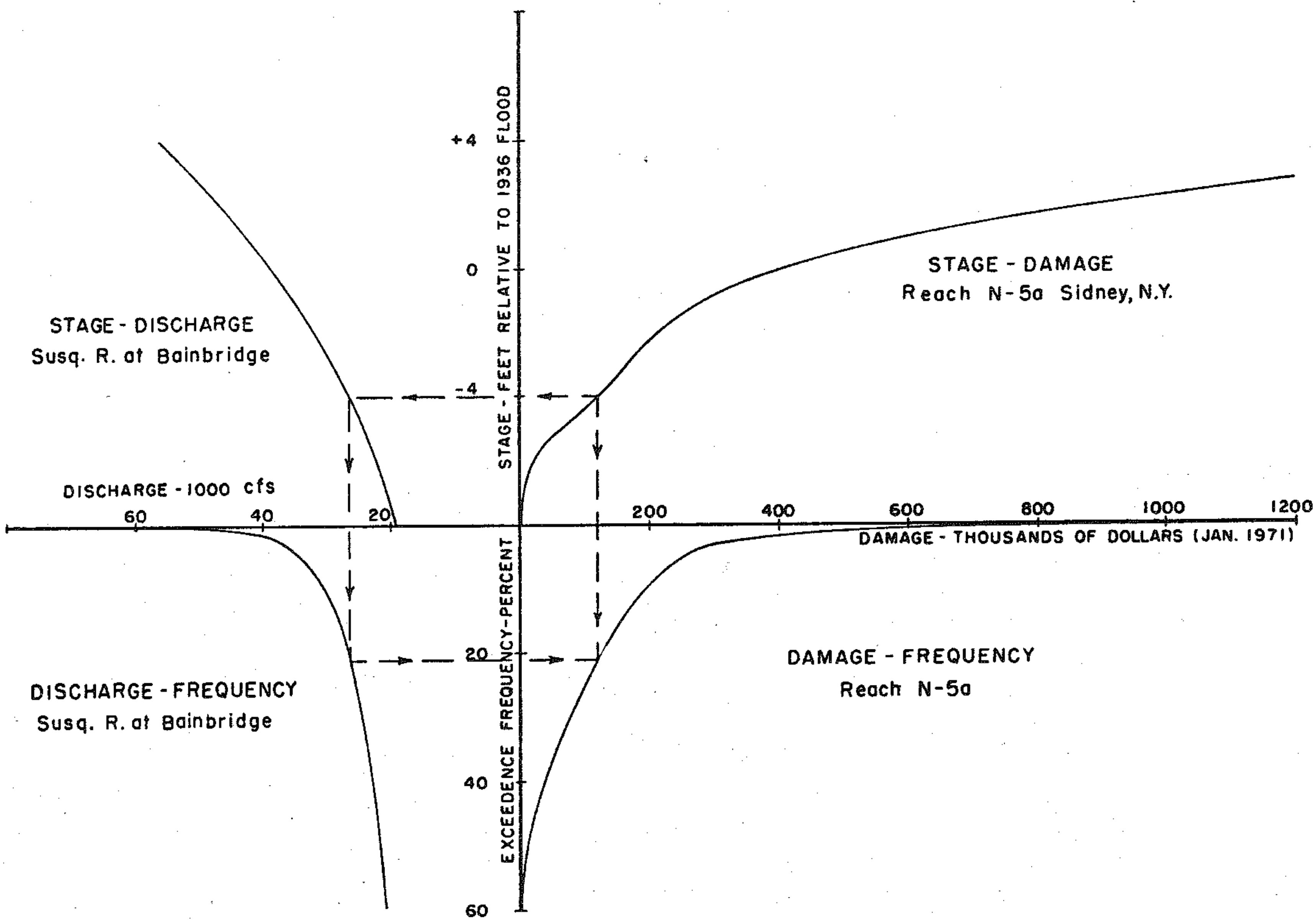
Normal growth and economic growth are adjustments made to the existing condition average annual damages. These allow for a certain amount of future expansion and upgrading of the existing development base.

Table IV

Stage-Discharge-Frequency-Damage Relations

	Stage (Ft. below F.O.R.)	Discharge (1000's CFS)	Frequency (years)	Est. Damage (Jan. 1971 prices) ($1000)
Reach	N-4			
Index Point	Unadilla			
Flood of Record	1936			
	0	31.3	667	79
	1	26.5	143	61
	2	22.5	42	51
	3	18.7	11	42
	4	15.5	4	30
	5	12.5	1	16
	6	9.8	1	2
	7	7.8	-	1
	8	6.0	-	0
Reach	N-5			
Index Point	Unadilla			
Flood of Record	1936			
	0	31.3	667	370
	1	26.5	143	228
	2	22.5	42	164
	3	18.7	11	115
	4	15.5	4	64
	5	12.5	1	35
	6	9.8	1	0
Reach	N-5a			
Index Point	Bainbridge		Sample Reach	
Flood of Record	1936			
	0	37.8	59	407
	1	34.0	27	282
	2	31.4	14	211
	3	28.8	8	166
	4	26.5	5	118
	5	24.5	3	66
	6	22.2	2	14
	7	20.5	1	7
	8	18.5	-	0

FIGURE I. DAMAGE-FREQUENCY CURVE CONSTRUCTION



C. Normal Growth

Future construction within unprotected portions of the flood plains of the Susquehanna River Basin can be expected to occur. It is assumed that additional development within the flood plain will continue at the same rate as in the past. In order to assure consideration of all potential damages likely to be incurred and prevented within the period of economic analysis, the average annual damages computed for existing conditions are adjusted for additional property improvements expected to develop within unprotected portions of the flood plain over the next 100 years with or without additional flood protection.

Past trends in flood plain land use are determined by the number of establishments and buildings in the flood plain, as of 1936 and 1964, in representative areas where complete field inventories are available. The rate of change indicated by a straight line plot of these quantity values versus time is extrapolated as a straight line to provide a projection of normal flood plain use for the next 50 years as limited by the areal extent of the flood plain. Because of the uncertainty of future conditions conducive to changing land use in the flood plain (such as economic activity and flood plain zoning), the second 50-year period rate of change is arbitrarily restricted to half the rate for the first 50-year period, also limited by the areal extent of the flood plain.

An index is computed for each town studied by discounting expected future development to present worth and distribution of the total growth over the 100-year analysis period. The index so developed provides a means of converting present annual flood damages to equivalent average annual damages that reflect estimated future growth in the flood plain.

Urban centers selected for the previously described analysis are representative of the general region of the Basin in which they are located. Throughout the Susquehanna River Basin, the configuration of the land has a direct bearing on the pattern of flood plain occupancy. For this reason, development within the flood plain could not be equated directly with widespread changes in economic activity or population trends. Thus, the discounted indices reflect the combined effects of topography, with the more dynamic economic influences and population changes applicable to development of flooded and non-flooded areas alike.

These indices are grouped into areas that are similar in respect to topography, economic conditions, and population structure. They are averaged for each group and are adopted as the appropriate index for each area. Average annual flood damages under present conditions are converted to estimated damages over a 100-year analysis period by multiplying by the appropriate index.

D. Economic Growth

An additional category of flood damages that can be expected results from increased economic activity. Estimates of damages with normal growth (residential, commercial and industrial only) are adjusted to reflect increases in the added value of the properties and contents in the flood plain over the period of analysis. Per capita personal income is projected to increase at an average rate of 2.75 percent, compounded annually, in the Susquehanna Basin. However, it is assumed that economic activity and the associated value increases within the flood plain will be slower than the projected growth in the area as a whole and, therefore, a rate of growth of 2 percent over the 100 years of the analysis period, compounded annually, is used to compute the economic growth adjustment.

Appendix 2

Why are Many Proposals to Regular Development in Flood Hazard Areas Not Acted Upon?

Costs and benefits are often perceived differently by those proposing regulations than by those directly affected.

Costs and Benefits as Seen by Those Affected by Proposed Regulations to Control Development In Areas Considered to Have Flood Hazards

Range of Interest	Benefits	Costs
How Meaningful are they?	Vague, e.g., reducing fear of floods	Real, e.g., loss of property values
How Exact are they?	Speculative, e.g., reduction of unknown flood damages and savings on disaster relief	Definite, e.g., restriction of area available for development
How Soon will they be realized?	Deferred, e.g., benefits forthcoming at unspecified future time	Immediate, e.g., costs begin upon enactment of regulations
How Sure are they?	Uncertain, e.g., no guarantee of benefits during time flood hazard area is occupied	Firm, e.g., denial of building permits

Fear of floods often recedes as time passes (perhaps many years) without one. Loss of property values, however, is perceived as a real threat to personal investments which exist now.

Reduction of future flood damages and disaster relief expenditures are necessarily estimates of losses which have not yet occurred; hence, in some people's minds, they are merely speculative assertions. Restriction of the area available for development, on the other hand, is an act resulting in a definite perceived outcome.

It is difficult to set a specific time when the benefits of flood hazard regulations will be realized, otherwise than sometime in the future (perhaps years). Enactment of regulations, in contrast to this, will have immediate effects.

Benefits from flood hazard regulations, although statistically sure in the long run, are uncertain during the time an individual may occupy the area. Denial of building permits is an action whose consequences (thrawted plans) are firmly felt under regulations.

-- adapted by Lyle C. Raymond from James R. Finley,
A Study of Water Resources Public Decision-Making

Glossary of Terms

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Normally a flood is considered as any temporary rise in stream flow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity.

Flood Crest. The maximum stage or elevation reached by the water at a given location.

Flood Peak. The maximum instantaneous discharge of a flood at a given location.

Flood Plain. The relatively flat area or low lands adjoining the channel of a river, stream, or other water-course which has been or may be covered by flood water.

Flood Profile. A graph showing the relationship of water surface elevation to location. It is generally drawn to show surface elevation for the crest of a specific flood.

Flood Frequency. Flood frequency is defined as the percent chance of occurrence of a given flood in any year, i.e. the 100-year flood is identified as the flood having a one percent chance of occurrence in any year, and the 20-year flood would have a five percent chance of occurrence in any one year.

Reach. A segment of a river or stream, usually limited by a major tributary or town, which has similar hydraulic characteristics throughout its length. A reach may also be limited to that portion of a river within a town or metropolitan area.

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