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SNOHOMISH RIVER BASIN

LEVEL 3

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NON-STRUCTURAL APPROACHES FOR FLOOD DAMAGE REDUCTION

NOVEMBER 1980

SNOHOMISH MEDIATED AGREEMENT FEASIBILITY STUDY

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This report analyzes means of controlling existing and probable future flood damage problems in the Snohomish River Basin in Washington State through the use of "nonstructural" methods. These methods include small scale structural modifications to existing buildings and property subject to flood damages as well as strategies (such as land use controls) to avoid increases in damage levels. A variety of mechanisms were found to be promising for the control of existing problems in this river basin, and for the avoidance of increases in

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) damage levels in the future. Specific recommendations are made for control strategies in each of the eight subregions studied, and basin-wide strategies for flood hazard management were also articulated. Information needed for the implentation of these strategies are outlined, and responsibilities for the achievement of these flood damage reduction strategies on the part of various levels of government are discussed.

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TO THE

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Bill Beyers

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CHAPTER I

INTRODUCTION

The purpose of this study is the identification and application of nonstructural approaches to present and future flood damage problems in the Snohomish River Basin. In contrast to major physical developments such as dams as a means of reducing flood hazards, nonstructural approaches may be regarded as both on-site coping actions and regional development strategies which reduce current damages and future damage potential by programs and policies that do not involve major structures.

Nonstructural approaches have been given greater emphasis in recent years by those responsible for water resources management because of their positive environmental values and because they may lead to more effective economic approaches to natural hazard reduction. Many of these approaches are already in a partial state of application, such as floodplain zoning preventing development in hazardous locations. Other approaches are only concepts which have not been implemented, and therefore we have little in the way of experience to guide us in the evaluation of the effectiveness of these measures.

This report is organized as follows. The first three chapters develop background information against which the specific problems of the Snohomish River basin may be considered and against which recommended strategies to deal with these problems may be articulated.

Chapter II provides an overview of federal legislation and programs which are significant at a local level in the management of floodplains from a nonstructural perspective. Chapter III contains a discussion of the general concept of a nonstructural approach to flood hazard reduction. The complex nature of the nonstructural approach is emphasized and then a general classification of various nonstructural strategies is proposed.

We then consider each nonstructural approach in detail, outlining the concept, describing types of benefits and costs associated with each, and discussing relationships between these approaches as flood hazard reduction strategies and other aspects of water resource and environmental management. Chapter IV outlines state and local government programs which relate to flood hazard management, with particular emphasis on Snohomish River basin local governments. This review leads to the conclusion that many existing programs can be considered nonstructural approaches to floodplain management in the Snohomish River basin, although these approaches are utilized in varying degrees of effectiveness.

Chapter V describes the Snohomish River basin in a general way, and then reach by reach descriptions of the study area are given. These descriptions are relatively concise, as there are many, much more detailed, descriptions of the study area readily available elsewhere. We have tried to emphasize aspects of the flood hazard problems in our description of these reaches. After describing current characteristics of the region, we then consider the potential for growth in the basin. We focus on growth in the recent past, and discuss growth prospects for the short run (to 1992), medium run (2012), and long run (2042) in the context of existing programs for land management in the region. This section of the report emphasizes the uncertainties surrounding the course of future development in the basin, and on the floodplain. The key role played by the evolution of local government land-use policies and federal programs for flood hazard management is emphasized.

In Chapter VI we review statistics related to existing flood damages in the Snohomish River Basin. These data were primarily supplied to us by the Corps of Engineers. We also assessed probable future damage levels in the basin, for the years 1992 and 2041, given current land use policies of local governments. This assessment leads to the conclusion that the damage potential will not increase very significantly if current policy remains in effect through the study period.

Chapter VII provides detailed assessments of the flood damage problems by reach, and then provides descriptions of alternative approaches to the reduction of these damages. Recommended strategies are also defined for each reach. In general, these assessments are made qualitatively, as insufficiently precise quantitative evidence was found related to the various strategies. We try to suggest information needs to help cope with this problem in our report. After this reach-by-reach treatment, we then attempt to suggest some basin-wide strategies, although we argue that this is inherently difficult for a nonstructural approach, which must be tailor-made to the particularities of each sub-region with a flood hazard.

The report concludes in Chapter VIII with some more general remarks about nonstructural analysis, and some suggestions for the next steps in researching the application of these concepts to the Snohomish River Basin.

CHAPTER II

FEDERAL SUPPORT FOR NONSTRUCTURAL ALTERNATIVES

Federal laws and policy now require that nonstructural alternatives be given equal emphasis in planning and implementation of water resource projects undertaken by federal agencies such as the U.S. Army Corps of Engineers. This policy direction is clear and unambiguous, although confusion remains as to authority and inclination for funding of nonstructural measures by individual agencies. The following is a brief summary of federal actions which have had key roles in the development of federal policy on floodplain management, with special attention given to the evolution of emphasis for nonstructural measures. A chronological approach demonstrates this evolution.

House Document 465

This 1966 Presidential Task Force report entitled A Unified National Program for Managing Flood Losses focused national attention on floodplain management. Reflecting a concern with rising national flood losses, House Document 465 recognized that traditional structural flood control measures alone were not sufficient to achieve flood loss reduction. The document provided the first major policy level recommendations for alternative techniques including flood insurance, flood proofing, relocation, forecasting and warning, and floodplain regulations. To promote sound and economic development of the floodplain, the following recommendations for federal action were made by the task force: 1) improve basic knowledge about flood hazard; 2) coordinate development planning on the floodplain; 3) provide technical services to managers of floodplain property; 4) move toward a practical national program for flood insurance; and 5) to adjust federal flood control policy to sound criteria and changing needs.

Executive Order 11296

This order accompanied House Document 465 and directed all federal agencies to "provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development of the Nation's floodplains and, in particular, to lessen the risk of flood losses in connection with Federal lands and installations and federally financed or supported improvements."

National Flood Insurance Act of 1968 (P.L. 90-448)

Under the National Flood Insurance Program, the federal government subsidizes flood insurance for existing property in the flood hazard area in return for local enactment and enforcement of floodplain management regulations designed to reduce future flood losses and regulate new development in the designated flood hazard area. As amended by the Flood Disaster Protection Act of 1973 (P.L. 93-234), the Act requires that communities become eligible under the National Flood Insurance Program within one year after identification of floodprone areas by the Federal Insurance Administration or thereafter be denied federal financial assistance (broadly defined) for acquisition or construction purposes in identified flood hazard areas. The status of individual Snohomish basin communities under the national flood insurance program will be discussed later.

National Environmental Policy Act of 1969 (P.L. 91-190)

NEPA declared environmental quality to be a national goal and established a procedure for environmental impact assessment for proposed federal projects and programs that may have significant environmental effects. The act requires that the environmental review process incorporate both public involvement and an accounting of the various alternatives considered and their respective impacts. This legislative and administrative foundation established by NEPA has prompted efforts to restore and preserve natural floodplain values.

The National Environmental Policy Act also requires agencies to focus upon the indirect and cumulative long-run effects of their programs. Thus, in studying a region such as the various reaches of the Snohomish River system, impacts of federal programs originating outside this region must also be considered. For example, the management programs of the U.S. Forest Service may have a downstream cumulative effect on the floodplain in the Snoqualmie River basin. If this were the case, under NEPA the Forest Service should document these effects and would be obligated to suggest measures to mitigate these impacts if they were considered adverse impacts upon the environment.

Water Resources Council Principles and Standards (38 PR 24778)

In 1973 the U.S. Water Resources Council (WRC)--created by the Water Resources Planning Act of 1965 (P.L. 89-80)--published the Principles and Standards for Planning Water and Related Land Resources to establish uniformity in planning by federal agencies. The Principles and Standards identify two coequal national objectives as the basis for formulation of plans for the conservation and use of water and related land resources--protection and enhancement of 1) national economic development (NED) and 2) environmental quality (EQ). Alternative plans are to be formulated reflecting contributions to various mixes of the NED and EQ objectives, ranging from maximizing contributions to the NED objective to maximizing contributions to the EQ objective. Even the NED plan or the EQ plan may include elements which address the other objective.

Principles and Standards set up a system of accounts to be used in organizing information on the ects of alternative plans. Four accounts are to be used in the comparison of alternative plans: national economic development (NED), environmental quality (EQ), regional economic development (RED), and social well being (SWB). The NED account is to be expressed in monetary units, being basically the traditional benefit-cost analysis. Principles and Standards now require that this be only one of four independent assessments of plan impacts. Values in the EQ account may be in quantitative units or qualitative terms; the RED account is represented by a combination of monetary and other quantitative units; and the SWB account is in monetary units, other quantitative units, or qualitative terms.

Principles and Standards identifies benefit categories to be used in the NED account: urban flood damage; agricultural floodwater, erosion, and sedimentation; recreation; municipal and industrial water supply; commercial fishing; hydropower; agricultural drainage; agricultural irrigation; inland navigation; deep draft navigation; and other NED.

The EQ account is used to assess the net effect of environmental quality for an alternative plan. Beneficial and adverse effects in the EQ account are changes in the quantity of natural and cultural resources or changes in the quality of these resources are measured by ecological, aesthetic, historic, educational/scientific, and pristine values.

The regional economic development account is intended to show the extent to which the income and employment impacts of alternative plans occur within the "significantly affected" region as opposed to the "rest of nation" region. The RED account is to be organized in the same categories as the NED account so that interregional transfers can be identified.

The social well being account registers plan impacts from perspectives not taken in the NED, EQ and RED accounts. Categories in the SWB account may include: urban and community impacts; life, health, and safety factors; and energy requirements and conservation.

Use of the four account systems gives nonstructural measures a more favorable position relative to structural measures than previously when only the economic cost-benefit criterion was used in project evaluation.

Water Resources Development Act of 1974 (P.L. 93-251)

Section 73 of this act provides strong legislative support for nonstructural approaches. This section calls for consideration to be given to nonstructural alternatives when formulating the most economically, socially, and environmentally acceptable means of reducing or preventing flood damages. The act specifically requires that floodproofing of structures, floodplain regulation, relocation, and acquisition of floodplain lands for recreational, fish and wildlife, and other public purposes be considered. Where a nonstructural alternative is recommended, non-federal participation is to be comparable to the value of land and easements required for structural protection measures, but in no event will the local share exceed 20 percent of project cost. Agency cost-sharing practices have been slow to respond to the Congressional intent in Section 73.

Executive Order 11988--Floodplain Management

This Presidential Order, issued in May 1977, builds on the National Flood Insurance Act, the Flood Disaster Protection Act, and the National Environmental Policy Act. The objective of E.O. 11988 is "to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." E.O. 11988 adds new prominence to the environmental aspects of floodplain management, requiring that decision making by federal agencies clearly recognize that floodplains have unique and significant public values. Consideration must be given, therefore, to natural and beneficial floodplain values and to the public benefit to be derived from their restoration and preservation.

Guidelines for implementing E.O. 11988--Floodplain Management--were issued by the U.S. Water Resources Council in 1978 (43 FR 6030).

Executive Order 11990--Protection of Wetlands

Issued simultaneously with E.O. 11988, this order has the objective "to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative." Taken together, these two executive orders place increased emphasis on land use regulations and administrative policies as a means of reducing flood damages and protecting the natural and beneficial values of floodplains and wetlands.

Presidential Water Policy Message and Memorandum

In 1978, the President's Water Policy Reform Message and subsequent memo to the WRC set forth many water policy initiatives affecting floodplain management. The President stated that reforms in agency evaluation procedures were essential in order to achieve both economic efficiency and environmental quality in water resources management. Support of E.O. 11988 is reemphasized. Greater use of nonstructural floodplain measures is encouraged by specific directives to: 1) modify federal water resource planning procedures to require formulation of at least one primarily nonstructural alternative plan where a structural project is being considered; 2) restructure federal cost sharing to remove biases against nonstructural measures; and 3) utilize federal programs to help reduce future flood losses by acquisition of flood-prone land and property. The President's water policy initiatives also direct that water conservation be included as a specific component of both the NED and EQ planning objectives.

Revisions to Principles and Standards (44 FR 72978)

WRC responded to the President's water policy directives by publishing revisions to the Principles and Standards for Planning Water and Related Land Resources in 1979. These revisions 1) integrate water conservation elements (as opposed to new storage facilities) into project planning as a means of achieving both the NED and EQ objectives and 2) require that a primarily nonstructural plan be included as one alternative whenever structural alternatives are considered. This alternative plan should combine nonstructural or demand-reducing measures which could feasibly be employed or adopted to achieve the overall project purpose.

Alternative plans are to be formulated which reflect different relative contributions to identified objectives. Required alternative plans now include 1) optimum contributions to the NED objective; 2) emphasis on contributions to the EQ objective; and 3) a primarily nonstructural plan. The plan ultimately selected from among these and other alternative plans must have combined bneficial NED and EQ effects exceeding combined adverse NED and EQ effects. Therefore a plan without net NED benefits may be recommended when the EQ benefits are sufficiently large. Presentation of alternatives with analysis of tradeoffs is to be made in explicit terms.

The assessment of nonstructural measures as alternatives to traditional structural measures is to be considered for all water resources planning purposes including flood control, water supply, hydropower, recreation, fish and wildlife, and other purposes. The revised Principles and Standards gives examples of nonstructural alternatives for specific project purposes. For example,

> Nonstructural alternatives for flood hazard reduction include, but are not limited to:
> a) Reducing susceptibility to flood damage by land use regulation, redevelopment and relocation policies, disaster preparedness, flood proofing, flood forecasting and warning systems, floodplain information, floodplain acquisition, floodplain easements;

b) Reducing the adverse burden of flooding by flood insurance and flood emergency relief programs;

c) On site detention of flood waters by protection of natural storage areas such as wetlands and in man-made areas such as building roofs and parking lots.

Procedures for evaluation of NED benefits and costs were also published by the WRC in 1979 (44 FR 72892) to ensure consistency and accuracy among agencies.

Other Related Federal Legislation

Other federal legislation is related to water resources planning, floodplain management, and nonstructural alternatives. Only the most important legislation is mentioned here.

The Wild and Scenic Rivers Act of 1968 (P.L. 90-542) provides that in planning for the use and development of water and related land resources consideration shall be given to potential wild, scenic, and recreational river areas in river basin and project plan reports and comparisons be made with development alternatives which would be precluded by preserving these areas.

The Clean Water Acts of 1972 and 1975 (P.L. 92-500 and P.L. 95-217) assign important responsibilities affecting floodplains to the Corps of Engineers and the Environmental Protection Agency. It expands Corps jurisdiction for issuing permits for alterations of navigable waters to all waters of the United States, including adjacent wetlands. Under Section 404(b) EPA issues guidelines for protecting the aquatic environment, including wetlands, from any unacceptable adverse impacts of the discharge of dredged or fill material.

The Coastal Zone Management Act of 1972 (P.L. 92-583) assists states in the preservation, protection, development and restoration of coastal resources through a federally approved management program. Explicit definition of permissible land and water uses in the coastal zone and of the means of exercising state control over these areas is required.

The Endangered Species Act of 1973 is intended to provide for the conservation of endangered and threatened species of fish, wildlife, and plants. Listings of such species are prepared by the Secretaries of Interior and Commerce. The Endangered Species Act allows for the use of the Land and Water Conservation Fund and various fish and wildlife acts for land acquisition for conservation purposes.

The Disaster Relief Act of 1974 (P.L. 93-288) as amended, deals with floods as well as other natural disasters or emergencies. Federal funding is provided for planning by state and local governments for disaster preparedness. The concerns of the act for disaster preparedness and prevention relate the planning emphasis directly to disaster response and to the regulatory requirements of the National Flood Insurance program.

CHAPTER III

NONSTRUCTURAL MEASURES FOR FLOOD LOSS REDUCTION

THE NONSTRUCTURAL APPROACH

Structural measures such as dams, channel modification, and levees are responses to flooding where natural physical systems are modified in an attempt to reduce loss of life and damages to property resulting from human development in floodplains. In contrast, under a nonstructural approach human use of the floodplain is adapted to the flood threat. Examples of nonstructural approaches are reducing flood losses to existing floodplain structures by floodproofing, relocation, demolition, reducing damages which would result from future floodplain development by land use regulation or purchase of development rights, and protecting or restoring the natural water retention capacities of floodplains and wetlands.

The term "nonstructural" must not be taken too literally. A levee protecting a town or neighborhood is clearly a structural approach. Floodproofing of individual structures, which may include the use of small ring dikes or levees, is classified as a nonstructural approach. "Nonstructural" is taken herein to mean any alternative to traditional large-scale engineering approaches.

Attention has shifted to nonstructural alternatives from traditional structural flood damage reduction measures with the recognition that even given historical and ongoing support for construction of dams, levees, and channel modification projects, annual flood losses and economic damages have continued to increase throughout the United States. The economic benefits and costs of nonstructural alternatives place them in an increasingly competitive position relative to structural responses to flood hazard. This trend is especially reinforced by rising land, labor, and construction costs, by a dramatic increase in the interest rate used in evaluation of projects, and by increased competition among programs for use of federal revenues. Another advantage of nonstructural alternatives is that certain approaches may have longer effective "project lives" than structural measures (usually assumed to be 100 years). Another factor which increasingly favors nonstructural measures in many locales is that existing structural flood control development has already responded to basin flood problems based largely upon economic efficiency and engineering feasibility to the extent that only much more expensive or harder-to-solve "residual" damages remain.

While the relative economic merits of structural and nonstructural approaches require much more creative and detailed analysis, the relative environmental advantages of nonstructural approaches are unquestionable. The requirement of mitigation for negative environmental impacts of federal structural flood control projects is a response to net negative environmental impacts. Nonstructural alternatives, taken as a class, have net positive environmental impacts. Preservation or restoration of floodplain environmental resources is often compatible with or inherent in a nonstructural approach.

The remainder of this chapter deals with the concept of nonstructural measures for achieving flood loss reduction. First, nonstructural measures are analyzed in terms of purpose and mechanism. Nonstructural measures are presented as responses to river basin problems and opportunities, primarily for the purpose of flood loss reduction to existing and future floodplain development but also for other purposes including environmental quality, recreation, fisheries, agricultural lands preservation, and erosion and sedimentation reduction. The second and major section of the chapter presents a wide range of individual nonstructural measures, with attention given to purposes served, types of benefits and costs, information requirements, and potential and problems of implementation. A final section of the chapter is an attempt at describing the relative advantages and disadvantages of these individual nonstructural measures on criteria such as effectiveness in flood loss reduction, economic costs, multiple purposes, environmental quality impacts, institutional feasibility, level of government responsibility, and off-site effects. These measures are applied specifically to the Snohomish River basin in Chapter 7.

Many of the ideas and information contained in the following discussion and descriptions of individual nonstructural approaches have come to varying degrees from certain documents and reports which merit special mention:

Corps of Engineers, New England Division (1976) Water Resources Development Plan for Charles River Watershed, Massachusetts

Corps, Hydrologic Engineering Center (1977) Annotations of Selected Literature on Nonstructural Flood Plain Management Measures

Corps, Hydrologic Engineering Center and Institute for Water Resources (1978) Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures

Corps, St. Paul District (1979) The Development of Nonstructural Alternatives

Corps, New England Division (1980) Formulation, Assessment, and Evaluation of Flood Damage Reduction Techniques for Keene, New Hampshire, prepared by CDM/Resource Analysis

Corps, Baltimore District (1977) Cost Report on Nonstructural Flood Damage Reduction Measures, for Residential Buildings Within the Baltimore District

U.S. Water Resources Council (1979) A Unified National Program for Flood Plain Management

U.S. Water Resources Council (1973) Principles and Standards for Planning Water and Related Land Resources, and as revised.

Institute of Public Administration (1976) Evaluations of and Recommendations for Legal, Institutional, and Financial Methods...

The Snohomish Mediated Agreement (1974)

Pacific Northwest River Basin Commission, Snohomish River Basin Resource Management Program, Study Team Review Draft, Vol. 2, May 1980.

PURPOSES OF NONSTRUCTURAL MEASURES

The implementation of nonstructural measures should be seen as responding to a set of river basin problems and opportunities. The primary focus of this contract is nonstructural measures as an alternative approach to flood loss reduction. Nonstructural measures can achieve the purpose or objective flood of loss reduction either by reducing future flood damages to existing floodplain development or by reducing future flood damages to future floodplain development. Nonstructural measures are especially effective in the latter case when used to control development and land use change. Some individual nonstructural measures such as emergency preparedness and preservation and/or restoration of natural water retention capabilities of floodplains and related basin wetlands may serve to reduce future flood losses to both existing and future floodplain development.

Just as with structural flood control projects, nonstructural approaches may have multiple purposes and multiple impacts beyond flood loss reduction. While focusing on flood loss reduction, this report places nonstructural measures in the broader context of relating to other basinwide problems and opportunities as well. The relationships of nonstructural measures to these other basinwide objectives are often very complex. For convenience, the discussion of other objectives is organized in five main topics--environmental resources, recreation, fisheries, agricultural (and forestry) lands preservation, and erosion and sedimentation reduction.

This section treats and classifies nonstructural approaches and measures according to purposes served: 1) primarily intended to reduce future flood losses to existing floodplain development, 2) primarily intended to reduce future flood losses to future floodplain development, 3) to reduce future flood losses to both existing and future development, and 4) to satisfy other floodplain land use goals such as preservation and restoration of environmental resources, providing public recreation, enhancing fisheries, maintenance of agricultural and forestry land use, and reduction of erosion and sedimentation. Table 3-1 outlines the relationships of various nonstructural approaches and measures as responses to one or more of the above purposes. Individual nonstructural measures are described and analyzed in much greater detail in the last section of this chapter.

Types of future flood losses which may result from existing or future floodplain development are loss of life, property damages, loss of income, disruption of lives, businesses, and communities, and expenditures for emergency relief and aid. Although this report focuses on the more easily measured and predicted property damages and emergency relief and aid expenditures, it should be remembered that certain nonstructural measures are especially well suited for reducing other nonmonetary flood-related losses such as loss of life and individual and community disruption.

These types of flood losses--loss of life, property damages, loss of income, disruption of individual lives, businesses, and communities, and expenditures for emergency relief and aid--are obviously interrelated. For example, actions designed to reduce future property damages will also reduce the other types of losses to varying degrees. Reduction of expenditures on emergency relief and aid is at least a secondary or indirect effect of most individual nonstructural measures discussed in this report, although these reductions may vary widely in magnitude with the type of

TABLE 3-1. NONSTRUCTURAL APPROACHES AND MEASURES FOR REDUCING FLOOD LOSSES DUE TO EXISTING AND FUTURE FLOODPLAIN DEVLEOPMENT

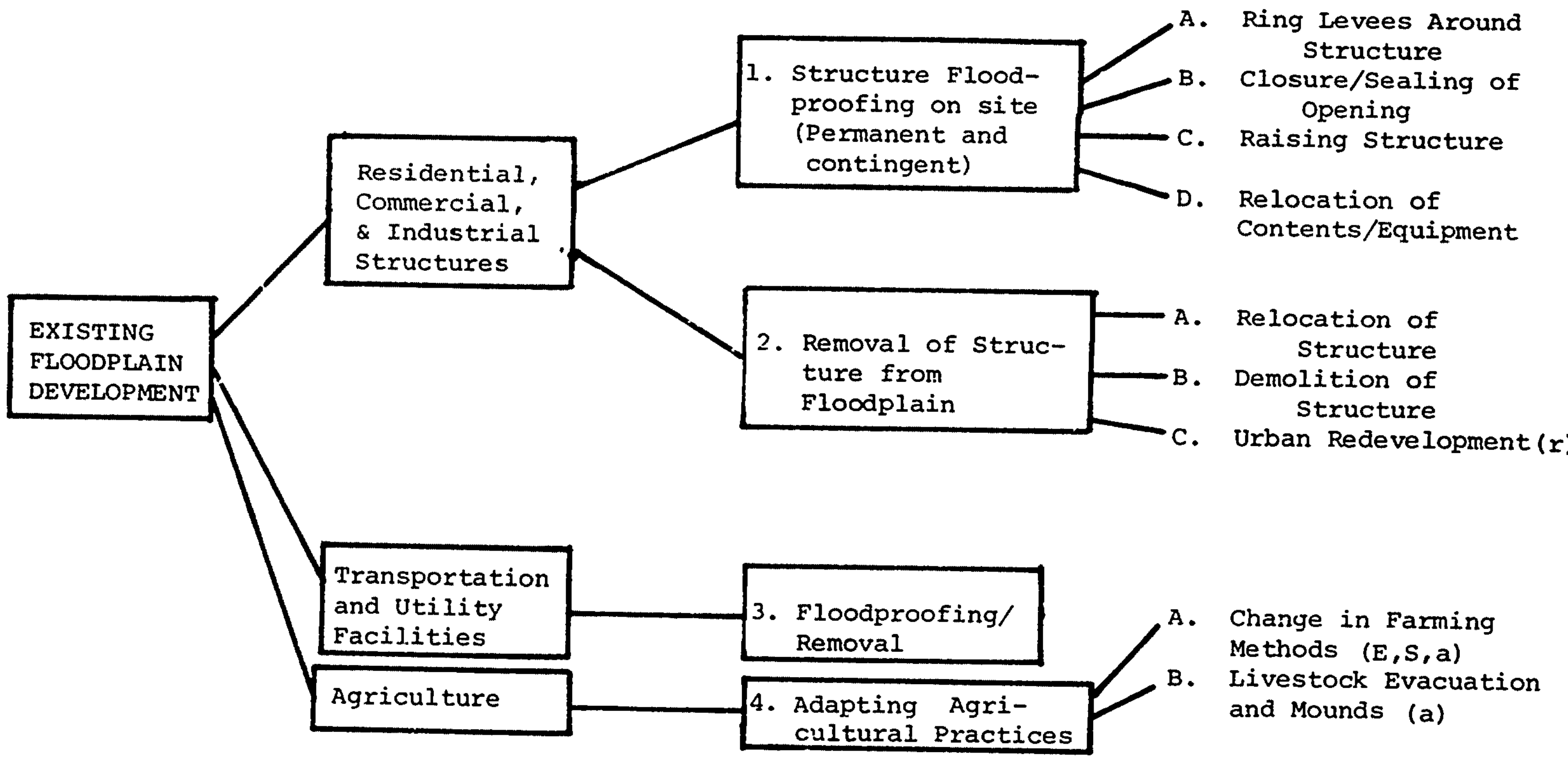


TABLE 3-1. (cont'd)

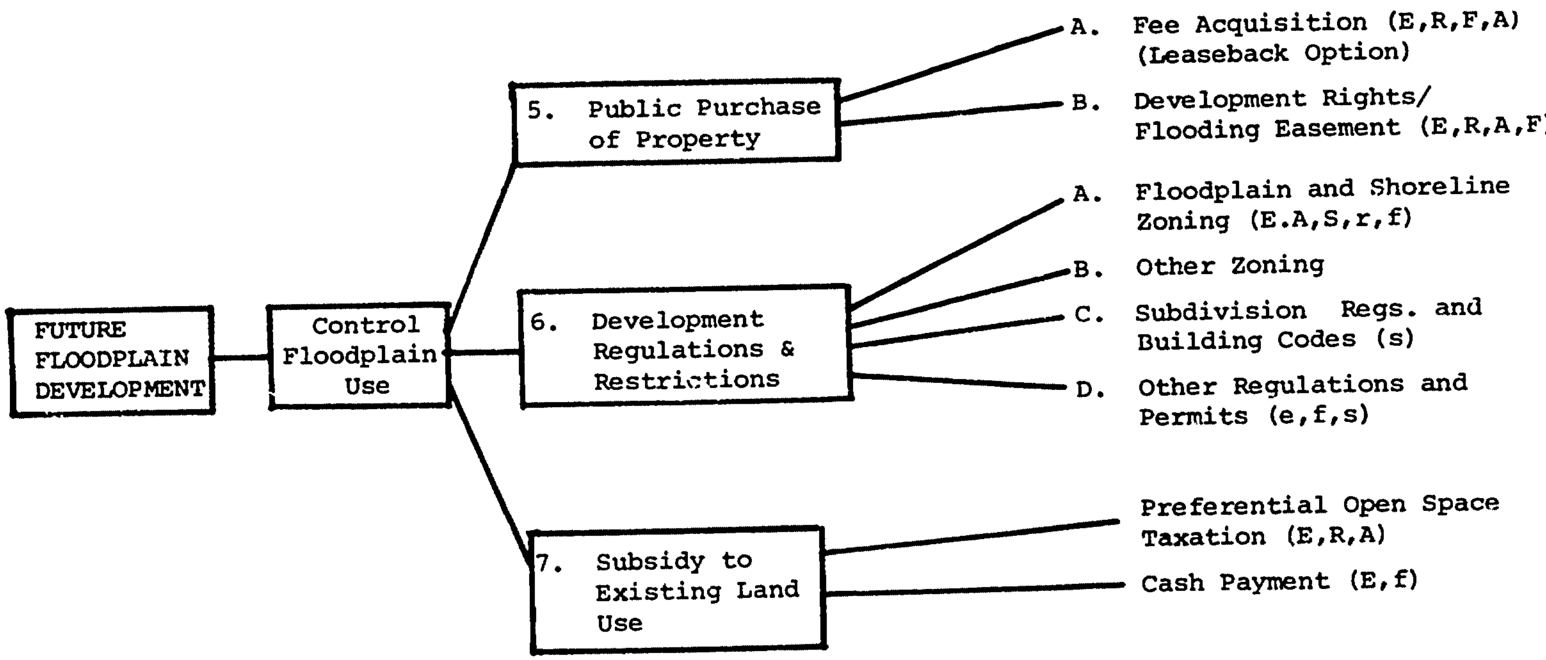
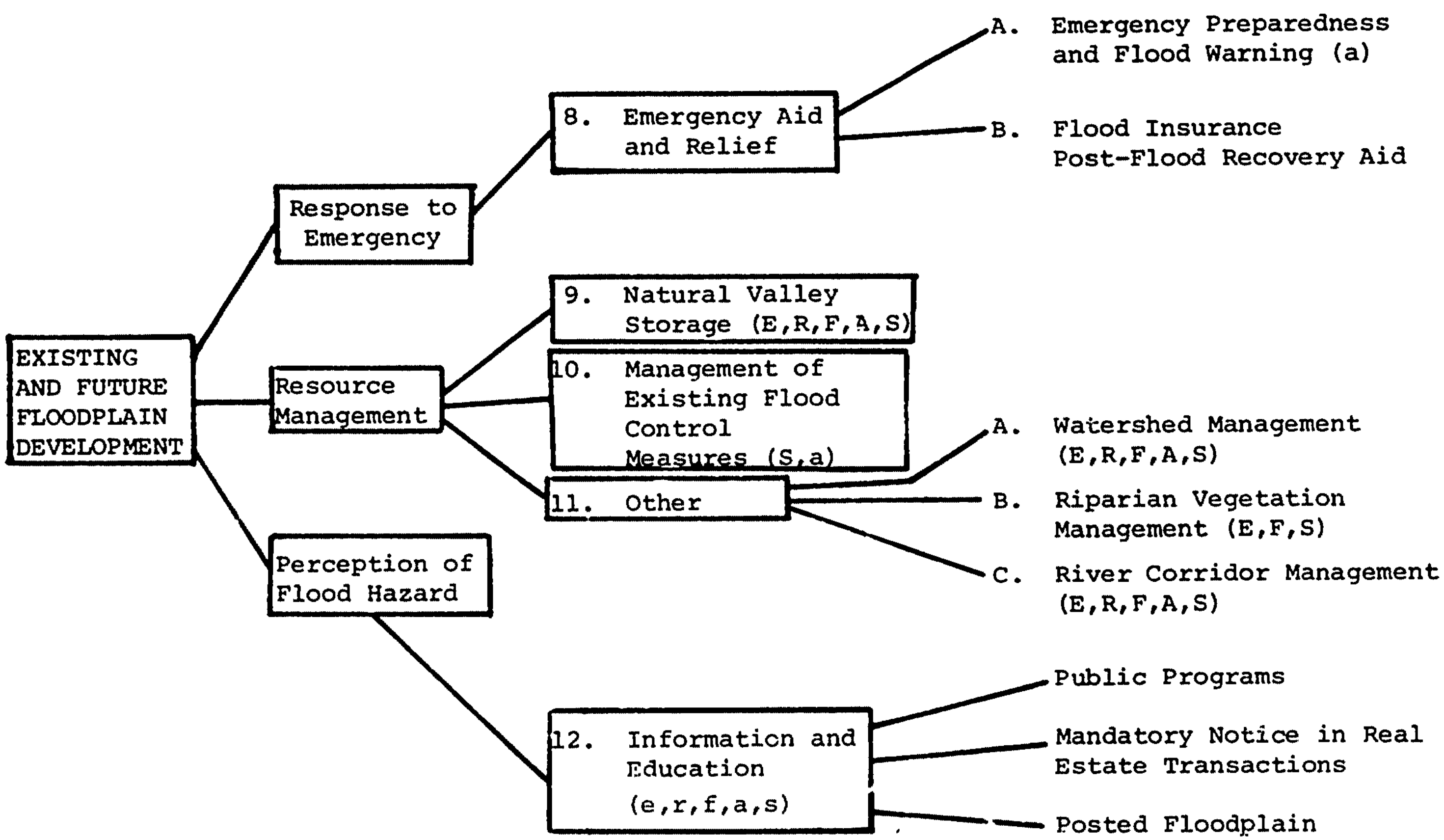


TABLE 3-1. (cont'd)



*Other purposes served:

E Environmental Resources Preservation/Restoration
R Recreation
F Fisheries Enhancement
A Argicultural (and Forestry) Land Use Maintenance
S Erosion and Sedimentation Reduction

(Lower case indicates secondary or indirect effect.)

Reduce Future Flood Losses Due to Existing Floodplain Development

Most nonstructural measures for reducing future flood damage to existing floodplain development (residential, commercial, and industrial structures, transportation and utilities facilities, and agriculture) are based on adapting floodplain occupance to the flood hazard. There are, however, some alternatives to the structural approach of further alteration of natural systems which can also reduce the degree of flooding. Three such nonstructural approaches to flood water control are 1) natural valley storage (in which the natural water retention capabilities of basin floodplains and wetlands are preserved or restored), 2) management, maintenance, and coordination of existing flood control measures such as dams, channel modifications, and levees to ensure maximum safety and proper performance, and 3) watershed management (in which land uses and practices on upland and non-floodplain lands in the basin are adjusted to reduce or retard runoff).

Since these nonstructural approaches to flood water control also can reduce flood losses to future development, they are discussed more fully in a later section.

Reducing future property damages to existing floodplain development may also be accomplished by adapting that development to the flood threat or by removing it. The specific nonstructural measure used depends upon the type of development. For residential, commercial, and industrial structures, alternatives for reducing flood loss are "floodproofing," relocation of contents and equipment within structures, and removal from floodplain. Floodproofing measures are intended to keep water out of the building and reduce structural damage and range from small-scale structural ring dikes, to sealing of structure openings, to raising or elevating the buildings on-site above the flood hazard level. An option to moving the structure vertically is removing it from its floodplain site, either by relocation or demolition. Commercial and industrial buildings are much less subject to elevation or relocation than residential structures. Urban redevelopment can be seen as a nonstructural measure where damage-prone residential, commercial, and industrial structures in urban floodplains are removed with the site being reused either for new floodproofed development or for another purpose such as public recreation. As with structures, existing transportation and utility development in floodplains may be protected on site or be relocated in order to reduce or avoid future flood damages.

Nonstructural measures to reduce flood loss to existing agricultural development focus on the individual farm. Flood damages to floodplain farms may be to crops, livestock, residences, buildings and fences, machinery and equipment, and land. Changing farming methods--such as changing planting times, changing type of crop, or changing from cropland to pasture--can be used to reduce crop losses. Contingencies may be provided for safe evacuation of livestock from flooded areas, including the construction of on-farm evacuation mounds. Farm residences are subject to the same nonstructural measures as are urban homes, except that removal of the house from the farm may be incompatible with retaining the viability of the farm.

<u>Reduce Future Flood Losses Due to Future Floodplain Development</u>

Continued development in floodplains will lead to increased future flood damages unless mitigation actions occur. Nonstructural approaches which deal primarily with reducing future flood losses to future floodplain development are all based on controlling future floodplain land use. This set of nonstructural measures is based on influencing the type, amount, and location of future floodplain development, including residential, commercial, and industrial structures and transportation and utility facilities. Totally preventing future floodplain development (to the extent that it is politically and economically feasible) is a subclass of controlling what type, how much, and where development may occur.

Using land use controls and incentives as a means of reducing flood damages implies properly articulated land use objectives. If certain areas of the floodplain are not to be used for residential, commercial, and industrial structures, then what are acceptable uses? As will be discussed later, this group of nonstructural measures can serve many purposes in addition to reducing flood losses and provide much flexibility in influencing (proper) floodplain land use.

As shown in Table 3-1, future floodplain land use may be influenced either by transferring or limiting private property rights or by providing incentives for private landowners to maintain desired land uses. Private property rights may be taken either through public purchase of property rights or by development regulations and restrictions. Fee simple acquisition is the most effective as all layers of private ownership are removed, but is also the most costly. Fee simple acquisition is especially appropriate for parcels facing strong development pressures and/or having significant environmental values. Areas purchased outright are often used for public recreation or wildlife areas. If people are now living on properties to be purchased in fee, they may be given a life estate, allowing them to remain on the property for life. Lands purchased in fee may also be leased back for specified uses such as forestry or agriculture. Alternatively, partial property rights may be acquired, leaving the land in private ownership. Relevant examples are purchases of development rights or flooding easements. Development rights may also be purchased for such purposes as preservation of agricultural lands and open space.

Private property rights may also be limited by development regulations and restrictions which act in the public interest by influencing future floodplain development. Such regulations and restrictions include nonstructural measures which in effect are mandatory limitations on private development rights. Zoning has long been used to influence the type, amount, and location of development. Floodplain zoning and shoreline zoning are examples of increasingly geographically specific resource-based zoning. Other zoning classifications such as agriculture, forestry, or cluster development have implications for future floodplain use and density of development. Subdivision regulations and building codes may restrict or place conditions on development in flood hazard areas. Other governmental regulations and permit requirements can be used to control and influence future development and land use in floodplains, shorelands, wetlands, along navigable waters, and in basin uplands.

A final nonstructural approach designed to control floodplain land use and thereby reduce potential future flood losses is to provide a monetary incentive to landowners for maintaining or converting to certain land uses. Preferential taxation is the most common method of subsidy for maintaining an existing land use. Under such a program, lower tax rates are applied to lands kept in agricultural, forestry, or other open space land uses. A less used land use incentive is a direct cash payment for maintaining features such as wetlands and woodlots or for tree planting on private property.

Incentives and subsidies are relatively less reliable ways of influencing future floodplain development because of their voluntary nature. Development regulations and restrictions are also less reliable than purchase of property rights since zoning and regulations are subject to exception, lack of enforcement, political corruption, and change. Being most effective, public purchase of property rights is also the most expensive, although the administrative, technical, legal, and enforcement costs of effective ongoing zoning and regulatory programs can be considerable.

Reduce Future Flood Losses to Both Existing and Future Floodplain Development

Some nonstructural approaches by their nature act to reduce potential future flood losses to both existing and future floodplain development. As shown in Table 3-1, these nonstructural measures may be grouped under changing or improving 1) response to emergency, 2) resource management, or 3) perception of flood hazard.

Considerable costs are often incurred in providing emergency services and aid during and after a flood event. Examples of measures which modify the impact of flooding on individuals and communities are emergency evacuation, flood fighting, levee repair and restoration, disaster area relief funds, and crop losses reimbursement payments. Some of these costs can be reduced by implementing nonstructural measures discussed above for reducing property damages to existing floodplain development. Other nonstructural approaches can also modify the susceptibility to flooding and therefore reduce emergency costs and disruption. Emergency preparedness planning can improve response to emergency evacuation and flood fighting. Flood forecasting and warning systems are another approach to flood emergency preparedness. Flood insurance programs and post-flood recovery aid can modify the impact of responding to flood emergency and loss by individuals and communities. Flood emergencies may be compounded, sometimes dramatically, by failure of existing structural flood control measures such as dams and levees. A program of management, maintenance, and coordination of existing flood control elements can help to reduce such heightened emergency events and also realize savings on repair and restoration.

Another set of nonstructural approaches are basically resource management concepts, some of which have already been mentioned above.

Natural valley storage is the preservation and restoration of the natural water retention capabilities of floodplains and related wetlands. These natural systems have evolved through time and maintaining their integrity can be an especially low-cost nonstructural approach in the long run. Levees and drainage and filling of floodplain lands and wetlands act to diminish natural valley storage. Management, maintenance, and coordination of existing flood control measures can ensure proper performance and diminish the change of failures which greatly magnify the emergency and loss situation during flood events.

Other resource management schemes consider water and related land resource problems and opportunities at different geographic scales than most of the other nonstructural measures discussed in this report which focus on management of floodplain lands, resources, and development. Watershed management recognizes that land use and practices on upland non-floodplain lands throughout the drainage basin have an impact on flooding in floodplains. Forestry, agricultural, and development practices on non-floodplain lands may be designed to maximize water retention or retardation of runoff. Riparian vegetation management takes a finer geographic interest, focusing on the river course and its immediate banks. Natural riparian vegetation has often been extensively cleared. Maintenance and restoration of stream-bank vegetation has perhaps less impact on directly reducing flood losses than other nonstructural measures presented in this report, but can significantly reduce losses to land by stabilizing the river channel and reducing bank erosion during flood events. Maintenance of riparian vegetation also has important benefits to fish and wildlife. A final resource management concept is river corridor management, which is similar to but somewhat broader in scope than floodplain management. River corridor management focuses on the river course, floodplain, and adjacent lands, being concerned with purposes such as recreation, open space, and environmental quality as well as flood loss reduction. Wild, scenic, and recreation rivers programs are essentially river corridor concepts.

Perception of the flood hazard underlies all responses to flood hazard. Information and education about flooding and floodplain processes, both in concept and applied to specific flood hazard areas, can serve to directly and indirectly reduce flood losses. Information and education should go hand in hand with implementation of all the other nonstructural approaches and measures discussed above. Existing programs which provide flood hazard information and technical assistance to the public and to local communities can be improved and expanded. Other nonstructural measures falling in the information and education category are mandatory notice of flood hazard in real estate transactions involving floodprone lands and conspicuous posting of floodplain areas by signs or marking historic or potential flood heights on utility poles.

Satisfy Other Floodplain Land Use Goals

Although this report focuses on the flood loss reduction aspects of nonstructural measures, many of the individual measures identified have implications for other basin problems and opportunities as well. Other floodplain land use purposes such as preservation and restoration of environmental resources, provision of recreation, fisheries enhancement, maintenance of agricultural (and forestry) land use, and erosion and sedimentation reduction are often compatable, if not inseparable, from the purpose of flood loss reduction via nonstructural approaches.

The major purposes served by individual nonstructural measures are summarized in Table 3-2. The measures (1A through 4B) which focus on reducing flood losses to existing floodplain development offer little in the way of meeting other purposes, either directly or indirectly. Certain changes in farming practices, such as reduction in draining and filling of wetlands, can

TABLE 3-2. POTENTIAL NONSTRUCTURAL MEASURES, BY PURPOSE

NONSTRUCTURAL MEASURE	FLOOD LOSS REDUCTION		ENVIRON. RESOURC.	RECREA-TION	FISH-ERIES	AG. LAND PRESERV.	EROSION & SEDIMENT
	EXIST. DEVEL.	NEW DEVEL.					
1A Ring Levees Around Structure	X						
1B Closure/Sealing of Structure Openings	X						
1C Raising of Structure	X						
1D Relocation in Structure of Contents/Equipment	X						
2A Relocation of Structure	X						
2B Demolition of Structure	X						
2C Urban Redevelopment				(X)			
3 Floodproofing/Removal of Transport./Utilities	X						
4A Change in Farming Methods	X		X			(X)	X
4B Livestock Evacuation and Mounds	X					(X)	
5A Public Purchase--- Fee/Fee & Leaseback		X	X	X	X	X	
5B Purchase Devel. Rights or Flooding Easement		X	X	X	(X)	X	
6A Floodplain and Shoreline Zoning		X	X	(X)	(X)	X	X
6B Other Zoning		X	(X)	X		X	
6C Subdivision Regulations and Building Codes		X					(X)
6D Other Regulations and Permits		X	(X)		(X)		(X)
7 Preferential Open Space Taxation		X	X	X		X	
8A Emergency Preparedness and Flood Warning	X	X				X	
8B Flood Insurance	X	X					
9 Natural Valley Storage	X	X	X	X	X	X	X
10 Management of Existing Flood Control Measures	X	X	X	X	X	X	X
11A Watershed Management	X	X	X	X	X	X	X
11B Riparian Vegetation Management	(X)	(X)	X		X		X
11C River Corridor Management	X	X	X	X	X	X	X
12 Information and Education	X	X	(X)	(X)	(X)	(X)	(X)

X - indicates that the measure is applicable to the purpose listed at top of page.
(X) - possibly applicable

have environmental benefits. Other effects of this group of nonstructural measures may be 1) maintaining the viability of agriculture by reducing flood losses by changing farming practices and provision for livestock evacuation and 2) provision of recreation in urban redevelopment projects.

Nonstructural measures 5A through 7 which are designed to reduce flood losses to future development by controlling floodplain land use are especially amenable to meeting other purposes, as shown in Table 3-2. Fee simple acquisition provides the surest opportunity to meet other land use goals, including management for environmental resources, recreation, fisheries, and agricultural lands preservation, although partial acquisition of property rights such as purchase of development rights and flooding easements can be quite effective in certain situations. Floodplain and shoreline zoning can have wide-ranging impacts on floodplain land use and natural systems, as can other zoning approaches, depending upon specific provisions. Other regulations and permits dealing with floodplain development may also be sensitive to environmental resources and fisheries. Preferential taxation can be used to both influence future floodplain development and promote desired floodplain land uses such as recreation, agriculture, forestry, open space, and other natural features by providing a subsidy to existing or changed land use.

Among nonstructural measures which act to reduce flood losses to both existing and future floodplain development, emergency preparedness and flood warning can serve the purpose of agricultural lands preservation by increasing the viability of floodplain farming operations, especially for livestock. The various nonstructural resource management concepts are especially well suited to meeting multiple purposes since they are broad in nature. Natural valley storage, watershed management, and river corridor management stand out in Table 3-2 as meeting all seven of the flood loss reduction and other selected purposes. Riparian vegetation management stands out in providing enhancement of fisheries and reducing erosion and sedimentation. Information and education measures designed to reduce flood losses can be excellent mechanisms to point out the relationships between meeting the purpose of flood loss reduction and satisfying other related floodplain objectives.

INDIVIDUAL NONSTRUCTURAL MEASURES

This section discusses in more detail individual nonstructural measures identified in the previous overview of purposes of nonstructural measures outlined in Table 3-1. Many of these measures are overlapping concepts and they should not be seen as mutually exclusive. The following pages present a compendium of approaches, which are described conceptually at the outset, and then types of benefits and costs are discussed for each approach. This inventory of approaches will be used in the subsequent reach-by-reach consideration of the applicability of individual approaches and combinations of approaches to flood loss reduction. The initial application of these measures to river reaches is presented in Chapter 7. Alternative combinations of individual nonstructural measures are also presented in Chapter 7, including the advantages and disadvantages of each alternative.

Many of the nonstructural measures to be discussed have already been applied in the Snohomish River basin, some quite extensively, but others not at all. Chapter 4 identifies nonstructural approaches already being employed in existing state and local legislation and governmental programs.

Floodproofing Existing Structures on Site (Measures 1A-1D)

"Floodproofing" is not absolute, and is taken herein to mean an adaptation of a floodplain structure (residential, commercial, or industrial) so as to make it less subject to the flood hazard and thereby reduce, but rarely prevent, future flood losses attributable to that structure occupying that site. In order to reduce future flood losses to existing floodplain structures, these structures may be "floodproofed" on site or they may be entirely removed from the floodplain by relocation or demolition. Types of floodproofing for providing partial protection to structures on site are: Measure 1A--ring levees or dikes around the structure; Measure 1B--closure or sealing of structure openings; Measure 1C--raising or elevation of the structure; and Measure 1D--relocation in the structure of damageable contents and equipment. All except raising may be contingent measures taken in response to specific flood warnings or emergencies. If new structures are to be built at all in flood hazard areas, they should be designed for flood loads and be constructed of flood resistant materials. Debris and logs in floodwaters can multiply damages to structures, even those which have been "floodproofed".

Closure of openings is mainly limited to masonry and concrete commercial and industrial structures and to residences having concrete, masonry, or brick at least on the first floor. Construction of circle levees and elevating or raising are influenced by site characteristics, including soils. Damageable contents and mechanical and electrical equipment may be relocated to an existing part of the structure above the 100-year flood level. Mechanical and electrical equipment such as water heaters, furnaces, fuse boxes, and pumps may be relocated to a utility room addition above the 100-year flood level or relocated to a waterproof cell in the basement.

Benefits and advantages of adapting floodplain structures on site are reduction in damage to structures and contents, reduction in flood insurance claims, reduction in regional flood insurance premiums paid, increase in regional construction employment, reduced disruption to individuals and communities, and reduced damage cleanup and repair. Implementation costs, including technical assistance, design, and construction costs, are all compounded by the individuality of each structure relative to the implementation of nonstructural measured. A disadvantage is since floodproofing measures are only partially effective they may lead to over-confidence in perception of flood hazard and delay evacuation too long in emergency events. New floodproofed floodplain development may carry higher design and construction costs, and even though floodproofed, will at least cumulatively, have net negative environmental impacts.

Data requirements for analyzing floodproofing measures relate to characteristics of the individual structure, including its flooding depth-frequency relationship which is based on its location relative to flood hazard. Other needed information are expected annual damages and physical characteristics of structures such as type of construction, dimensions and weight, location of damageable contents and equipment, structural soundness, and expected life. The individuality of each structure increases data costs.

The various floodproofing measures allow more intensive use of floodplain lands. Floodproofing is generally less expensive than removal of the structure from the floodplain, but offers only partial reduction in future flood losses. Floodproofing may be undertaken at the individual level, and often is a makeshift and piecemeal response to flooding. Implementation of a more comprehensive floodproofing program would require technical assistance. A question is the degree to which the public should subsidize modifications to private structures.

Contingent floodproofing includes temporary closure of openings in structures or in ring levees or walls constructed around structures, and temporary relocation of damageable contents and equipment within the structure. Conteingent floodproofing is more unreliable and reduces flood losses less than permanent floodproofing, but is cheaper and easier to implement. A contingent approach requires timely action to be effective and must be coordinated with an effective flood forecasting and warning program.

Removal of Structures from Floodplain (Measures 2A-2C)

An alternative to floodproofing existing structures on site is removing certain structures from the floodplain entirely. The major benefit is that future flood losses relating to a floodplain structure are permanently eliminated when the structure is removed. Other benefits of removing existing structures from flood hazard areas are the opening of floodplain lands for other desired land uses (especially large potential benefit for restoration of open space in proximity to urban areas), the restoration of natural floodplain processes (including natural flood storage capabilities), savings on emergency aid and relief, savings on flood insurance premium subsidies, and the elimination of recurrent disruption, turmoil, and misery due to flooding. With new less damage-prone activities subsequently occupying the site, reduction in land economic value accompanies the elimination of flood losses to existing higher-use development. The site may also be redeveloped with new structures designed to minimize future flood hazard.

A structure may be removed from the floodplain by: Measure 2A--relocation to a new site or Measure 2B--on-site demolition. Moving of larger commercial or industrial structures is rarely feasible, so relocation as a nonstructural measure applies generally only to certain residential structures. The choice between relocation and demolition of residences depends on such factors as characteristics of the house (e.g., structural soundness, type of construct-on, and size, shape, and weight), economic value of house, expected life, and availability of alternative homesites. The decision between floodproofing and removal of residences is based upon degree and frequency of flooding and upon characteristics of the house.

Removal from the floodplain has been found to become economically feasible for structures within approximately the 20-year floodplain. Th^ program may be mandatory or at the option of the property owner.

Either relocation or demolition of structures means the resettlement of residents and businesses. There are potential scale economies in evacuating whole floodplain communities. Provision of an alternative upland site could be a possibility for a larger scale evacuation. Otherwise, displaced persons would relocate to scattered sites.

Structures located in the floodway and other high hazard areas may be permanently removed by moving the structures to new locations (Measure 2A). Relocation is especially applicable to structurally sound residences of medium to high economic value and is more cost effective for one-story houses than for two-story houses. Relocation to a higher nearby site is preferable to demolition for single farm houses in order to retain the viability of the farming operation. Relocation is especially relevant to the removal of trailer parks from the floodplain since "mobile homes" are cheap and easy to move. Relocation is usually superior economically to demolition because existing resources, especially scarce housing resources, are being reused. The value and economic life of the relocated house will increase since it is no longer subject to flood hazard.

Structures located in the floodway and other high hazard areas may also be permanently removed by demolition on site (Measure 2B). Demolition is especially applicable to substandard, deteriorating, and/or low economic value housing. Demolition is an alternative to relocation when structural soundness, type of construction, or size or shape make moving the house impossible or impractical. Demolition must also be used when it is decided to remove certain residences from the floodplain and alternative homesites are not available. New construction may be stimulated in the immediate region to the extent that displaced persons relocate in the area. This replacement housing will often be superior to the floodplain structure.

Costs of removing floodplain structures are purchase of land and structures (over half of total program costs), program operations costs, and expenditures for relocation of occupants. For relocation (Measure 2A), there are those costs associated with physically moving the structure and for demolition (Measure 2B) there are clearance costs. Perhaps the greatest disadvantage of removal of structures are the social effects associated with relocation of households, including hardship, attachment to place and home, and loss of community cohesion.

Data requirements for assessing removal of structures are similar to those for floodproofing of structures, being focused upon characteristics of individual structures such as susceptability to flooding (depth-frequency relationship), expected annual flood damages, and previously mentioned physical characteristics. Other data requirements are structure and land acquisition costs, costs of moving structures, costs of clearance, and costs of relocating occupants.

Unsurprisingly, floodplain occupants are strongly opposed to forced relocation. There is little experience with using removal of structures as a nonstructural approach and there is little funding available for floodplain evacuation in the nonstructural sense. Certain public agencies such as state highway departments and the Corps of Engineers have had extensive experience with evacuating structures and whole communities and towns within limited access expressways and reservoir flood pool areas.

Urban redevelopment may be treated as a distinct nonstructural approach (Measure 2C) involving removal of structures from the floodplain. Urban redevelopment is often a mechanism for changing urban floodplain use. Two goals of redevelopment of the urban floodplain are 1) clearance of an area of deteriorating structures (blighted in part because of the flood hazard) and 2) establishment of a new land use for that area, such as recreation or new residential, commercial, or public facility development compatable with the flood hazard. Urban redevelopment does not generally apply to smaller towns because of lack of land development pressures and availability of alternative sites. Certain structures such as buildings of historical or architectural value may be optionally retained in redevelopment plans. Although redevelopment has a broader purpose than just flood damage reduction, floodplain management objectives can be accomplished. Occasionally, a flood is the agent or stimulus for urban redevelopment.

Urban redevelopment can reduce flood losses (damages to old structures and development minus damages to new structures and development). Land use intensification benefits are possible, but if the land is converted to urban recreation use the potential benefits may also be quite high. An urban redevelopment program may stimulate new investment within the immediate region. Urban redevelopment also has the potential benefit of providing public access to urban riverfronts.

Costs of urban redevelopment are purchase costs of land and structures, construction costs for new development, and program development and implementation costs. The latter are especially high for urban redevelopment, joining other disadvantages of legal problems and the long time frame for implementation. Federal funds exist for urban redevelopment, and even though reducing flood losses is usually a secondary goal, there exists a high potential for combining floodplain management programs and urban redevelopment programs.

Floodproofing/Removal of Transportation and Utility Facilities (Measure 3)

Flood losses can be considerable because of location in floodplains of transportation and utility facilities such as: roads, bridges, and railroads; electric power and telephone lines and substations; natural gas and petroleum pipeli , and substations; water supply treatment plants; and sewage systems and treatment plants. Just as with structures, these existing developments can either be floodproofed or removed from the floodplain. Nonstructural Measure 3 is the floodproofing or removal of transportation and utility facilities. New transportation and utility developments in the floodplain should be required to minimize subjectivity to flood hazard as well as to minimize environmental impact.

Flood losses may be due to property damages caused to the facility itself or due to disruption caused by interruption of service. Flooding-induced closure of roads and bridges, loss of electricity and telephone service, and lack of a safe water supply are especially disruptive and threats to public health and safety. Power and telephone line poles can be anchored. Roads, substations, and treatment plants can be elevated on fill or protected by ring levees. Photograph 3-1 shows an electrical substation elevated on fill in the Snoqualmie River floodplain just north of Fall City.

Electric, telephone, and gas utilities now have little incentive to take preventive nonstructural measures to reduce flood damages to facilities because these utilities are in effect self-insured, recovering any flood losses through rate hikes, usually granted. The disruption caused by interruption of these services, however, makes floodproofing or removal from the floodplain of facilities a public objective. Better planning coordination and stronger public input into right-of-way location decisions can help minimize the flood hazard and environmental impacts of future development of transportation and utility facilities.

Data requirements are identification of facilities subject to flooding

PHOTOGRAPH 3-1. ELECTRIC SUBSTATION ON FILL IN
SNOQUALMIE RIVER FLOODPLAIN NEAR FALL CITY

hazard, costs of various protection schemes (including relocation where necessary), and identification of alternative development sites or rights of way.

Adapting Agricultural Practices (Measures 4A-4B)

Flood damages to agricultural activity in floodplains may be to crops, livestock, residences, buildings, and fences, machinery and equipment, and land. Nonstructural approaches to reducing these flood losses attempt to adopt practices used on individual farms. Two measures are discussed here. Measure 4A is change in farming methods, mostly to reduce crop losses. Measure 4B is contingency for safe evacuation of livestock from flood hazard areas, including the construction of on-farm evacuation mounds. Farm residences are subject to the same nonstructural measures as are urban homes, except that removal of the house from the farm may be incompatible with retaining the viability of the farm. Adapting agricultural practices should be done in conjunction with other nonstructural techniques which help maintain the viability of agriculture such as purchase of development rights or open space taxation and flood preparedness and warning.

Changes in farming methods to reduce crop losses include such measures as changing planting times (e.g., delaying planting to reduce potential losses from spring floods), changing type of crop to a more flood tolerant one, and changing from cropland to pasture, idle, or woodland in key flood hazard areas. A change in land use from cropland implies a change to livestock or to natural succession. Irrigation might be used in conjunction with changing of planting times and types of crops. Altering the continued trend toward drainage of wetlands for agricultural purposes can also provide the benefit of maintaining natural flood water retention capabilities.

Be'des reduction of future crop losses, these measures may also prov ‸sh and wildlife enhancement and improved water quality through erosion and sedimentation reduction. A regional benefit is the maintenance of a local source for fresh produce. Types of costs of changing farming methods vary with the individual approach taken, although many involve conversion to a "lower" land use, giving up some part of maximum gross productivity in return for reducing flood losses to crops. Data requirements also vary, but include depth, frequency, duration, and timing of flooding, existing farming practices and land use, and flood damages incurred by existing and alternative agricultural practices. There are potential problems with farmer acceptance, farmer education, and funding, although once agreed upon, changes in farming methods can be accomplished in a relatively short time.

Under Measure 4B, livestock are evacuated to higher ground in the face of flood events and emergencies. Evacuation procedures would be in conjunction with flood warning to allow enough time for the safe removal of livestock to higher ground. In many areas, evacuation to higher ground is not feasible because of road innundation and fences. An alternative in this case is the construction of on-farm earthen mounds which provide a safe place for livestock above the 100-year floodplain. Photograph 3-2 shows such a cattle mound built by a dairy farmer in the French Creek diking and drainage project area. These mounds should be built and located so that flood waters will not wash them away and destroy their effectiveness. Implementation of effective livestock evacuation measures, including high pad mounds, help maintain continued production of fresh meats and dairy products for local markets.

Livestock mounds are especially applicable to dairy operation since dairy cattle must be milked at least once every 24 hours to prevent onset of conditions in the animal which lead rapidly to serious infection and loss of milk production capability.

PHOTOGRAPH 3-2. CATTLE MOUND
IN FRENCH CREEK AREA

the purpose of emergency milking parlors to reduce this health threat to the herd above and beyond the purpose of preventing loss due to drowning. Such mounds are also useful for purposes such as high ground storage of damageable farm equipment and machinery.

Costs include those relating to evacuation plan development and implementation, actual evacuation costs, and construction costs in the case of mounds. The cattle mound pictured was built from spoil deposited by the 1975 flood and cost about $5500, most all for transportation of the nearby flood spoil. The cost of livestock mounds can be much greater where materials are less available. Evacuation of animals to sites off the farm include difficulties and costs such as loading and transporting livestock in an emergency situation and availability of safe locations in the vicinity, including support facilities for milking of dairy cattle.

Data requirements include identification of farm livestock herds subject to flood hazard, identification of adjacent lands suitable for temporary evacuation (including escape routes), evaluation of evacuation techniques, and costs of evacuation and construction of mounds.

Implementation of livestock evacuation measures largely depends on acceptance by individual farmers and availability of funding assistance. Longer duration floods present the problem of length of use of evacuation areas by livestock when they are isolated for long times. Mounds may also reduce the natural flood water retention capabilities of floodplains depending on their number and location within specific floodplain areas.

Purchase of Property Rights (Measures 5A and 5B)

One set of nonstructural measures for controlling the type, amount, and location of future floodplain development and future floodplain use are those involving public purchase of private property rights. This taking of property rights may be total as in the case of Measure 5A--fee simple acquisition--or partial as for Measure 5B--purchase of development rights or flooding easements.

Fee simple acquisition (Measure 5A) transfers all property rights for specific parcels to public ownership, allowing maximum effectiveness in control of floodplain land use, but at a relatively high initial cost. Fee simple acquisition is especially applicable to parcels subject to strong development pressures and to lands with significant environmental values such as natural flood water retention capabilities, recreation potential, and wildlife habitat. Fee simple purchase is most appropriate for undeveloped or minimally developed land, especially near growing urban areas. Areas purchased outright are often used for public recreation or wildlife areas. Fee simple purchase is also involved in relocation or demolition of selected floodplain structures and in urban redevelopment schemes.

Present occupants may be allowed to remain on the property for life (life estate) to diminish relocation impacts, although they thereby remain subject to the flood hazard. Publically acquired land may also be leased back to the private sector where appropriate. For example, agricultural or forestry lands may be leased back to previous or new users with public control of use conditions and any subsequent development.

Benefits of fee simple acquisition are reduction of flood losses to future floodplain development and possible new use benefits such as recreation and lease income and resale value for non-flood hazard use. Provision of public open space may also lead to induced higher values for adjacent and nearby parcels. Preventing future development by fee purchase also has considerable environmental benefits including maintenance and enhancement of natural floodplain processes (flood storage, water quality, and ground water recharge) and maintenance and enhancement of natural systems features such as vegetation and wildlife. Open space provision through public acquisition also has aesthetic and quality of life benefits.

The main cost of fee simple purchase is that for land acquisition itself. However, the cost of lands in the floodway which are not also prime agricultural lands may be comparatively low. Other costs are program implementation costs such as title searches, surveys, and legal fees, and ongoing operation and maintenance costs which vary with the type of land use planned for. Disadvantages are loss of tax base and loss of land for future development where supply of suitable land in the immediate region is limited.

Data requirements include existing land use, land ownership, and land value; subjectivity to flood hazard; identification of lands to be acquired according to purposes and priorities; availability of other lands for development; and possible leaseback opportunities.

Public purchase of lands often faces oppositition from landowners and real estate interests. Availability of public funding for purchase of lands with the specific purpose of reducing flood losses to future development are limited. Possible measures to alleviate this funding shortage are: negotiation of right of first refusal so that lands can be acquired gradually; maintenance of an acquisition fund from annual appropriation and receipt of gifts; and negotiation for higher priority for floodplain purchases in existing acquisition programs relating to other purposes such as recreation. If the acquisition program is to be implemented over a relatively long time period, stringent zoning or permit requirements should be implemented at the outset to assure the economic availability of the land to the public.

Like fee simple acquisition, Measure 5B- purchase of development rights or flooding easements serves to keep floodplains in future land uses such as agriculture, recreation, or wildlife and natural areas which are compatible with the flood hazard. Unlike fee simple acquisition, only partial property rights are acquired, leaving the land in private ownership. Use and rights of access are negotiable. Benefits are similar in type to those for fee simple acquisition, but may not be realized to as great an extent. Types of cost are also similar to those for fee simple purchase and although the total costs are less, they may run as high as 80-90 percent of costs for outright acquisition. Opposition from private property interests and shortage of funding sources are also problems common to programs for purchase of development rights.

Development Regulations and Restrictions (Measures 6A-6D)

Another set of nonstructural measures for controlling future floodplain development are governmental regulations and restrictions on such development. These measures are designed to limit property rights in the public interest and are in effect mandatory limitations on private development rights. Individual nonstructural approaches to be discussed in this section are floodplain and shoreline zoning (Measure 6A), other zoning (Measure 6B), subdivision regulations and building codes (Measure 6C), and other regulations and permits (Measure 6D).

Zoning has long been used to influence the type, amount, and location of development. Floodplain zoning and shoreline zoning are examples of increasingly geographically specific resource-based zoning. In typical floodplain zoning, the 100-year floodplain is divided into an inner floodway--in which future development is prohibited--and an outer floodplain fringe--in which future development is permitted subject to damage in the 100-year flood and to not induce higher flood depths beyond some limit. Photograph 3-3 shows construction of new milking barn elevated on fill in French Creek area. Detailed floodplain delineation studies and maps are a necessary part of a floodplain zoning program. Floodplain zoning programs have been one of the most widely used nonstructural approaches to reducing future flood losses. The state of Maryland is now considering legislation

PHOTOGRAPH 3-3. NEW BARN ERECTED ON FILL
IN FRENCH CREEK AREA

which would prohibit future development in any part of the 100-year floodplain, in reaction to the fact that new construction in the floodplain fringe which has been floodproofed to the 100-year flood level may still be subject to losses in the cases of larger magnitude events or failure of existing flood control measures. Shoreline zoning embodied in shoreland management programs is designed to control development in a corridor along the river channel which is often more narrow than the floodplain. Shoreline zoning categories from urban to natural/conservancy define uses and restrictions on dredge, fill, and construction activities.

Other zoning classifications such as agriculture, forestry, and open space can also serve to influence the extent and density of future development in flood hazard areas. Another zoning technique is cluster zoning, which concentrates development on specified sites while leaving large adjacent land areas in open space uses. Effective zoning measures have types of benefits similar to those for purchase of property rights since both act to control future development, including open space and other environmental resources benefits. Floodplain and shoreland zoning increase the costs of construction, when permitted at all, by placing conditions and restrictions on development. The administrative, technical, legal, and enforcement costs of an effective ongoing zoning program can be considerable.

Implementation of (new) zoning classifications less favorable to development interests can expect to meet opposition from private landowners and the construction and real estate sectors. Zoning and other regulations and restrictions are less reliable than public purchase of property rights since zoning and other regulations and restrictions are subject to exception, lack of enforcement, political corruption, and change.

Subdivision regulations and building codes (Measure 6C) can be used to place additional restrictions on new floodplain development, although often duplicative with or not as stringent as floodplain zoning. Subdivision regulations apply to development of large tracts using plats. Restrictions relevant to flood hazard may be listed on the plat including requirement of adequate drainage, prohibition of encroachment on the floodway, and requirement of elevation or other floodproofing of structures and transportation and utility facilities to some minimum flood level. Building codes may also have special provisions for new construction or substantial remodeling or repair in flood hazard areas. Regulations may require use of water-resistant materials, minimum elevation of the first floor relative to flood depth, anchoring the structure to its foundation, design for structural load standards relative to flood depth and velocity, special method or location of utility hookups, and special location of electrical and mechanical equipment within the structure. Costs of subdivision regulations and building codes are higher construction or remodeling expenses, higher design and engineering costs, and costs of enforcement of regulations. Such regulations are often unpopular with development interests since the costs are concrete and the benefits are based on more future probabilities of damage reduction that would be received by purchases of structures.

Other governmental regulations and permit requirements (Measure 6D) can be implemented to control and influence future development and land use in floodplains, shorelands, wetlands, along navigable waters, and in basin uplands. These have benefits and costs, information requirements, and implementation problems and opportunities similar to those for zoning and subdivision regulations and building codes.

Subsidy to Existing Land Use (Measure 7)

A final broad approach to influencing future floodplain development is the use of monetary incentives or subsidies to landowners for maintaining or converting to certain desired land uses. Preferential open space taxation (Measure 7) is the most common method of subsidy for maintaining an existing land use. Lower tax rates can be used as an incentive to keep flood hazard areas in open space, low density development, agriculture, forestry, or other flood tolerant uses. A less used taxation concept is the imposition of a penalty tax to discourage development in flood hazard areas, the proceeds of which could be used to help pay for publically-provided emergency aid.

Preferential open space taxation can serve to reduce flood damages to future floodplain development by limiting the amount and type of such development. Other benefits depend on the use which is made of the land, whether for agricultural production, recreation, or wildlife habitat. Maintenance of open space on floodplain lands through the use of preferential taxation rates may lead to increased value of adjacent lands, in which case increased tax revenues on these lands would offset the tax subsidy given to open space lands. Open space taxation can have significant environmental quality benefits in terms of maintaining the integrity of natural systems processes. More human oriented environmental quality benefits are the aesthetic and recreation aspects of open space areas, especially in proximity to metropolitan areas.

Costs of preferential open space taxation include the loss of some increment of tax revenues, potential loss of income from other floodplain uses, and program implementation and operations costs.

Data requirements include determination of criteria to select eligible lands, establishment of priorities, and determination of level of subsidy required to meet desired objective of open space maintenance.

A preferential open space taxation program has the advantage of relatively rapid implementation. A major problem is the usually voluntary nature of the program. Furthermore, even if a landowner opts to participate in such a tax break program, he is not precluded from developing his land in the future, but may do so with the often insignificant penalty of paying the difference between back taxes on the developed use and the open space tax actually paid. This nonstructural approach appears to be less well insulated from the pressures of the real estate market than others.

Another form of subsidy for maintaining certain land uses are direct cash payments. These may be used as an incentive for the landowner to retain such features as wetlands or woodlots or for tree planting.

Emergency Aid and Relief (Measure 8A, 8B)

Certain nonstructural measures deal not so much with preventing property damages but with reducing the costs of emergency services and aid provided during and after a flood event and with modifying the impact of flooding on individuals and communities. Emergency preparedness plans and flood warning systems (Measure 8A) can modify the susceptibility to flooding by improving the response to emergency evacuation and flood fighting and therefore reduce emergency costs and disruption. Flood insurance programs (Measure 8B) and post-flood recovery aid can modify the impact of responding to flood emergency and loss by individuals and communities.

An emergency preparedness and flood warning program does not replace the need for other structural or nonstructural approaches to flood loss reduction, but instead complements them. An advantage is that such a program can often be implemented in rather short order, holding the line on certain types of flood losses. Other nonstructural measures such as contingent floodproofing, contingent rearranging of structure contents, and livestock evacuation are enhanced when used in conjunction with an effective emergency preparedness and flood warning program. The viability of certain floodplain land uses such as agriculture are improved by the existence of such a program.

Emergency preparedness plans and flood warning systems allow added time to prepare for and take action against flood flows and allow for more efficient evacuation and flood fighting. Some local emergency preparedness program usually exist, but are often in need of improvement and expansion. Preparedness plans of action are often in need of updating because of the often long interval between large flood events. Forecasting and warning systems may be improved by use of state-of-the-art equipment. One local agency should be specified to integrate objectives and task assignments of each agency involved with flood emergency services. Coordination with citizen councils is important because of their intimate knowledge of the land and their ability to relay information within the community.

Costs are for program development and implementation, information dissemination, stream gauge and warning equipment, and possibly the provision of evacuation sites.

Information requirements are an evaluation of effectiveness of existing programs and equipment, an inventory of emergency agencies and their activities, availability of flood warning technology, program costs, and geographical and temporal aspects of flood emergencies such as location and use of schedules of major industrial, commercial, and public facilities and the closure of roads and streets by flood depth.

Flood insurance (Measure 8B) is not a nonstructural flood loss reduction measure in the ordinary sense, although it does have the same effect. Flood damages may be reduced in the long term, although they may be increased in the short term, depending on circumstances.

Since the Federal Flood Insurance Program applies throughout the nation, this discussion of flood insurance is oriented to that existing program. The federal program is divided into two phases--emergency and regular. The emergency phase occurs between the time when a community decides to participate in the program, and the time when flood studies are completed and required ordinances are passed by the local governing body. The regular phase comes after the emergency phase. Federal statutes passed after the insurance program became law make it almost mandatory for communities with flood hazards to participate in the program. At this point, all areas of the Snohomish Basin are participating in one of the two phases. Unincorporated King County, Everett, Carnation and Duvall are the only basin local governments within the regular program at present.

The emergency program is more of a relief program than a damage reduction strategy. It makes insurance available at subsidized rates up to a certain coverage limit to people within the flood hazard area. This portion of the program may increase flood damages by precipitating development before the regular program and the stricter regulations accompanying it take effect.

The regular program starts after flood studies have been completed, floodway and floodway fringe have been delineated, and regulations meeting the Federal Insurance Administration's minimum standards have been enacted. Minimum standards include the prohibition of significant obstruction of the floodway and residential construction within the floodway. In addition, construction in the flood fringe must be either raised above the 100-year flood level (residential) or floodproofed to above the 100-year flood level (commercial and industrial). Mobile home park regulations and a floodproofing certification program are also required.

The regular program operates as a nonstructural measure in two ways. The community regulations required for participation are forced into existence, and they are nonstructural measures themselves. The second way it by disseminating information about the flood hazard and trying to make the location decision-maker share the costs of the decision to locate within a flood hazard area. Both effects probably are significant, compared to a no-program alternative. Unfortunately, they do not work as well as they might. It is very difficult for the federal government to oversee enforcement at the local level. In addition, although governments are almost forced to participate, individuals do not have to unless they need bank financing. (FIA's stick is the withholding of federal mortgage insurance, making the mortgage a piece of financial paper that the issuing bank can't sell if it wants to.) If a large flood occurred, the government would be unlikely to deny aid to those without insurance, so in that sense, there is a loophole. The actual long-run effectiveness of the program is unknown because of its recency. It may take time to see whether the program has a real effect.

Natural Valley Storage (Measure 9)

Natural Valley storage (Measure 9) is a process where water is retained in soil, wetlands, and topographic depressions, and is stored or gradually returned to the river corridor via water-table transport. Natural valley storage is a natural process and is an important link between the hydrologic cycle and the regional biological ecosystem. Thus, not only can natural valley storage reduce present and future flood damages as a nonstructural application, but it can also serve to provide natural process benefits such as fish and wildlife enhancement, and water quality maintenance through filtration, and reduction of erosion and sedimentation. It is compatible with other land uses, including wildlife preservation, fishing, boating, and to a lesser extent, golfing, playfields, and agriculture.

Floods and flood peaks are moderated by water retention in natural valley storage areas; the flood or runoff water is filtered in the process as well, maintaining water quality in the river basin. The U.S. Army Corps of Engineers (1977, 1) states that natural valley storage is, "in the form of wetlands which moderate extreme highs and lows in stream flow, the least-cost solution to future flooding. Rather than attempt to improve on this natural protection mechanism, it is both prudent and economic to leave the hydrologic regime established over the millenia undisturbed."

Policies to protect critical natural valley storage areas from adverse development, or to restore lands to their natural natural valley storage hydrologic function, are required in order to use natural valley storage as an effective nonstructural flood control measure. Protection policies may include fee purchase; fee purchase and leaseback; subdivision regulation; purchase of conservation easements, development rights, or flood easements; and open space taxation. Restoration policies may include relocation of structures; demolition of structures; or watertable restoration by levee-like breaching or filling drainage ditches.

The usefulness of natural valley storage as a solution to potential future damage rests on a) the probability of an increase in floodplain land values and future flood damage (the "without condition"); and b) the natural capacity of the soil, vegetation, and surficial structure to absorb flood flows moderating both highs and lows in river discharge.

Flood protection benefit calculations are based on a determination of "without natural valley storage" and "with natural valley storage" effects on damages and related economic values. They include the "reduction in damage to development which occurs in the floodplain after the measure is applied, but would have occurred there even without the measure..."* The expected annual difference between "with" and "without" flood damage is a benefit attributable to a natural valley storage program, although measurement is difficult.

Natural valley storage compliments existing floodplain zoning and land use controls and restrictions on floodplain development required by the National Flood Insurance Program. Critical to the justification of natural valley storage-related projects is the evaluation of the "without" condition.

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*Douglas, James L. Economics of Water Resource Planning, New York, McGraw-Hill, 1971 (from Level B Study).

Based on trends in land conversion, benefits due to new developments (the "without" condition) will be due to new construction on the flood fringe and conversion of present natural valley storage lands to other land uses, e.g. riparian wetland to agriculture.* Natural valley storage benefits are claimable or justifiable based on real property value gained downstream of the natural valley storage area. This benefit includes the marginal gains in land and building property values realized in future years. Since the "with natural valley storage" condition would result in an unexpected reduction in future flood damages for these increased property values, gains to the natural valley storage project alternative can be claimed.

As indicated above, the justification for natural valley storage depends heavily on the hydrologic regime. Computer simulation of flow routing can roughly estimate the discharge-retention capacity of each potential natural valley storage area. Inferences can be made by evaluating soils, vegetative and tree cover, as well as stream meander and "braidedness". Natural valley storage areas along a river can easily be recognized for their ability to moderate flows by routing water circuitously through secondary channels (e.g. oxbows) which slow the discharge and spread floodwaters over a larger permeable area.

The cost of acquiring flood easements in each natural valley storage area is likely to vary from site to site. Since all areas are subject to flood hazard and certain development restrictions, the current market price for natural valley storage parcels is likely to be less than the value of comparable upland acreage. In general, most of the land in each of the areas is neither suitable for septic tanks (because of poorly drained wet soils) or serviced by sewer lines. This diminishes the market value of land for development and suggests a relatively narrow margin between the value of land in open space use (for natural valley storage) and its possible highest

*This assumes that current regulations effectively prohibits structural floodway development.

and best use. This difference represents the price that would have to be paid for flood easements.

Management of Existing Structural Flood Control Measures (Measure 10)

Flood emergencies may be compounded, sometimes dramatically, and especially in terms of loss of life, by failure of existing structural flood control measures such as dams, channel modifications, and levees. Many structural measures have been built and not properly maintained or have been built in a piecemeal fashion with little regard to their interrelationships with each other or with the basin as a system. Off-site (usually downstream) effects of structural measures are also often ignored or downplayed. A program of management, inspection, maintenance, and coordination of existing flood control measures which ensures maximum safety and proper performance can therefore be seen as a "nonstructural" approach (Measure 10). Such a program would help reduce flood losses in emergency events heightened or induced by structural failure and also realize savings on repair and restoration.

Many states have instituted mandatory dam inspection programs in recent years in response to catastrophic failures of dams in West Virginia and of the Teton Dam. Program costs are mainly for periodic inspections and preventive maintenance. Such a program could also be extended to river basins where extensive levees exist. An important element of such a levee management program would be coordination within a systems context.

Other Resource Management Programs (Measures 11A-11C)

In addition to natural valley storage and management of existing flood control measures, there are other resource management programs which may be seen as broad nonstructural approaches applied at different geographical scales. These are: watershed management (Measure 11A) which recognizes that land use and practices on upland non-floodplain lands throughout the drainage basin have an impact on flooding in floodplains; riparian vegetation management (11B) which focuses on the river course and its immediate banks; and river corridor management (11C) which is similar to but somewhat broader in scope than floodplain management.

Upstream land use, including non-floodplain land use, may have an impact on flooding, erosion, and sedimentation in downstream areas. Watershed management (Measure 11A) involves managing lands in the basin as a system so as to meet certain objectives in floodplain areas. Agricultural, forestry, and construction practices should be evaluated for their downstream impacts and altered if necessary. Forestry is a predominant land use in upstream areas of the Snohomish basin. However, as pointed out in the Pacific Northwest RBC* Level B study, the debate on water retention characteristics of various forestry practices is not resolved. Recommendations include limits on clear cut acreage, immediate replanting in disturbed areas, and upgrading roads to reduce erosion and run-off. Water retention measures might also be implemented in areas of new construction.

Benefits from a watershed management program might include flood damage reductions due to reduced peak discharge levels and a reduced sediment load. If this type of program involves less dramatic forest landscape modification by either clear-cutting or road construction, environmental quality benefits might also accrue, and local economic development benefits from increased recreational use in a high quality watershed environment might occur. The costs of such a program would include increased construction costs for roads which were either located in such a way as to minimize soil damage and erosion, or were structurally "hardened" to prevent erosion of adjacent lands.

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*River Basin Commission

Timber management programs might also be somewhat more costly if harvest practices were changed to smaller sized clearcuts or selective harvesting designed to minimize soil disturbances and flash runoff levels. Relatively costly timber harvest techniques, such as balloon logging, helicopter logging, or skyline logging systems might also be sources of logging cost increase in environmentally sensitive watersheds.

The need for and effectiveness of programs of this type appears to be highly variable among topographic situations. Site specific studies are apparently needed to evaluate the potential benefits and costs from such programs. The variation of "low" altitude elevations (and amount of land likely to have heavy accumulations of wet snow), differing orientations of slopes vis-a-vis prevailing wind patterns at times of chinook weather conditions, the amount of soil disturbance and floatable debris associated with past and present logging activity, the geometry of stream branching patterns, and stream gradients are all variables which influence the need for a watershed management program related to timber harvest programs. The responsibility for evaluating the need for such programs is probably shared by the federal (USFS) and state (DNR) governments, which respectively have program evaluation responsibilities under NEPA and SEPA for downstream cumulative impacts of their programs on the environment. At present, few evaluations of this type have occurred.

While the current use of land in the Snohomish River basin upstream from the floodplain is dominated by timber management and road construction activities, in the long-run consideration of urban runoff is also a factor which should be considered as apart of a watershed management program. In several decades urban runoff management may become an aspect of watershed management programs in this area because of urbanization processes within the basin, but above the floodplain.

Riparian vegetation management (Measure 11B) concerns the botanic growth along a streambank which is periodically submerged, partially or wholly. It is also associated with seasonally flooded lowland or wetland trees.

Protection or management of this vegetation is important for a wide variety of reasons, including economic and natural systems values, including a) fish and wildlife habitat; b) biomass input to estuarine foodchain; c) stabilizing streambanks; d) reducing general land erosion; e) maintaining hydraulic control of the river f) nature study-recreation and education; g) timber and fuel wood production. Riparian management also includes preservation and protection, and restoration and vegetation programs. For example, a preservation/revegetation program includes maintenance/protection of streambank growth in conjunction with revegetation of a 30 to 200 foot buffer strip to protect natural values of the riverine ecosystem, as well as to reduce soil erosion.

Fish and wildlife values are associated with riparian vegetation in the following manner. The shade effect from streambank trees and vegetation provide concealment for fish, higher oxygen levels, and lower water temperature. Trees provide branches and snags as important fish habitat. Also, their leaf litter is transported downstream as detritus, an essential basic component of the estuarine and riverine foodchain. In an economic sense, this natural function maintains (and has the potential to enhance) commercial and sport fisheries.

Wildlife values include, but are not limited to, refuge, nesting, shade, and resting habitat. The riparian association provides edge zone habitat which is recognized by ecologists as a most important factor for the wildlife community. In this context, multi-layered riparian vegetation, from brush-to-shrub-to-trees of different levels, affords numerous ecological niches., thereby increasing the diversity of fauna and flora.

Riparian vegetation has value for hydraulic functions which, if used to advantage, reduces structural construction and maintenance along streambanks. Many riparian lowlands are topographic depressions that serve to store flood and runoff waters, and gradually release these waters through water-table transport. In this process the storm waters are filtered, maintaining riverine water quality, and the flood peak is moderated. This storage and filtration function becomes more valuable as the upland regions become more populated, increasing both the amount of runoff and human-development associated contaminants. Levees can be protected from wind-driven wave wash with a proper vegetation covering. As well, all levees should be covered with deep-rooted vegetation to strengthen the earthen framework and reduce the potential of erosion and breaching from over-topping flood waters.

Streambank erosion can be reduced with an appropriate selection and planting of tenatious vegetation. The Washington Department of Game (1980) has listed and described the characteristics of over 20 species suitable for riparian revegetation programs. Most desirable species identified are willow, snowberry, vine maple, and red-stem dogwood. In addition, a healthy streambank riparian association can reduce the amount of valuable farm soils lost via erosion runoff and moving flood waters.

Riparian woodlots can be managed for recreation, education, as well as red cedar and fuelwood production. Nature study in a recreational and academic sense is considered a high quality use for this ecosystem. A large variety of avian and small mammal fauna inhabit and use riparian vegetation. The frequent proximity of such land to the water edge lends the potential for water access for fishing and canoe launching. Another approach is to carefully manage the riparian trees as a crop; this is not necessarily mutually exclusive of other riparian values. Economic gains from timber can be significant as the growth rate tends to be very high. A program of fuelwood (alder, etc.) for quick cash flow, and red cedar for long-term investment is a feasible and potentially significantly rewarding riparian use.

A riparian vegetation program may be accomplished by one or more of the following methods:

a) zoning,

b) purchase fee simple,

c) tax incentives for private owners,

d) change in farming practice,

e) conservation easement,

f) modifying channelization construction and maintenance procedures,

g) modifying flood control construction/maintenance procedures,

h) set-back dikes

i) modify clearcut harvest practice along streambank, and

j) state/federal small woodlot incentive programs.

River corridor management (Measure 11C) is a flexible resource management concept which encompasses floodplain management and many of the nonstructural measures discussed above, but may be broader in purpose and geographical scope. River corridor management focuses on the river course and floodplain but may also include adjacent lands and valley slopes and may be concerned with purposes such as recreation, open space, public access, wildlife habitat, and environmental quality in addition to flood loss reduction. It is basically a nonstructural multiple-purpose water and related land use planning concept. Wild, scenic, and recreational rivers programs are essentially river corridor concepts.

River corridor management is especially relevant to relatively undeveloped river reaches and valleys. In proximity to urban areas, even short sections of relatively undeveloped river corridors/valleys are important for their natural, recreational, scenic, and historical values. A river corridor management program may integrate individual nonstructural measures such as fee simple purchase, fee purchase and leaseback, purchase of development rights or flooding easements, zoning, preferential open space taxation, removal of structures from the floodplain, changing farming methods, natural valley storage, watershed management, riparian vegetation management, and information and education in order to achieve desired land use objectives for a specified section of the river valley. A river corridor concept can take advantage of a wide range of existing program authority and funding provisions available at all levels of government.

Information and Education (Measure 12)

Perception of the flood hazard underlies all response to flood hazard. Information and education (Measure 12) about flooding and floodplain processes, both in concept and applied to specific flood hazard areas, can serve to directly and indirectly reduce flood losses. Information and education should go hand in hand with implementation of all the other nonstructural approaches and measures described above.

Although available in many forms and from many sources, flood hazard information is frequently not of uniform quality or availability. The development of needed technical information and public education are essential for floodplain management. This would include information on the hydraulics of small and large floods, areas subject to inundation, role of the floodplain and the potential impact of land use decisions on flooding. Public education of the various alternatives in floodplain management is necessary so that management schemes can be formulated and optimal solutions derived to best solve flood damage problems. Better information and understanding thereof will translate the hazard into terms that will stimulate appropriate local actions. After floods there is a high demand for flood information. To date there are very few published materials that are written with a general public format on this subject.

The benefits of this nonstructural approach are reduction of future flood losses, rapid implementation in comparison to many other measures, increased awareness of the flood hazard, steering of future development away from the floodplain, and better community planning. The costs of implementing this measure would be those associated with the development of an educational program, reorganization of existing programs, integrating with new programs for an information data bank, and public relations costs. In addition to provision of information through public inquiry and dissemination of publications, a more active educational outreach program may be undertaken which includes the use of conferences, workshops, lectures, media presentations, outdoor education programs, and field trips. These may be organized for public officials in areas relating to river basin management as well as to general public groups such as garden clubs, arboretum societies, environmental organizations, church groups, and school classes. These activities not only provide necessary information but also generate political support for desirable resource management programs.

Public agencies involved in flood loss reduction and other natural resource management programs need constant feedback and support from the affected public. Participation in the project formulation and review process is vital, including the opportunity for testimony at public hearings. Early public involvement can provide a wealth of information and creative ideas. This coordination can help avoid conflicts later in the planning or implementation process.

Besides these program-oriented information and education efforts, other nonstructural approaches falling into a broad information and education category are 1) mandatory notice of flood hazard in real estate transactions involving floodprone lands and 2) conspicuous posting of floodplain areas by signs or markings on utility poles. The first formalizes the information exchange of potential flood hazard between the seller and buyer of properties with specific data pertaining to the likelihood of damage prior to the deed transaction. The buyer would be required to read, sign, and date his acknowledgement of the potential flood risk to life and property. The new landowner would thus be aware of the hazard, allowing for preventive measures to reduce loss and hardship. Costs of such an apprcach are the development of site specific data for properties, promulgation and enforcement of the new legislation, and potential diminished value of affected properties.

Posting flood hazard information on the floodplain site is common sense and potentially very effective mechanism of information and education. Water depths from previous flood events and the projected 100-year frequency flood could be marked and annotated on utility poles (or other signs) throughout a basin's floodplains. Special attention should be given to areas where residential development may occur. Costs of such a program are minor compared with potential benefits. Opposition may come from real estate interests and private landowners. A local agency would need to assume responsibility for implementing the program.

Comparison of Individual Measures

Table 3-3 shows how the 25 individual nonstructural measures identified previously in Tables 3-1 and 3-2 and discussed in detail in this chapter compare with each other across various criteria. This evaluation treats these measures as general concepts. It must be remembered that the application of nonstructural measures are especially sensitive to site-specific

TABLE 3-3. COMPARISON OF INDIVIDUAL MEASURES

		Effectiveness/Flood Loss Reduc.	Econ. Costs	Distr. Feasibility	Impacts	Level of Gov't: Loc.	Level of Gov't: State	Level of Gov't: Fed.	Offsite Effects	Multiple Purposes
EXISTING	1A Ring Levees Around Structure	5	5,5	5	1		X	–		0
	1B Closure/Sealing of Structure Openings	2	1,1	3	5	X			0	0
	1C Raising of Structure	7	5,5	3	5			X	0	0
	1D Relocation in Structure of Contents/Equipment	5	1,1	3	5	X			0	0
	2A Relocation of Structure	10	7,1	2	8			X	+	0
	2B Demolition of Structure	10	8,1	1	8			X	+	0
	2C Urban Redevelopment	10	10,3	3	8	X	X	X	+	(+)
	3 Protection/Relocation of Transport./Utilities	5	5,3	7	5	X	X		–	0
	4A Change in Farming Methods	3	3,3	2	8	?	X?	X?	0	(+)
	4B Livestock Evacuation and Mounds	10	6,1	10	5			X	(–)	(+)
FUTURE	5A Public Purchase--Fee/Fee & Leaseback	10	10,2	5	10	X	X	X	+	+
	5B Purchase Devel. Rights or Flooding Easement	10	9,3	8	9	X	X		+	+
	6A Floodplain and Shoreline Zoning	9	2,5	9	9	X	X	X	+	+
	6B Other Zoning	8	2,5	9	9	X			+	+
	6C Subdivision Regulation and Building Codes	8	7,5	9	7	X	X		+	(+)
	6D Other Regulations and Permits	8	6,5	9	8	X	X	X	+	+
	7 Preferential Open Space Taxation	9	2,2	10	10		X		+	+
BOTH	8A Emergency Preparedness and Flood Warning	10	5,2	10	5	X	X	X	+	0
	8B Flood Insurance	10	5,5	10	5			X	+	0
	9 Natural Valley Storage	10	7,3	5	10	X	X	X	++	+
	10 Management of Existing Flood Control Measures	8	1,5	9	9	X		X	+	+
	11A Watershed Management	4	2,2	5	9	X	X	X	+	+
	11B Riparian Vegetation Management	1	2,2	6	9	X	X	X		+
	11C River Corridor Management	8	5,5	9	9	X	X	X	+	+
	12 Information and Education	6	2,2	10	(10)	X	X	X	0	+

conditions so that applicability may vary widely. The evaluations made in Table 3-3 are subjective estimates based on existing information from other sources and on the analysis presented in this chapter.

Categories of comparison included in Table 3-3 are effectiveness in flood loss reduction, level of initial and ongoing economic costs, institutional feasibility, environmental quality impacts, level of governmental responsibility, offsite effects, and potential for meeting multiple purposes. The table shows how each measure compares relatively on each criterion and therefore the tradeoffs to be considered in the application of alternative nonstructural measures.

In columns 1 through 4 a rating on a ten-point scale is given, with a ten being considered highly desirable, and a one being very ineffectual or difficult. The last five columns indicate the most likely level of government to either fund or program the concepts identified, and an indication as to whether the measure has off-site effects or multiple purposes. An X indicates an applicable measure, while a + indicates a measure which has beneficial effects or multiple use effects, or possib._ negative off-site effects, and a 0 suggests no relationship.

CHAPTER IV

NONSTRUCTURAL APPROACHES IN EXISTING STATE AND LOCAL LEGISLATION AND GOVERNMENTAL PROGRAMS

Chapter III analyzed nonstructural measures as general concepts with only brief mention of their current application within the Snohomish River basin. This chapter focuses on nonstructural approaches in existing state and local legislation and governmental policies, regulations, and programs. These political elements having nonstructural implications are discussed, first at the state level and then for regional governments, King County, Snohomish County, and individual municipalities. These legislative and governmental influences on floodplain development are used in the projection of future conditions and "no action" futures in the next chapter.

STATE

Washington State flood control, development, land use, open space, and environmental legislation relating to nonstructural floodplain management in the Snohomish River basin is discussed in this section. Only the most significant laws and resulting programs are mentioned here.

Flood Control Laws (Title 86 RCW)[1]

The Washington flood control laws deal with aspects of flood control within the authority of the state.

Chapter 86.16, passed in 1935, specifically authorizes the state to designate flood control zones to alleviate recurring flood damages to property, health, and safety and to the development of natural resources.

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[1]This section is largely summarized from the Snohomish Level B study.

The state is directed to establish control within flood control zones through the issuance of permits for planning, building, and operation and maintenance of any structures which might adversely affect a stream regimen or the security of life, health, and property by increasing flood damages through improper design or location. The Washington Department of Ecology (WDE) administers the state flood control zone permit program.

The state determines the boundaries of the state flood control zones for various streams using the best available floodplain information and extending the zone to the nearest upland land boundary; i.e., section line. When available, WDE uses FIA established boundaries to define floodways. WDE reviews permit applications for all proposed structures within the state flood control zone boundaries. If construction of a structure will adversely affect flooding, WDE will refuse to grant a permit. WDE may delegate the responsibility of program administration to a local government, if so requested, and if the requesting body is found to have the capability and intent to administer the program. Any structure built or modified without the proper approval is assumed to be a public nuisance and subject to abatement by law. The state program does not apply to any plat which was filed for record before August 15, 1966.

The state program preceded the National Flood Insurance Program by about thirty years. At first, however, the state program was applied only to major projects such as roads, bridges, and public buildings. Later, as the result of a change in state platting laws, subdivisions were required to submit permit applications. When communities participating in the National Flood Insurance Program discovered that WDE was already administering a program which met the federal requirements, WDE received greatly increased numbers of permit applications for smaller projects. As a result of reviewing more permit applications for structures in the state flood control zones, WDE theoretically prevents a larger amount of flood damage. The increased effort in permit review, however, has paradoxically left less time for proper enforcement.

Other sections of Washington flood control laws relevant to non-structural alternatives are:

86.12 Gives counties authority to levy a tax of up to 1 mil for a river improvement fund, which may include a flood control maintenance account.
86.13 Provides for joint action between counties.
86.14 Provides for establishment of flood control districts and enumerates powers.
86.15 Provides for establishment of flood control zone districts which have powers similar to counties in 86.12.
86.18 Establishes a flood control contribution fund to aid political subdivisions, when funds cannot be raised through other normal methods. This, however, requires the availability of some federal funds.

Shoreline Management Act

The Shoreline Management Act of 1971 calls for comprehensive policy and goal development with specific regulations to ensure the wise use and conservation of Washington's shoreline resources. In the Snohomish River basin the Act pertains to land use adjacent to rivers whose flow is not less than 20 cfs. Master programs for the land use planning of unincorporated shoreland and for municipalities have been prepared for King and Snohomish counties.

These programs provide the policy framework for allowing only those uses which are particularly dependent upon their location on, and use of, shorelines. The Act establishes seven basic land and water use elements which must be incorporated into each county shoreline master program. Elements to be included are shoreline use, economic development, public access, conservation, recreation, historical/cultural areas, and circulation. The Act exempts single-family residences and all lands platted between April 13, 1961 and April 1, 1971.

Subdivision Laws (RCW 58.17.120)

Municipalities and counties must consider flood inundation and wetland conditions in reviewing applications for proposed subdivisions. Subdivisions may be disapproved based on natural resource criteria or protective improvements may be required and noted on the plat.

Open Space Taxation Act (RCW 84.34)

The Open Space Taxation Act, enacted in 1970, allows landowners to voluntarily dedicate their properties to agricultural or forestry uses for a minimum of ten years. In return, the property is taxed at current use value instead of "highest and best use" or developed value. Withdrawal from the program requires payment of back taxes plus a twenty percent penalty. Open space preferential taxation is now being applied to over 20,000 acres on the lower Snohomish floodplain. Only 2316 acres were enrolled in 1973.

The enactment of Chapter 84, Laws of 1979, additionally exempts lands enrolled in the open space taxation program (or otherwise committed to agriculture) from paying assessments for land improvements such as sewers, water supply lines, and new roads. If the landowner subsequently decides to develop the land and change its status, the share of the improvement for that property is applied retroactively, including interest and inflation.

Other related sections of Washington Open Space Taxation Act are:

84.34.210	State authority to acquire lands and lease them back.
84.34.220	State authority to acquire development rights for open space purposes to be known as "conservation futures" (not to be by eminent domain).
84.23.230	State authority to levy up to 6.5 mils for purchase of conservation futures.
84.28	Lands over 40 acres may be classified by the Department of Natural Resources as "Reforestation Lands" if timber is immature, non-forested or cutover. Assessed valuation is sixteen dollars per acre. The timber is taxed when cut.

84.33 Lands classified as "Timber and Forest Lands" will be valued at the value of land only, not including timber. Land value is based on DNR determination of forest land grade and Department of Revenue valuation of each grade at the state level and on assessors calculations at the county level. If land is withdrawn from this classification, the difference in tax for up to ten years is required.

Scenic River System Act (RCW 79.72)

The purpose of the Scenic River System Act is to "protect and preserve the Natural character" of the designated river "and fulfill other conservation purposes." The law applies only to publicly (state or local) owned or leased lands. Policies are to be integrated with those of the Shoreline Management Act. Regulations are to be written by the State Parks and Recreation Commission, subject to review by a committee of members from participating agencies. Parks will then administer the Scenic River System Act. The Parks Commission, subject to committee approval, is authorized to purchase property or property rights such as easements and development rights in the designated river areas.

The Skykomish is the first state scenic river system. Several areas are designated, among them the stretch from the junction of the North and South Forks, downstream to the junction with the Sultan River.

The regulations to this Act are in the process of being written, but they are a low priority for the Parks Commission. No regulations are yet finalized.

Forestry Practices Act

The State Forestry Practices Act regulates timber harvest programs on non-federal public and private lands; it is implemented by the counties. The program is site specific, and considers the impacts of particular forest practices on adjacent streams and lakes, as well as the impacts of the proposed actions on the land itself. A permit process is used; the permits define the types and locations of environmental impacts of programs, and influence the types and qualities of roads used to access timber as well as the logging technologies utilized for the removal of timber. Standards for post-harvest land management are also considered by this program. Timber harvest programs taking place on the floodplain are subject to regulation under this proposal.

State Environmental Policy Act

The State Environmental Policy Act of 1971 calls for alternatives to proposed actions which involve unresolved resource conflicts. The Act requires preparation of an environmental impact statement in certain cases and identifies what must be included in the EIS. In many cases an EIS is not prepared, but in order to make this determination, a SEPA "checklist" must be filled out which provides the threshold determination as to whether an environmental assessment or statement must be prepared.

SEPA requires that agencies consider not only the direct impacts of some proposed action, but also the indirect and cumulative impacts. Within this framework, agency programs which involve many small separate actions may be seen to have "generic" impacts, and "generic" impact statements may be prepared (such as the recent Department of Natural Resources statement relating to management of trust lands in the state over the next century or so).

One type of generic impact which may be relevant to the management of the flood hazard in the Snohomish River basin is the cumulative downstream impact of upstream timber management activities. This is an extremely complex subject, and information which we have received is that there is likely to be great variation in impacts between river basins and timber harvest regimes. Nevertheless, inherent in SEPA is the requirement that there be an assessment of such impacts (if any), but it is not clear which agency is responsible within state or local government to undertake this type of evaluation (the Forest Service has a similar obligation under NEPA for its management programs on federal lands).

LOCAL

Puget Sound Council of Governments (PSCOG)

This agency serves as a voluntary organization of local governments in King, Pierce, Snohomish, and Kitsap counties, and serves as a clearinghouse and review agency for certain federal programs, as well as the best existing vehicle for regional planning efforts. At present, the Council is organized into four subregional councils, one centered in each of the four counties. The council as a whole has articulated "Goals and Policies for Regional Development," and individual counties have developed subregional plans. A number of statements in these documents relate to the management of the Snohomish River basin. These statements might be regarded as the most fundamental statements of policy on the part of the local governments which have land-use management responsibilities for this region.

PSCOG goals and policies are the most general of the various local government policies covering the Snohomish River basin. These policies and goals provide the framework within which the subregional plans are articulated, and then individual jurisdictions must further articulate their own even more specific goals and policies. At each of these lower levels within this hierarchy of governmental agencies, specific programs are then developed to implement the goals and policies. These programs may be implemented through permit processes, hearings, detailed policies related to specific environmental topics, such as run-off or platting of subdivisions. In general, the policies developed at each level are to be consistent with each other. At the present time, the subregional plans for King and Snohomish County are being considered by the various member governments, and could therefore be subject to revision.

PSCOG Regional Development Goals and Policies were approved in February 1977, and make direct reference to environments such as those found in the Snohomish River basin in several places. Many of the other goals and policies could also be interpreted as indirectly applicable to the Snohomish River basin. Within the framework of the Growth Policies for Natural Environment and Amenities, Goal B states:

> "It is in the public interest to maintain sufficient quantities of recreation and open space land."

Policy 9 states:

> "Local jurisdictions are encouraged to acquire those swamp, marsh, bog or other wetland sites with locational and/or natural qualities which have value for wildlife conservation, scientific, educational or recreational purposes or otherwise accomplish open space land preservation and natural drainage function objectives."

Goal B of the Natural Environment and Amenities section states:

> "It is in the public interest to mitigate natural disasters by guiding urban growth within the central Puget Sound region so that natural disaster hazards to person, property, and community welfare are minimized."

A number of specific policies are developed with respect to this goal. They are listed as follows:

15. Critical facilities which would be vital to the preservation of life or which would require the priority attention of emergency service resources during a disaster emergency should not be located within disaster hazard areas when alternative locations are possible.

16. Critical utilities or major employers which would be important to community welfare and the recovery of community stability following a disaster emergency should not be located within disaster hazard areas when alternative locations are possible.

17. Hazardous facilities which would pose significant additional threats to life or property if damaged by a natural disaster should not be located within disaster hazard areas when alternative locations are possible.

18. Permanent structures designed for human habitation, commerce, employment or public assembly should not be located within high risk zones including 100-year floodways, earthquake fracture zones or active landslide zones.

19. Development which is neither critical nor hazardous may be located within natural hazard zones, other than the high risk zones, but only to the extent that the total population and property placed at risk does not exceed acceptable limits.

20. Facilities or structures should be located within natural hazard areas only when their locational benefits to the region outweigh their additional risks.

21. Structural measures utilized to reduce the risks of disaster losses should not be allowed if their general use would have the effect of causing greater risks to the lives and property of others, or to future generations.

22. Critical or hazardous facilities which might be located within natural hazard areas should be designed to maintain functional integrity or to control potential hazards, and emergency plans should be developed to protect life, property and community welfare.

23. Strengthen disaster response planning to include areawide coordination of emergency service delivery.

24. Post-disaster redevelopment should be consistent with the regional disaster mitigation goals and policies.

25. The adopted Regional Disaster Mitigation Plan and Technical Study is recognized as providing guidance for the interpretation of the disaster mitigation goals and policies.

Source: Goals and Policies for Regional Development, PSCOG, Feb. 1977.

King County Subregional Council

The plan of the King County Subregional Council (which is currently in draft form and being reviewed by member governments) is based on the goals and policies found in the Regional Development Plan. Again, many of the policy statements are indirectly applicable to the Snohomish River Basin. Policy 8 appears to be directly applicable, and the various implementation guidelines provide further definition of this policy for member governments. The text of this policy goal and the implementation guidelines are:

POLICY 8 LOCAL LAND USE PLANS SHOULD RECOGNIZE AND PROTECT AREAS WHERE OPEN SPACE OR EXTREMELY LOW INTENSITY USES ARE OF LOCAL OR SUBREGIONAL BENEFIT.

Policy Implementation Guidelines

8.1 Tax incentives, development rights purchase, open space easements and other measures should be applied to reinforce agricultural activity where it is still a productive, beneficial and financially feasible land use.

8.2 Encourage land use regulations and economic development programs that foster retention or creation of agricultural support activities, such as food processing or transportation facilities.

8.3 Recognize that withholding or urban services and development from designated agricultural areas underscores the need for more efficient development in urbanized areas.

8.4 Development should be prevented or curtailed in environmentally hazardous areas.

8.5 Nonstructural solutions to environmental hazards should be encouraged.

8.6 Urbanization of designated flood prone areas should be discouraged.

8.7 Incentives should be provided to those jurisdictions that make progress toward setting aside lands for purposes of environmental resource protection or prevention of hazards to human settlement.

8.8 Procedural guidelines established in the State Environmental Policy Act should be rigorously followed in evaluating development proposals that affect environmentally hazardous areas.

Source: King Subregional Plan.

In addition to these policies and implementation guidelines, broader goals are also relevant. King County Subregional Council policies are designed to "contain" development, to discourage sprawl into currently unsettled areas until such time as that expansion is necessary:

> "It is in the public interest to seek the concentration of intensive land uses in designated centers or areas in order to protect open space and low density land use."

In the case of the Snohomish River basin, this statement implies a desire to contain development outside the basin (except in the few existing urban nodes). This concept is developed more fully in the King County General Development Guide, which will be discussed in more detail later in this chapter.

In addition to the articulation of these goals and policy statements about specific places and qualities of the COG region, the Subregional Council also addresses the question of intergovernmental coordinator. Given the large number of governmental agencies associated with the Snohomish Mediated Plan, it seems wise to review these coordination policies. Several are listed here: implementation guidelines are contained in the Subregional Plan.

> "Local growth management decisions or options should not be hindered by state or federal policies."

> "Land use and growth management issues and decisions should be identified and brought to the attention of all potentially affected jurisdictions, with measures taken cooperatively to resolve conflicts."

> "Functional responsibilities of county, state and federal governments which influence growth management decisions or development patterns of cities should be subject to joint consideration and review by affected jurisdictions."

> "The King Subregional Council should be utilized as a forum for identification, discussion and debate and conflict resolution of issues affecting more than one jurisdiction."

"Local growth management plans and policies that affect more than one jurisdiction should be reviewed and discussed by those affected jurisdictions prior to adoption to insure consistency with the King Subregional Plan."

King County

Most of the acreage in the Snohomish River Basin in King County which is in the flood hazard zone is within the jurisdiction of King County. The preceding paragraphs referred to cooperative/joint management of lands by all governments in King County; this section of the report will refer to policy directions for lands directly under the jurisdiction of King County government.

1. Comprehensive Plan/General Development Guide

The operative policy document for land use in King County is the 1964 Comprehensive Plan. However, this plan has been amended by ordinance numerous times, and the County is now in the process of a complete revision of the 1964 comprehensive plan. The draft statement reflecting the new directions in county land use management is entitled the "General Development Guide." The County Council is in the process of revising the draft (March 1980) developed by staff in county government; it is not possible at this time to tell how much change there will be between the draft and final general development guide (or whether the council will agree to this wholesale revision in the basic planning program for the county).

The general planning concepts embodied in the General Development Guide are consistent with the King Subregional Plan. While the general development guide may be in a draft form, the goals and policies statement in the development guide represent the collective work of all affected agencies in county government, and substantial input of citizens through institutions such as the Policy Development Commission and the Community Planning Districts.

The development concept embodied in the General Development Guide envisages the classification of the county into a variety of subcounty areas: urban, suburban, transitional, reserve, and rural. Almost all of the land in the Snohomish River basin is suggested for rural classification; the only exceptions are the existing small towns. The rural subcounty area is anticipated to remain rural in the long-run (in this case for at least 20 years). This expectation is based on a development concept which encourages centralization of new employment opportunities in existing nodes, and new housing to be constructed near to existing employment nodes (and for infilling of skipped over parcels in already partially developed areas prior to the development of new "greenfield" parcels).

Within this framework, considerable attention is given to open space and environmental protection (Chapter V), and to agriculture (Ch. X). Both of these chapters contain elements directly applicable to the Snohomish River basin.

Open Space & Environmental Protection. This set of policy areas includes general directions, and then specific recommendations with respect to parks and recreation, resource lands, environmentally sensitive areas, surface water runoff, and heritage sites. Many of these policies are applicable to the Snohomish River basin, as they address the general role of open space (to):

> "Insure a relief within the urban environment, provide sufficient space for active and passive recreation, and to protect valuable and hazardous environmental features."
>
> "Open space areas should be connected visually and/or physically where possible to promote urban separation, provide linkages for plant and animal communities, and preserve significant natural features."
>
> "To the extent feasible, open space preserved for urban separation should be based upon natural land forms."
>
> "Multiple uses should be encouraged in open space areas, provided that the uses are compatible and adequate area is provided for each specific function."

> "The county should attempt to preserve those open space lands designated in community plans or on the regional open space map of this plan through acquisition or other appropriate methods."

Other general policies have also been articulated for open space which are not reproduced here, as they are less directly applicable to the region under study.

Considerable detail is provided in the General Development Guide regarding the management of environmentally sensitive areas, which clearly includes areas subject to flooding. The broadest of these policies simply states:

> "The allowable uses and densities on a site should reflect its natural constraints."

More detailed general objectives for environmentally sensitive areas are also developed, and then relatively specific objectives and policies for watercourses and waterbodies, floodplains, wetlands, steep slopes, seismic hazard areas, wildlife habitat and critical natural areas, coal mine hazards, and heritage sites are described. Many of these policy statements have a direct and significant bearing on the future management of the Snoqualmie River basin, for they are the current (proposed) policies of the local government with land management responsibilities over the largest proportion of the acreage in the floodplain. The relevant sections of these policies are reproduced here.

development. For this reason, the protection of sensitive areas is considered both in terms of mitigating adverse impacts and providing valuable amenities such as urban separation and land for passive recreation and scenic enjoyment. Although acquisition of all sensitive areas County-wide is neither feasible nor necessary, acquisition may be needed to preserve certain areas with particular open space value where development is not precluded by natural constraints.

Additional policies relating to sensitive area protection for local sub-areas of the County are included in adopted community plans. These plans are referenced in Appendix . Sensitive areas associated with lakes larger than 20 acres in size or streams with a mean annual flow greater than 20 cfs are also subject to the State Shoreline Management Act of 1971. For more detailed policies affecting floodplains, wetlands, water bodies and watercourses in these areas, see the King County Shoreline Management Master Program, Chapter XI.

GENERAL POLICIES

OS-401 THE ALLOWABLE USES AND DENSITIES ON A SITE SHOULD REFLECT ITS NATURAL CONSTRAINTS.

The intent of this policy is that zoning designations should give a realistic indication of the natural limitations on the use of property, so that constrained lands are not zoned for intensive development. In

Source: King County General Development Guide, Draft.

cases where zoning designations do not accurately reflect natural constraints, the maximum density allowed in the zone should not be permitted on a site.

OS-402 WHERE FEASIBLE, KING COUNTY SHOULD ACQUIRE SENSITIVE AREAS WHICH ARE VALUABLE AS OPEN SPACE. SENSITIVE AREAS ARE APPROPRIATE FOR ACQUISITION WHEN KING COUNTY DETERMINES THAT A SITE:

(A) REQUIRES ACCESS FOR PUBLIC MANAGEMENT FOR SUCH PURPOSES AS DRAINAGE CONTROL OR WILDLIFE HABITAT; OR

(B) SUPPORTS SCENIC, EDUCATIONAL, OR SCIENTIFIC RESOURCES MAKING PUBLIC ACCESS DESIRABLE; OR

(C) CONTAINS A VALUABLE NATURAL FEATURE OR PROVIDES URBAN SEPARATION BENEFITS WHICH CANNOT BE PROTECTED THROUGH DEVELOPMENT REGULATION (E.G., A WOODED STEEP SLOPE WHICH COULD BE DEVELOPED WITH CAREFUL ENGINEERING).

OS-403 SENSITIVE AREAS LOCATED ON COUNTY-OWNED PROPERTY SHOULD BE MANAGED FOR LOW INTENSITY USES AND SHOULD BE RETAINED IN THEIR NATURAL STATE, TO THE EXTENT PRACTICABLE.

OS-404 THE COUNTY SHOULD REVIEW ALL PROPOSED CAPITAL IMPROVEMENT PROJECTS FOR THE IMPACT ON SENSITIVE AREAS AND TAKE APPROPRIATE ACTIONS TO MITIGATE OR AVOID ANY ADVERSE IMPACTS.

OS-405 WHERE NECESSARY TO MEET THE SENSITIVE AREA POLICIES OF THIS PLAN, DEVELOPMENT SHOULD BE REQUIRED TO LOCATE OUTSIDE SENSITIVE AREAS BY CLUSTERING UNITS ON NON-SENSITIVE PORTIONS OF THE SITE.

Source: King County General Development Guide, draft.

This policy may be implemented through a planned unit development or clustered subdivision. In cases where a site is predominantly a sensitive area, developers should be encouraged to combine the development site with adjacent properties in order to utilize density credits outside the sensitive area.

A. Waterbodies and Watercourses

Waterbodies surrounded by land on all sides and watercourses, including rivers and streams, are a critical element of the natural drainage system. Preserving their natural drainage functions can reduce public costs for storm sewers and other drainage improvements. Waterbodies and watercourses also provide varied recreational opportunities and support fish populations, in addition to having unique aesthetic characteristics. Damage to these functions can result from development activity on shorelands near the water's edge.

Many of King County's rivers, streams, and lakes are vital to the life cycle of various anadromous fish species, including salmon, steelhead, trout and Dolly Varden. These species are recognized for their special value in commercial and sports fisheries. Anadromous fish-bearing waters in King County have been identified using data from the Department of Fisheries and other agencies with expertise and are mapped in Appendix . This data is also summarized in Figure .

Source: King County General Development Guide, Draft.

OS-406 SETBACKS, LIMITATIONS ON VEGETATION REMOVAL, AND OTHER APPROPRIATE DESIGN AND CONSTRUCTION CONTROLS SHOULD BE REQUIRED OF ANY NEW DEVELOPMENT ADJACENT TO LAKES, RIVERS, AND STREAMS IN ORDER TO PROTECT WATER QUALITY, MINIMIZE EROSION AND SEDIMENTATION, AND PRESERVE THE NATURAL DRAINAGE, HABITAT, AND AESTHETIC FUNCTIONS OF THE WATER BODY OR COURSE.

OS-407 NEW DEVELOPMENTS ADJACENT TO WATERCOURSES SHOULD PRESERVE AN UNDISTURBED CORRIDOR ALONG THE RIVER OR STREAM, WIDE ENOUGH TO MAINTAIN THE NATURAL FUNCTIONS OF THE WATERCOURSE.

OS-408 STREAM CHANNELS SHOULD NOT BE PLACED IN CULVERTS UNLESS ABSOLUTELY NECESSARY FOR PROPERTY ACCESS.

OS-409 WHERE FEASIBLE, THE COUNTY SHOULD REQUIRE THE REHABILITATION OF STREAM CHANNELS AND BANKS AS A CONDITION OF DEVELOPMENT APPROVAL.

OS-410 SPECIAL PRECAUTIONS SHOULD BE TAKEN, INCLUDING STUDIES AND ADDITIONAL DEVELOPMENT RESTRICTIONS WHERE NECESSARY, TO AVOID DAMAGE TO ANY ANADROMOUS FISH-BEARING WATER IDENTIFIED BY THE WASHINGTON STATE DEPARTMENT OF FISHERIES OR OTHER AGENCIES WITH EXPERTISE ON THIS SUBJECT.

B. Floodplains

Floodplains are lands adjacent to lakes, rivers, and streams which are subject to periodic inundation. The floods of King County's major rivers, like those of other river systems throughout the world, have historically been responsible for greater loss of life and property than any other natural hazard. While floodplains are

Source; King County General Development Guide, Draft hazardous areas for development, they also serve as natural flood storage areas, protect water quality, and have significant value for recreation, agriculture, and wildlife habitat. The reduction of flood storage capacity caused by development of the floodplain can result in increased flooding on adjacent and downstream lands.

The 100-year floodplain is that area which has a 1% chance of flooding in any given year. The location of 100-year floodplains of major rivers and waterbodies in King County is shown on maps in Appendix and summarized in Figure . In some areas there is uncertainty in the identification of floodplain boundaries due to the lack of long term historical data and incomplete field survey data necessary to establish accurate flood elevations.

Flood damage to structures and injury to persons or animals in the path of a flood is a function of water depth and velocity. Because a greater danger is associated with deep, high velocity flows, the floodplain is divided into a "floodway" and a "floodway fringe." Floodways include the river channel plus the adjacent area which contains deep and fast-flowing water during a 100-year flood. Floodway fringes are characterized by shallower, lower flows. Quantitative definitions of floodway and floodway fringe are contained in the zoning code.

* Source: King County General Development Guide, draft.

OS-411 THE VALUABLE NATURAL FUNCTIONS OF THE COUNTY'S FLOODPLAINS SHOULD BE PRESERVED AND SHOULD BE RESTORED WHERE OPPORTUNITIES TO DO SO EXIST.

OS-412 NEW DEVELOPMENT SHOULD BE DISCOURAGED WITHIN THE 100-YEAR FLOODPLAIN. ANY PROPOSED DEVELOPMENT OR MODIFICATION OF THE 100-YEAR FLOODPLAIN SHOULD BE EVALUATED FOR THE PURPOSE OF PROTECTING THE FLOODPLAIN'S VALUABLE NATURAL FUNCTIONS AS WELL AS MINIMIZING FLOOD HAZARDS.

OS-413 DUE TO THE GREATER RISKS ASSOCIATED WITH DEEP AND FAST-FLOWING FLOODWATERS, NO DEVELOPMENT OF PERMANENT STRUCTURES SHOULD BE PERMITTED WITHIN THE FLOODWAY.

OS-414 FOR SMALL STREAMS WHERE THE STORAGE VALUE OF THE FLOODPLAIN IS ESSENTIAL TO REDUCING DAMAGES DOWNSTREAM, THE FLOODPLAIN SHOULD BE REGULATED AS A FLOODWAY.

OS-415 WHERE FEASIBLE, DEVELOPMENT SHOULD BE REQUIRED TO LOCATE OUTSIDE THE 100-YEAR FLOODPLAIN BY CLUSTERING UNITS ON NON-SENSITIVE PORTIONS OF THE SITE OR ON ADJACENT PROPERTY.

C. Wetlands

Wetlands are defined as areas that are inundated or saturated by ground or surface water at a frequency or duration to support and, under normal circumstances, do or would support a prevelence of vegetation typically adapted for life in saturated soil conditions. Wetlands include but are not limited to marshes, bogs, and swamps, which are described as follows:*

- o <u>Marsh</u> - A low flat area on which the vegetation consists mainly of herbaceous plants such as cattails, bulrushes, tules, sedges, skunk cabbage, and other aquatic or

Source: King County General Development Guide, draft semi-aquatic plants. Shallow water usually stands on a marsh, at least during a considerable part of the year. The surface is commonly mud or muck, and no peat is present.

- Bog - A depression or other undrained or poorly drained area containing, or covered with, peat (usually more than one layer) on which characteristic kinds of sedges, reeds, rushes, mosses and other similar plants grow. In the early stages of development the vegetation is herbaceous and the peat is very wet. In middle stages the dorminant vegetation and the peat, at least near the surface, may be comparatively dry.

- Swamp - A swamp is similar to a marsh except that trees and shrubs comprise the characteristic vegetation.

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* Rigg, George B., Peat Resources of Washington, Department of Conservation, Washington State Division of Mines and Geology, p. 3.

Source: King County General Development Guide, draft.

Wetlands are areas of high natural productivity and diversity, are important for drainage and flood controls and water quality, and are highly productive as fish and wildlife habitat. The valuable functions of wetlands are described in U.S. Army Corps of Engineers regulation 33 CFR 320.4 and recognized by numerous agencies of local, state and federal government. The major functions and values of wetlands include:

(1) Storm water drainage and flood control; wetlands act as holding basins, slowing the flow of storm water running off the land to a rate which can be handled by stream and river channels. Furthermore, significant amounts of water eventually seep into the ground to become part of the acquifer system, contributing to minimum stream flows and lake depths and protecting water supplies in rural areas;

(2) Protection of water quality; Wetlands act as a trap for sediments suspended in water, which drop out as an entering stream moves into the wetland area. They also serve to absorb pollutants and nutrients which are carried by the water. By slowing the flow of storm water runoff, erosion and sedimentation are reduced;

(3) Provision of habitat for flora and fauna which are unique, fragile, and/or of prime importance to the food chain; and

Source: King County General Development Guide, draft.

(4) Provision of scientific, educational, and aesthetic resources.

In addition to being valuable natural areas, wetlands present a number of potential hazards for development, including unstable soils and flooding or drainage problems. Even filled or drained wetlands are often seismically unstable.

OS-416 WETLANDS WHICH ARE VALUABLE FOR FLOOD CONTROL, DRAINAGE, WATER QUALITY, HABITAT OR OTHER IMPORTANT NATURAL FUNCTIONS SHOULD BE RETAINED IN A NATURAL STATE.

OS-417 AN ADEQUATE BUFFER AREA SURROUNDING VALUABLE WETLANDS SHOULD BE PRESERVED IN A NATURAL STATE TO PROTECT THE NATURAL FUNCTIONS OF THE WETLAND.

OS-418 DEVELOPMENT SHOULD NOT BE PERMITTED ADJACENT TO A WETLAND WHERE SUCH DEVELOPMENT WOULD CREATE ADVERSE IMPACTS IMPAIRING THE VALUABLE FUNCTIONS OF THE WETLAND.

OS-419 WHEN ANY IMPROVEMENT TO ENHANCE ONE OR MORE OF THE VALUABLE FUNCTIONS OF A WETLAND IS PROPOSED, ADVERSE IMPACTS TO ALL OTHER VALUABLE FUNCTIONS SHOULD BE EVALUATED AND AVOIDED TO THE EXTENT POSSIBLE.

OS-420 DEVELOPMENT ON FILLED OR DRAINED FORMER WETLANDS SHOULD NOT BE PERMITTED WITHOUT CAREFUL SOILS ANALYSIS AND ADEQUATE MEASURES TO MITIGATE THE POTENTIAL HAZARDS OF UNSTABLE SOIL AND DRAINAGE PROBLEMS IN THESE AREAS.

Source; King County General Development Guide, draft.

Agriculture. The current General Development Guide refers back to the 1964 Comprehensive Plan for policy direction regarding agricultural lands. The 1964 plan simply states:

> "In the non-urban area...the existing towns and cities would be recognized and fostered through encouragement of urban type residential growth concentric to existing development rather than separate from it. In order to discourage urban sprawl, the remainder of the non-urban area would be retained in its present form of agricultural, suburban farm, forest or recreation area with measures taken for the expansion and conservation of public recreation area wherever possible."
> (P. 30, 1964 Plan)

2. Emergency Preparedness

Table 4-1 outlines major action elements of the King County emergency preparedness program. This program is related to a series of monitoring stations, which automatically report stream flow characteristics. As each phase is reached, this system leads to various levels of action, ranging from a simple telephone warning system to aggressive floodfighting programs coupled with warnings and preparedness for evacuation.

TABLE 4-1

King County Department of Public Works
Division of Hydraulics

EARLY WARNING PHASE SYSTEM
SNOQUALMIE RIVER

PHASE	FLOW	ACTION TAKEN	EXTENT OF FLOODING
I	Sum of Forks 10,000 cfs and rising rapidly	Alert Division of Hydraulics personnel.	Minor - Lowlands
II	Sum of Forks 12,000 cfs and continuing to rise OR Snoqualmie Falls 8,000 and forks continuing to rise	Hydraulics personnel man the Fall City office. Warn Priority call list.	Normal - Lowlands Some access limited. Roads overtopped Neal Road Fall Station Road Pleasant Hill Road Snoqualmie/Meadowbrook Road Millpond Road Vincent Flat Road Adair Road West River Road
III	Sum of Forks 20,000 cfs and rising OR Snoqualmie Falls 15,000 cfs and forks rising	Warn priority call list.	Major - Entire Snoqualmie Valley experiencing varying depths of flooding. Roads overtopped Fall City-Carnation *Tolt Hill Road Novelty Hill Road Dutchman Road Snoqualmie-Fall City
IV	Sum of Forks 38,000 cfs OR Snoqualmie Falls 35,000 cfs and forks rising	Warn priority call list.	Extreme - similar to December 1975 flood or greater. Roads overtopped Woodinville-Duvall

3. Agricultural Lands Program

King County, with voter approval (on November 9, 1979) of a $50 million bond measure, has developed a farmland preservation program. The effort is aimed at retaining the most productive agricultural land through the purchase of development rights to voluntarily offered properties. Approximately 33,000 acres countywide are eligible for the program, of which about 14,000 acres are in the lower Snoqualmie River valley. These lands are assigned "Priority Two" in the program's acquisition strategy. This means that they will be eligible after action on higher priority farmland. The availability of funding for King County basin farmland after earlier acquisition rounds will be determined by the participation rate of landowners with higher program priority farmland and the amount spent to purchase the development rights to those lands (from Snohomish level B study).

Funding will most likely run out at some level of "Priority Two" acquisition (Snoqualmie and Enumclaw areas). The County Council would then have to vote on which lands to include in the program.

4. Floodplain Zoning

King County uses a flood hazard "overzone" in addition to regular zoning classifications. Lands within flood hazard zones are defined by maps made by the County Hydraulics Department with additions from the Federal Flood Insurance Administration's 1978 study. The county regulates floodplain use in two land categories, the floodway category and the flood fringe category.

The floodway is the more restricted area. Some new non-residential structures of a temporary, seasonal or site-specific natural resource nature are allowed. The structures must be removed during flood season or be built to withstand flood stresses. New residences, businesses, public buildings, and uses that would change flood flow or quality are not permitted.

Flood fringe regulations are less restrictive. Residential and non-residential structures may be constructed. Residential structures must have the first habitable floor above the 100-year flood level. Non-residential structures must either have the first habitable floor above the 100-year flood level, or be floodproofed and structurally resistant to hydrostatic, hydrodynamic and buoyant flood stresses. The sufficiency of flood resistance must be certified in the latter case by a licensed professional engineer. Within the fringe, vehicular access and 5000 or more square feet of each building site must be above the 100-year flood for subdivision to be allowed. Grading or construction that would raise the 100-year flood one foot or more or add pollution and turbidity are not allowed.

5. Flood Control Zone Permits

State flood control zone permits within King County's unincorporated area are issued by the county hydraulics department. Chapter 21.55 of the King County code requires a permit for construction, reconstruction or modification of any "structure or work" within a state flood control zone within unincorporated King County.

6. Shoreline Management Program

The King County program divides the Snohomish River basin region into four general land use categories: urban, rural, conservancy, and natural. General regulations regarding shoreline protection (regarded as "action taken to reduce adverse impacts caused by current, flood, wake, or wave action") for the county include the following:

1. Structural solutions to reduce shoreline damage should be allowed only after it is demonstrated that non-structural solutions would not be able to reduce the damage.

2. Planning of shoreline protection should encompass entire river systems and/or sizeable stretches of lake or marine shorelines. This planning should consider off-site erosion, accretion or flood damage that might occur as a result of shoreline protection structures or activities.

3. Shoreline protection on marine and lake shorelines should not be used as the reason for creating new or newly usable land.

4. Shoreline protection structures should allow passage of ground and surface waters into the main water body.

5. Shoreline protection should not reduce the volume and storage capacity of rivers and adjacent wetlands or flood plains.

6. River shoreline protection should be planned, designed and constructed to allow for channel migration whenever possible.

7. Whenever shoreline protection is needed, natural berms and vegetation should be favored over artificial means.

8. The burden of proof for the need for shoreline protection to protect existing or proposed developments rests on the applicant(s).

9. Shoreline protection activities which may necessitate new or increased shoreline protection on the same or other affected properties where there has been no previous need for protection, should be discouraged.

10. New development not shoreline dependent should be encouraged to locate so as not to require shoreline protection.

Source: King County Shoreline Master Program.

7. Other Zoning

Most of the land in unincorporated King County in the floodplain is either zoned Forestry and Recreation or Agriculture. In and of themselves, these are rather general zoning categories which permit considerable variation in actual land use for low density uses. Ultimately, the Snoqualmie Valley Community Plan will provide more detailed zoning for this region. Other special purpose programs (such as the shorelines program) and flood hazard overzones provide significant constraints on land uses permitted within the current very broad zoning classifications of King County in this region.

8. Subdivision Regulations

County subdivision regulations do not address flood hazard programs. Certain subdivision restrictions, however, are contained in the zoning and surface runoff regulations.

9. Building Codes

The Uniform Building Code, as amended by King County, contains no regulations regarding construction materials or structural design levels for flood hazard areas. Floor level (relative to the 100-year flood) and floodproofing restrictions are contained in the zoning regulations.

10. Surface Water Runoff Policy

This policy requires a drainage plan prepared by a registered civil engineer for any substantial development or construction in excess of 5000 square feet. Retention or detention facilities are required for all water in excess of the peak natural discharge.

11. Grading Policy

King County regulates the grading of land areas greater than some certain minimum acreage with a permit system. Within the floodway, topographic modification is not allowed if it would obstruct flood flows. Filling is not permitted, without compensatory storage.

Municipalities

The towns of Fall City, Carnation, Duvall, Snoqualmie, and North Bend occupy parts of the flood plain, and their comprehensive plans and shoreline management programs should provide direction to the management of the floodplain in their jurisdictions. We have ascertained that neither Snoqualmie or North Bend have yet to develop a regular federally funded flood insurance program, and as will be pointed out in Chapter V this program has clearly been influential in limiting new recent development on the floodplain. The degree to which this planning gap is related to conflicts with local comprehensive plans is yet to be identified. In addition, we did not inventory whether these municipalities have comprehensive plans which address the flood hazard within their boundaries. These jurisdictions may or may not have approved the King County Subregional Plan which has substantial policy direction regarding floodplain management.

Snohomish County Subregional Council

In striking contrast to the King Subregional Plan, the Snohomish Subregional Development Plan makes no specific reference to agricultural lands policy or to environmentally sensitive areas. Therefore, since the Snohomish plan must be compatible with the regional plan, and since the regional plan discusses these matters in detail, it will be assumed that Snohomish County policies are equivalent to the regional policies already reviewed for the PSCOG.

Snohomish Coun

1. Comprehensive Plans

Snohomish County has approached the comprehensive planning process from the perspective of a number of sub-county plans. Three of these plans cover the Snohomish River basin floodplain being analyzed here, but only two of the three plan documents are yet in the draft stages: The Snohomish/Lake Stevens Area Comprehensive Plan and the Skykomish Valley Area Comprehensive Plan. Much of Reach I will be covered in another comprehensive plan document.

The Snohomish/Lake Stevens Comprehensive Plan covers the north side of the Snohomish River in Reach I. Most of the land in the floodplain is considered to be agricultural, and a small amount is considered to be a "sensitive area". Policy direction given to the management of floodplain lands is as follows:

> The County should limit land use in the flood plain to those that are least affected by flood waters. These uses include open space, parks and recreation, agriculture and timber land. In line with existing federal, state, and local regulations, this plan recommends extremely limited use of the designated 100 year flood plain. In response to changing river hydrology and with advice from the U.S. Army Corps of Engineers and the U.S. Department of Housing and Urban Development, Snohomish County regularly revised the boundaries of the designated 100-year flood way and flood plain. This comprehensive plan recommends that residential, commercial and industrial development be prohibited in the flood way and severely restricted in the flood plain. Any necessary buildings, such as farm houses in the flood plain, should be flood proofed to minimize injury and property damage. The traditional response to flood hazard has been to construct dikes as a means of flood control. Dikes are successful in minimizing localized flood damage from the less severe floods. However, experience in Snohomish County and elsewhere has shown that dikes may also aggravate flood damage. The natural human tendency is to explicitly trust these structures so that when dikes are overtopped, the flood damages may be in excess of what would have occurred if no dikes existed in the first place. Dikes also influence flood damage by shifting flood waters to other locations, both upstream and downstream. Consequently, this plan recommends that the County de-emphasize structural responses to flood hazard wherever possible. Before additional dikes are approved, a master levee program should be developed to evaluate the impact of proposed dikes on each other, on unprotected land, and on total flood damages. In the long run,

> the preferred response to periodic flooding should be better control of land use in the designated floodplain. Another response to flood hazard concerns river basin land use patterns and practices. Anytime someone removes natural vegetation, disturbs the soil structure, or constructs impervious surfaces, we increase storm water runoff and worsen flood volumes. Clear cutting timber, clearing land, building homes, paving roads and parking lots are all land use practices which reduce the amount of water that soaks into the earth, and increases the amount that runs off into streams and rivers. These activities not only increase flooding but also tend to increase erosion in upland areas and siltation problems in the lowlands. Consequently, land use practices which aggravate storm water runoff should be eliminated wherever possible.

This policy statement is clear and unambiguous endorsement of nonstructural approaches to management of the floodplains.

In contrast to the detailed and specific statements in the Snohomish/ Lake Stevens Area Comprehensive Plan, the Skykomish Valley Comprehensive Area Plan (which is in draft form) is much less specific. The plan draft states:

> The Skykomish Valley is visited by recurring floods which exact a heavy toll in flood damage. The public pays a high price for structural rehabilitation after floods and the cost of flood-fighting. In recognition of these costs, a policy of limited future floodplain development is recommended. Only those activities and uses that supply necessary public services or are compatible with the existing hydrological regime, including agricultural and low-density recreational development should be permitted. Floodplain development should also be conditioned upon a determination of minimal disruption of existing riverine and riparian wildlife habitat. (P. 14)

Other directions are given in sections dealing with Natural Conservation Uses, including water resources, wetland conservation, scenic resources, parks, trails and open space, etc., and in the discussion of problems in specific geographic areas, such as the Braided Channel. In general, these policies are quite supportive of nonstructural approaches to floodplain management.

2. Emergency Preparedness.

We did not come across an emergency preparedness program developed by Snohomish County. However, such a program may exist.

3. Floodplain Zoning

Like King County, Snohomish County has a flood hazard "overzone" in addition to a regular zoning classification. Although all floodways will not be finally defined until the completion of the unincorporated areas flood information study, the county has stricter regulations in the floodway than in the flood fringe.

Within the floodway, uses not explicitly permitted are prohibited. Allowed uses are agriculture, forestry, including portable processing, regulated sand and gravel removal, preservation and recreation. Explicitly prohibited uses include residential development, and alterations to the floodway which would significantly alter flood routing, quantity, quality or timing.

Floodway fringe development is subject to the restrictions of the national flood insurance program, and has restrictions on new construction or substantial improvements similar to King County. Water and sewage systems are required to be floodproofed. Subdivision plans will be reviewed to make sure that design and layout, utilities and drainage are arranged to minimize flood damage.

In riverine situations, provided that until a floodway has been designated no use (including landfill) shall be permitted within the floodplain area having special flood hazards unless the applicant for the land use has demonstrated that the proposed use, when combined with all other existing and anticipated uses, will not increase the water surface elevation of the 100-year flood more than one (1) foot at any point.

In riverine situations, when a floodway has been designated pursuant to the National Flood Insurance Program, the following conditions shall apply:

> The provisions of Section 18.68.050 A through F.
>
> Existing nonconforming uses in the floodway shall not be expanded but may be modified, altered or repaired in accourdance with Chapter 18.84 of this title to incorporate floodproofing measures, provided such measures to not raise the level of the 100 year flood.
>
> Fill or encroachments within the designated floodway that would materially impair its ability to carry and discharge the waters resulting from the 100 year flood shall be prohibited, except where the effect on flood heights is fully offset by stream improvements.
>
> (Snohomish County, 1980)

4. Flood Control Zone Permits

Flood control zone permits, within unincorporated Snohomish County, are issued by the State Department of Ecology for lands within a flood control zone platted after August 18, 1966. Lands platted before that date or within a 100 year floodplain outside a flood control zone must obtain permits from the county.

5. Shoreline Management Program

Snohomish County's program has added two elements in addition to the seven required in the State Act. These are agriculture--to reflect its local importance and the desire to maintain this type of land use--and implementation--to ensure effective and equitable implementation of the program's goals, policies, and regulations.

The Snohomish County program recognizes that "structural measures can have a potentially adverse impact on the overall hydraulic operation of the streamway corridor." Specific regulations which guide county and municipal planners in the evaluation of development and construction permits that may impinge on proper flood protection management are as follows:

1. Shoreline stabilization and flood protection measures shall be designed and constructed a) in such a manner as to result in channelization of normal stream flows, or 2) so that downstream banks will be adversely affected.

2. All applications for shoreline stabilization and flood protection measures shall include the following (at a minimum): purpose of project; hydraulic characteristics of river within one-half mile on each side of proposed project; existing shoreline stabilization and flood protection devices within one-half mile on each side of proposed project; construction material and methods; and resultant hydraulic characteristics of river.

3. Flood control diking shall be landward of the designated hydraulic floodway and any marshes or swamps directly interrelated and interdependent with the river.

4. Shoreline stabilization measures, such as riprap, are not allowed within any designated hydraulic floodway except as may be necessary to protect existing development or prevent serious impairment of channel function.

5. Streambank vegetation shall be preserved to the maximum extent feasible consistent with safe construction requirements.

6. Cut-and-fill slopes and backfill areas shall be revegetated with natural grasses, shrubs and/or trees in keeping with existing river bank vegetation.

The Snohomish County program divides the river basin into five general land use categories. Shoreline stabilization and flood protection measures are not permitted in the "natural environment" zone except as may be necessary to protect existing development and only when their construction would not destroy the viability of the "natural environment" zone. Shoreline stabilization and flood protection measures are permitted in the other four zones--"conservancy environment", "rural environment", "suburban environment", and "urban environment",--subject to the general regulations.

6. Building Permits

Building permits have restrictions placed on them in flood hazard areas. Residential permits will be granted for sites above the 100-year flood, even within the perimeter of the floodway. Existing farmhouses may be replaced, subject to certain conditions. Remodelling, but not addition, is permitted for existing residences within the floodway. New agricultural structures are permitted within both designated and undesignated floodways, but they must not obstruct flood flow, must be floodproofed, and designated to withstand flood stresses. Building permits will be granted for flood fringe areas, provided that floodproofing is employed and at first floor elevation is above the 100-year flood level.

7. Mobile Home Park Standards

Mobile home park standards do not permit a mobile home park within a designated 50 or 100 year floodplain.

8. Agricultural Resources Program

In response to the rapid conversion of Snohomish County farmlands to other uses, the Board of County Commissioners has adopted a resolution to preserve prime agricultural soils for agricultural uses. In 1978 the Board established an Ad Hoc Agricultural Advisory Committee to make recommendations for attaining this goal. This committee, with the assistance of the County Planning Department, has been working on identifying the problems and potential solutions which the County might adopt. No final decisions have been reached to date.

Municipalities

The comprehensive plans of the municipalities should presumably give philosophical direction to the management of the floodplain. Unfortunately, we did not secure adequate inventories of these comprehensive plans, and other related ordinances. These would include the Shoreline Management Plans within the boundaries of these jurisdictions, including the towns of Snohomish, Monroe, Sultan and Gold Bar. In addition, the cities of Everett and Marysville abut the floodplain, and some lands of these cities are in the floodplain. The city of Marysville should be noted in particular for its recent annexation of part of the flood fringe and designation of this area for industrial development. More work needs to be done to outline the land-use policies of all of these municipalities.

The City of Everett has developed a regular Federal Flood Hazard Insurance Program, while Marysville, Snoqualmie, Monroe, Gold Bar, Sultan, and Startup have yet to complete these programs.

U.S.D.A./A.S.C.S. Federal-Local-Landowner Cooperative Programs

The following are cost-share programs developed by the United States Department of Agriculture and administered through the Agricultural Stabilization and Conservation Service at the state and county levels. These cost-share programs not only help farmers develop better use of their lands but are also a source of funds so that implementation of flood damage reduction measures such as watershed management and riparian management are possible even it it is at an individual level.

Emergency Conservation Program

This program provides cost-share assistance to eligible agricultural producers who have suffered damage from floods, windstorms, or other natural disasters. Practices are available to remove debris, grade and shape land, and restore structures. In times of severe drought, the program may provide assistance for water conservation and improvement measures. The Government pays 80% and the farmer 20% under this program.

Water Bank Program

Under the Water Bank Program, directed primarily to important migratory waterfowl nesting and breeding areas, landowners receive annual payments for conserving and protecting wetlands from drainage, filling, or other adverse practices. The program also helps to conserve surface water and reduce water runoff, and contributes to improved water quality.

Currently in Washington State the Water Bank Program is operating in Spokane and Douglas counties only. The previous rate of 12 to 15 dollars an acre is expected to double by fiscal 1981 to 28 or 30 dollars per acre. In addition to wetland acreage, adjacent lands up to two times wetland acreages may be entered into the program. There is a minimum 5 acre wetland requirement in order to be eligible for this program.

In order for the Water Bank Program to be implemented in King and Snohomish counties, a proposal needs to be submitted to the state executive director of A.S.C.S., and from there a proposal must be sent to the national A.S.C.S. board for approval and allocation of funds.

Agricultural Conservation Program

This program is the principal channel through which the Government assists farmers and ranchers to carry out conservation practices such as terracing land with steep slopes, installing grasslined waterways, planting trees for erosion control, and other measures designed to hold the soil in place and prevent pollution of streams. These measures are implemented through a cost-share program where A.S.C.S. pays up to 75%.

To be eligible for ACP the farmer must submit a proposal to the county A.S.C.S. committee for their approval. Upon approval of proposal the farmer can then implement his conservation practice with cost-shared funds. If the farmers proposal calls for planting trees usually acreages of 10 and under apply, if over 10 acres then tree planting is handled under the Forestry Incentives Program. There is no minimum acreage requirement for this program but the farmer must show that his proposal is to benefit his farm and not to create a family park or picnic area.

Forestry Incentive Program

This program was authorized by Congress to share the cost of tree planting and timber stand improvement with private landowners. The cost-sh program ratio ranges up to 75%, depending on the rate set by the particular State and county by A.S.C.S. committee. The objectives of the Forestry Incentives Program are to increase the production of timber and increase growth of trees on sites suitable for production of saw timber and veneer logs, while also improving environmental quality. Both softwood and hardwood improvement practices will apply. Precommercial thinning, pruning of crop trees, and releasing of desirable seedlings are acceptable measures, as well as site preparation for natural reforestation. The maximum cost-share that a person can earn is $10,000. Under long term agreements, a landowner can plan tree planting and timber stand improvements over a period of 3 to 10 years and be assured of cost-sharing for practices to be carried out in future years.

In order to be eligible for cost-share assistance under FIP, a landowner must:

1) Own no more land than 1,000 acres of eligible forest land (unless the Secretary of Agriculture determines it is in the public interest to grant an exception for a larger acreage not to exceed 5,000 acres).

2) Be a private forest landowner. Any individual, group, association, or corporation whose stocks are not publicly traded may be eligible provided they are not primarily engaged in the business of manufacturing forest products or providing public utility services of any type.

3) Have land that is suitable for forestation if presently not in trees, for reforestation, or for improved forest management.

4) Have land that is capable of producing marketable timber crops and which meets minimum productivity standards established for this program in the landowner's state. At least 10 acres of eligible forest land is required for FIP.

5) A forest management plan must be developed through consultations between the landowner and the State forester to qualify for cost-sharing. When completed, the plan must be approved by the State forester or the forester's representative and a copy provided to the county A.S.C.S. committee.

6) Finally, the state forestry agency must certify that the project has been completed satisfactorily before cost-share payments can be made by the county A.S.C.S. office.

If land is already in forest these funds may be used only to improve timber stand by pruning or thinning. Although there are no requirements for the harvest of trees under this program, in order to be approved by the A.S.C. committee the landowner must show intent to harvest. The landowner may use these funds on two or more separately constituted farms as long as they are under the same farm manager and that the proposal is approved by the county A.S.C.S. committee.

A minimum of 300 trees per acre is necessary to comply with the Washington DNR forester who is responsible for assessment of land and project implementation as well as compliance. Under this cost-share program, the farmer pays about $50/acre and the A.S.C.S. pays about $150/acre. Usually land of suitable quality for forestry is planted to Douglas Fir but in wet areas the use of cedar and hemlock is approved.

Privately Funded Programs for Public Land Acquisition

Two privately funded programs for the conveyance of part of all of the value of critical lands into the public domain should be identified. These include organizations such as The Nature Conservancy which may purchase critical parcels at opportune times and hold them until the organization may be reimbursed by local governments. Another approach involves the use of conservation easement. Both could be used in the study area to help achieve the flood control programs of the counties and local governments.

Long term protection for the natural or open space qualities of private property may be provided by selling or donating conservation easement to an appropriate private conservation organization or public agency. Various tax benefits may be gained by taking this option. A conservation easement ensures specific use or development of a particular piece of property. In granting such an easement, the landowner is not precluded from using the property if he so desires but he essentially agrees to convey a number of rights he or his successors normally would have in order to develop or use the property. The development rights conveyed are specifically spelled out in a legal document.

Among other things, a landowner could convey his rights to harvest timber or graze the property, or to construct additional roads, hunt, use insecticides, herbicides, excavate, etc. A conservation easement is an estremely flexible concept, tailored to meet the desires and needs of the landowner and receiving agency.

Existing Nonstructural Programs in the Snohomish River Basin

The review of existing federal, state, and local governmental programs in this chapter and in Chapter II clearly indicate that many nonstructural approaches to flood damage reduction are already being utilized in the Snohomish River basin. The importance of these measures cannot be underestimated in helping to minimize the growth of the flood damage hazard in this region. Table 4-1 enumerates the nonstructural measures identified in Chapter III, and identifies examples of the application of these measures to the Snohomish Basin. This list of applications is by no means complete, and many of these approaches have not been applied as aggressively as they might be. Some programs are obviously of critical importance. Measure 8B has been adopted over most of the floodplain (significantly not as a regular program in North Bend or Snoqualmie), and evidence presented in Chapter V indicates that this program has probably been very effective in detering new development in the floodplain. However, Measure 8B is clearly tied into zoning regulations, Measures 6A and 6B, and other codes which effectively implement the incentive elements in a flood insurance program.

These existing programs may have proceeded a long way towards preventing an increase in future flood damages in the basin, as will be suggested by projections in Chapter VI, but they do little to ameliorate present damage problems, as will be evident by the discussion to be presented in Chapter VII focusing on means for reducing the existing flood hazard.

TABLE 4-2. EXISTING NONSTRUCTURAL MEASURES IN THE SNOHOMISH RIVER BASIN

NONSTRUCTURAL MEASURE		EXAMPLES IN SNOHOMISH BASIN
1A	Ring Levees Around Structures	
1B	Closure/Sealing of Structural Openings	
1C	Raising of Structure	Houses built with second floor as primary living space on Ebey Island. Some barns in Reaches 1 and 2.
1D	Relocation in Structure of Contents/Equipment	Valuable farm equipment stored on second floor of barns.
2A	Relocation of Structure	
2B	Demolition of Structure	
2C	Urban Redevelopment	
3	Protection/Relocation of Transport./Utilities	Substation on fill, east of Fall City.
4A	Change in Farming Methods	
4B	Livestock Evacuation and Mounds	Cattle mounds on dairy farms behind French Creek levee.
5A	Public Purchase -- Fee/Fee & Leaseback	State Wildlife Recreation Areas-- Cherry Valley Stillwater State Monroe Penitentary Farm King County Tolt River Park
5B	Purchase Development Rights or Flooding Easement	King County Agricultural Lands Program--purchase of development rights. Most of floodplain lands in King County portion of Reach 2 are eligible. However, no funds presently available because of lower priority.
6A	Floodplain and Shoreline Zoning	State Flood Control Zone permits, administered by Department of Ecology King County flood control zone permits King County floodplain zoning for unincorporated areas Individual municipalities floodplain zoning: Everett, Duvall, Carnation State Shoreline Management Act King County Shoreline Management Master Program Snohomish County Shoreline Management Master Program

Table 4-2. (cont'd)

	NONSTRUCTURAL MEASURE	EXAMPLES IN SNOHOMISH BASIN
6B	Other Zoning	King County, Snohomish County, and individual municipalities zoning of flood-plain areas in various classifications such as general, residential (single-family, multiple family, various maximum densities), suburban estate, agriculture, and forest-recreation.
6C	Subdivision Regulations and Building Codes	State Subdivision Regulations Law. Subdivision regulations and building codes by King County, Snohomish County, and individual municipalities.
6D	Other Regulations and Permits	Corps of Engineers Section 404 permits. King County Surface Runoff Policy. King County Grading Permits. Snohomish County Mobile Home Park Standards.
7	Preferential Open Space Taxation	State Open Space Taxation Act--applies to agricultural and forestry lands, including reforestation lands.
8A	Emergency Preparedness and Flood Warning	King County Division of Hydraulics early warning phase system.
8B	Flood Insurance	Eligible areas under federal FIA program.
9	Natural Valley Storage	Existing water retention capabilities of floodplains. Existing water retention capabilities of wetlands.
10	Management of Existing Flood Control Measures	Required annual inspection of USDA PL-566 French Creek and Marshlands levee projects.
11A	Watershed Management	State Forestry Practices Act. King County Surface Runoff Policy.
11B	Riparian Vegetation Management	
11C	River Corridor Management	Washington Scenic River System.
12	Information and Education	Ongoing technical assistance programs relating to flooding and floodplains--Corps of Engineers, King County Hydraulics Department, etc.

CHAPTER V

SNOHOMISH BASIN AND SNOHOMISH, SNOQUALMIE, AND SKYKOMISH RIVER FLOODPLAINS:

CURRENT CHARACTERISTICS AND FUTURE DEVELOPMENT

This chapter presents information about the Snohomish Basin and its floodplains. Current conditions in the basin are described briefly, focusing on aspects of natural systems and human development relevant to the articulation of flood damage reduction strategies. This arbitrary distinction between natural systems and human systems is made for convenience of discussion and it must be remembered that certain topics such as land-use and recreation fall on more intermediate ground. After we consider qualities of each reach of the river system, and discuss probable patterns of development in the basin and on the floodplain for the years 1992, 2012, and 2042. This general discussion emphasizes the contingent nature of the forecasts for floodplain development--contingent on the nature and types of structural and nonstructural actions taken to cope with the flood hazard.

BASIN CHARACTERISTICS

There have been many studies of the Snohomish River basin flood hazard problem which have included excellent descriptions of the region from both a natural systems and human use perspective. There is no need in this report to repeat such descriptions; instead we wish to emphasize only certain factors which are of significance to our study purpose: the development of non-structural approaches to flood damage reduction in this basin.

Map 5-1 defines the study region, which encompasses a floodplain of some 59,000 acres, or 92 square miles. The floodplain extends for some fifty miles downstream through the Snoqualmie and Snohomish River systems from the

North Bend area to Puget Sound, and about ten miles upstream along the Skykomish River from Monroe to Gold Bar. Thus, the floodplain in the study region is about sixty miles in length, and averages only about one mile in width. In addition, this study also considers flood damage problems on the North Fork and Middle Forks of the Snoqualmie, where there is no designated floodplain.

The floodplain constitutes a small proportion of the Snohomish River basin, only about 92 of 1780 square miles. Much of the Snohomish River basin is mountainous terrain lying on the west flanks of the Cascade Mountains. The study area is low in altitude, with the floodplain being about 400-450 feet above sea level above Snoqualmie Falls, and ranging downward from 100 feet to sea level below the falls. Thus, the floodplain has a very gentle gradient, with the natural river course being characterized by classic meander-arms and oxbow lakes. Smaller side valleys extend off the main channel, and while some of these also have flooding problems they are not focussed upon in this study.

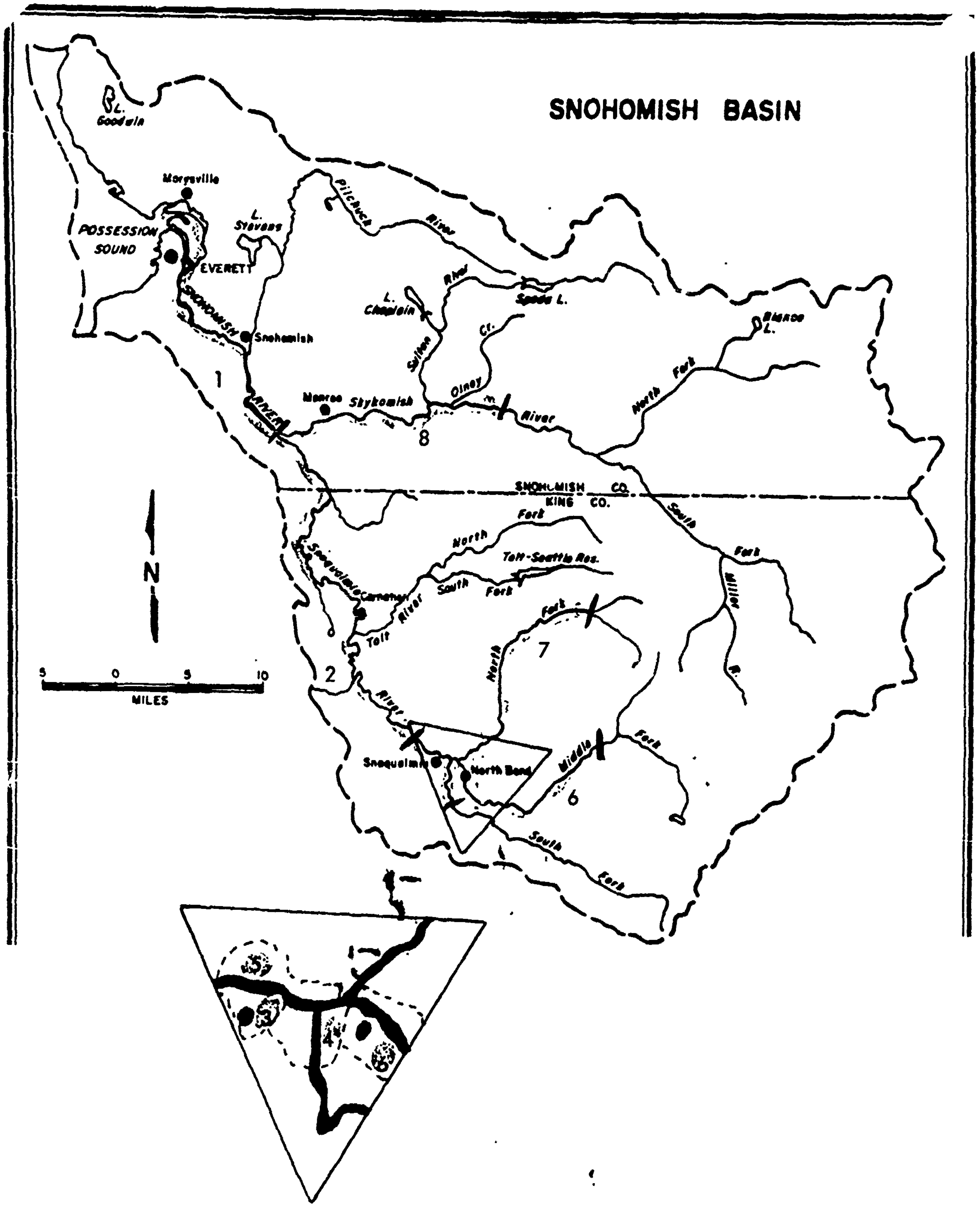
The climate in the basin as a whole is strongly related to the incidence of flooding problems. Rainfall levels are only 30-50 inches per annum over the floodplain itself, but increase dramatically in the foothills and mountains of the Cascades to the east of the floodplain. There, accumulations of 100 inches per annum are not uncommon. Most of this precipitation occurs during the winter months, and above 2500 feet in altitude primarily in the form of snowfall. The flooding problem in the valley typically occurs as an unpredictable phenomenon related to very specific meteorological sequences. Most commonly a period of heavy rainfall with very mild winter temperatures occurring after a period of cold weather with significant accumulations of snowpack on lower elevation slopes produces very rapid increases in discharge volumes. Smaller floods occur in springtime, again related to combinations of rapid snowmelt and rainfall.

The topography of the floodplain in the basin is flat and bounded by morainal hills (below Snoqualmie Falls) with steep sides. Some have characterized the area as a "bathtub", such that there is a very confined floodway relative to the overall size of the basin. Thus, the acreage flooded in a relatively common flood--say a 10-year flood--is not significantly different from that flooded in a 100-year flood. Even above Snoqualmie Falls, where morainal physiography is replaced in part by hardrock physiographic features, there is little variation in the acreage flooded with respect to flood severity. Therefore, the primary physiographic change as discharge volumes increase is an increase in the depth of water on the floodplain.

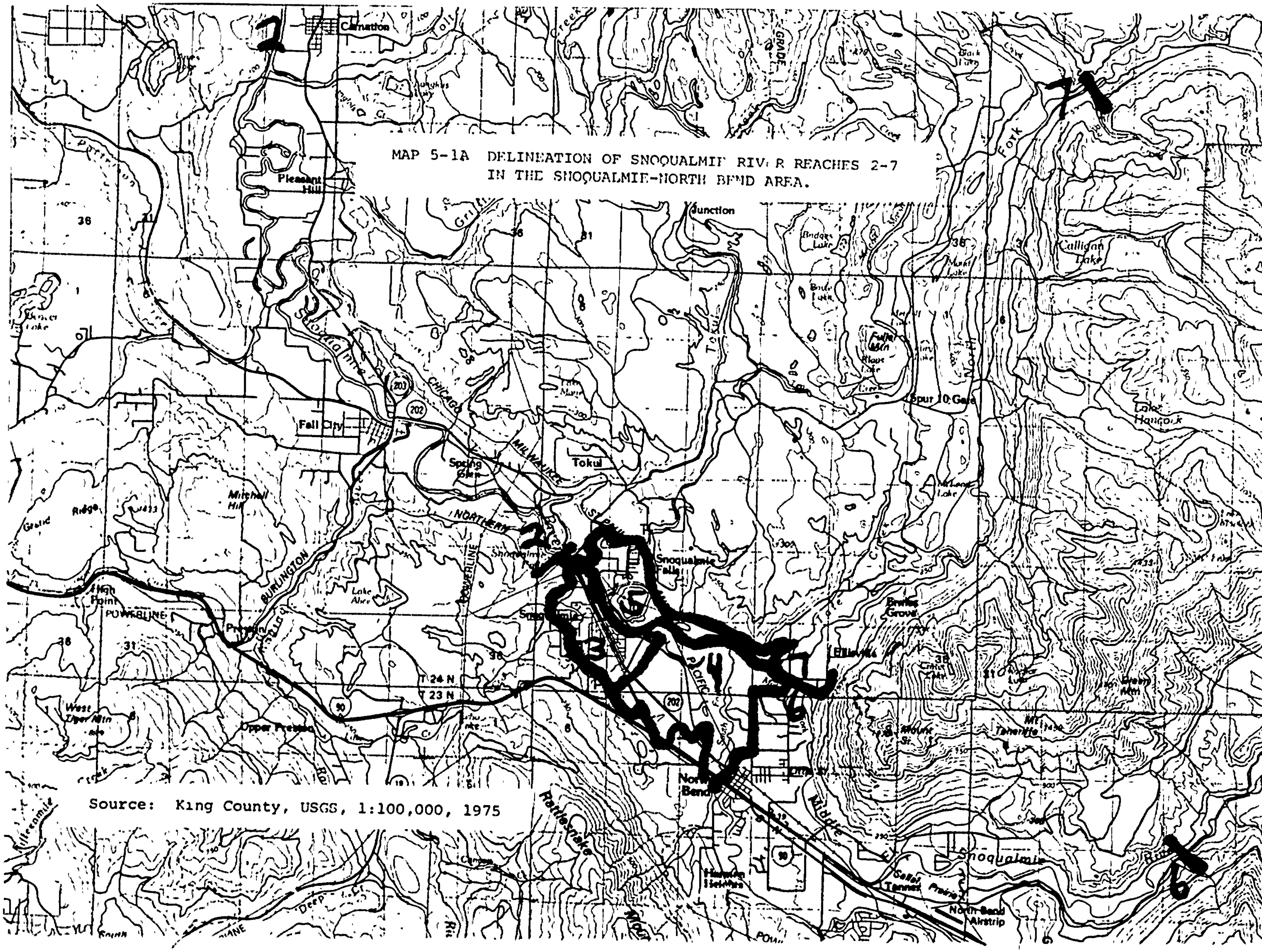
The study area has been divided into a number of subregions or "reaches" which are differentiated in terms of their physical characteristics and human uses. See Map 5-1 for boundaries of these reaches.

Reach 1 is the Snohomish River from its outlet into saltwater Possession Sound upstream to where the Snohomish is formed by the confluence of the Snoqualmie and Skykomish Rivers. Reach 2 is the lower main channel of the Snoqualmie River from Snoqualmie Falls downstream to its confluence with the Snohomish and Skykomish. Reaches 3, 4 and 5 are along the main branch of the Snoqualmie River above the Falls. Reach 3 is primarily the town of Snoqualmie and some surrounding area. Reach 4 is an area on the south side of the Snoqualmie, upstream from the town of Snoqualmie to the vicinity of the confluences of the South, Middle, and North Forks, including a portion of the South Fork. Reach 5 is on the north side of the river opposite reaches 3 and 4, and is composed mainly of the site of the Weyerhaeuser Mill. Reach 6 is the lower ten miles of the Middle Fork and Reach 7 is the lower 11.7 miles of the North Fork. Reach 8 is the Skykomish River from its mouth to 1 mile upstream from the town of Gold Bar.

MAP 5-1. SNOHOMISH BASIN RIVER REACHES



MAP 5-1A DELINEATION OF SNOQUALMIE RIVER REACHES 2-7 IN THE SNOQUALMIE-NORTH BEND AREA.



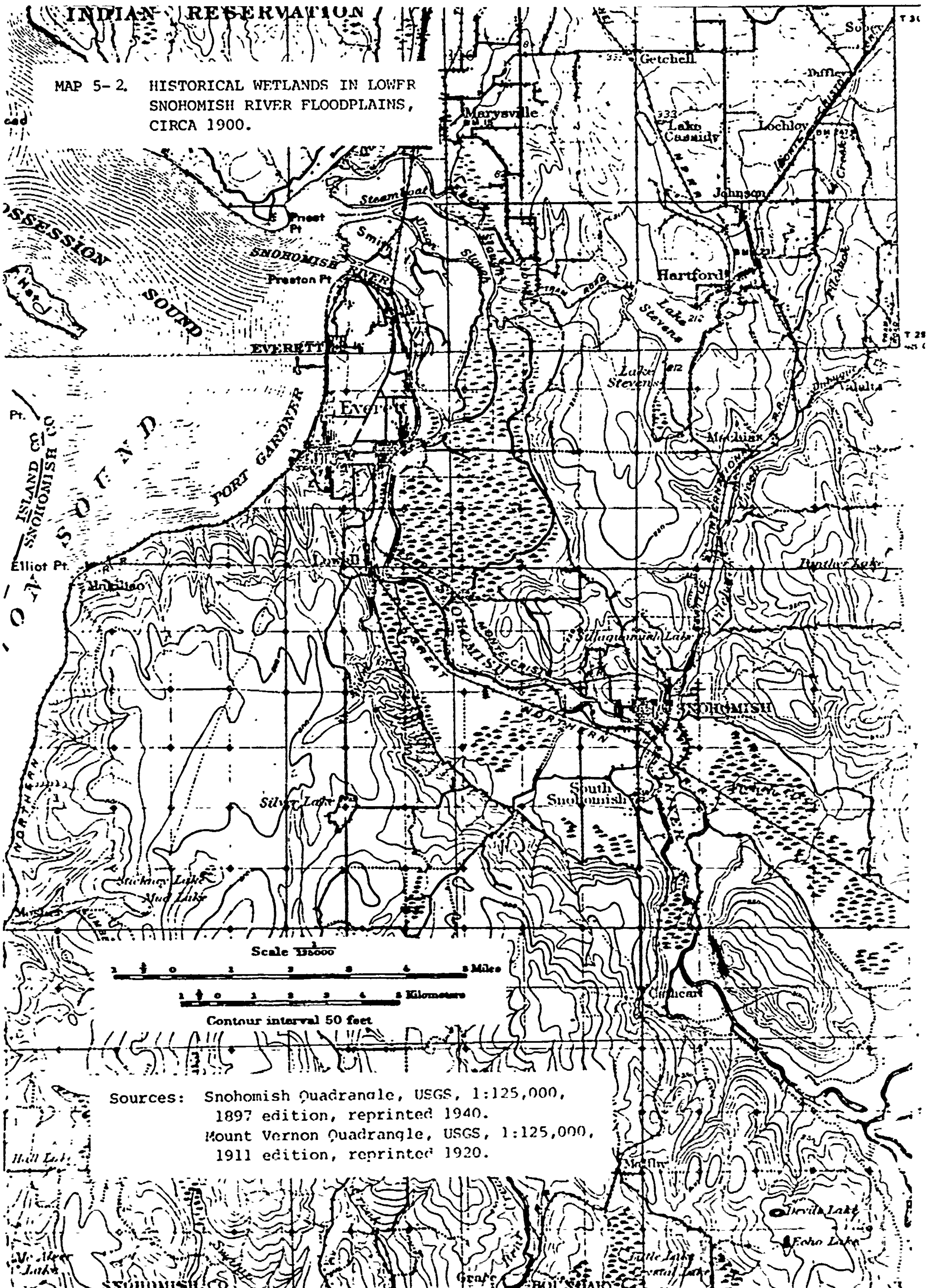
Source: King County, USGS, 1:100,000, 1975

There are an estimated 57,300 acres in the 100 year floodplain within the Snohomish, Skykomish and Snoqualmie Rivers. About 18,000 of these acres are in the Snoqualmie River system within King County. In Snohomish County, there are an additional 4600 acres of floodplain along the lower few miles of the Snoqualmie, as well as 8,900 acres along the Skykomish and 25,800 acres along the Snohomish, including delta lands. (Pacific Northwest Basin Commissions, 1980, 1-3) The floodplains of the Snoqualmie River may be divided into two distinct subareas--the lower valley floodplain below Snoqualmie Falls (reach 1 and 2) and the middle valley floodplain above the Falls (reaches 3, 4, 5, and portions of 6 and 7).

Wetlands in the Snohomish River basin may be divided into three types: salt marshes in the delta lobes of reach 1; freshwater floodplain wetlands primarily found in reaches 1 and 2 and including swamps, marshes, oxbow ponds, and seasonally flooded agricultural fields; and upland wetlands. Agricultural use of the floodplains has led to elimination of over half of the basin's naturally occurring estuarine and floodplain wetlands through draining and filling. Map 5-2 shows the extent of wetlands in the lower Snohomish River floodplains around 1900. Natural floodplain vegetation, most notably mature cedar trees, has been almost totally removed and replaced with agriculture and other development. Important floodplain habitat types for fish and wildlife in the basin are wetlands, oxbow ponds, seasonally flooded agricultural lands, riparian forest, and the riverine environment itself.

Photograph 5-1 shows Round Lake, associated wooded swamp, seasonally flooded agricultural lands, and the Snoqualmie River just north of the county line. Photograph 5-2 shows an oxbow lake typical of those found in reach 2.

The bald eagle, designated as a threatened species, winters in concentration in critical habitat along the Skykomish River. Anadromous fisheries



MAP 5-2. HISTORICAL WETLANDS IN LOWER SNOHOMISH RIVER FLOODPLAINS, CIRCA 1900.

Sources: Snohomish Quadrangle, USGS, 1:125,000, 1897 edition, reprinted 1940.
Mount Vernon Quadrangle, USGS, 1:125,000, 1911 edition, reprinted 1920.

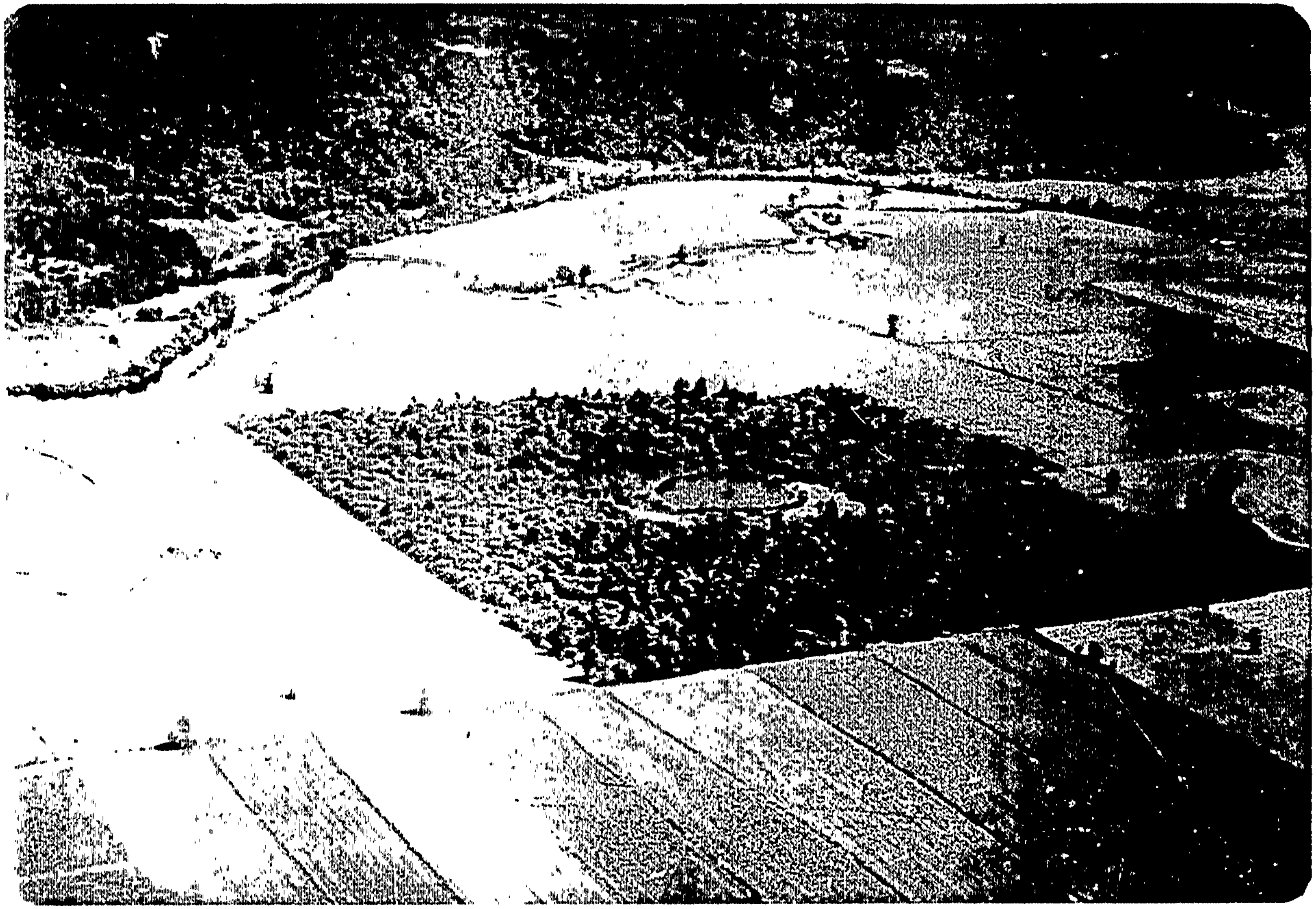
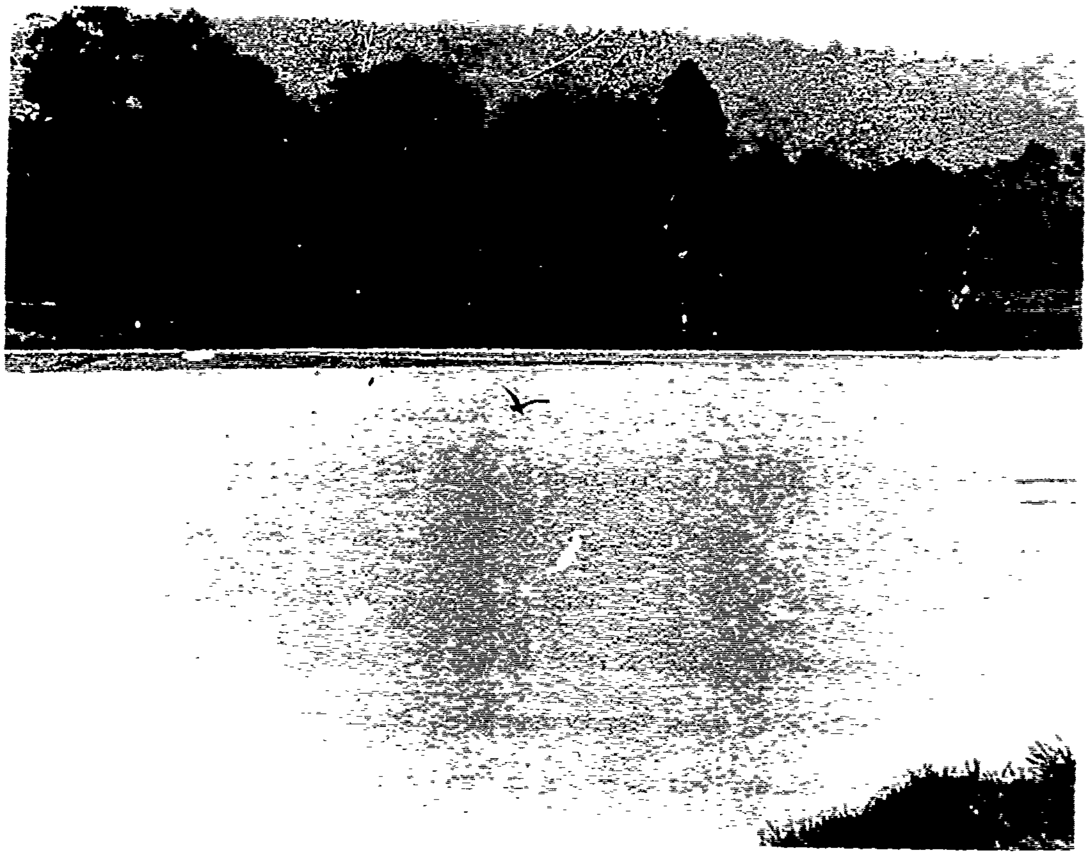


Photo 5-1 Round Lake and Snoqualmie River at County Line.

PHOTOGRAPH 5-2. OXBOW LAKE IN REACH 2



resources are significant on the Skykomish River, and to a lesser extent on the Snoqualmie River below Snoqualmie Falls.

Contemporary Human Use

Today the floodplain may be characterized as pastoral over most of its area. Agriculture is the dominant land use (60%), but substantial areas of forest and brush also occur (32%). Urban, residential and industrial uses account for the balance of the area. Table 5-1 reports current acreages of land use in King County. The soil over much of the floodplain is of high quality, either class II* or III*, while soil on surrounding morainal topography is generally of much poorer quality. Given the scarcity of good quality agricultural soil in Western Washington, it is not surprising that this area was settled early in the region's history for agricultural purposes.

In recent years agricultural land acreages in King and Snohomish counties have diminished significantly. In the period 1945-1969 acreage in King County decreased from 165,635 to 61,107, and in Snohomish County from 194,687 to 95,415 acres. Unfortunately, data are not available over time to indicate changes in acreages farmed on the floodplains being studied here. Much of the decline in King County has been concentrated south of Seattle in the Green River Valley, but even so it can be assumed that some of the loss of acreage farmed was in the Snohomish River basin. In addition to declines in acreages farmed, there has been a shift away from the production of crops, and an increased emphasis on livestock and dairy production in the region. Declines in the production of vegetables have been much more significant than the production of fruits, and increases have occurred in the production of horticultural crops. While data available to us on these trends were specific to the counties as a whole, it can be assumed that these trends have characterized farm land use change in the study region as well, for it constitutes a large proportion of the good quality agricultural land in

*conservation service classifications

TABLE 5-1. EXISTING LAND USE BY RIVER REACHES
(ACRES)

LAND USE CATEGORY	REACH: I	IIa	IIb	III	IV	V	VI	VII	VIII	TOTAL
Vacant	4,380	1,192	4,195	350	1,115	455	975	195	4,436	17,293
Public	1,060	63	470	75	145	25	10	55	217	2,120
Agricultural	18,861	3,331	8,275	60	340	10	75	140	3,835	34,927
Residential	180	30	250	295	15	10	180	20	372	1,352
Commercial	80	0	5	20	0	0	0	0	0	105
Industrial	1,230	0	0	0	15	220	0	0	41	1,506
TOTAL	25,971	4,616	13,195	800	1,630	720	1,240	410	8,911	57,313

Note: Reach IIa is the Snohomish County portion of Reach II.
Reach IIb is the King County portion of Reach II.

Source: King and Snohomish Counties.

the two counties. Unfortunately, there is no systematic documentation on the uses of lands withdrawn from agricultural production. Some of this land has probably reverted into brushland or forest, with regeneration of alder forests seeming to be a likely initial vegetative response on lands left for long periods in a fallow condition.

This period of decline in local agriculture may have ended, as new programs have been articulated to "save" agricultural land and to stimulate the marketing of locally produced produce. The revitalization of the Pike Street Market, the success of the Bulk Commodity Exchange, and local government programs (described in Chapter IV) to prevent the conversion of agricultural lands into urban land uses, may all contribute to a stabilization or expansion in the acreage farmed locally. In the floodplain being studied here, many restraining influences on land conversion have been identified, which may also help retain the viability of basin agriculture.

Forest land in the floodplain is located in scattered parcels, primarily found in conjunction with adjacent farmland. Old river meander arms or old oxbow lakes are often surrounded by forest, or have grown up in forest. Larger contiguous tracts of forest land are found in reach 8, at the confluence of the Skykomish and the Snoqualmie Rivers, and near the confluence of the North, Middle and South Forks of the Snoqualmie Rivers. Upstream from the floodplain in reaches 6 and 7, extensive forest cover is found, which is managed by large timber companies for sustained-yield production. The ownership of the forest land over much of the floodplain is probably by local farmers, and most of the land does not appear to be part of "tree farms" managed systematically for timber production. However, it should be emphasized that we did not find any good systematic treatment of the use of the forest resource in the floodplain.

Urban development in the lower reaches of the river has been minimal. Small towns such as Carnation and Sultan have portions of their incorporated areas on the floodplain, but most development appears to be occurring above the floodplain. On the other hand, significant urban development has occurred on the floodplain in reaches 3, 5, and 6, and this development is continuing in reaches 3 and 6, the towns of Snoqualmie and North Bend. Besides urban settlement, infrastructure has also been located on the floodplain, most notably roads and utility systems. In some cases this development has been elevated to avoid flooding (such as the mainline of the Burlington-Northern Railroad), but in many cases flooding occurs.

BRIEF OVERVIEWS OF REACHES UNDER STUDY

Reach 1

Reach 1 consists of the Snohomish estuary (1A) and the Snohomish River upstream to the confluence of the Skykomish (1B).

The estuary is the alluvial mouth of the River and was virtually a broad wetland of approximately 10,853 acres. Photograph 5-3 shows the Snohomish estuary area. Today only 20% of 2,270 acres of functional wetland remain; much of it has been diked for agriculture (6,405 acres) and used for sewage treatment facilities and filled for industrial parkland (1,352 acres). Additionally within reach 1A are vacant lands (665 acres), residential development (92 acres) and commercial land use (69 acres).

Land use in reach 1B is almost entirely agricultural--12,601 acres farmland out of a total floodplain area of 13,686 acres. Other land use categories in 1B include wetland-riparian vegetation (485 acres), vacant land (462 acres), industrial (51 acres) and seven residential sites (87 acres) within the town of Snohomish. The dominant agricultural use is hay, greencut, and pasture as opposed to vegetables. In addition the

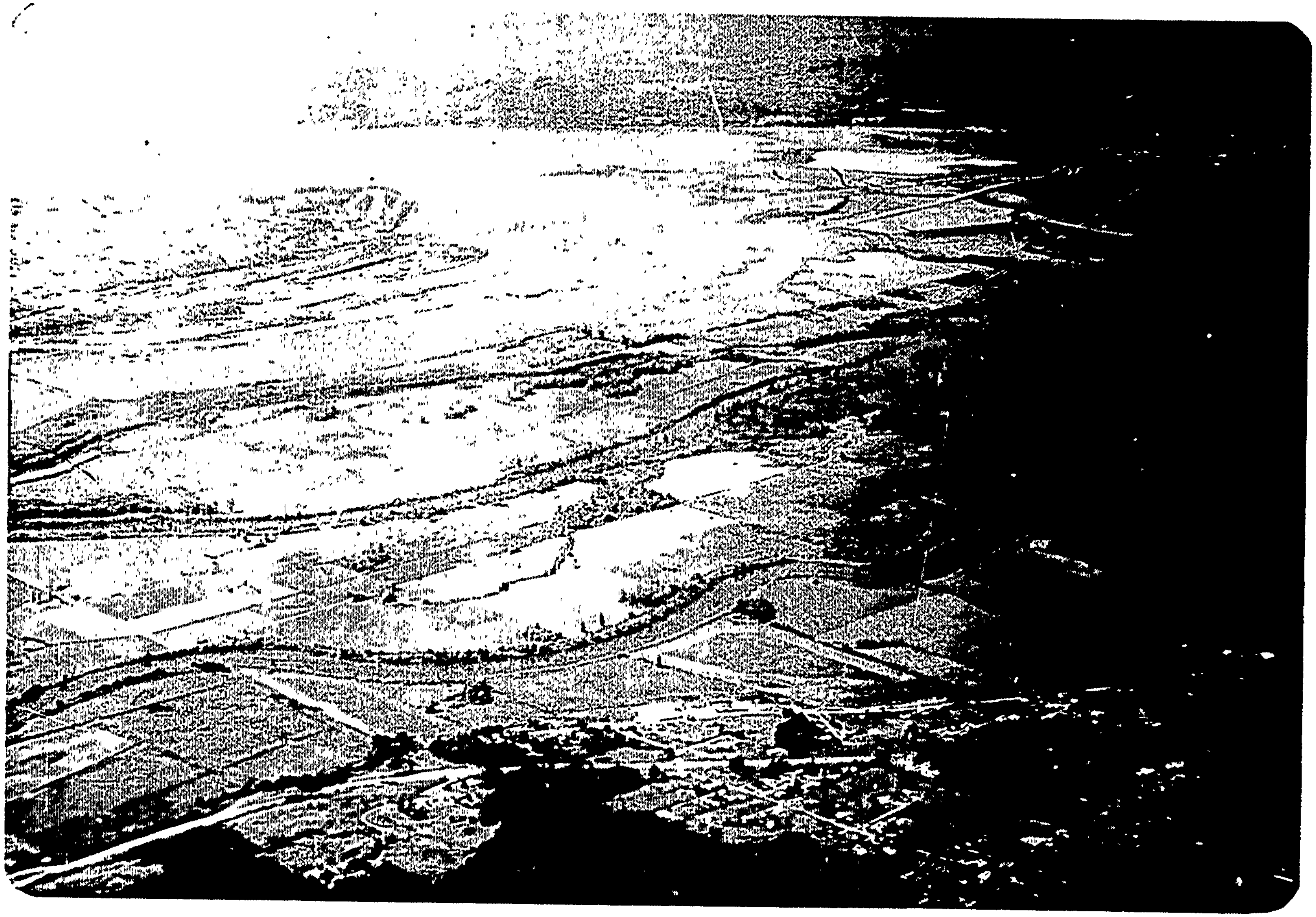


Photo 5-3 Snohomish River Estuary Delta Downstream From U.S. 2

current 1980 classification of vacant land in reach 1 indicated a greater portion of farmland left fallow. Presently there are over 1000 acres of land classed as vacant.*

Land use in the estuary is presently seen to be in a transition stage from agriculture to an increasing amount of industrial and vacant land use classification. Much of the estuary region has been classified as rural under the Shoreline Management Act, indicating that it is to be left as a buffer zone or open space adjacent to the predominantly urbanized area to the west.

The single residential development on the estuary (near Rt. #2) has a number of structures raised off the floodplain.

Reach 2. Lower Snoqualmie River

Reach 2 is the main channel of the Snoqualmie River from Snoqualmie Falls downstream to its confluence with the Skykomish and Snohomish Rivers. The lower Snoqualmie Valley is a scenic agricultural area in close proximity to the Seattle metropolitan area, being adjacent to the developing East Snohomish Plateau and being within ten miles of Redmond and Bellevue. The valley is one of viable agriculture, predominantly dairy, and of small towns--Fall City, Carnation and Duvall--and smaller places--Spring Glen, Pleasant Hill, Stillwater, and Novelty.

In reach 2, agriculture is the dominant land use, covering 8275 of 13,915 acres. Photograph 5-4 shows the floodplain between Carnation and Duvall. "Vacant" lands, which include forest, brushland, and marshland, cover 4,195 acres; 470 acres are in public ownership, and only 255 acres or 2% of the area are in residential or commercial use.

The shoreline of the Snoqualmie River in this reach has been designated as "conservancy" under the Shorelines Management Act over most of reach 2, indicating a desire by King County to maintain the existing character of

*See Appendix II for a recent letter from Snohomish County on anticipated future land use in the year 1991. The average figures suggest some additional floodplain development over figures used in this report.

Photo 5-4 Snoqualmie River Floodplain Between Carnation and Duvall.

of the river bank region.

Reach 3

Reach 3 is the most densely developed reach in the Snohomish Basin. The entire town of Snoqualmie and additional residential development are within this reach. The area developed earlier than most parts of the basin and recent growth has been slower than other areas, possibly due to the flood hazard and to the existence of nearby North Bend, closer to the main east-west traffic stream.

Almost one-half of the acreage in reach 3 is forested land, on the north and west sides of the town of Snoqualmie. Three hundred and ten of the 800 acres in this reach are urbanized, another 60 acres are in agriculture, and 75 acres are in public ownership.

Natural areas remaining within reach 3 include wetlands in Meadowbrook, Maskrod, and Quarry Hill Sloughs, the Kimball Creek Marsh, and areas directly south of downtown Snoqualmie. Riparian forest occurs along the Snoqualmie River north of town as well as along both forks of Kimball Creek and south of the Quarry. Most of this acreage would be inundated to depths greater than three feet in a 100-year flood.

Reach 4. Three Forks-Snoqualmie Area

This area lies northeast of the town of Snoqualmie, and west of the town of North Bend. It includes the confluence of the North, Middle, and South Forks of the Snoqualmie River. Most of the land in this reach is forested as is shown in Photograph 5-5 (1115 acres of 1630 acres in total), although it also includes 340 acres of agricultural land, 145 acres of public land, and small amounts of residential and industrial lands.

Part of the area is proposed as an addition to the State Park system, most notably the floodplain near the confluence of the three rivers. This

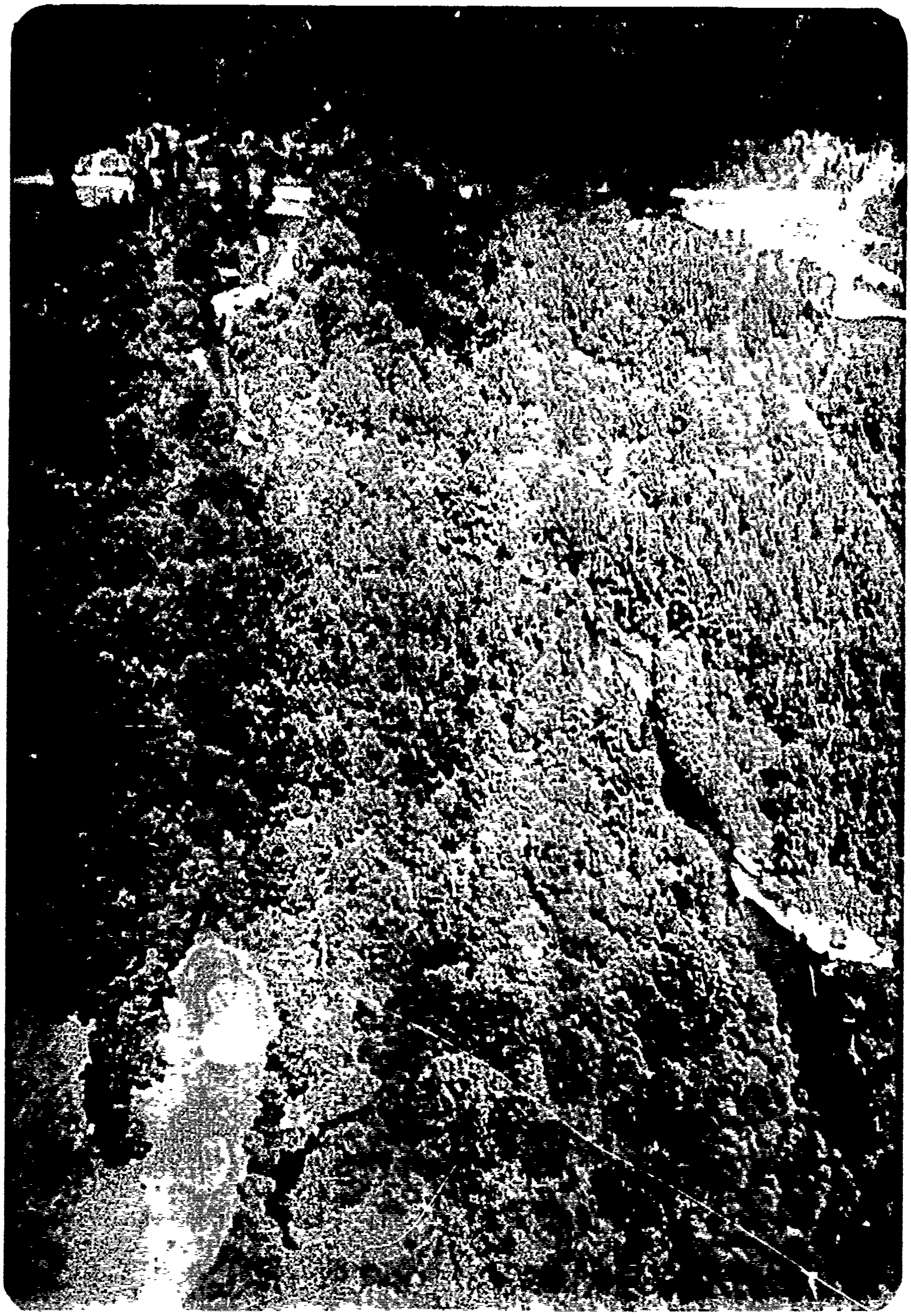


Photo 5-5 Riparian Forest Along South Fork Snoqualmie River at Three Forks Junction.

park would possibly be joined to the Mt. Si Preservation Area, which is located to the east and south of reach 3. However, the area is also subject to development pressure, and pressure to annex the . . ι as part of North Bend exists at present.

The area has been designated as a conservancy district by King County as part of the Shorelines Management Program, indicating a desire to have the region retain its present character.

Reach 5. Weyerhaeuser Mill

Reach 5 is located on the north side of the Snoqualmie River across from the town of Snoqualmie. It is primarily a forested area (455 of 720 acres, but also includes a large forest products processing complex owned by the Weyerhaeuser Company. This milling complex and associated log storage area is located on the floodplain.

Reach 6. Middle Fork Snoqualmie River and North Bend

Reach 6 is the lower ten miles of the Middle Fork of the Snoqualmie River. This reach includes the town of North Bend and related suburban development to the northeast and southeast. The small town of Tanner also lies within the reach. Estimated 1980 population in reach 6 floodplain is 450. Land use in the floodplain is 75 percent vacant and commercial forest, 14 percent agricultural (two-thirds pasture), 10 percent residential, and one percent public. This reach also includes considerable acreage upstream from the floodplain, which is primarily second growth timber along the streamside corridor. The reach extends as far northeast as the National Forest Boundary, and lands in this area are primarily devoted to commercial timber production. The river valley is also heavily used for recreational purposes, including hunting, fishing, camping, white-water kayaking, and mushrooming.

Some new development is occurring in the floodplain within reach 6. The town of North Bend does not yet have a "regular" flood hazard insurance program in force, and recent annexations of lands from King County on the north side of North Bend within the floodplain have been controversial because of the hazard posed by development of these lands within a community having a permissive attitude towards such developments. An interlocal agreement between King County and North Bend has been consummated to try to prevent such damages; in effect King County has retained the newly annexed portions of the floodplain.

Upstream from the city of North Bend in the Tanner area and east, there is continuing residential growth. Some of this growth may be located on the floodplain, although it has not been delineated upstream from Tanner. There have also been suggestions for residential developments in the upper Middle Fork valley, including inside the National Forest boundary. The road up the Middle Fork is part of the Federal Forest Highway system, and recent proposals have been made to upgrade this road and pave it as far as Camp Brown. Such road improvements would encourage development of now relatively isolated lands in reach 6, including possible development of attractive homesites along the river bank which have an unknown flood hazard. Current King County land use policy opposes such development because of the high cost of servicing it, and the county has also opposed improvement of the highway standard in this area.

Reach 7. North Fork Snoqualmie

The North Fork of the Snoqualmie River originates from alpine lakes, most of which are in the Alpine Lakes Wilderness Area, and terminates at its confluence with the Middle Fork Snoqualmie River near North Bend. The communities of Ernie's Grove and Ellisville constitute the majority of population in this reach and are located a few miles upstream from the confluence. Photograph 5-6 shows residential development in Ernie's Grove. It is in these communities where most damages occur due to flooding. Map 5-3 and 5-4 show Reach VII along the North Fork.

Land ownership along the North Fork is for the most part under the Weyerhaeuser Company and used for timber production. The State is the second largest landholder with just a few sections and private investors hold the remaining titles, these being primarily in or adjoining the communities of Ernie's Grove and Ellisville and consisting of small amounts in terms of acreage. Land use for state lands is also in forest products while private lands have some agricultural use, mainly grazing. Some of the Weyerhaeuser land is natural wetlands. There are two public campgrounds located along the North Fork near the Alpine Lakes Wilderness Area boundary.

The floodplain in reach 7 is confined to the area near the confluence of the river with the other branches. Most of this land is either forest or agricultural; the small existing flood damages are primarily to a local (holly) farm.

The river corridor on the North Fork is considered to be of very high quality, although some of the surrounding lands have been heavily logged. A recent evaluation of various rivers' environmental quality in Western Washington rated this reach with a value of 39, a value only slightly below the highest magnitude designation (42) which was given to the Middle Fork Snoqualmie River.

By extrapolating gauge data from gauging station 12-143000, the 100-year floodplain height was determined in this reach to be 11.3 feet above the stream bed. Since there is no available 7-1/2-minute Mt. Si quadrangle topographic map and there hasn't been a H.U.D. floodplain map for insurance purposes developed for Ernie's Grove, there is a need to do so in further studies. Given the streambank morphology at Ernie's Grove, rising sharply

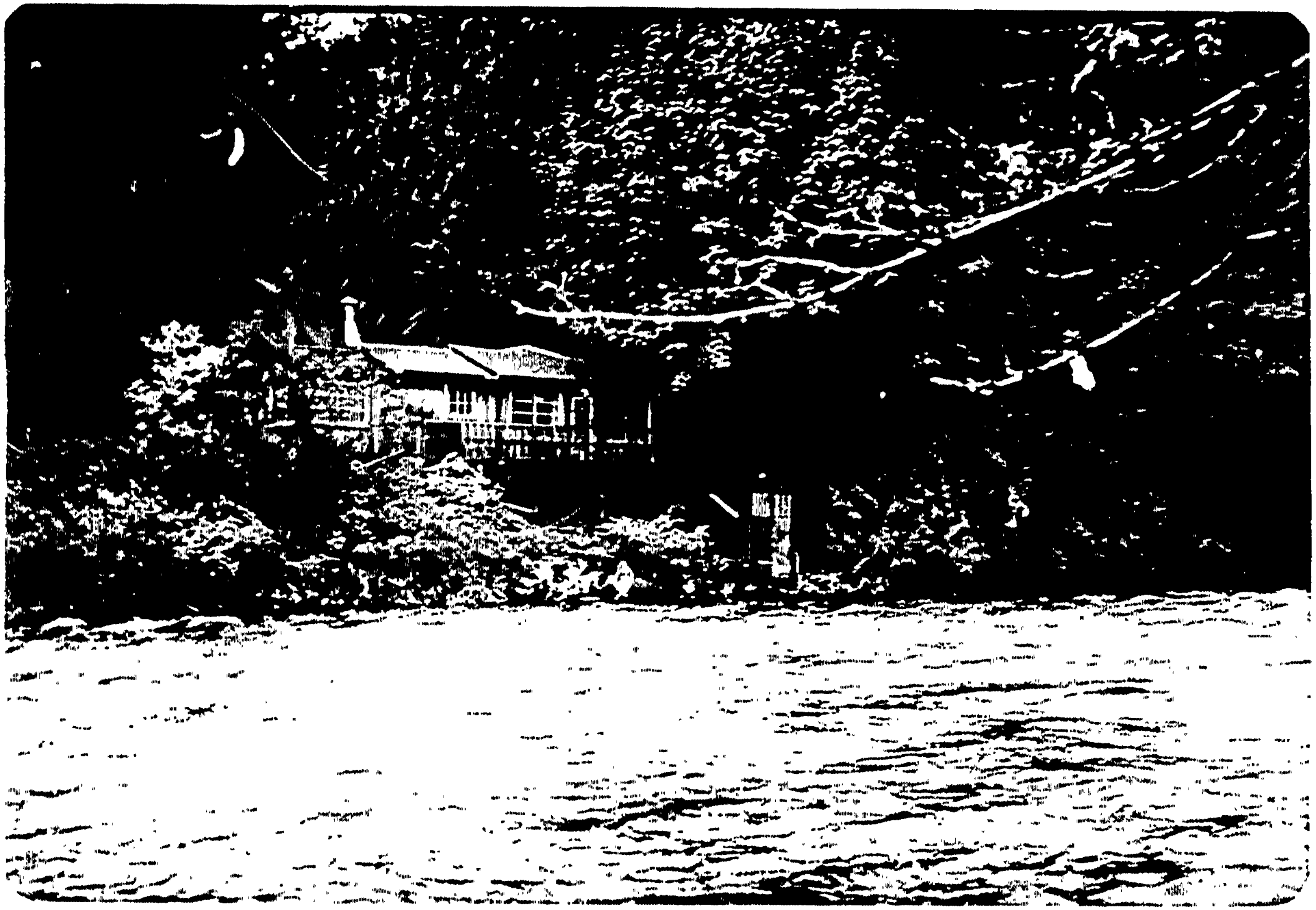
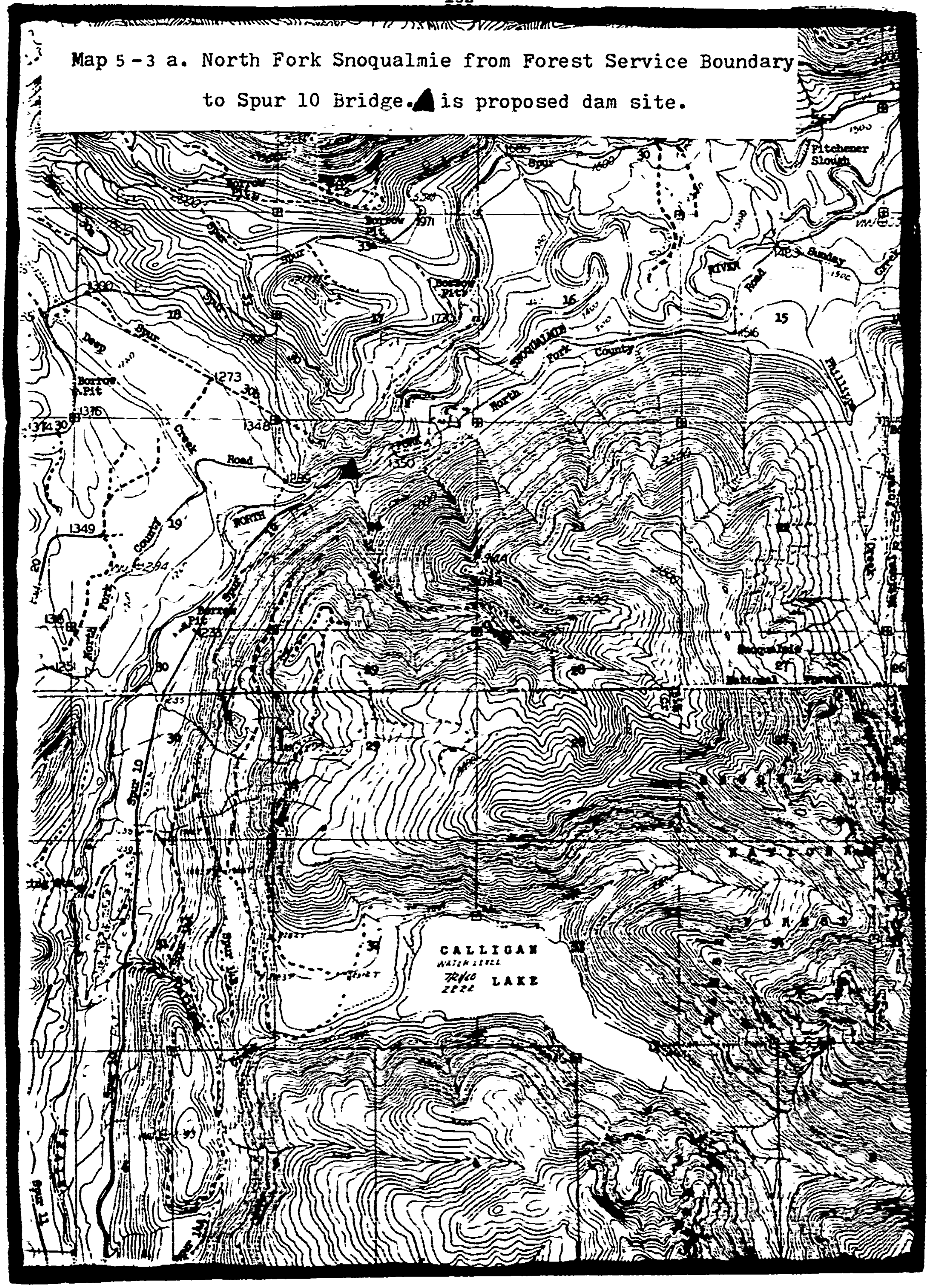
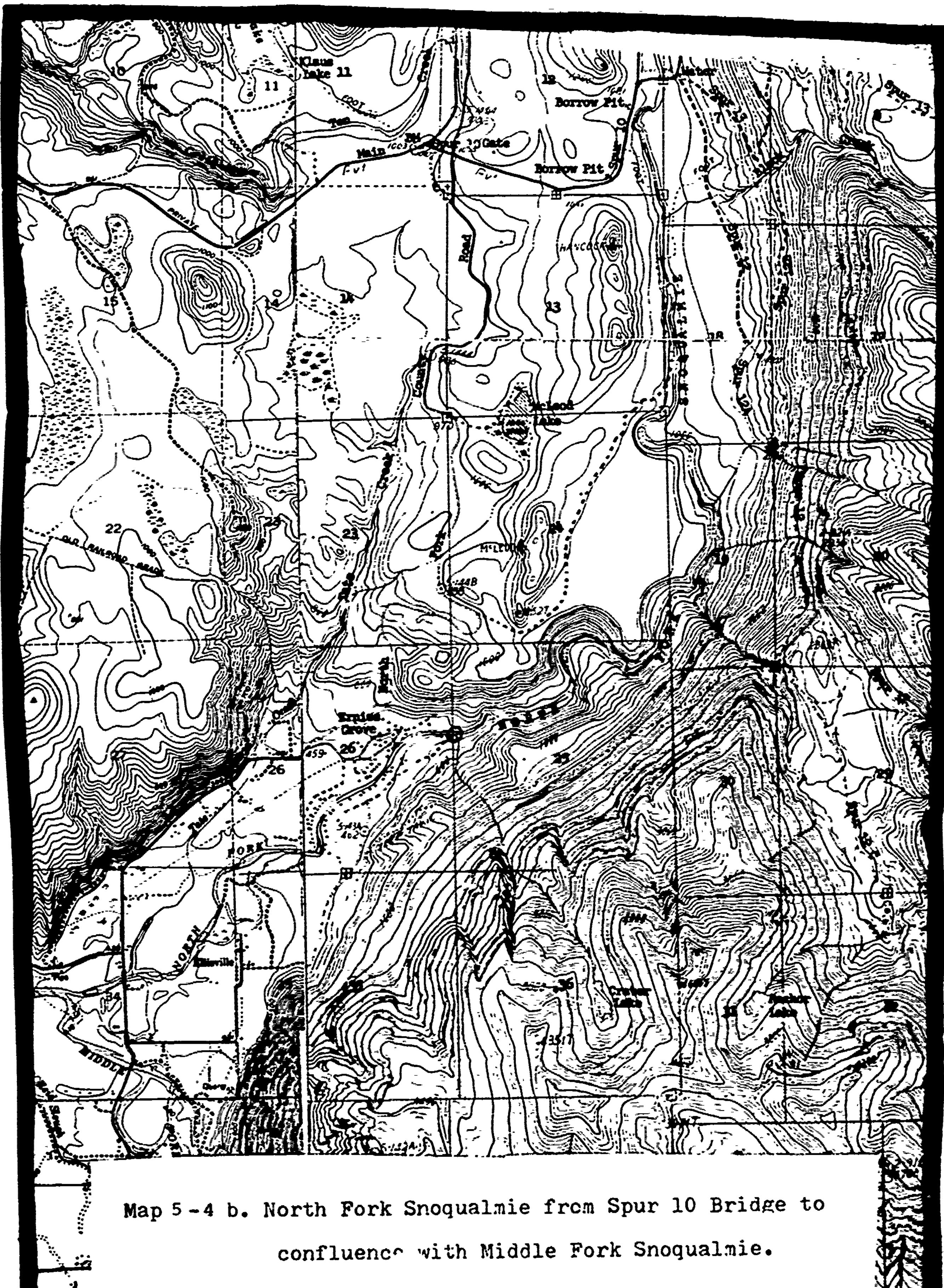


Photo 5-6 Residence Along North Fork at Ernies Grove.



Map 5 - 3 a. North Fork Snoqualmie from Forest Service Boundary to Spur 10 Bridge. ▲ is proposed dam site.



Map 5-4 b. North Fork Snoqualmie from Spur 10 Bridge to confluence with Middle Fork Snoqualmie.

on the west bank and terraced on the east bank with both formations becoming less distinct as you move downstream, and that some of the houses are set low on the terraced side, an estimated 25% of the houses are in the 100-year floodplain out of an estimated 118 structures in this vicinity. To map the floodplain in this area will require further fieldwork to determine exact boundaries.

Reach 8. Skykomish River

Reach 8 is the 100-year floodplain of the Skykomish River from its confluence with the Snoqualmie (to form the Snohomish), upstream to a point 1-1/2 miles east of Gold Bar where SR 2 crosses the River. The floodplain includes portions of Woods Creek, the Sultan River, the Wallace River, and May Creek. River channels, gravel bars, riparian forest and agriculture characterize the reach. Photograph 5-7 shows a portion of the braided channel between Startup and Sultan.

PRESENT CONDITIONS OF NATURAL SYSTEMS

The river itself is the key to the ecosystem of reach 8. The Skykomish may be classified into three zones, all of which fall into the SMA planning area. The upper zone, in which the river is eroding its banks and picking up sediment, lies upstream of Startup. The transitional zone downstream to a mile or so below Sultan, is characterized by a meandering and migrating river course, with little net erosion or deposition, and downstream to the confluence, the river is depositing the sediments picked up above Startup. In this zone the river is raising the valley floor through the building of channel bars and through overbank and floodplain deposits of sand and silt during floods. The subreach from Monroe to the confluence is of particular note for its high rate of bedload deposits, particularly in river bars. Gravels in this area are of commercial interest.

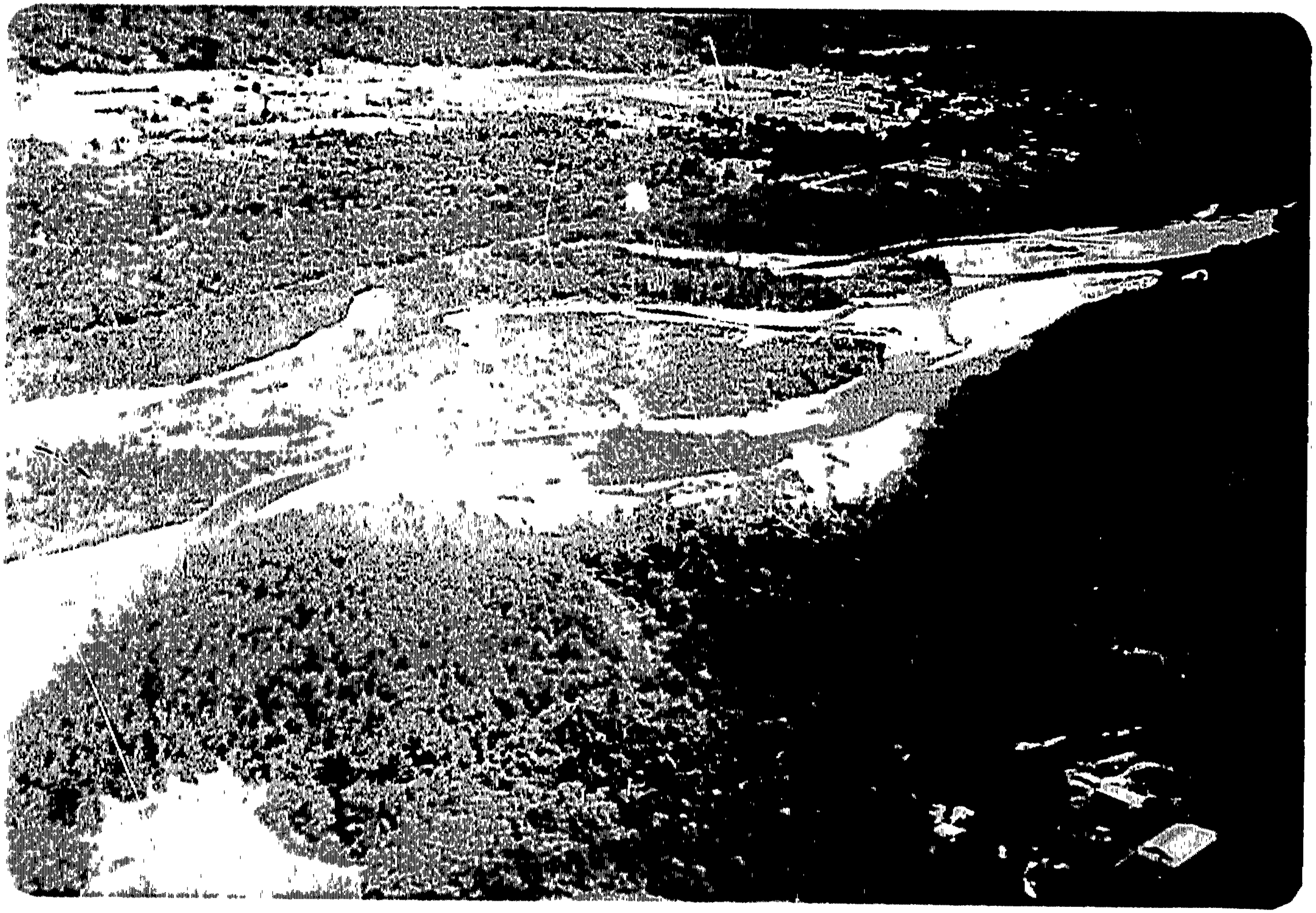
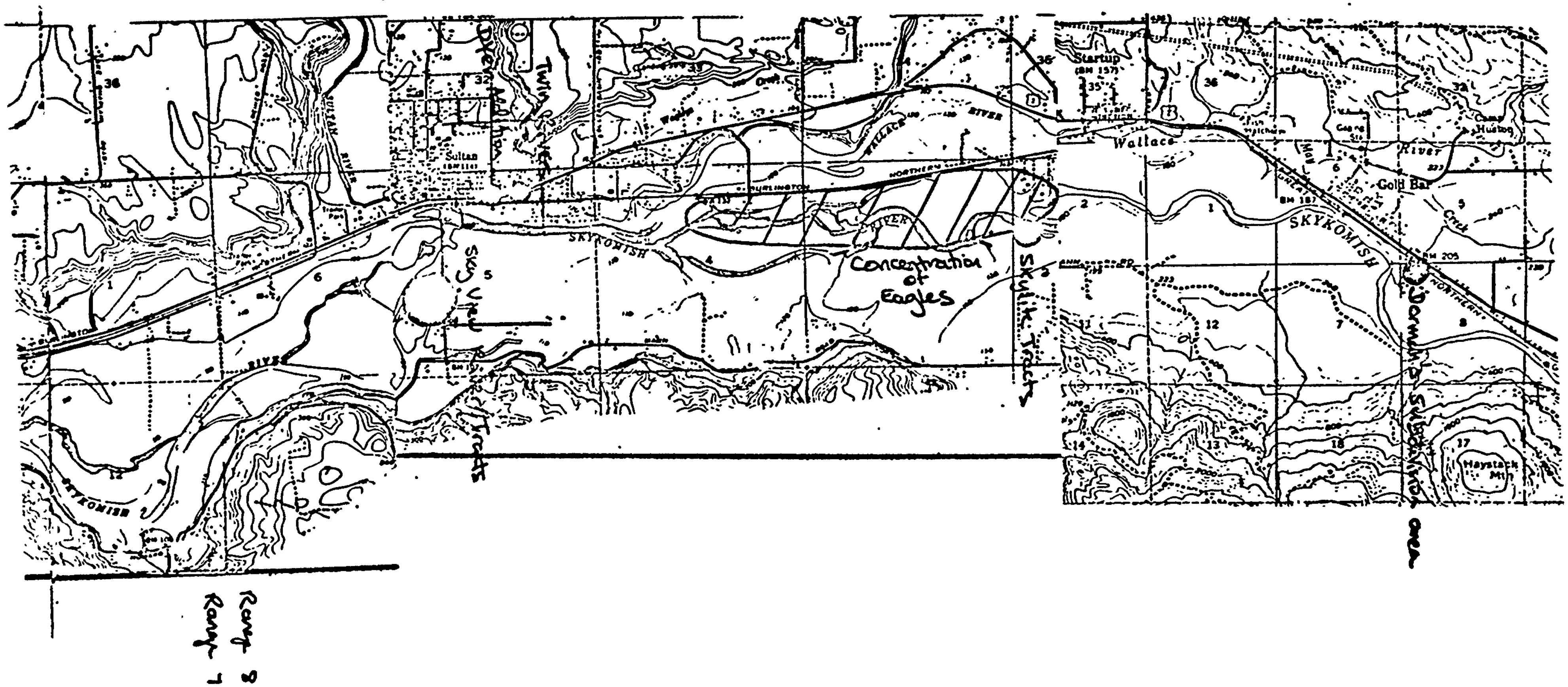
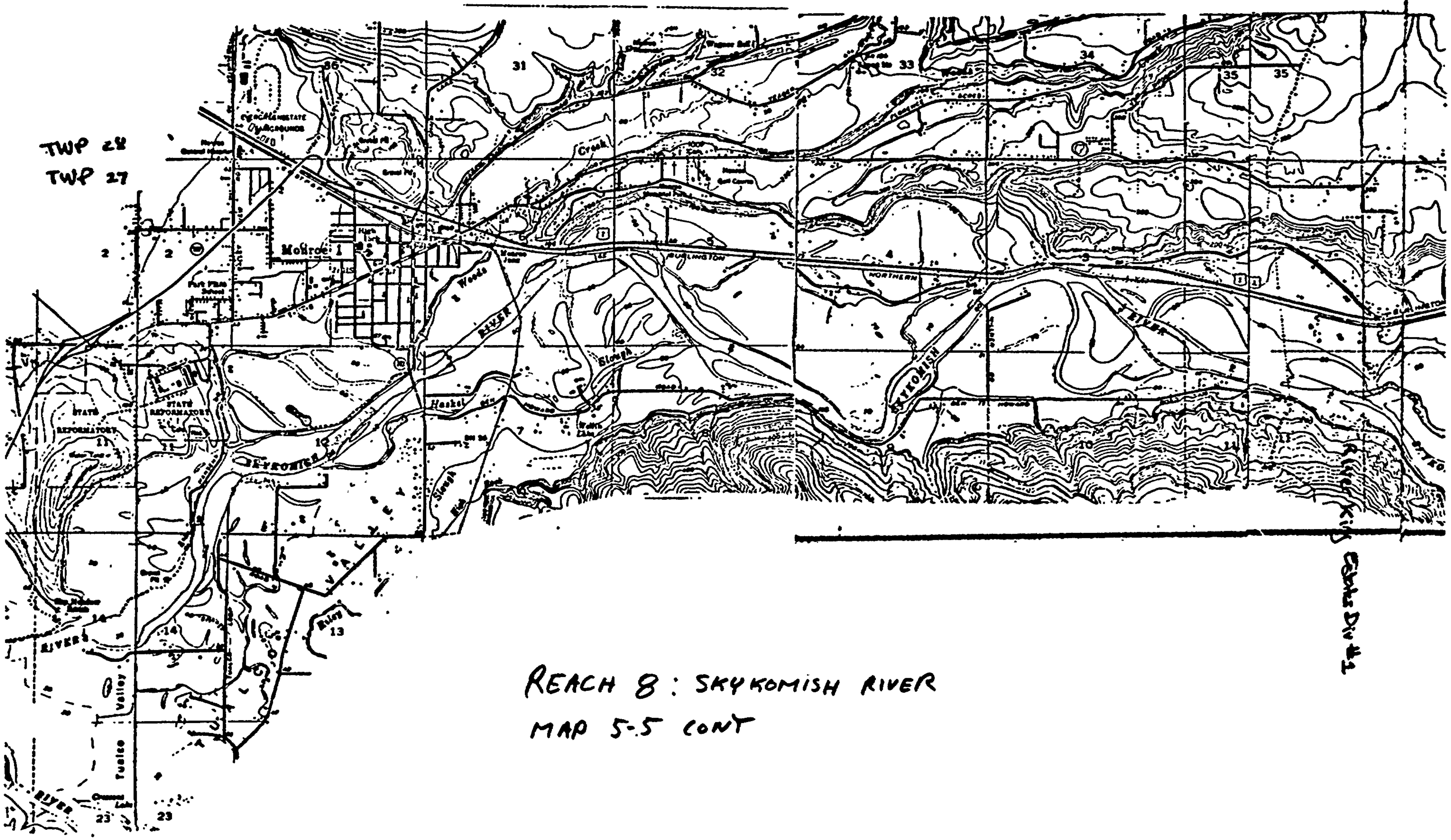


Photo 5-7 Skykomish River Braided Channel Between Startup and Sultan



REACH 8: SKYKOMISH RIVER
MAP 5-5



REACH 8: SKYKOMISH RIVER
MAP 5-5 CONT

The Floodplain

Two different estimates of acreage of the floodplain have been made for reach 8. One, 4,448 acres, made by the Fish and Wildlife Service, uses a western boundary short of Monroe, and another 8,911 acres by the Snohomish County Planning Department, uses a boundary south of Monroe in the Tualco Valley (including approximately half of section 13, T 27 R6) and includes the portions of the Wallace River and May Creek which are shown on Corps of Engineers maps to be in the Skykomish floodplain.

Vegetation

The dominant habitat type on the Skykomish floodplain is riparian forest (forests adjacent to and directly influenced by streams or standing water). Typical of this forest type are willow, cottonwood, alder, western red cedar, red stem dogwood, and snowberry. The Fish and Wildlife Service analysis of the reach (exclusive of tributaries) shows that 44% is in riparian forest, 3% in wetlands (mainly freshwater swamps), 6.7% in gravel and sand bars and 23.5% in agriculture. Freshwater swamps are characterized by reed and cunary grass and gravel bars by willows and occasionally, black cottonwood.

Fish and Wildlife

Bald eagles and anadromous fish are the natural residents of most human concern: eagles because they are classified as threatened in this state under the Endangered Species Act, and anadrmous fish because of the high levels of interest in preserving the diminishing commercial and sports fishery.

The Skykomish upstream to Gold Bar with its gravel bottom and gravel bars, is particularly used by chinook, chum, and pink salmon and steelhead trout for spawning. Spawning of coho and steelhead in the tributaries is extensive and juvenile fish rearing on both the mainstream and tributaries is extremely significant. A salmon hatchery at May Creek near Startup supplements the natural fishery.

Steelhead sports catches on the Skykomish, all Forks, in the past five years are available from the State Game Department.

Bald eagles are attracted by spawned-out fish as a food source and the relatively undisturbed, forested river habitats. They are found throughout the reach, but are heavily concentrated in the braided channel area, especially between Startup and Sultan.

The vegetation, fish, wildlife and soils of reach 8 are best seen in the context of the topography, geology, and weather systems which affect the Skykomish. The sand, silt and gravels of its bedload, and the depth and velocity of its waters created the physical river bottoms and floodplains which enable the vegetation (also agriculture) and fish to flourish. These are in turn major factors in the varieties and numbers of vegetation and wildlife to be found in this area.

Human appreciation of the Skykomish is enhanced by its accessibility. A major railroad and highway parallel the river to the north, affording vistas across the floodplain with a mountain backdrop. Even the easternmost part of reach 8 is within an hour's drive of the Seattle-Everett metropolitan area. The State of Washington has declared the Skykomish a shoreline of statewide significance and named it the first state scenic river system.

FUTURE DEVELOPMENT IN THE SNOHOMISH RIVER BASIN

A variety of forces are at work shaping the magnitude and geographical distribution of social and economic activities in the central Puget Sound region. As we consider future human demands on the Snohomish River basin, it would be worthwhile to review some of the controlling forces. At least five major factors need to be considered: demographic pressures, residential preferences, employment locations, transportation and communications networks, and public policies regarding landscape use and development. Consideration will be given to each of these variables separately in the succeeding paragraphs. However, it should be stressed that these forces are inter-dependent, and inherently unpredictable. For example, it is clear that public policies shape, but do not determine private actions; the decision to find a homesite is related to the location of workplace; the overall regional level of growth is a function of the success of regional industries in export markets; etc.

The unpredictable nature of future development is easily illustrated by turning to history. We are asked to visualize this region's development in the year 1992, 2012, and 2042, or about 10, 30, and 60 years from today. Consider how much change there has been in this region since 1920, 1950 or even 1970, and more importantly try to place yourself in the position of a forecaster in 1920 or 1950, and ask whether you would have even remotely guessed the course of development in the central Puget Sound region to 1980. Just consider the dynamic impact of new inventions exported from this region which hardly existed in 1920 (like airplanes) or even in 1950 (like jet airplanes), or even inventions used in the region which were in their infancy of application in these earlier eras--such as electricity and automobiles.

These dynamic elements in our settlement system have led to considerable restructuring of the system as it has evolved through time, as it has responded to the new stimuli in the environment around it. The fact that we could not even predict the existence of some of these factors 30 or 60 years ago points out a fundamental weakness in social science prediction: unlike the (largely) climatically and physiographically defined qualities of an event such as a flood in the Snohomish River basin, where is it possible to calibrate probabilities of future flood events, with human affairs we are not now in a position to engage in such predictions, or in many instances to even know the reasonable distribution of outcomes because many of the controlling variables have yet to be invented or have yet to become an influential part of society's value system.

Recent Growth Trends

Before turning to an assessment of future growth prospects in the Snoqualmie River basin, let us review recent growth trends in the region, and in the floodplain.

The Central Puget Sound region has historically had a higher population growth rate than the nation as a whole (i.e. since 1860) and has grown more rapidly than the rest of Washington State during the twentieth century. However, the last decade has witnessed a different trend, with a more balanced growth trend in the state of Washington. In the early 1970's, population expansion in King County came to a virtual halt, largely because of the economic slump caused by The Boeing Company (which laid off over 60,000 workers in the 1969-71 period). At the same time, growth in relatively rural parts of the state outside the influence of major metropolitan centers resumed, after decades of decline in some cases. This pattern mirrored emerging national trends; it now appears as though the United States is entering a period of decentralization, as migration to nonmetropolitan areas is now greater than migration to metropolitan areas for the first time in our history.

During this period (ca. 1970-77) of regional stagnation of population, there was considerable population redistribution <u>within</u> the region. Most notably, the urban-suburban decentralization trends of the fifties and sixties persisted, with older urban centers such as Seattle losing population while suburban places grew quite rapidly. Much of this population growth has occurred in unincorporated areas, as is shown in Table 5-2.

It is clear that growth rates of unincorporated areas have been higher than incorporated areas. However, some incorporated suburban towns such as Redmond have also had very rapid growth rates. The east Sammamish Plateau has certainly been the location of much of this growth, and this plateau is located just west of the Snoqualmie River valley. Data collected recently by Richard Morrill for King County indicate that this region grew more rapidly by 1980 than had been forecast by the PSCOG for 1990. The significant growth rates of Carnation and Duvall are probably a reflection of this eastward expansion of the Seattle-based metropolitan system.

While these data suggest rapid population expansion in the area proximate to the Snohomish River floodplain, recent data also suggest very modest levels of population increase on the floodplain itself, as shown on Table 5-3. These data clearly show very few permits for new residences built on the floodplain over the past seven years, even in areas such as reach 2 where urban development pressures are significant.

Data are not available on a small area basis for the Snohomish River basin describing recent changes in employment. However, PSCOG data again show a rapid increase in employment in suburban locations, with more decentralization of employment than has been forecast. Particularly strong growth in manufacturing and wholesaling in the Bellevue-Redmond area has occurred in the past decade, and Boeing and other high technology manufacturers have significantly expanded their workforce in southwest Snohomish County in the past few years.

The transportation network in the region has been reshaped in the past two decades by the construction of the freeway system. Some of the suburban employment growth, and much suburban or exurban population expansion is

TABLE 5-2. RECENT POPULATION TRENDS, SNOHOMISH RIVER BASIN REGION

	1970	1980	% Change
King County	1,159,375	1,256,800	8
Unincorporated	411,750	483,829	12
Incorporated	747,625	772,971	3
Snohomish County	265,236	321,800	21
Unincorporated	127,952	167,376	31
Incorporated	137,284	154,424	12
Seattle	530,831	498,000	-6
Bellevue	61,196	79,550 (872)	30
Redmond	11,020	22,000 (255)	100
Carnation	530	951	79
Duvall	607	860 (11)	42
North Bend	1,625	1,620 (18)	0
Snoqualmie	1,260	1,270 (60)	0
Gold Bar	504	637	26
Monroe	2,687	2,760	3
Snohomish	5,174	5,110 (102)	-1
Sultan	1,119	1,413 (115)	26

Source: Office of Financial Management, State of Washington, Population Trends, 1980, September 1980.

Data in ( ) following 1980 populations are the numbers gained through annexations between 1970 and 1980.

TABLE 5-3. RESIDENTIAL GROWTH IN THE SNOHOMISH BASIN: NEW STRUCTURES

REACH	I	II	III	IV	V	VI	VII	VIII*
1973	ND	0	0	0	0	9	0	ND
1974	ND	1	0	0	0	0	2	ND
1975	ND	0	0	0	0	1	2	ND
1976	ND	1	0	0	0	1	0	ND
1977	0	0	0	0	0	0	2	0
1978	3	0	0	0	0	1	0	3
1979	2	ND	ND	ND	ND	ND	ND	2
1980	2	ND	ND	ND	ND	ND	ND	1

The table above shows residential growth within 7 reaches of the Snohomish Basin. The net growth rate is unknown due to the lack of information on the abandonment of houses and removal or abandonment of mobile homes. Field trips into the study area suggest that abandonment is a significant factor. Therefore, the number of residences within the flood plain is either declining slightly or growing slightly, depending on the abandonment rate, throughout most of the Basin. The exception is in Reaches 6 and 7. There, new structures almost certainly exceed abandonments. Recent developments in Snoqualmie and the Interlocal Agreement between Snoqualmie, North Bend, King County and the Snoqualmie Valley Land Company suggest that this growth will continue.

*Skykomish floodplain, exclusive of back-up into Woods Creek, Sultan River, Wallace River and May Creek.

probably related to this improved transportation network, which has made relatively peripheral locations more accessible to the metropolitan region.

Future Growth Prospects

The data just presented are suggestive of current trends in population in the Snohomish River basin. While it has been argued that it is impossible to predict with certitude the future levels of use of the basin, a number of forecasts have been made, and a number of conditioning forces may be identified which will be influential in determining the levels of human use. Let us review some of these shaping forces, and then discuss some likely levels of human use in the future.

Five shaping forces need to be considered: (1) employment centers, (2) residential preferences, (3) demographic pressures, (4) transportation systems and costs, and (5) public policies. It has already been argued that these are interdependent forces, and their separate considerat is somewhat artificial.

Employment Centers

Today we have only a few activities located on the Snohomish River basin floodplain which might be considered "basic"* employment. Besides agriculture and forest products, some proportion of the trade and service functions of basin small towns probably serve as part of the economic base of these communities. The Puget Sound Railway Historical Association in Snoqualmie, the gas stations, restaurants, taverns, bakery, etc., in North Bend, illustrate this function.

In contrast to the rural economy, the expanding urban system to the west of the Snohomish River basin is clearly focussed on diversified manufacturing and export services. As this urban system grows, the need for new nodes of basic economic activity will increase. In recent decades one large new employment center in the region was located on a floodplain: the Green River

selling in nonlocal (floodplain) markets valley. Similar patterns of urban development have prevailed elsewhere in the United States, as these lands are flat and involve relatively low development costs for large contiguous tracts--providing there is flood protection. It is not inconceivable that in the next several decades that at least one such node of basic economic activity will develop in the Snohomish River basin, for example, in Monroe or North Bend. As residential growth occurs on both sides of the floodplain, the relative attractiveness of floodplain lands for intensive economic development will rise, not only for basic industry but also for urban related service developments (such as shopping centers). Clearly, the resolution of this matter in specific terms is a function of the overall level of development in the region and the actions of government with respect to development on the floodplain. Current programs and regulations could inhibit such intensive employment centers (alternative sites above the floodplain are abundant). Given the seemingly widespread commitment to the prevention of floodplain development (for a variety of reasons), it seems safe to assume that through the study period that the floodplain will not be the location of much intensive economic development--particularly if nonstructural approaches are emphasized in managing the flood hazard.

Demographic Forces

This region has traditionally had significant inmigration, although the level has been subject to considerable fluctuation over time. Thus, in considering future population levels in the central Puget Sound region, both in the short run (1992) and the long run (2012 and 2042), we should anticipate continued inmigration to our relatively attractive environment which does have significant capacity to absorb population growth. Only partially offsetting this inmigration is the decrease in the natural population growth

*There is currently 500-year flood protection in the Green River Valley, assuming the levee system will contain a 12,000CFS flow.

rate because of lowered fertility. These lowered fertility rates may be a short-run phenomenon, but it is also clear that the longer term impacts of current demographic trends are to lower the need for new housing twenty to thirty years in the future, and therefore somewhat slowing the expansion geographically of the urban system into the Snohomish River basin.

Residential Preferences

The very rapid population growth rates shown in Table 5-2 for the areas located in or proximate to the Snohomish River basin are a reflection, in part, of many American's historic preference for a pastoral residential setting. While the suburban boom of the post-World War II era may have been fueled by relatively low cost transportation between residences and workplaces and federally promoted low cost household mortgage programs, even now in an era of much higher transportation costs and skyrocketing housing construction and financing costs we still see considerable new construction in suburban or exurban locations. The shift of the national job structure towards the servicessector has given people more job location flexibility as many of these service sector jobs are quite decentralized (and key employers are also selecting some suburban locations--such as Weyerhaeuser corporate headquarters in Federal Way).

Scholars are divided on the question of the geographical impact of the anticipated much higher energy costs for travel, and the very high costs of new single family housing relative to the average family income level. The theory of land rent suggests that as transportation costs become higher that settlement densities should increase, but with smaller cars and public transit offsetting these increased costs to some extent, density substitutions may not occur. On the other hand, developers realize that their construction and infrastructure costs are lowered in denser developments, which may reduce land absorption rates per capita. There may also be some gradual increases in settlement densities in existing metropolitan centers, which may also lead to somewhat diminished "greenfield" land absorption rates. Offsetting this force is the relatively low cost of land in outlying locations, which may lead to large lots and low residential densities.

Very long run forecasts of population levels in King County prepared by the county indicate a possible doubling of the population in the next century. If this were to occur with settlement densities approximating those already characteristic of the region, it is quite clear that the Skykomish River Basin would be as much a part of the urban system as Bellevue is today. Already we see the beginnings of this urbanization process in areas such as Cherry Valley and Lord Hill. If this type of urban growth does occur, then the valley floodplain would have increased attractiveness as open space/parkland <u>and</u> as a location for service centers. King County policy calls for the systematic acquisition and development of a system of parklands as the urban system expands, and as has been reported in Chapter IV, county policy also calls for the preservation of agricultural lands and the prevention of development on lands with environmental hazards. Thus, from a long-run perspective, the floodplain in the Snohomish River basin may have significant open space/urban parkland value. It may be that development of the floodplain for park use may be compatible with periodic flooding as part of a nonstructural management strategy.

Although the value of the valley will undoubtedly increase as open space/parkland from the perspective of adjacent residents over time, current federal and local policies are sufficiently restrictive regarding occupance as to deter much additional housing, as was shown in Table 5-3 for the recent past. If these policies continue, if no flood protection is provided, and if emerging local government land management strategies (such as the King County revised comprehensive plan--General Development Guide) "stick", then it seems unlikely that there will be major residential development on the floodplain in either the short-run or the long-run. Stated alternatively, existing regulations seem to be maintaining and capable of maintaining the status quo with respect to residential development over most of the study area (North Bend and Snoqualmie may be exceptions), and without major changes in governmental programs weakening existing flood hazard avoidance programs or structural actions conferring a significant degree of hazards protection, it seems safe to assume that there will be negligible residential development on the floodplain.

Transport Corridors

The Snohomish River basin region is currently outside the high-speed transportation system of the central Puget Sound region. While Interstate 90 passes along the southern boundary of the region, and U.S. 2 passes through its northern boundary, access is not easy today from towns such as Duvall or Carnation into the employment core of the central Puget Sound region. However, as urban type development spreads eastward (if history is any guide), transportation systems will be upgraded in the Snohomish River basin. Earlier proposals for another "ring" freeway, east of Interstate 405 are currently dormant, and it may well be that future urban growth will not have highways of the type that have proliferated over the past 25 years associated with it.

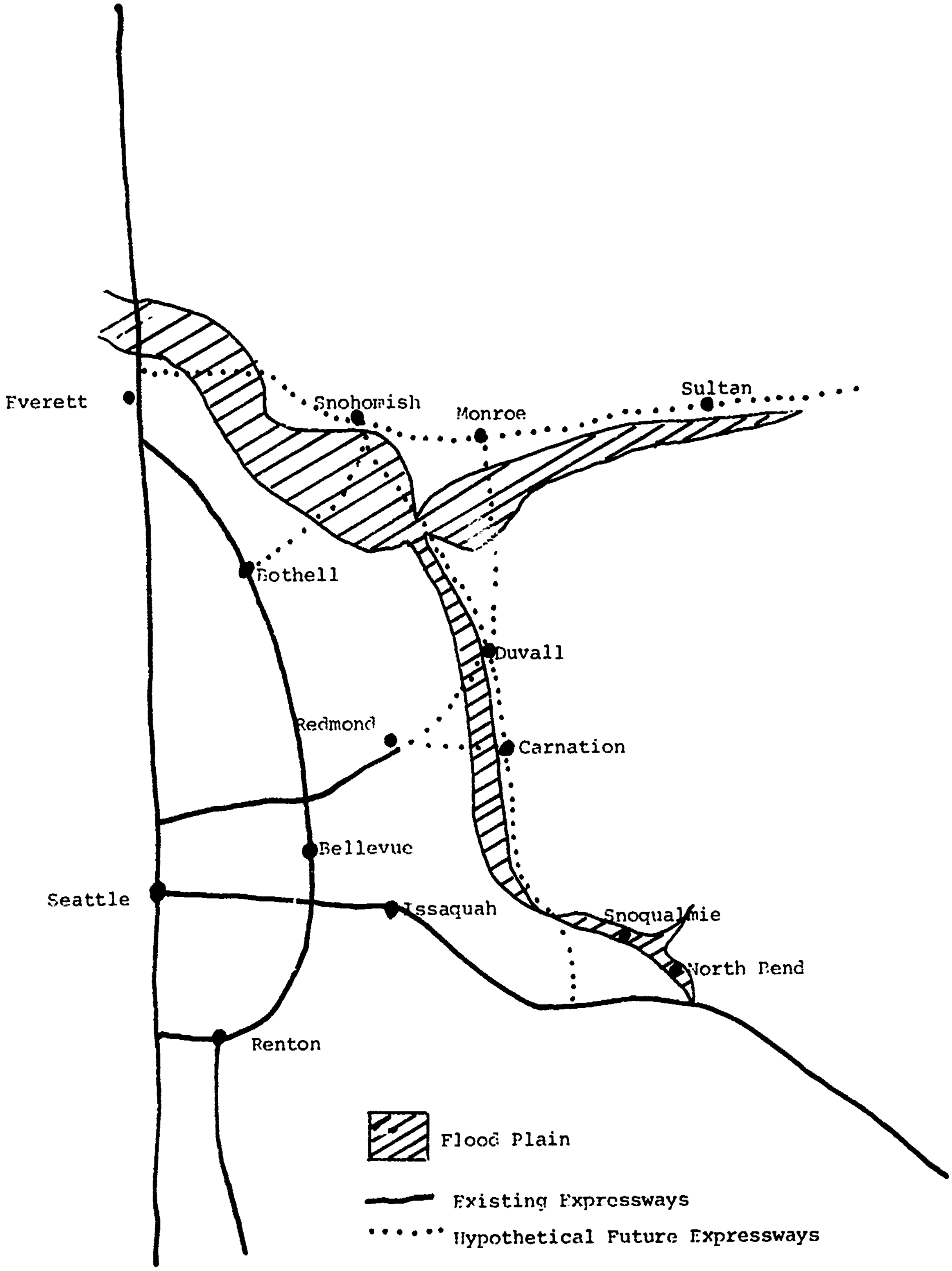
It seems more likely to assume that as the metropolitan area expands, that the highway system in the Snohomish River basin will be gradually improved, increasing the accessibility of the area to other parts of the metropolitan region, and simultaneously fostering development of the area.

The existing corridor of SR 203 may be upgraded in the long-run into a four-lane highway, and connected with radials running out from existing freeways in the metropolitan area (such as SR 520). Map 5-6 illustrates a possible scenario for a system perhaps 30 years into the future. Floodplains or lands immediately adjacent to them have often been utilized as the location for such highway facilities (for example in the Green River valley and part of the route of I-5 through Seattle), and it is possible that such a strategy could be followed in the long-run development of the Snohomish River basin. The siting of such major facilities is not entirely a local government matter, but is rather the primary responsibility of the State government and possibly the federal government. Given the key role that such facilities play in shaping and conditioning the timing of development, consideration should be given to their location vis-a-vis the floodplain and other governmental programs regarding its management.

Public Policies

Chapters II and IV have outlined in detail various governmental policies as they pertain to the floodplain in the Snohomish River basin. There is no need to recapitulate these policies here. However, it should be stressed that there are many other general programs of government at all levels which will impinge upon and do impact the development of this river basin; these programs are not discussed elsewhere in this document. It should be evident from this brief overview of growth prospects that current policies are strongly aimed towards the diversion of economic development from the floodplain. But these policies are fragile in a long run perspective, for they do not have attached to them the implementing mechanisms which will guarantee that the floodplain will remain undeveloped.

MAP 5-6.
PRESENT AND HYPOTHETICAL FUTURE EXPRESSWAY SYSTEM.



It should be emphasized that our track record has not been good in the use of zoning as a method of defining land uses in metropolitan regions over long periods of time. As metropolitan systems evolve, we have changed our minds about how specific parcels should be managed. In particular, as market forces have worked to increase the value of specific parcels, we have gradually allowed them to become absorbed in the increasingly complex urban system. The only open space that we have retained in urban systems is that which we have acquired in fee simple as part of a regional park system.

As we turn to the Snohomish River basin, it is clear that without protection from flooding the urban development scenario just outlined is not likely to include the floodplain, as the risk of flood damage would tend to be too great for most urban development. However, it should be pointed out that current programs to deter development have only been in place for a few years, that policies of local governments regarding management of the floodplain are of recent origin, and that current planning frameworks call for the periodic revision of land use plans. The forecasts of local planning agencies are also short-run from the standpoint of analyses conducted by agencies such as the Corps of Engineers. While PSCOG projections extend out twenty years, Corps analyses are required to extend forward 100 years. This discrepancy in planning horizons highlights the discontinuity also possible in policy. The fact that local governments "replan" every decade or so their long range comprehensive plans allow for considerable flux in their goals and objectives in comparison to the requirements imposed on agencies such as the Corps for planning and forecasting.

Short Run

Current policies (as cataloged in Chapter IV) will probably be similarly articulated in a decade. Assuming federal floodplain management programs remain in effect, and assuming that the King County agricultural lands acquisition program moves forward and is extended (either by additional local funding or federal funding) to include more of the Snoqualmie River basin in reach 2 and a similar program is launched in reach 1 in Snohomish County, then it seems safe to assume that the open space qualities of the region will be similar in 1992 and 1980. Modest residential/urban development may be anticipated in reaches 3, 6 and 8. If King and Snohomish counties acquire development rights to lands adjacent to existing municipalities in reaches 1 and 2, then annexations of these lands would probably be precluded by these municipalities. These areas would still be beyond the sewered areas served by the METRO system in King County. However, the lands adjacent to the floodplain will be more strongly tied to the Central Puget Sound region urban system than today, as residential development spreads eastward, and as low order service centers are constructed or expanded to serve the needs of this growing population. The most likely places for such business expansion would be the existing town centers.

2012: Medium-Run

Within 30 years it seems likely that significant residential and commercial growth will have occurred in areas adjacent to the floodplain. Associated with this growth will have been several planning cycles of local governments. Significant annexations and incorporations will probably have taken place, and the area will probably be serviced by sewerage systems. The impact of these changes on policies regarding the floodplain very much depends upon how the complex set of institutions discussed in Chapter 2 and 4 respond to the management of the flood hazard. It is conceivable that current policies will remain in effect, and that the area will retain its pastoral character. However, if society decides to undertake a program of structural protection for this floodplain, or to floodproof developments on it (a policy scenario quite different from those prevailing today), then it is quite likely that urbanization will occur on part of the floodplain as a natural economic response to the provision of flood hazard protection.

2042: Long-Run

Sixty years into the future it is even more likely that urban development will have been significant on areas adjacent to the floodplain, including some of the currently more remote parts of reaches 6 and 8. The impact of these developments on floodplain land management policy are even harder to visualize than for the medium-run. If the floodplain lands are brought into public or quasi-public ownership, then it seems likely that by this time significant portions of the floodplain would serve an open space/ parkland function for the surrounding settlements--but again only if the public managing agencies choose to utilize these lands for such purposes. In the long run, it may become even more attractive to provide significant flood hazard protection, and utilize the floodplain intensively. Clearly, there are many options available to society in the long run, and even if the most hazard-prone lands are publically acquired, at present it is not possible to forecast shifts in governmental attitudes about the management of this land. This conclusion is not begging the question of what is going to happen: it is a recognition that we change our minds about how we want to use lands over long periods of time in human settlements.

CHAPTER VI

FLOOD LOSSES IN THE SNOHOMISH RIVER BASIN: CURRENT AND FUTURE

This chapter provides an overview of flood related losses and problems in the Snohomish River basin floodplains. Flood damages to existing floodplain development are discussed first. Different categories of damages are discussed at the basin level and in detail by river reach. The next major section of this chapter deals with flood losses due to future development, and is by its nature more general and less geographically specific than for existing development. This chapter provides the basis for application in the following chapter of nonstructural measures to meet the primary purposes of reduction of future flood losses to existing and future floodplain development.

FLOOD LOSSES DUE TO EXISTING FLOODPLAIN DEVELOPMENT

Table 6-1 shows estimated annual average damages to existing floodplain development in the Snohomish basin by damage category. All damage figures have been supplied by the Corps of Engineers, Seattle District. Their reliability varies by reach and damage category. At the time of this study, a recent detailed study of residential damages had been done for reach 3. On the other hand, the only reach 2 data available were based on field studies completed some years ago, and updated for this analysis. All of the damage projections are of a probabilistic nature and should not be taken too literally.

These estimates are based on damage data from historical floods and flooding depth-frequency probabilities. Major damage categories are agricultural and emergency aid, each accounting for about 30 percent of total

TABLE 6-1. EXPECTED ANNUAL FLOOD DAMAGE IN SNOHOMISH RIVER BASIN, BY DAMAGE CATEGORY

(1980 dollars)

DAMAGE CATEGORY	$1000	% OF BASIN
Agricultural	1615	27.5
Emergency Aid	1678	28.6
Residential	1058	16.0
Industrial/Commercial	657	11.2
Roads, bridges, public	558	9.5
Other	307	5.2
Total	$5867	100.0

Source: Corps of Engineers.

basin flood damages. Agricultural damages due to flooding include crop losses, damage to farm structures, and losses to equipment, livestock, stored crops and feed, and fences. Also included are damages to lands due to erosion and sedimentation. Emergency aid expenditures are primarily for flood fighting, evacuation, and levee restoration. Damages in residential, commercial, and industrial categories account for nearly another 30 percent of total damages.

Table 6-2 disaggregates total basin estimated annual average flood damages by river reach. Damages are concentrated in the reaches 1 and 2, where two-thirds of basin flood damages occur. It should be noted that damages by reach are a function of the land use in specific reaches. The smaller reaches (3, 4, 5, 6 and 7) in the middle and upper Snoqualmie valley account for 28.4 percent of basin damages when taken together.

Each reach has different existing flood damage problems. Table 6-3 shows the percentage breakdown by reach within each damage category of annual average damages. Agricultural damages are notably concentrated in the lower reaches of the river (1 and 2), as are emergency aid expenditures. Residential damages are concentrated in the towns of Snoqualmie and North Bend (reaches 3 and 6). Commercial and industrial damages occur primarily in the estuary near Everett (reach 1) and at the Weyerhaeuser mill near Snoqualmie (reach 5). Damages to infrastructure are relatively widely distributed among reaches.

The lower reaches of the river system are the most damage prone, accounting for two-thirds of the total average annual damages. This region is largely agricultural in nature. Most of the rest of the damages occur in the urbanized and industrialized portions of the floodplain above Snoqualmie Falls, primarily in the towns of North Bend, Snoqualmie, and

TABLE 6-2. EXPECTED AVERAGE ANNUAL FLOOD DAMAGES IN SNOHOMISH RIVER BASIN, BY REACH

(1980 Dollars)

REACH	$1000	% OF BASIN
1	2106	35.9
2	1812	30.9
3	662	11.3
4	68	1.2
5	279	4.8
6	426	7.3
7	26	.4
8	488	7.9
TOTAL	5868	100.0

Source: Corps of Engineers

TABLE 6-3. PERCENTAGE BREAKDOWN BY REACH WITHIN EACH

DAMAGE CATEGORY OF EXPECTED AVERAGE ANNUAL DAMAGES

SNOHOMISH RIVER BASIN

(1980 Dollars)

DAMAGE CATEGORY	REACH 1	2	3	4	5	6	7	8	BASIN-WIDE
Agriculture	39.2	56.5	0.1	0.2	--	(*)	(*)	3.9	100.0
Emergency Aid	58.2	21.5	4.8	0.2	0.2	11.5	*	3.3	100.0
Residential	10.4	15.3	39.3	0.6	0.3	17.7	0.6	15.9	100.0
Industrial/ Commercial	47.0*	--	5.1	0.8	41.1*	2.2	1.9	2.1**	100.0
Roads & Bridges; Public	9.0	42.7	19.4	8.6	0.4	3.8	1.0	15.4	100.0
Other	21.4	39.7	6.5	0.4	0.1	2.8	0.1	28.9	100.0

*Mostly industrial

**all commercial

(*) less than 0.1 percent

Source: Corps of Engineers

at the Weyerhaeuser mill near Snoqualmie. Reaches 4 and 7 are relatively damage free, and are in a more nearly natural environmental condition than other reaches subject to flood damages.

Major expected annual average damage estimate by reach and by damage category are:

Reach	Damage Category	Amount
2	Emergency Aid	$ 980,300
2	Agricultural	912,700
1	Agricultural	633,600
3	Residential	415,600
2	Emergency Aid	360,300
1	Comm/Industrial	307,800
5	Industrial	269,600
6	Emergency Aid	193,200
6	Residential	187,500
8	Residential	168,000

Actual damages in the Snohomish River basin incurred in the December 1975 and January 1976 floods are shown in Table 6-4. These events are the largest recent floods in the basin, being about the 10 to 20 year frequency flood, depending on location in the basin. Damages in reach 1 were compounded by the failure of dikes and the pumping station of the French Creek PL-566 Soil Conservation Service project.

Following is a description of flood damages in individual river reaches.

Reach 1

Estimated average annual flood damages in reach 1 are the greatest of all reaches in the Snohomish basin. Table 6-5 shows that emergency aid and agricultural damages are the largest damage categories in reach 1. Much of the emergency aid expenditures are due to failures of extensive levee systems along the Snohomish River. Photograph 6-1 shows the French Creek project area, typical of intensive agricultural development in reach 1. The French

TABLE 6-4. ACTUAL FLOOD DAMAGES IN THE SNOHOMISH RIVER BASIN

IN THE DECEMBER 1975 AND JANUARY 1976 FLOODS

DAMAGE CATEGORY	$1000 in 1976 dollars		
	SNOHOMISH (REACH 1)	SNOQUALMIE (REACHES 2-7)	SKYKOMISH (REACH 8)
Emergency Aid[a]	4,609[b]	516	142
Agriculture	3,537	760	125
Residential	1,039[c]	375[d]	425[e]
Roads and Bridges	935	293	23
Commercial/Industrial	708	154	29
Bank Erosion	500	172	250
Railroads	338	7	1
Public Utilities and Facilities	106	82	34
TOTAL	11,772	2,359	1,029

[a]Includes levee restoration, evacuation, and flood fighting.

[b]$3,825,000 for levee restoration.

[c]Damages to 237 homes.

[d]Damages to 176 homes in Snoqualmie.

[e]Damages to 130 homes in Sultan and Monroe.

Source: U.S. Army Corps of Engineers, Seattle District (1977).

TABLE 6-5. EXPECTED AVERAGE ANNUAL FLOOD DAMAGES IN REACH 1,

BY DAMAGE CATEGORY

(1980 Dollars)

DAMAGE CATEGORY	$1000	% OF REACH
Emergency Aid	980	46.5
Agricultural	634	30.0
Industrial	308	14.6
Residential	109	5.2
Roads & Bridges/Public	50	2.4
Other	25	1.2
TOTAL	$2106	100.0

Source: Corps of Engineers.

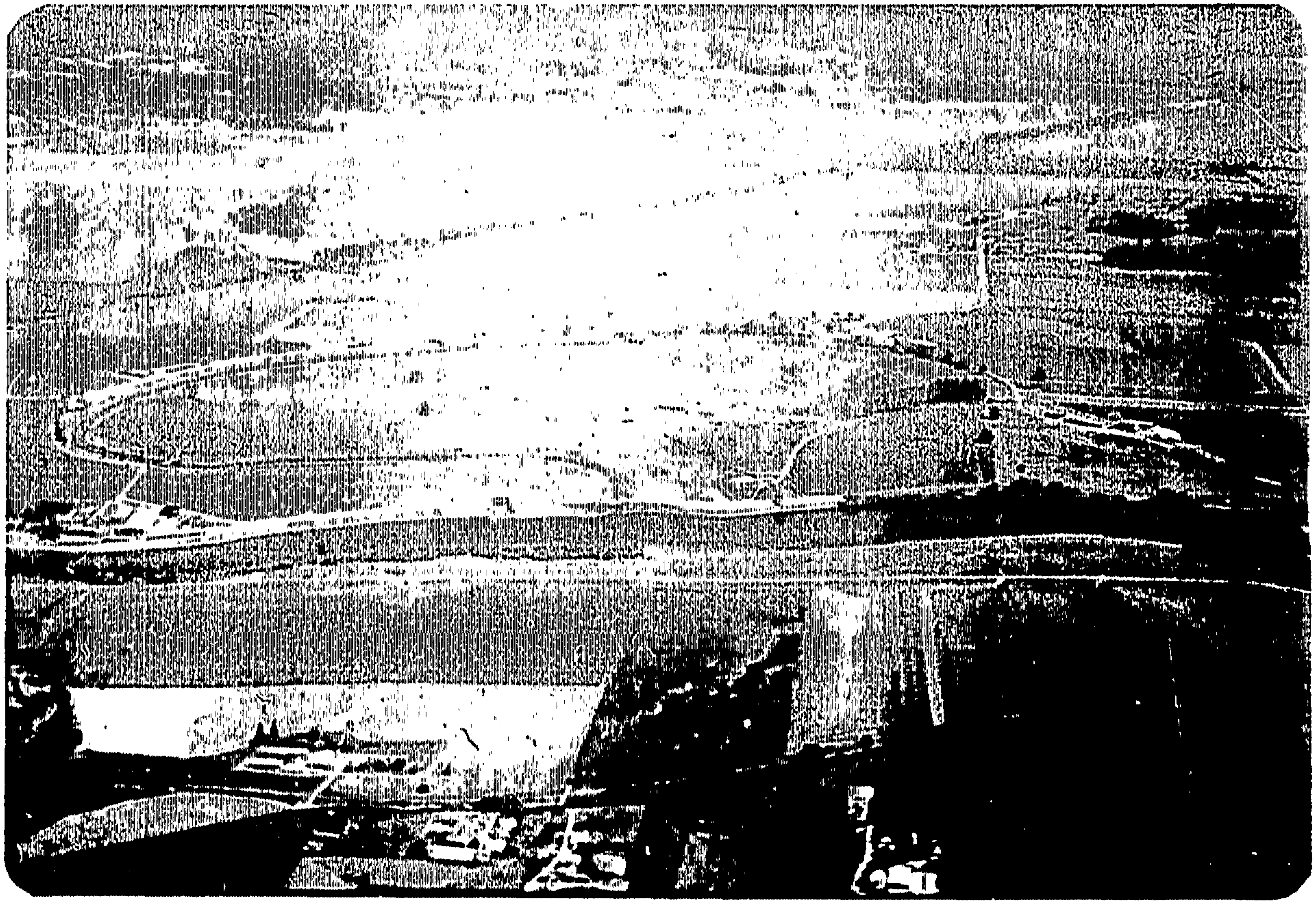


Photo 6-1 French Creek Project Area Across Snohomish River

Creek levee failure in the 1975 flood led to large livestock losses and emergency aid expenditures. Agricultural damages from the 1975 flood are broken down as follows:

Livestock	44[1]
Land	23
Crops	15
Buildings and fences	12
Machinery and trucks	6

Industrial damages are incurred on the east and north sides of the City of Everett. Residential damages are to homes located at Ebey Island and south of the town of Snohomish.

Reach 2

About 50 percent of all flood damages in the lower Snoqualmie valley are to agriculture, as shown in Table 6-6. The $912,700 annual average damages to agriculture in reach 2 may be broken down as follows based on records of high frequency floods:

Livestock	15[1]
Crops	52
Land	11
Buildings and fences	12
Equipment	10

Damages to crops are also incurred during the spring flooding season.

There are residential damages in reach 2, which were included in earlier COE reports with agricultural damages. An estimate of these residential damages has recently been developed, and studies are currently in progress to update these estimates. Residences appear potentially damageable near Fall City, at Spring Glen (an unincorporated community of 30-40 homes just

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[1] Livestock damages include loss of life and milk production.

TABLE 6-6. EXPECTED ANNUAL FLOOD DAMAGES IN REACH 2
BY DAMAGE CATEGORY

(1980 Dollars)

DAMAGE CATEGORY	$1000	% OF REACH
Agricultural	912.7	50.4
Residential	161.1	8.9
Emergency Aid	360.3	19.9
Roads and Bridges/ Public	238.0	13.1
Other	140.0	7.7
TOTAL	$1812.0	100.0

Source: Corps of Engineers.

north of Carnation, and in the area from Duvall north to the junction of reach 1 and 8. Photograph 6-2 shows a large house, a newer residence on the riverbank in the Spring Glen area (near Carnation). Many houses in this area are likely on higher ground within floodprone areas or have been built with the first floor elevated and may therefore be surrounded and isolated by flood water, but not receive damage. Results of current studies will help define the residential flood damage hazard in this reach.

Reach 3

The largest flood problem (to existing development in reach 3 is residential damage in the town of Snoqualmie, as shown in Table 6-7. The magnitude of the problem is caused by susceptibility to high frequency floods as well as the less frequent 50 year and greater events. Some houses in the town of Snoqualmie experienced damage in January 1975, December 1975, December 1977, and December 1979. Photograph 6-3 shows the community of Meadowbrook which is highly susceptible to frequent flood damage. Commercial damage is much less significant, although the fact that much of the town floods in a 10-year event could be a significant disruption to business. Other damages that occur include public and utility damages.

Reach 4

Flood damages to existing development in reach 4 is very low. Principal developments susceptible to flood damage include the Mt. Si Golf Course, a petroleum products distribution facility, roads, and railroads.

PHOTOGRAPH 6-2. NEWER RESIDENCE
ON SNOQUALMIE RIVERBANK
IN SPRING GLEN AREA

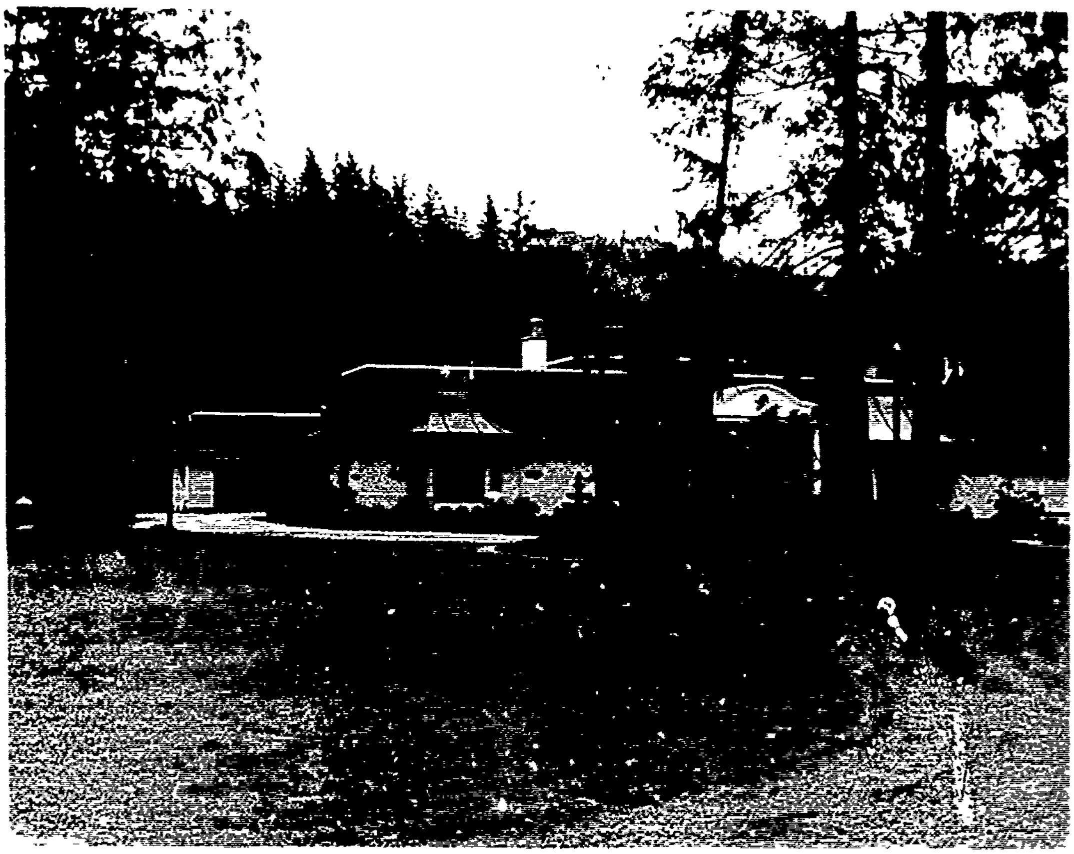


TABLE 6-7. EXPECTED ANNUAL FLOOD DAMAGES IN REACHES
3, 4, 5, 6, AND 7

(1980 Dollars)

	REACH									
	3		4		5		6		7	
DAMAGE CATEGORY	$1000	%	$1000	%	$1000	%	$1000	%	$1000	%
Residential	416.0	62.8	7.0	9.6	3.0	1.2	186.0	43.7	6.8	25.9
Industrial/ Commercial	33.0	5.0	5.0	7.6	270.0*	96.7	14.0	3.3	12.2	46.4
Roads & Bridges/ Public	108.0	16.3	48.0	71.5	2.0	0.8	21.0	4.9	5.4	20.5
Emergency Aid	80.0	12.1	4.0	5.3	3.0	1.2	193.2	45.4	0.6	2.3
Agricultural	2.0	0.3	3.0	3.8	--	--	0.1	0.0	0.8	3.0
Other	23.0	3.4	1.0	21.	0.2	0.1	10.0	2.3	0.5	1.9
TOTAL	662.0	100.0	68.0	100.0	278.8	100.0	426.0	100.0	26.3	100.0

*All Industrial

Source: Corps of Engineers.

Photo 6-3 Meadowbrook Community in Town of Snoqualmie

Reach 5

Reach 5 is different from the rest of the basin in that nearly all flood damages are industrial (in part due to definition of the reaches). Most of the area in reach 5 is occupied by a Weyerhaeuser sawmill and support facilities. Flood losses incurred by the mill are physical damage to the plant, employee wage losses, loss of plant output and raw material (log) input.

Reach 6

Flood damages in reach 6 are primarily to residential structures located on the north and east sides of North Bend and subject to flooding from the Middle Fork of the Snoqualmie River. Significant emergency aid expenditures are also incurred in this reach. Existing commercial and industrial structures in North Bend are outside the 100-year floodplain, but would sustain damage during a larger flood. Actual damages from the December 1975 flood (about an 11-year frequency event in reach 6) were $490,000 for emergency aid (mostly levee repair and restoration), $19,400 to residences and contents, and $4200 to public roads, bridges, and buildings.

Reach 7

Flood damages along the North Fork are only 0.4 percent of total annual average damages in the basin. Most of these damages are to a holly growing operation (shown in Photograph 6-4) situated between the North Fork and the Middle Fork about one mile upstream from their confluence. Actual damages from the 1975 flood (slightly less than a 5-year frequency event in this reach) were $4000 to roads and bridges and $2000 to agriculture.

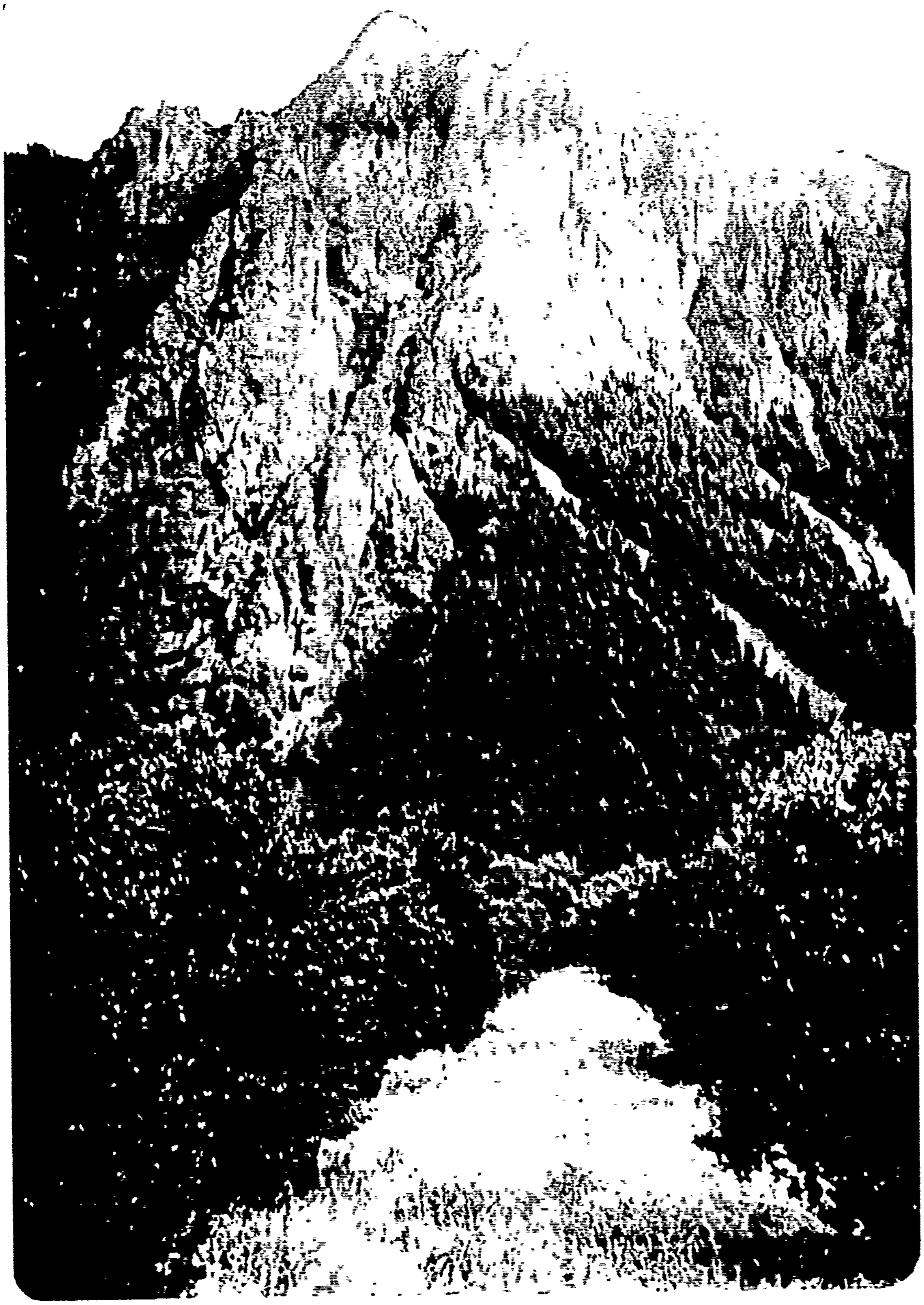


Photo 6-4 Holly Farm Along North Fork With Mt. Si In Background

Reach 8

Estimated average annual damages along the Skykomish River are shown in Table 6-8. Residential damages in Monroe and Sultan, damages to roads, bridges, and utilities, agricultural damages, and emergency aid expenditures are the largest categories. The relatively large "other" category is mainly bank erosion damage. Agricultural damages are broken down as follows:

Buildings	53%
Land	19
Crops	16
Livestock	10
Fences	2

For the "braided channel" subarea of reach 8 (from Sultan to Gold Bar including areas south of Sultan and southeast of Gold Bar), expected average annual damages have been estimated as:

Residential	$ 50,900
Agriculture	9,600
Emergency Aid	7,300
Roads	6,900
Commercial	3,600
Other	200

Damages from the 1975/1976 floods during which areas adjacent to the Skykomish, the Tualco Valley, and the western portion of the Sultan commercial district were inundated are shown by damage category in Table 6-4.

Future Flood Damages

Estimates of future flood damages by damage category and reach were not available to us at the time of this study. In order to assess the probable nature of changes in damages, we made an evaluation which is certainly subject to revision. We started with forecasts of future land use acreages provided to us by King County for reaches 2 through 7, and then judgementally developed estimates of future land use for reaches 1 and 8. We assumed that

TABLE 6-8. EXPECTED SKYKOMISH RIVER AVERAGE ANNUAL FLOOD DAMAGES IN REACH 8
(1980 Dollars)

DAMAGE CATEGORY	$1000	% OF REACH
Residential	168.0	34.4
Roads & Bridges/ Public	85.0	17.4
Agricultural	64.0	12.9
Emergency Aid	56.0	11.5
Commercial	14.0	2.9
Other	102.0	20.9
TOTAL	488.0	100.0

Source: Corps of Engineers.

the level of future flood damages was probably a function of the number of acres in each damage category. We also assumed that the Mediated Agreement was not in effect; King County supplied us with two sets of future land use figures: with and without the Mediated Agreement. The without scenario presumably embodies continuance of existing goals and objectives regarding floodplain management.

Table 5-1 indicated acreages of land use for 1980 by reach in King County, and Tables 6-9 and 6-10 are the King County estimates of future land uses without the Mediated Agreement. Analysis of these tables reveals modest changes in land use, with stability in the acreage of agricultural land, and slight increases in the amount of residential, commercial, industrial, and public acreages, particularly in reaches 3-6. Coefficients were developed relating these anticipated acreages to present acreages; these coefficients are presented in Table 6-11. For example, in reach 2 residential acreage is forecast by King County to increase from 250 acres in 1980 to 285 acres in 2041, an increase of 14%. Thus, the coefficient in Table 6-11 is 1.14. It was assumed that the vacant land category had zero damages, that public acreage was related to infrastructure damages, that agricultural, residential, commercial, and industrial were directly related to the flood damage categories with the same names. Factors for changes in emergency aid levels were related to the anticipated intensities of structural development in each reach. Given these coefficients, current (1980) damage levels in each reach were projected to 1992 and 2042. The results of these computations are shown in Tables 6-12 and 6-12. For Snohomish County we assumed that land use change in reach 8 would mirror change in reach 2. For reach 1, we tried to relate coefficients of land use change to recent trends, and to county policies.

TABLE 6-9. 1991 LAND USE - WITHOUT MEDIATED AGREEMENT - RIVER REACHES

LAND USE CATEGORY	1	2	3	4	5	6	7
Vacant	2,884	4,185	345	1,105	450	905	180
Public	1,060	470	75	165	25	55	60
Agricultural	19,800	8275	60	340	10	75	140
Residential	240	255	295	15	10	205	30
Commercial	85	5	25	0	0	0	0
Industrial	1,722	5	0	15	225	0	0

Source: King and Snohomish Counties.

TABLE 6-10. 2041 LAND USE - WITHOUT MEDIATED AGREEMENT

	REACHES					
LAND USE CATEGORY	2	3	4	5	6	7
Vacant	4170	330	975	415	850	150
Public	470	75	165	25	55	60
Agricultural	8275	60	320	10	75	140
Residential	285	295	15	10	260	60
Commercial	5	40	0	0	0	0
Industrial	5	0	65	260	0	0

Source: King County.

Note: Snohomish County did not estimate 2041 land use for Reaches 1, 2, and 8.

TABLE 6-11. COEFFICIENTS OF LAND USE ACREAGES WITHOUT MEDIATED AGREEMENT
1991 AND 2041 COMPARED TO 1980

	1	2	3	4	5	6	7	8
Vacant	0.66 0.66	1.0 .99	.99 .94	1.01 .87	1.01 .91	.93 .87	.92 .77	1.0 .99
Public	1.0 1.0	1.0 1.0	1.0 1.0	1.14 1.14	1.0 1.0	5.5 5.5	1.09 1.09	1.0 1.0
Agricultural	1.05 1.05	1.0 1.0	1.0 1.0	1.0 .94	1.0 1.0	1.0 1.0	1.0 1.0	1.0 1.0
Residential	1.33 1.4	1.02 1.14	1.0 1.0	1.0 1.0	1.0 1.0	1.14 1.44	1.5 3.0	1.02 1.14
Commercial	1.06 1.06	1.25 1.0	- 2.0	- -	- -	- -	- -	1.0 1.0
Industrial	1.4 1.4	(to 5 ac.) 5	- -	1.0 4.33	.98 1.18	- 1.18	- -	- -
Est. Aid Coefficient	1.02 1.15	1.02 1.15	1.2 1.75	1.0 2.0	1.0 1.1	1.2 1.2	1.2 1.75	1.02 1.15

Reach 8
Assume by
extrapolation
from Reach 2

Note: The upper coefficient in each cell refers to the year 1991, and the lower coefficient refers to the year 2041.

Tables 6-12 and 6-13 indicate modest increases in damages over the next decade and half-century. Current policy regarding the preservation of agricultural lands is reflected in stable damage values. Tables 6-14 and 6-15 summarize the changes in damage levels by damage category and reach, respectively. These projections suggest that most increases in damages will be associated with residential development in reaches 3 and 6, inclusive of the supporting infrastructure and induced emergency aid expenditures.

How realistic are these estimates? Probably not very realistic, for they fail to take into account all kinds of changes in agricultural technology, changes in urban settlement systems, changes in the nature of urban infrastructure, etc. However, they will have to serve us for working purposes. Their general stability with respect to present damage levels suggests that if current policies remain in effect for the forseeable future, the most promising nonstructural approaches to flood damage reduction are those that reduce current damages, as future damage potential is forecast to increase only modestly. However, this conclusion could be wrong if its premise is violated: that current policies remain in effect through the forecast period. Chapter V has already discussed in detail how contingent this matter is upon the future quasi-predictable nature of development and the many opportunities which we will have to change our goals and objectives for the management of the region over the next 20 to 60 years via the planning process.

It is our opinion that the King County figures underestimate the amount of future development on the floodplain (without the Mediated Agreement scenario), particularly near the existing towns of North Bend, Fall City and Carnation. Although we did not have complete estimates from a government agency of anticipated land use change in Snohomish County, our c n extrapolation procedures (which mirrored King County's projections) probably

TABLE 6-12. EXPECTED 1992 FLOOD DAMAGES (WITHOUT MEDIATED AGREEMENT) DERIVED BY APPLYING COEFFICIENTS TO 1980 DAMAGES (1980 Dollars)

	REACH								
	1	2	3	4	5	6	7	8	Total
Agricultural	665.7	912.7	1.9	2.6	-	0.1	0.8	63.0	1646.8
Emergency Aid	999.9	367.5	96.4	3.6	3.4	231.8	0.7	57.1	1760.4
Residential	145.0	164.3	415.3	6.5	3.4	213.8	6.9	171.4	1126.6
Industrial/ Commercial	431.0	-	41.6	5.2	264.2	14.4	12.2	14.0	782.6
Infrastructure	-	238.3	108.1	55.2	2.2	115.5	5.9	85.0	610.2
Other	75.3	139.9	22.8	1.4	0.2	9.8	0.5	102.0	351.9
TOTAL	2316.9	1822.7	686.1	74.5	273.4	585.4	27.0	492.2	6278.6

TABLE 6-13. EXPECTED 2041 FLOOD DAMAGE (WITHOUT MEDIATED AGREEMENT) DERIVED BY APPLYING COEFFICIENTS TO 1980 DAMAGES
(1980 Dollars)

	REACH								
	1	2	3	4	5	6	7	8	Total
Agricultural	665.7	912.7	1.9	2.4	-	0.1	0.8	63.0	1646.6
Emergency Aid	1127.3	414.3	140.5	7.2	3.7	231.8	1.1	64.4	1990.3
Residential	152.6	183.7	415.6	6.5	3.4	270.0	20.4	191.5	1261.7
Industrial/ Commercial	431.0	5.0	66.6	22.5	318.1	14.4	12.2	14.0	883.8
Infrastructure	-	238.5	108.1	55.2	2.2	115.5	5.9	85.0	610.2
Other	75.3	139.9	22.8	1.4	0.2	9.8	0.5	102.0	352.0
TOTAL	2451.9	1893.9	754.9	95.2	327.6	641.6	40.9	519.9	6744.6

TABLE 6-14. EXPECTED AVERAGE ANNUAL FLOOD DAMAGES IN SNOHOMISH RIVER BASIN, BY DAMAGE CATEGORY (1980 Dollars)

	1980	1992	2042
Emergency Aid	1,678	1,760	1,990
Agricultural	1,615	1,647	1,647
Residential	1,058	1,127	1,262
Industrial/ Commercial	657	783	884
Roads & Bridges, Public	508	610	610
Other	352	352	352
TOTAL	5,867	6,279	6,745

TABLE 6-15. EXPECTED AVERAGE ANNUAL FLOOD DAMAGE IN SNOHOMISH RIVER BASIN, BY REACH

(1980 Dollars)

REACH	$1000		
	1980	1992	2042
1	2,106	2,317	2,452
2	1,812	1,823	1,894
3	662	686	735
4	68	75	95
5	277	273	328
6	426	585	642
7	26	27	41
8	488	492	520
TOTAL	5,867	6,279	6,745

understate residential floodplain growth in and near Monroe and Snohomish, and industrial development near Everett. It seems likely that these and other municipalities will want to expand their boundaries on the floodplain as urban growth takes place above the floodplain near them (particularly in reaches 1, 2, and 8). If large tracts of floodplain lands remain in private hands (because programs like the King County agricultural development rights acquisition program fail to acquire all existing farmlands), including much presently wooded land, it seems likely that some of these tracts would be annexed to municipalities. Some of this land could be filled for development, particularly on the flood fringe. If communities like Snoqualmie and North Bend (or Snohomish County) delay for many years the articulation of a "regular" federal flood hazard insurance program, these opportunities for annexation and development are enhanced. The cumulative effect of the development of residential/commercial/industrial activities on already platted lands on the floodplain, the filling of floodfringe in municipalities for urban/land uses, and annexations which allow even more urban development, could be to significantly raise damage levels above those forecast here. Even if structures implied by such development were floodproofed, some residual damages can be expected, and induced damages to infrastructure and for emergency aid and assistance could be anticipated.

Offsetting this trend of increased damages via new development, will be the gradual replacement of existing damage prone structures by buildings in compliance with FIA mandated regulations. Some existing structures may be abandoned, may burn down, etc., and not be replaced. This should cause damage levels related to existing development to slowly decline. The rate of decline will depend on the housing replacement and/or removal rate and the effectiveness of regulation and design of new structures. At the same time as residential damages decline for the reasons just stated, emergency preparedness costs may go up.

CHAPTER VII

NONSTRUCTURAL PROGRAMS TO MITIGATE FLOOD DAMAGES IN THE SNOHOMISH RIVER BASIN

The preceding chapters have outlined concepts generally regarded as nonstructural approaches to flood damage prevention. It has been emphasized that these concepts are complex and grade into one another, and involve elements which may be regarded locally as "structural." Many nonstructural programs have already been identified which are already in various degrees of implementation in this river basin. However, some of these programs are at present piecemeal or less effective than they could be. Current damages have been reviewed, and some possible future courses of development for the floodplain have been discussed. We now turn to more specific recommendations for nonstructural programs in this river basin.

Major uncertainties presently surround the application of these nonstructural concepts to the Snohomish River basin. Nonstructural approaches are by their very nature subject to myriad interpretations as to precise definition and intensity of application. Existing programs could be strengthened or weakened without statutory change in regulatory programs of affected governments. The historical record of damages is not perfectly constructed. All of these factors make the assessment of suggested future programs difficult.

It is quite clear to us at this juncture that it is relatively difficult to apply traditional methodologies for the assessment of flood damage reduction via structural approaches to many nonstructural concepts. Many Corps of Engineers documents echo this conclusion. Yet, nonstructural concepts to seem to be promising approaches to flood damage reduction, as will be detailed shortly for the study region. Site specific conditions seem much more influential in the quantification or even the ordinal ranking of the effectiveness of particular nonstructural approaches than is the case for structural solutions to flood damage problems.

In this chapter, we discuss problems existing in each reach of the floodplain under study, and then discuss what appear to us to be promising strategies for dealing with these problems in each reach. We then turn to the articulation of the most promising strategies in each reach, including a discussion of data needed to more precisely evaluate the effectiveness of the proposed actions and implementation responsibility. This analysis is followed by a discussion of approaches which seem to have basin-wide significance. It should be recognized that attempts to find basin-wide strategies which may be "easy" to "promote" may defeat the inherent logic of a nonstructural approach: each place may have its own unique combination of strategies which best serves its problems. Thus, it is not easy for us to sort out simple "fixes" which may be arrayed distinctly as alternative management strategies. Our suggestions for basin-wide strategies may either be obvious approaches which would yield flood damage reductions to even a cursory student of the problems, or tney may be concepts which will be properly applicable to only limited regions after much further study throughout the basin.

REACH 1: LOWER SNOHOMISH RIVER

A. Overview

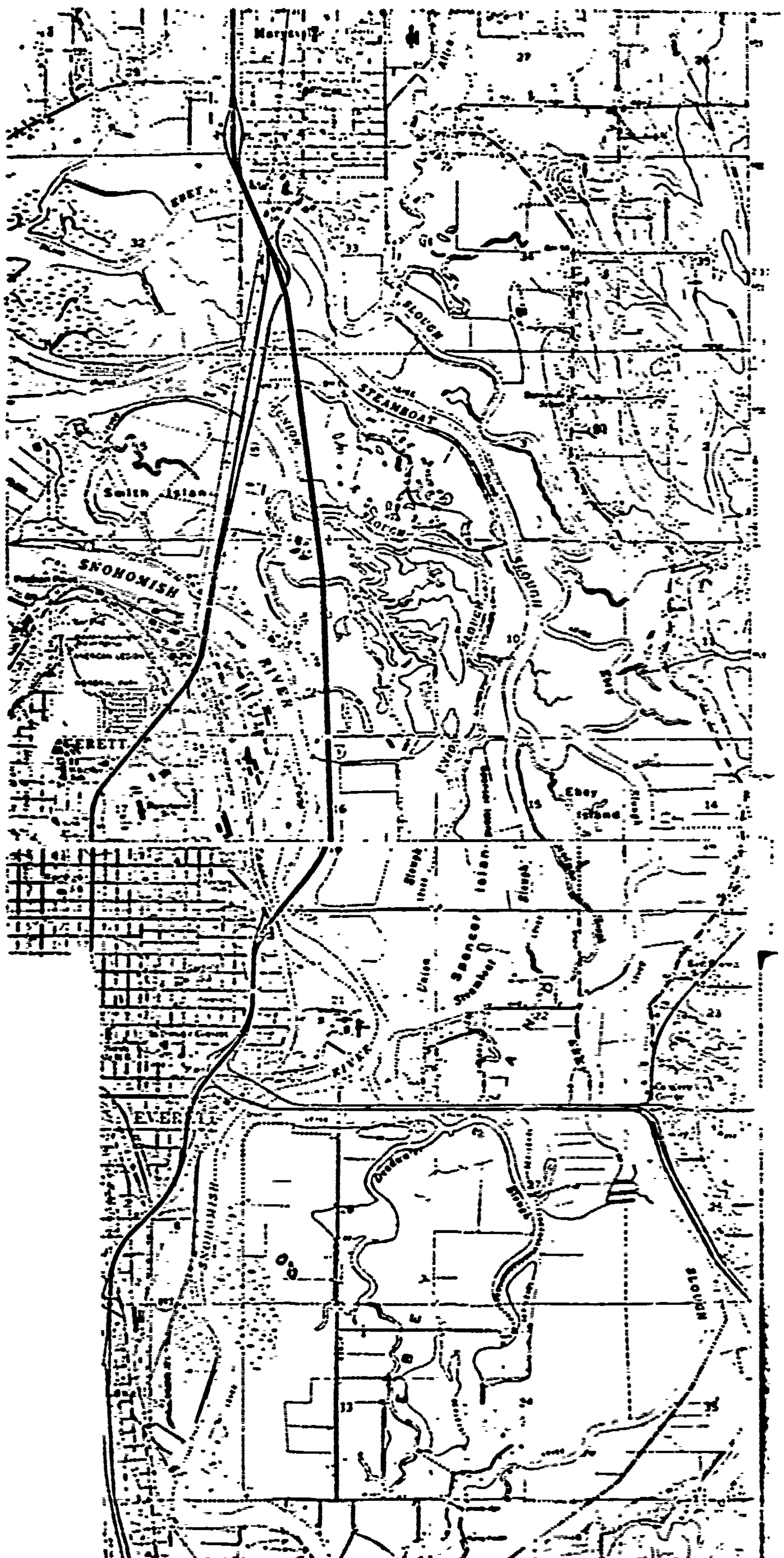
In reach 1 the floodplain from Fiddler's Bluff to the river's mouth is a broad expanse of land almost entirely flooded in a 10-year flood event. Structures and land use activities are inundated with flood currents or with backwater, both of which frequently incur severe damage to property.

Table 6-5 presented data on expected average annual flood damage in this reach. These damages total $2.1 million, with emergency aid expenditures accounting for almost one-half of the total outlay (46.5%). Agricultural damages account for another 30% of the total, and are followed by industrial (14.6%), residential (5.2%), and "other" (3.6%) damage. Most of the emergency aid expenditures are directly or indirectly associated with agricultural land uses which predominate this reach of the river.

While residential development in the floodway has been effectively halted (see Table 5-3), there exists the continuous presence of homes in immediate danger of flood destruction. The majority of homes are concentrated on Ebey Island (see Map 7-1), and most are in "below-standard" condition.

Diking and drainage districts were created and developed starting in the late 1800s. They have helped to make agriculture economically feasible in the estuary by eliminating tidal inundation, reducing seasonal flooding, and enabling the creation of new land by filling and/or draining. Diking and drainage activities have resulted in substantial economic development of the floodway which has been supported by public flood disaster aid. In effect, the publically supported diking and drainage districts have increased potential property damages during flood events.

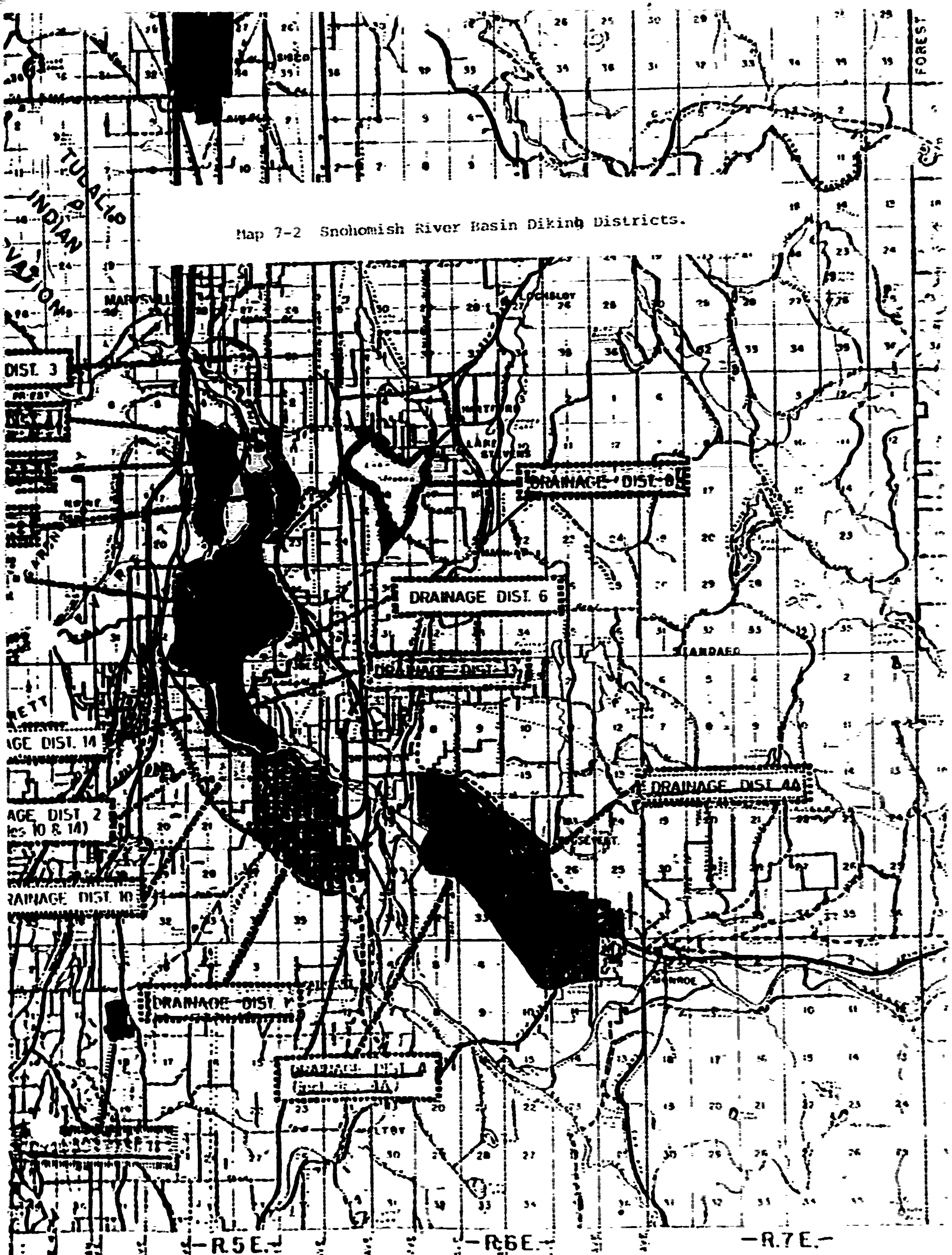
MAP 7-1. Structures located along the Ebey Island river bank in the Snohomish Estuary.



It should be recognized that these structural programs have also degraded significant amounts of estuarine habitat. Map 7-2 shows the location of these districts. There appears to be little coordination between districts, and many levees have variable heights and qualities which affect the utility of other nearby levees. Table 7-1 details the Snohomish River's diking and drainage systems.

Another problem in this reach is a hydraulic bottleneck which exists along Dike District #13, which causes agricultural damage. Constricted flow backs up as far as the French Creek area and overflows District #13 downstream. In the December 1975 flood the bottleneck put too much hydrostatic pressure on the improperly designed levee at French Creek, causing failure of the structure. Perhaps proper engineering has corrected this event from reoccurring, but it would be best to relieve the situation entirely. Almost every year homes are flooded along district #13; two homes were lost in 1975.

The other major flood event problem within reach 1 is the impact of past estuarine development on the hydraulic floodway and flood fringe. Attempts to fill lowland to qualify for flood fringe land use has occurred in the recent past. "Hog fuel" has been spread on Spencer Island. Large sewage settling ponds and considerable commercial and industrial development on Smith Island and the Tulalip Fill have also effectively displaced flood water. These activities have raised the flood fringe which negatively impacts Ebey Island during flood events. In addition, the flow of flood water is such that it "bounces" off the Rt. #2-West Ebey area and flows northeasterly across Ebey. This has the effect of severely inundating the residential area of Ebey and the more easterly side of the estuary with current water. The westerly side of the estuary is inundated to a lesser extent with backwash water (see map depiction).



Map 7-2 Snohomish River Basin Diking Districts.

TABLE 7-1. SNOHOMISH RIVER LEVEE/DIKE/DRAINAGE SYSTEMS, SNOHOMISH COUNTY

Organization	Area Protected (acres)[1]	Length Levees (miles)[2]	Maximum[3] flow river levees will withstand (cfs)	Probable recurrence of flooding in districts (years)
Diking Imp. Dist. #1	2,962.2	13.1	59,000	< 2
Diking District #2	523.4	2.3	80,000	3
Diking District #3	411.1	1.0	160,000+	80
Diking District #4	158.2	1.2	80,000	3
Drainage District #1	2,964.3	-	-	-
Drainage District #2	1,979.2	-	-	-
Drainage District #4	5,068.13	-	-	-
Drainage District #4A	3,986.3	-	-	-
Drainage District #6	553.6	2.4	50,000	1
Drainage District #7	877.2	-	-	-
Drainage District #12	1,786.6	-	-	-
Drainage Imp. Dist. #13	563.0	2.°	59,000	< 2
French Creek Flood Control District	5,676.0	4.4	125,00	10
Marshland Flood Control District	5,936.1	8.6	70,000	2
Private Dikes[2]	(1,717)[4]	24.6	Variable	Variable
Totals	33,446.0	67.9		

Sources: [1]Snohomish County Planning Dept., 6/28/78.

[2]Corps of Engineers, 1969. Snoqualmie River, Washington Report on Flood Control and Other Improvements, v. 1.

[3]Discharge of river at stage 1 foot below lowest sections of levees (Snohomish guage at Snohomish).

[4]Not included in total since acreage from Corps probably in later organized districts.

Level B Study: Snohomish River Basin Resource Management Project, Vol. II.

B. Opportunities for Flood Damage Reduction

Existing Damages

Floodproofing Existing Residential Structures

Residential structures are currently subject to considerable damage in this reach. Residential damages are concentrated on Ebey Island, and south of the town of Snohomish. Damage potential is great at a mobile home park located near Snohomish along SR 522.

These damages could be reduced by either floodproofing these structures *in situ* or by their relocation or demolition. A trial evaluation for a similar set of houses in Reach 8 indicates that floodproofing *in situ* by elevating structures, constructing ring levees around selected homes, or relocating contents subject to damage were cost-effective in most cases (see Appendix I). This finding is probably applicable to the structures subject to flood damages in this reach.

All residences and non-commercial farm operations of less than 5 acres should be evaluated for relocation out of the floodway. This could be done in a number of ways, including:

1) fee simple purchase

2) fee simple with leaseback (if an appropriate use of the land without permanent residence is sought).

3) demolition of "below-standard" housing and reconstruction of housing for those displaced; "good-quality" homes could be relocated.

4) relocation of displaced homes could be done through Sec. 73 funding, preferably using DNR lands to relocate on, perhaps in trade for DOI lands elsewhere.

5) conservation easements could be purchased from the private property owner in the floodway, who has relocated, but still owns the floodway land. One type of easement program with the DNR might include revegetation of the land with a managed crop of red cedar and fuel wood.

Floodproofing Agricultural Structures

Maintenance of agriculture as a viable business is most important when considering the relocation of farm homes. Farm homes which can not be proximally relocated out of the floodway should be floodproofed, with specific flood contingency and preparedness plans on the part of the owner.

1) ring levees around the home and other important structures

2) elevate the home above flood level

3) relocate contents within home and other structures

4) change farming methods, e.g., prohibit livestock operations via purchase of livestock easement

5) (or) require livestock mounds

6) provide technical assistance information and ensure owners informed and prepared to handle potential flood events

7) have a specific, county approved, plan of action for dealing with flood event on farm, including anticipation of contingencies such as dike-breaching

Floodproofing Mobile Homes

The mobile home park adjacent to the bridge at the Skykomish and Snohomish confluence presently contains about 57 units (see Photograph 7-1). The secluded location may offer tremendous amenities but unfortunately is too close to the river to avoid flood damages. The facility could easily be relocated (2A), and should be moved to higher ground. If zoning regulations are in effect to prohibit such incompatible facility siting, they should be enforced; if not, regulations should be promulgated (6B).

An evaluation was made of the costs and benefits of relocating the mobile homes found in this reach. Please see Appendix I for details on this computation.

Photo 7-1 Trailer Park Along Snohomish River Downstream from SR 522 Bridge.

Information and Education

It is evident from reading the journal on the 1975 winter floods* that residents and farmers were caught totally unprepared for a flood magnitude which was experienced on the floodplain only 15 years earlier. Residents, farmers, and business people interviewed along the Snohomish River remarked that they were worried about suffering damage of equal or greater magnitude in the future. However, the county assessor indicated the market for floodplain housing improves with time after the memories of the flood fade. A comprehensive information and education program for dealing with a flood event on an individual level should be applied at least within the reach #1 area.

Specific contingency plans should be drawn up and approved by the County Office of Emergency Services. Flood information should be distributed prior to title transfer in real estate transactions. The staff of the Office of Emergency Services in Snohomish County needs to be enlarged; currently one persons serves the entire county.

Cattle Mounds

Much of the economic agricultural activity that takes place in this reach concerns livestock: dairy and beef cattle operations, horse and poultry farms. Livestock damages are highest on the broad floodplain areas where upland evacuation is not immediately available, and where levee breaching brings rapid inundation. Consequently, many animals drown or die from exposure and disease. To alleviate this situation in the future, the simplest and most cost-effective solution is to design a cooperative or private program for elevated lands, or "cattle mounds". The estuary, Marshland region, and French Creek should be studied for siting/construction of such

*Corps of Engineers, 1977. Report on Floods of December 1975 and January 1976. Seattle District, WA USACE, 1977.

artificial uplands which could be built with loans from the Dairyman's Foundation, Department of Agriculture, or Sec. 73 funds. Seasonally flooded agricultural lands are shown on the USF&W habitat maps. Inundation severity could be correlated with the present type of farm operations for specific sites, and then evaluated for cattle mound construction.

Protection, Relocation of Utilities

The city of Everett and suburbs adjacent to the Snohomish River have experienced power shortages due to damage from high water. The impacts of these shortages included production and business losses from closing down industrial and commercial operations, as well as inoperable traffic lights. Protection or relocation measures should be taken to correct this situation.

Management of Existing Flood Control Measures

A number of dikes have been constructed in this reach to help minimize existing flood damages. In addition, many homes are already elevated to provide flood damage protection. However, much of the costs of emergency aid in this reach are associated with the repair of dikes during flood events, as was dramatically illustrated in the 1975/1976 floods. It is possible that these existing dikes and levees need better maintenance, which would help improve their stability. In addition, the proliferation of dikes in this reach of the river on a small scale basis may be exacerbating the effectiveness of larger flood control dike systems. An assessment of an optimal system of dikes in this reach of the river should be considered, including possible breaching of improperly located dikes or construction of new dikes in more appropriate locations if existing dikes are found to be mal-located.

Existing floodproofed structures (raised structures) may be subject to excessive damages because of improperly located contents, placed there after floodproofing. An inspection program could help reduce the risk of damage of this type.

2. Reduction of Future Damages

While Snohomish County has not yet provided projections of future land use in this reach without the Mediated Agreement, our analysis of current land use trends in this reach suggests that there is significant pressure to convert estuarine lands into industrial/commercial land uses, and that urbanization pressures are significant on and near Ebey's Island, near Snoqualmie, and near Marysville. Snohomish County has enunciated policies calling for the preservation of farm land, but does not yet have a program as aggressive as King County for acquisition of development rights to the most endangered parcels. In addition, Snohomish County and towns in this reach have not yet developed a "regular" federal flood hazard insurance program, with its associated implementing mechanisms. Data presented in Table 5-3 illustrate the effectiveness of such programs in halting building on the floodplain.

Flood Hazard Insurance Programs

Future damages may be reduced by the expeditious completion of a "regular" federal flood hazard insurance program for this reach, in Snohomish County and in the municipalities abutting the floodplain. Strong floodplain zoning which prohibits development to the maximum possible extent which would be subject to flood damages should accompany the completion of these programs, and be enforced stringently.

Purchase of Development Rights

Snohomish County should explore the desirability of an agricultural lands preservation program along the lines of that adopted by the voters of King County. While such a program appears to have negligible opportunities for the reduction of flood damage in the short-run, the long-run open space benefits of such a program may be associated with the reduction of flood damages. This matter is discussed in detail within section B. of the analysis of reach 2, and will not be repeated here.

Fee-Simple Acquisition

The estuary (Delta Lobes region) may have significant multiple-use water resource values, which could include future flood damage prevention benefits if the area were acquired in fee simple by state or local government. Annexation pressures are severe here in the long run, as the town of Marysville and city of Everett seek to expand their commercial/industrial acreages, and as the Tulalip Indians seek development opportunities for their lands. Recent trends of land fills and annexations in this area highlight this problem. These pressures are highlighted by the crazy-quilt pattern of land-use designations in this part of the reach, a matter discussed later in this section. If these trends continue, and more filling occurs, and the floodway is even more constricted than it is now, then not only would water levels tend to rise in the estuary (possibly increasing damages to existing development there), but such obstructions would also tend to block the passage of upstream floodwaters into Puget Sound, thereby causing greater upstream flood damages. Public acquisition of this land and retention of it in a natural condition would help avoid these problems, thereby helping reduce future flood damages. Other multiple-use values would also be associated with such acquisition programs, including recreational, fisheries, and wildlife values. The natural valley storage function of this portion of the estuary may also play a role in preventing future flood damage.

Upstream from the estuary, there may be other places where development pressures in the long-run would make it desirable to purchase land in fee-simple today for multiple-purpose water resources management reasons and for regional use as a part of a developing urban system. Snohomish County is encouraged to attempt to articulate a long-run plan for land use in this reach (say for the year 2041), which evaluates land use on the floodplain within the context of the estimated urbanized or still rural surroundings of the floodplain. Public land ownership strategies should be included in such an assessment, and the role that such a public land ownership program would play in reducing future flood damages should also be assessed.

Vegetation Managment

Protection and revegetation of riparian areas should be considered throughout this reach. Its importance, similar to wetlands, cannot be underestimated. Large lowland woodlots may serve as a flood water storage are (NVS), but this concept is most relevant in reach 1 for stream bank stability, fish and wildlife habitat values, management as a timber crop (cedar and fuel woods), and potentially as a guide for flood water current flow.

Historically, riparian vegetation covered the entire floodplain upstream from the confluence of Ebey's Slough and the Snohomish River. Agriculture is a relatively new landuse which started in the mid-1800s. The common agricultural practice of farming to the streamside bank without leaving a riparian buffer is detrimental. For bank stability, conservation of farm soils, and fish and wildlife habitat values, a minimum of 30'-200' riparian margin between tilled soil and stream edge should be maintained throughout the river basin. This could easily be established in many areas through the following programs:

1) conservation easement program
2) zoning
3) purchase fee simple
4) set-back levees
5) appropriate levee maintenance
6) state and federal woodlot incentive programs
7) other positive revegetation incentives for private owners
8) education and information

Riparian vegetation should be complementary with levee construction and management, not excluded. The Washington State Department of Game recommends that the entire length of levees, especially potential or historical weak spots, be planted with fibrous or densely-rooted vegetation (such as willow or vine maple) to avoid over-topping water from eroding and breaching*. Such a management program would also provide an important edge-zone for wildlife.

Unused lands, classified as "vacant", may be an excellent source for revegetating for riparian woodlots. Such woodlots could be managed for a relatively quick return from rapid fuel-wood growth and harvest, in addition to a much longer-term red cedar crop. Other lands, such as Areas of Environmental Concern/Importance (SEWS, 1979) may be acquired or have conservation easements purchased which would enable a restoration program that includes riparian revegetation (e.g., restoration of riparian wetland via dike breaching). Cathcart Gap is the largest contiguous riparian association within the reach and has important habitat and NVS value. Riparian vegetation within the estuary of reach 1 has especially high habitat values, serving as an important ecological transition (or edge) zone between water, wetlands, and open fields, as well as providing shade for juvenile fish. Thus, restoration/revegetation is more easily justified here from an environmental quality perspective than perhaps anywhere else in the basin, although flood damage reduction benefits may be negligible from such a program.

A novel use of riparian vegetation as a non-structural alternative would be as a guide for floodwater flow. This should be explored further for its potential use to "channel" and distribute floodwaters more evenly over Ebey Island. It would simply require a thick stand of trees which provide significant resistance to moving water at strategic locations

*Washington Department of Game, Habitat Management Division. These suggestions were made in a report prepared by T. Jelson entitled, "Suggestions for Streambank Revegetation in Western Washington," 1980.

(much like a jetty).

Inconsistencies in Land Use Designations

An assessment of land use designations and development trends is needed to design programs which steer economic development in a direction that reduces or minimizes flood hazards and is compatible with the natural systems values of this reach of the river basin. In this context, regulatory and policy constraints are important, including the adoption of suitable flood fringe designation. The potential exists for major land use conflicts in the Snohomish estuary by virtue of the inconsistency of zoning, comprehensive plans, jurisdictional policies and land use designations. Of the 20 estuary wetlands, only two, Maulsby and the Ebey Game Refuge, are protected by reasonably consistent land use policies. The rest, either wholly or in part, are not recognized for their habitat value by local jurisdictions or bodies involved in land use planning.

Table 7-2 provides a summary of land use designations of sites by the various managing authorities in the estuary. The most important conflicts are for the following parcels:

Mid Spencer Island

N. Ebey North

N. Smith Island

Evey Island

N. Ebey Tip

Mid Spencer Island is presently zoned rural use under the Snohomish County Shoreline Program (SMP), allowing a variety of activities that have substantial impact on habitat values. The Snohomish-Lake Stevens Comprehensive Plan designated the area "wetland".

TABLE 7-2. INCONSISTENCIES IN PLANNING DESIGNATIONS

Snohomish Estuary -- Plans and Designations

REVISED

Parcel	Location	Snohomish County: Zoning	Comp. Plan	SMP	Shapiro -USACE	Snoh. Med. Agreement	Port of Everett	Everett	Tulalip Tribe	DNR	Marysville
1	Otter	Ag*	W	C	AI	MA	ND	-	-	-	-
2	N Ebey	Ag*	W	C	AI	MA	ND	-	-	-	Urban* (partial) Urban*
3	N Ebey N	-	-	U*	AI	Dev*	ND	(-	( )	-	
4	Quilceda	-	-	C	AI	Partial*	ND	-	C	( )	C
5	N Ebey Tip	-	-	U*	AI	No*	ND	-	( )	( )	( )
6	N. Smith	LI*	W	Urban*	AI	Yes	ND	-	-	log*	-
7	Highway 2	Ag*	W	C	AI	Yes	ND	-	-	-	-
8	Mid Spencer	Ind-Ag*	W	Ru*	AI	Yes	ND	-	-	-	-
9	Maulsby	-	-	-	AI	No*	( )	C	-	-	-
10	Sunnyside	Res*	W	R*	AI	No*	( )	-	-	-	-
11	Jetty	-	-	-	AI	No*	FD* (South)	Mu*	-	( )	-
12	Jetty Mudflats	-	-	-	AI	No*	FD* (Partial)	W-ND	-	Park-Partial log*	-
13	Entrance Mudflats	-	-	C	AEC	Partial*	ND	( )	?		-
14	Ebey-Game	Ag	W	N	AEC	Yes	ND	-	-	-	-
	Ebey A	Ag*	Ru*	R*	AEC	No*	ND	-	-	-	-
	Ebey B	Ag*	Ru*	R*	AEC	No*	ND	-	-	-	-
	Ebey C	Ag*	Ru*	R*	AEC	No*	ND	-	-	-	-
15	Cavalero Corner	Ag*		C	AEC	No*	ND	-	-	-	-
16	Lowell	-	-	-	AEC	No*	FD* partial	Urban* partial Urban*	-	( )	-
17	Weyco	-	-	-	AEC	No*			-	(logs*)	-
18	Tulalip	-	-	C	AEC	-	ND	-	Res. Commer.	( )	-
19	Dikes of Concern	Ag	Ag-W	R-C*	AEC	No*	-	-	-	?	W
20	Maulsby Flats	-	-	R-C-N	AEC	No	-	-	-	-	?

KEY:
AI Area of Import. | PD Present Disposal Site | E Environmentally Sensitive | Ag Ag-10 Zone | ND Nondeposit Site
AC Area of Concern | FD Future Disposal Site | U Urban | Res Residential Zone | - No Jurisdiction
RU Rural Use | C Conservancy | W Wetland | LI Light Industry | MU Multiple Use
Ind. Industrial | N Natural | MA Preservation Area | R Rural | log Log Storage Area
Dev Development Priority | ? Policy not Developed

* Inconsistency in plans - designating re habitat value; preservation policy

Source: Jim Curry, Snohomish County Planning Dept.

North Ebey North   is designated urban by the Snohomish Co. SMP. As well, it is designated urban under the Marysville Comp. Plan. This parcel is categorized as wetlands by Snohomish County, but because ic is west of I-5 it is recognized as being suitable for development.

North Smith Island   is designated wetland in the Snohomish-Lake Stevens Comp. Plan and by the USACE (Shapiro). However, Snohomish County has zoned the area as "light industrial", and the County SMP designes it urban. The area is currently under private ownership by Foss Launch and Tug Co. and is used for log rafting, although Snohomish County has never issued a Shoreline Permit for that use.

Ebey Island   is not recognized as a wetland in the Snohomish-Lake Stevens Community Plan, with the exception of the State Game Refuge. This reflects a judgement that because the land is in private ownership, and because most of the acreage is riparian, regulatory protection should be less restrictive. The USACE (Shapiro) classifies this island as an Area of Ecologic Concern. We (see recommendations) propose to remove residential structures on Ebey Island while maintaining much of the present agricultural usage, and enhancing some of the land's natural systems values with riparian revegetation and wetland restoration in appropriate areas.

North Ebey Tip   is designated urban under Snohomish County's SMP. USACE (Shapiro) recognizes this wetland as an Area of Ecologic Importance. Presently the land is used for log storage under the jurisdiction of the Tulalip Tribe.

Less egregious conflicts between wetland preservation objectives and local policies persist in other areas. To a large extent, these problems stem from the inadequacy and inappropriateness of agricultural zoning by Snohomish County and its shoreline designations of rural and conservancy for wetlands.

C. Recommended Actions, Data Requirements, Institutional Opportunities

1. Reduction of Present Agricultural Damages

Livestock Mound Construction (see Figure 3-2)

This concept appears to be cost effective. We were quoted a price of $25,000 for construction of such a mound. Livestock damages are about $137,000 annually in this reach, which if spread over 30 farms would be $4,600 per farm. Thus, if this strategy were effective, in six years the investment would more than pay for itself. However, an inventory is needed of the number of farms at risk, and the cost estimate we were given needs to be evaluated more precisely vis-a-vis the farms found to be at risk. More work needs to be done on the design of such mounds. Their edges need to be properly designed to be hardened to the action of flood waters and protected from damage by the animals feet. Fencing may be necessary. In addition, mounds of this type may be used for the storage of equipment and feed, enhancing their benefits; these opportunities also need to be inventoried. We recommend that the Corps of Engineers be responsible for such an inventory and costing project, and suggest that the Corps is the most likely agency to implement such a program, which should be approached at the scale of the reach or basin as a whole in coordination with local government through institutions such as local improvement districts.

Elevated Yards for Equipment

The same type of opportunities for flood damage reduction just mentioned for livestock also appear to exist for equipment losses. We recommend a similar inventory of opportunities for equipment mounds/yards by the Corps, in association with the above-mentioned needs for livestock mounds.

Technical Assistance for Flood Preparation

At present, Snohomish County has only minimal staff available to assist those whose farms are at risk in the floodplain. An enhanced county program tied to inspections for compliance with zoning ordinances would appear appropriate. We provide recommendations on this subject at a basin-wide level later in this chapter.

Floodproof or Relocate Farm Structures

A specific assessment should be made of individual farm structures and residences where equipment could be relocated in the structures to prevent flood damage. In some cases the structures might be raised cost effectively, although we did not find existing studies which evaluated the cost effectiveness of raising structures larger than the size of residences. Ring levees may also provide adequate protection to selected structures, particularly on the flood fringe.

Dike Management

There has been a proliferation of dikes in this reach, but there is no coordinated dike management program. Such a program should be evaluated, probably as a coordinated program between The Corps of Engineers and Snohomish County. In addition, a setback dike should be constructed between Snohomish and Cathcart to reduce flood elevations here, as previously discussed. The Corps of Engineers should be responsible for the evaluation of the costs and benefits of this change in dike location. The natural valley storage benefits accruing from such a relocation need to be carefully evaluated.

A set-back dike between Cathcart and Snohomish would enable more NVS capacity and would reduce the pressure of current flow along the widened floodway, particularly at the Snohomish bend. A set-back dike would also effectively spread out the back-up water over a larger surface area, reducing the water elevation and hydrostatic pressure on the French Creek dike.

The existing river berm west of Snohomish should be lowered or breached along the river's south side between RM 10.5 and RM 13.5. This would enable more controlled local flooding, guide and spread the flow more evenly over Ebey Island, and reduce property damages. In the December 1975 flood, high velocity overflows caused numerous washouts and breaks along this river road berm, and incurred associated property damages. Proper management of the existing north shore river berm together with proper flood preparedness by the immediately affected property owners should create a better local flood management program than at present.

2. Reduction of Existing Residential Damages

Relocation of Structures

Some houses on Ebey Island and the mobile home park should be relocated outside the floodplain. A preliminary analysis we conducted suggests that the houses at risk can probably be economically relocated. We discuss these evaluations later in this chapter.

Technical Assistance

A number of existing structures in this reach are elevated or otherwise have some degree of flood damage prevention already in force. However, periodic inspection of these structures would help to reduce flood losses by noting repairs which are necessary to maintain effectiveness of the damage prevention strategies, identify property which has been placed in locations at risk, etc. Snohomish County could administer such a program.

Dike Management

See recommendations for reducing agricultural damages.

3. Present Industrial/Commercial Damages; Infrastructure

Opportunities for the relocation of equipment in forest products processing facilities or the relocation of processing facilities needs to be inventoried. Some facilities in this reach have recently been shut down (Weyerhaeuser sawmill in Everett), and care must be given to the flood damage potential of new industrial development on this site. The opportunities for seasonally varying operations of existing industries to reduce flood damage hazards is also worth careful study, including the relocation of log rafting activities off intertidal zones to reduce their adverse environmental quality impact and the losses of such logs during periods of flooding. Existing power utility flooding problems also need careful study, to see if this equipment should be elevated. The Corps and affected local governments should work together on these studies.

The elimination of lumber operations which presently inhibit flood flow over the Snohomish bend near the airport would facilitate water movement into the estuary, and this action needs study. The lumber company could be relocated to a more appropriate location using any one of the following nonstructural programs: 2A, 2B.

3. Reducing Future Incremental Damages

Residential, Commercial, Industrial

The analyses contained in Chapter 6 indicated minor increases in damage potential in this reach _if_ present regulations and policies are enforced. However, this means that Snohomish County and municipalities must finish the development of a regular federal flood hazard insurance program which, coupled with zoning ordinances, will help minimize additional construction on the floodplain. Inconsistent land use designations of state and local agencies have also been identified in reach 1, particularly in the estuary.

These inconsistencies should be remedied, recognizing the flood damage problems and environmental values of the estuary.

Acquisition of estuary lands should be seriously considered in a multiple-use framework, considering the flood damage prevention values of the natural valley storage capacity of the entire reach and the wildlife, fisheries, and recreational values of the estuary. Photograph 7-2 shows a portion of the estuary. The timing of such acquisition programss appears critical, as municipalities such as Everett and Marysville annex territory to extend their industrially zoned lands. The north edge of the estuary, which is on the flood fringe, is a current case in point, where the natural valley storage and environmental quality values may be lost via filling in this municipality for industrial development purposes. Snohomish County and the Corps, along with other state and federal agencies interested in the multiple use management of this estuary should engage in a coordinated study to ascertain which lands should be acquired by the public, and which should have their development rights for nonagricultural values purchased. The State Departments of Game, Fisheries, Parks, and Ecology appear to have an inherent interest in the environmental quality values of the estuary; Snohomish County clearly has an interest from a recreational perspective, and the Corps from the standpoint of flood damage prevention and other multiple-use water resource management values. Current studies being undertaken as part of the evaluation of the Mediated Agreement may provide the necessary basis for achievement of this recommendation. If this is not the case, we recommend that such coordinated studies be undertaken as soon as possible.

Future flood damage prevention may also be encouraged in this reach by a program of breaching of existing dikes, which would enhance the natural valley storage capabilities in this reach, and also make development on

Photo 7-2 Portion of Snohomish Estuary Delta.

the floodplain less enticing. Such a program would obviously be considered as a complement to programs of structural relocation or floodproofing of structures, livestock, and equipment already suggested to prevent current damages in this reach. The Corps is encouraged to undertake evaluations of this type.

Snohomish County is encouraged to proceed with present analyses of agricultural lands preservation programs, including the possibility of a development rights or fee-simple (and leaseback) acquisition program for lands endangered by conversion to urban/industrial/commercial uses with greater flood damage potential. This program should be tied to a long-run land use study for the flood plain in reach 1 and its relationship with the uplands adjacent to the floodplain. The open space and recreational values of the floodplain in the long run should be evaluated by the County, as part of a regional land use program which anticipates probably urban development in the medium (e.g. 2012) and long run (e.g. 2042).

REACH 2: LOWER SNOQUALMIE RIVER VALLEY

A. Overview

Reach 2--the lower Snoqualmie River valley--is a scenic agricultural area in close proximity to the Seattle metropolitan area, being adjacent to the developing East Sammamish Plateau and being within ten miles of Redmond and Bellevue. The valley is one of viable agriculture, predominantly dairy, and of small towns.

Existing flood damages in this reach, as indicated in Table 6-6, are largely related to the dominantly agricultural nature of this reach. One half of the $1.8 million expected average annual flood damages in this reach are to agriculture, while emergency aid accounts for another twenty percent of current damages. Damages to roads, bridges, and other public property accounts for 13% of current expected damages, while residential damages amount to 9% and the "other" category accounts for 8% of current expected damages.

Nonstructural measures in reach 2 would concentrate on reducing flood damages to agriculture, reducing emergency aid expenditures, limiting future residential development in flood prone areas, maintaining agriculture as the major floodplain land use, and preserving and restoring natural features.

B. Opportunities or Flood Damage Reduction

1. Existing Damages

Floodproofing Existing Residential Structures

Flood damages to existing residential structures are modest in this reach. Residential damage from the 1975 flood were small. Damage from larger floods could be significant. Current COE studies should help provide better data on these damages. However, when such data are available, the applicability of measures such as raising existing structures, relocating contents subject to flood damages in existing structures, or relocation of structures should be evaluated. The trail evaluation which we undertook for a sample of houses in reach 8 suggests that this approach is promising and frequently cost-effective. See Appendix I for a discussion of this analysis.

<u>Protection and Relocation of Transportation, Utilities</u>

Damages to roads, bridges, and utilities and public infrastructure are relatively high in reach 2. However, specific damages data were not available to suggest which specific actions could be taken to reduce these damages. Hopefully, current studies will identify opportunities for protection or relocation of these facilities which will help reduce these damages.

<u>Agricultural Practices and Farm Structural Modifications</u>

Agricultural damages in reach 2 are the highest of any category in any reach for the entire basin, with half being livestock losses and another third being crop losses. A key nonstructural element for reach 2 is the provision of contingencies for cattle evacuation from flood hazard areas during flood events, including the provision of on-farm elevated mounds (such as have been built on French Creek dairy farms downstream). Coordination with an effective flood warning program is necessary. Changing farming methods seem to offer little as a nonstructural approach to reducing crop losses in reach 2. According to discussions with the King County ASCS and agricultural extension offices, the existing farming practices of grazing dairy cattle and growing hay and silage chop are probably the best use for floodplain lands in reach 2. Changing from this use to grain crops that could be planted after the spring flooding season is probably not feasible due to growing season and lack of markets. One possibility is conversion to more flood tolerant perennial plants such as raspberries and cedar trees.

Emergency Preparedness; Maintaining Existing Flood Control Measures

Reducing emergency aid expenditures in reach 2 can be partially accomplished by implementation of any type of nonstructural measure which serves to reduce susceptibility to flooding. Measures which could act to more directly reduce emergency aid expenditures in reach 2 are 1) an improved emergency preparedness and flood warning program and 2) improved management of existing flood control levees, to reduce failures.

2. Future Damages

Purchase of Development Rights

Acceleration of the King County agricultural land development rights program appears to be desirable in this reach, particularly on the boundaries of existing incorporated and unincorporated settlements (such as Fall City). While this program may do little to prevent increases in flood damage potential in the near term (say 1992 or 2012), in the long run it may well reduce the potential for annexations into municipalities of certain parcels, and their development as commercial, industrial, or residential uses. These developments (which we now see occurring on a limited scale near North Bend, and whose development is reflected in forecasts of increased residential damages in reach 6) could be adverse from the standpoint of adjacent nonincorporated lands, which might suffer increased inundation (although within federal standards for increase).

The more subtle matter has to do with the long-run value of these lands to the citizens of King County. The current program has been viewed very much as an agricultural lands preservation program, and as such has little in the way of short-run benefits for a flood damage prevention program. If the surrounding area urbanizes, it may be in the public interest in the long-run to purchase the remaining value to some or all of these lands as part of a recreational lands or open space program. If this were done, then the multiple use potential of the land may be more fully realized, and flood damages could be diminished if existing structures were then removed, and other private sources of damage potential phased out (cattle, infrastructure, etc.). Conversion to purely open space uses might entail new public investment which could also be subject to damages, but presumably the direction of damages would be a net reduction.

Selected key sites within reach 2 (perhaps less rich agriculturally) might be purchased in fee simple for wildlife, recreation, and other environmental and open space benefits. Potential areas include Carnation Marsh, expansion of the Stillwater Wildlife and Recreation Area unit, larger areas of riparian forest at the junctions of the Snoqualmie with the Tolt and the Skykomish/Snohomish, and individual wetlands and oxbow ponds. Photograph 7-3 shows an osprey nest in Carnation Marsh and Photograph 7-4 shows the confluence of the Snoqualmie River with the Skykomish to form the Snohomish River.

The nonstructural natural valley storage concept may be applied to the lower portion of reach 2, whereby the natural water retention capabilities of the floodplain are maintained, thus benefitting areas downstream in reach 1, which incur the greatest flood losses of any one reach. On natural valley storage, the King County Flood Insurance Study (FIA, 1978, 27) states that

> ...due to the unique 'bathtub-like" floodplain of the Snoqualmie River, the community should consider enlarging the floodway to preclude possible adverse impacts from diminished valley storage after the floodway fringe becomes completely developed. The term 'bathtub-like' refers to the fact that the lower Snoqualmie River Valley, which is broad and flat, fills deeply with water during a flood and drains slowly, like a bathtub.

PHOTOGRAPH 7-3. OSPREY NEST IN CARNATION MARSH.

Photo 7-4 Confluence of the Snoqualmie, Skykomish and Snohomish Rivers

Vegetation Management

An opportunity exists for riparian vegetation management in reach 2. Much of the riverbank has been denuded by cropping as close as possible to the river and by livestock grazing and trampling. Restoration of riverbank vegetation has the benefits of reducing erosion, providing wildlife habitat, and improving fisheries.

In summary, nonstructural measures meriting further consideration for application in reach 2 are:

Livestock evacuation and mounds

Change in farming methods

Improved emergency preparedness and flood warning program

Management of existing flood control levees

Protection or relocation of transportation and utilities infrastructure

Purchase of development rights (acceleration of King County agricultural lands program)

Strong enforcement of existing zoning (including floodplain and shoreline) and development regulations

Preferential open space taxation

Fee simple purchase of selected parcels

Natural valley storage

Riparian vegetation management

C. Recommended Actions, Data Requirements, Institutional Structure

1. Existing Damages

Agriculture and Equipment

An analysis needs to be made of the number of farms at risk for which cattle and equipment mounds would provide evacuation areas above the 100-year floodplain. Specific aspects of such a program were discussed for reach 1, and will not be repeated here. This evaluation should again be undertaken by the Corps of Engineers.

Emergency Aid

The existing King County (and Snohomish County) emergency preparedness and flood warnings program needs to be improved. This would involve programs similar to those discussed for reach 1, and more specific recommendations for such programs will be discussed later in this chapter. Critical elements involve better management of existing flood damage prevention systems, and improved communications regarding specific risks on individual ownerships on a seasonal basis.

Residential

Once the present Corps of Engineers updating of residential damage potential is completed in reach 2, an assessment needs to be made of the damage reduction opportunities for modifications to existing structures or their relocation. The type of evaluation which we undertook on a trial basis in reach 8 (described in Appendix I) needs to be undertaken in this reach. The Corps of Engineers should undertake this evaluation, and consideration should be given to the formation of a cooperative program with King County (if such measures appear feasible) through the establishment of a program like a local improvement district to implement such a program of damage reduction.

Other Damages

Further studies are needed to ascertain the opportunities for reduction of infrastructure damages in this reach. Analyses also are needed of benefits which would accrue from a program of better management for the existing system of levees in this reach.

The potential for damage reduction from changes in farming methods appears limited in this reach, although certain measures may pay off on a farm by farm basis. These include possible shifts in types of crops, away from crops subject to strong damages in spring floods. The Agricultural Extension Service could work with individual farmers to devise the most effective strategies for maximizing revenue from cropped lands, while minimizing damages due to occasional spring floods.

2. Reducing Future Incremental Damages

Enforcement of Existing Zoning

We have discussed the urbanization pressures which we believe will be faced by this reach in the long-run. In the short-run, existing zoning programs must be enforced to limit new development of public and private structures on the floodplain, particularly near existing towns. King County has primary responsibility for this program, but incorporated jurisdictions must also strictly enforce their zoning codes and ensure procedures for compliance with their regular federal flood hazard insurance programs.

Purchase of Development Rights and Fee Simple Acquisition

The current strategy of King County appears to be to acquire development rights to parcels which have the greatest potential for land use conversion, but funds are insufficient to acquire all agricultural lands in this reach. A specific assessment needs to be made of the amount of land likely to be acquired under this program in reach 2 relative to lands likely to face annexation and development pressures over the next several decades.

A long-run plan needs to be developed for the role which this floodplain will play in a regional open space and park system, including the woodlands which cover a substantial portion of this reach. King County should undertake this study, possibly through the community plan process. However, the issues involved in the management of this reach are regional in scope, which would argue for the analysis to be done at a level higher than the community plan level. If King County determines that these lands have significant open space and recreational values as part of an urban system in the long-run, then maybe this finding would suggest that the current agricultural bonds program should be supplemented by additional programs of acqui...ng development rights or fee-simple acquisition with lease-back of farmland and an appropriate timber management program for the wooded areas in this reach. Additionally, land could be resold with deed restrictions on future use.

If King County finds that a program of the type outlined here is desirable, and to some extent this scenario is compatible with both the COG subregional plan and the General Development Guide, then other agencies could become involved in its implementation. Recreational values could be protected and enhanced by state funding of acquisitions through the Interagency Committee for Outdoor Recreation, or through expansion of the State Parks System. The Corps of Engineers could also help fund a multiple purpose program, in which recreation, flood damage reduction by removal of existing farming activities and prevention of future development, management of the natural valley storage capabilities of the river basin to help prevent flood damages, and enhancement of wildlife and fisheries values would become significant aspects of a management program for the floodplain.

Natural Valley Storage

The natural valley storage function of the floodplain lands downstream from Carnation to the confluence of the Snohomish and Skykomish Rivers should be maintained. This area contains considerable woodlands, and either the purchase of development rights or fee simple acquisition of the lands should be considered.

REACH 3: SNOQUALMIE

A. Overview

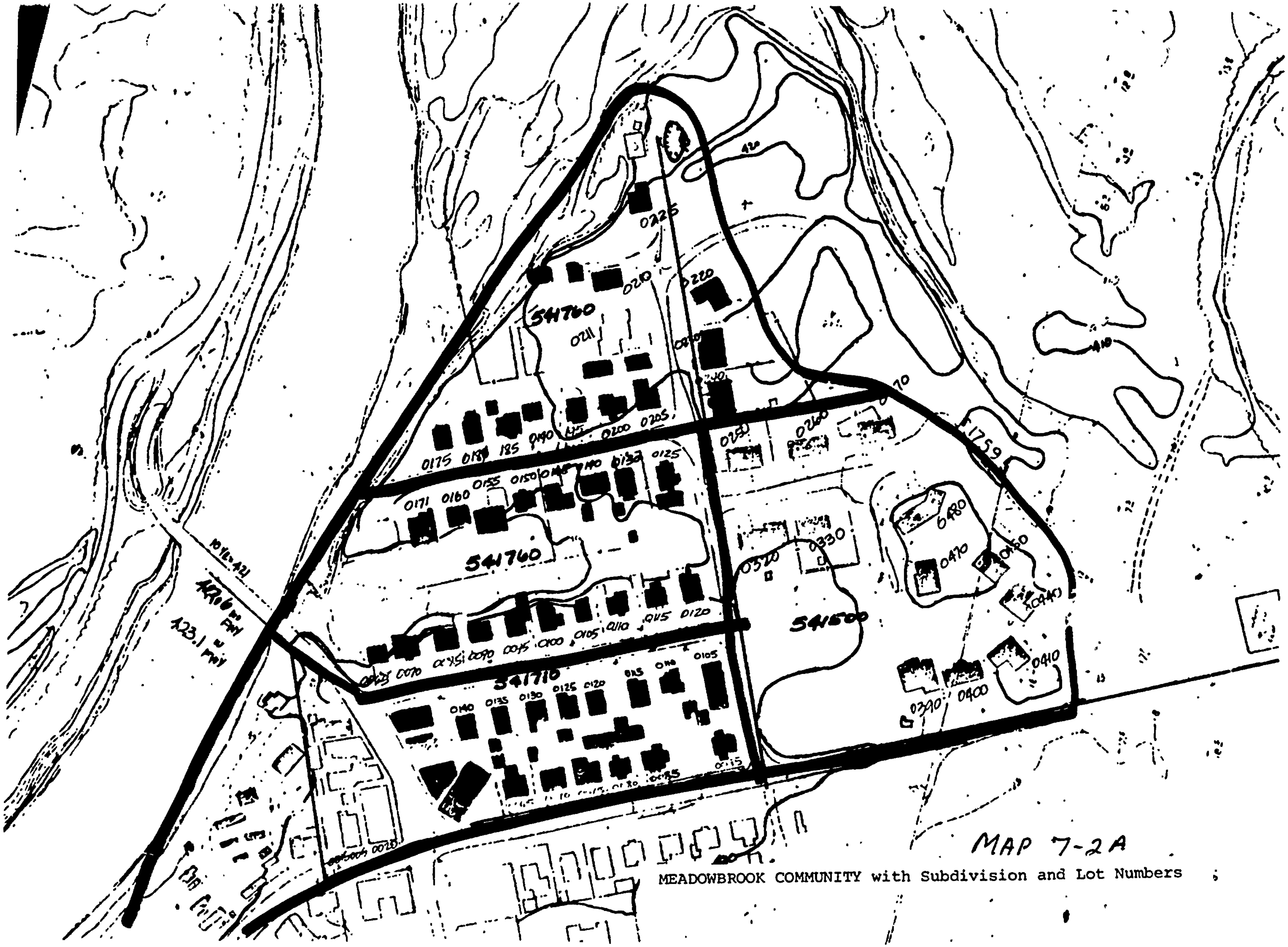
Reach 3 encompasses the town of Snoqualmie, much of which is located on the floodplain. As Table 6-7 indicated, most existing damage in Snoqualmie is to residential structures and related infrastructure. Expected average annual damages are two-thirds of a million dollars, and almost two-thirds of this figure is residential damages. Damages to public infrastructure and facilities account for another 16 percent of expected annual damages, while emergency aid accounts for 12 percent, industrial and commercial facilities 5 percent, "other" 3%, and there are negligible agricultural damages. Hence, a flood damage reduction strategy for Snoqualmie necessarily emphasizes reduction of the existing residential damages, and prevention of the expansion of residential-urban related damage potential.

B. Opportunities for Damage Reduction

1. Existing Damages

Modifications and/or Relocation of Structures

In Reach 3, homes in the Meadowbrook area were examined to determine the feasibility of techniques for reducing damage to existing residential structures (see Map 7-3 for the location of these structures). Homes examined were of two general types. The predominate house type in the Meadowbrook area is 1-story-with basement houses, generally built between 1920 and 1930. The remainder are one-story with slab floor types built between 1965 and 1970. The exact methodology and additional details of the calculation process can be found in Appendix I. The numbers provided here are examples only, and their validity depends on how well floor elevations from Jones and Associates and structure data from the King County Assessor's Office were matched up.



MAP 7-2A

MEADOWBROOK COMMUNITY with Subdivision and Lot Numbers

Raising and relocation of residential structures were both found to be viable options in the Meadowbrook area for some one-story slab-floor houses and some one-story with basement houses. Within each house type, feasibility varied with the probability of a flood above the first floor, and the assessed valuation. Benefit-cost ratios for the slab-floor houses varied between 3.2 and .80 for raising 3 feet and from 2.6 to .7 for relocation. For the one-story with basement type, ratios varied from .57 to 1.35 for raising 3 feet and relocation was not feasible due to assessed valuation and infrequent Interval of Return.
The ratios for the second group were lessened by the fact that most of the older houses in Meadowbrook have first floors at least a foot above the ground.

In addition to the Meadowbrook analysis, the Expected Interval of Return (EIR) (probability of a flood above first floor) was calculated for other parts of the reach. All calculations are included in Appendix I. Meadowbrook, along Kimball Creek, and subareas III-1-1 and III-2-1,2,3,9,10,11,12 all have some residences that look promising, based on their floor elevations and EIRs. (The above list is not all-inclusive.)

Commercial and industrial structures were not examined in the same detail as residences. Reasons include the following:

1. Structural data (such as construction type and floor area) are not available from the Assessor's Office

2. Detailed cost information of the type contained in the Baltimore District Study not found during the study period.

There may be opportunities to reduce damages to public structures in this reach by small scale structural actions. In particular, schools which are currently damaged could possibly be protected by ring levees. While this strategy does not appear to be particularly applicable to the densely settled neighborhoods in reach 3, for large relatively isolated structures like schools such an approach may be feasible. Unfortunately, cost data were not available to evaluate the feasibility of such an action, but they should be readily attainable.

Emergency Aid and Information and Education

Much current emergency aid costs in this reach appear to be related to evacuation costs for impacted residences. If structures are relocated and/or demolished, these expenditures would decline. However, they would probably continue to be incurred for residences which were floodproofed to the extent that they could not be occupied during a period of flooding.

The large stock of homes subject to flood damage in this reach suggest that a program of information and education about the flood hazard should be helpful in reducing present flood damage levels. Posting of flood depths conspicuously on telephone poles with brightly painted colored stripes related to the levels of particular flood frequencies would be a constant visual reminder of the flood risk in this reach. Information could be required in real estate contracts regarding the levels of historical flood damage to the particular structure being conveyed, and requiring the seller (or his agency) to show to the prospective purchaser the level of flood waters of the 100-year flood on the structure being conveyed.

2. Future Damages

Building Codes

One of the most important actions that could be taken in Reach 3 to avoid increased future residential damage levels is to maintain or strengthen present standards for the construction of new structures (for commercial as well as residential buildings). It should be pointed out that even a temporary lapse in the enforcement or existence of these types of standards can result in an increase in expected damage on an annual basis for 30 to 50 years or more. Photograph 7-5 shows new apartments in Snoqualmie with elevated living space. While it is evident that the liv..ng space of the structure shown in Photograph 7-5 is elevated, our field inspections showed

PHOTOGRAPH 7-5. NEW APARTMENT CONSTRUCTION IN SNOQUALMIE WITH ELEVATED LIVING SPACE

that some infrastructure is located on the lower levels of these new buildings which would be damaged in a major flood event. Stringent building codes would prevent such mislocated contents.

Flood Hazard Insurance

The town of Snoqualmie has not yet completed its "regular" federal flood hazard insurance program. Completion of such a program and adoption of related zoning and building ordinances would help to minimize future flood damages.

In addition, it would help if the town of Snoqualmie would define its floodway equivalent to the King County definition. This might be done with the provision that structures within the floodway could be rebuilt at the same size if they otherwise comply with the regulations and reduce the amount of obstruction to flow that existed with the original building in place. The difference between this proposal and King County's is that flood fringe would still be flood fringe, even if surrounded by flood way. This measure would keep damages to new construction very low, and might help to reduce damages to existing development.

Natural Valley Storage; River Basin Management

Damage to existing and future development in Reach 3, at the lower end of the upper valley, will be influenced by what happens in lands upstream. Changes in topography, runoff, natural valley storage or displacement area and development will all influence the location type and amount of flood damage in Reach 3. Consequently, it is very important that development upstream be managed to minimize increases in flood damage. One way for this management to occur is for Snoqualmie to annex lands thought to be important from the standpoint of affecting flood damages and to regulate development on those lands. Other ways to accomplish the same end would be for the county to acquire a flood easement or development rights of these lands or for the state to acquire them for a park/greenbelt. Snoqualmie with a population of about 1260, does not have the money or financial base to carry out the latter two alternatives, although the first would probably be within the town's capabilities. This alternative has already been, in part, suggested by the town. According to the town plan, as published in the Snoqualmie Valley Record, certain lands in NE SE 31 24 8 and SE NE 31 24 8 are designated flood storage. This is a concept that must have significant restrictions behind it to work properly. However, the fact that the town plan is not yet adopted prevents any evaluation of its effectiveness.

C. Recommended Program, Data Requirements, Institutional Opportunities

1. Existing Damages

Residential

The evaluations of nonstructural actions reported in Appendix J for this reach, and the results of these analyses reported for Meadowbrook earlier in this report suggest that various nonstructural measures for the modification or movement of existing structures are cost effective in the town of Snoqualmie. A program which emphasized relocation appears to offer greater opportunities for reduction in emergency aid costs than a program which emphasizes modification of existing structures *in situ*.

The data gathered by Jones and Associates needs to be reworked so that individual structures can be identified in the data. The cost data for various modifications or relocation need to be tied to assessor's records of value for particular structures to determine benefits more accurately. The Corps of Engineers should assume primary responsibility in the development of the data necessary for evaluation of structural modification and/or relocation or demolition. The results of these analyses should show for each residential structure the costs and benefits of each nonstructural approach applied to that structure for the 100-year flood event.

Once the Corps has developed such data, it should work with the Town of Snoqualmie and King County to develop a specific site-by-site program for implementation of a community-wide program of flood damage reduction via nonstructural means. Various community alternatives could be articulated as a result of such analyses, including relocation of entire neighborhoods and redevelopment of the vacated sites into public uses compatible with the flood hazard, or raising many adjacent structures to levels above the 100-year flood, along with necessary infrastructure. Given the variations of structural types and ages within given neighborhoods, the variations in local topography which affect the economic efficiency of particular actions in adjacent houses, etc., it may be difficult to develop such neighborhood or community damage reduction programs. However, a joint effort is recommended to evaluate opportunities of this type.

Commercial, Public

Similar programs to those just outlined for residential structures appear to be justified for commercial and public structures. While present commercial damages are modest, there may be opportunities for damage reduction via nonstructural approaches. Relocation of inventory and closure of openings should be explored for their flood damage reduction potential. Ring levees should be considered around the three public schools subject to flood damage in this community.

Emergency Aid

The opportunities to reduce these relatively large current damages appear tied primarily to the type of residential damage reduction strategy which is articulated by the people of the town and related governments. Structural relocations would appear to be most promising as a means of reducing these costs, but on a large scale this may not be politically feasible. Nevertheless, programs of evaluation for reductions of current residential damages should also focus on concurrent or contingent damage reduction opportunities in this category as well.

2. Future Incremental Damages

Residential

The opportunities for future residential flood damage to increase in this reach are great, if new residential development occurs on the floodplain. Prevention of such damage increases can be accomplished in a number of ways.

Flood Hazard Insurance Programs, Floodplain Zoning, Building Codes

The town of Snoqualmie should immediately complete its "regular" flood hazard insurance program, and implement stringent zoning codes and building ordinances to accomplish the goals associated with such a flood hazard insurance program. New structures should be discouraged from the flood fringe, even if they are "floodproofed". There is ample opportunity for the expansion of this town to the south of the floodplain, and the municipal plan should reflect these opportunities. "Floodproofed" new structures on the flood fringe would probably have residual damages associated with them, and they would undoubtedly induce emergency aid costs. Therefore, we recommend a strong program of land-use zoning which restricts such development. Obviously an information, education, and possibly a building and property inspection program can play a role in reducing the growth of residential flood damages in this reach.

The definitions of the floodway and flood fringe developed by the town of Snoqualmie need to be consistent with those adopted by adjacent King County as part of the federal flood hazard insurance program. This consistency would help to minimize situations where adjacent jurisdictions could be suggesting incompatible programs, possibly allowing development in the floodway if an overly generous definition of flood fringe were adopted by one jurisdiction.

The town of Snoqualmie and King County appear to have major responsibility for the implementation of these recommendations to prevent future increases in residential flood damages. State and federal agencies need to assure that adequate resources are available to the town of Snoqualmie to complete its flood hazard insurance program, and to assure coordination with the King County program.

<u>Emergency Aid</u>

Increases in emergency aid related damages appear to be contingent upon future residential development in this reach. If the recommendations just made with respect to such development are implemented, increased emergency aid costs should be negligible.

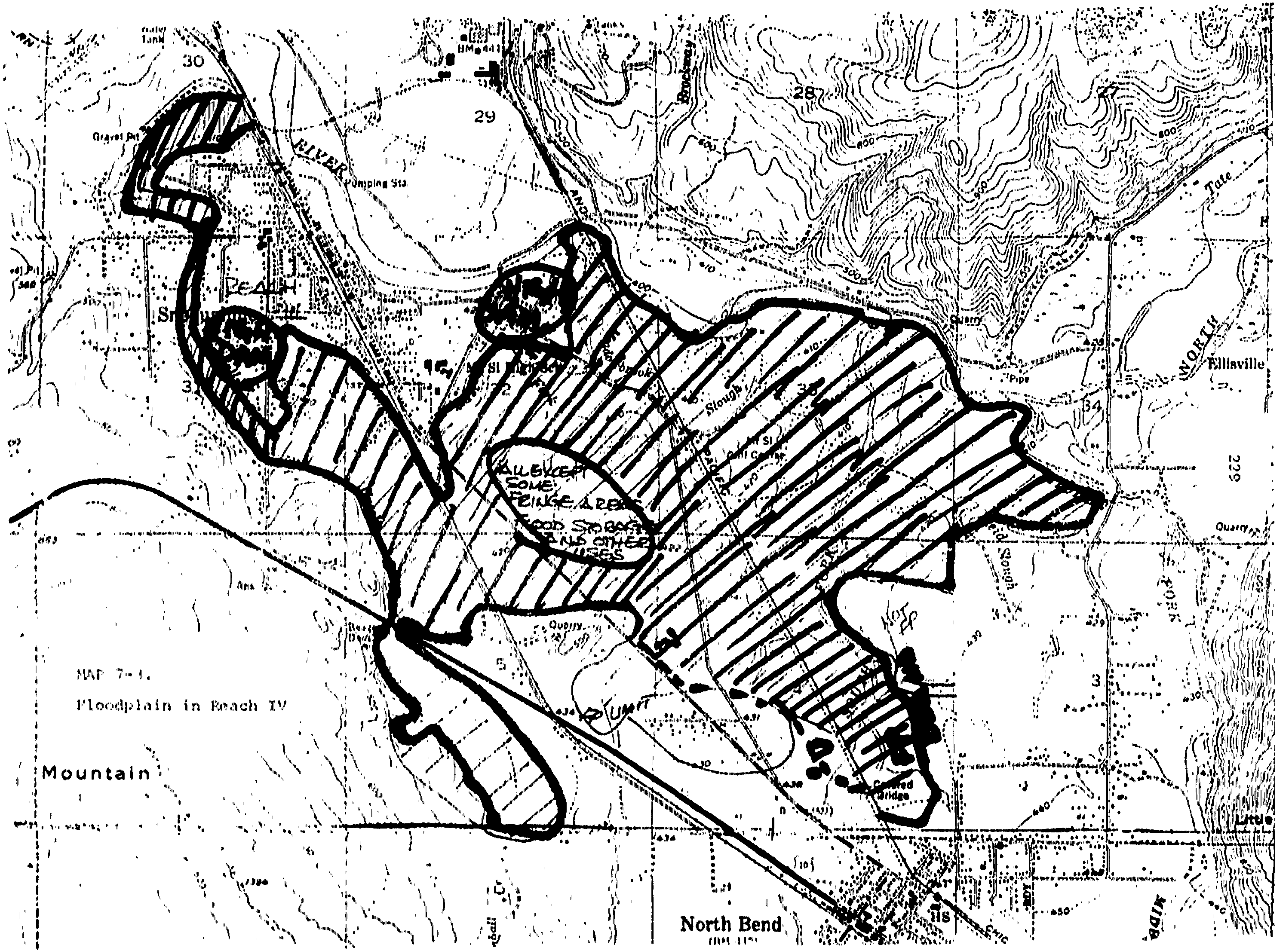
REACH 4: CONFLUENCE OF NORTH, MIDDLE, AND SOUTH FORKS OF THE SNOQUALMIE RIVERS

A. Overview

Most of the reach is low-lying and most of it is designated by King County as floodway at the present, preventing residential development, and severely hindering other types of development. Map 7-3 shows the floodplain in this area. The recent Interlocal Agreement signed by Snoqualmie, North Bend, King County and the Snoqualmie Valley Land Company designates areas south of the Milwaukee Road and southeast of Snoqualmie as flood fringe, allowing residential and other forms of development to occur. The areas involved have potential for future flood damages if county and municipal regulations are not enforced.

Existing expected damages in this reach are modest, only $.068 million per annum. These are dominated by expected damages to public facilities, particularly to school facilities. Minor damages are expected in other damage categories. Development of flood fringe lands in this reach would incur significant filling or floodproofing costs. In addition, development of these areas might increase damage to developed areas in Snoqualmie through effects on flood levels and flows. Filling or other obstruction of flood flows may raise water levels and displacement of natural valley storage may change run-off rates and flow timing.

In the northwest quarter of section 4, a small area exists which is above the level of the 100-year flood. Development of this area would not incur significant additional flood damages, although it would destroy a portion of one of the largest blocks of undeveloped riparian forest in the Snoqualmie Basin.



MAP 7-1.

Floodplain in Reach IV

Development of flood fringe areas in the reach would have environmental repercussions. Loss of wildlife habitat would be the most noticeable effect, although water quality would probably decrease. In addition, development in reach 4 would eventually lead to the destruction of qualities which shape the inhabitant's perceptions of the type of area that they live in. The North Bend-Snoqualmie area could easily become a detached fragment of the urban area to the west.

The proper mix of development and preservation in reach 4 could enhance the economy of the adjacent communities without adding significant flood damage problems and without destroying the environmental qualities that create its distinctive identity and appeal.

B. and C. Opportunities to Reduce Existing Damages and Recommended Actions

1. Existing Damages

Public Property

Table 6-7 indicated that damages to roads, bridges, and public structures were the current largest source of damage in this reach. These damages are concentrated at the school in Section 32. It appears as though these damages could be substantially reduced through construction of a ring levee around the school, as the floodwaters are less than 3 feet deep in a 100-year flood event. The Corps and the local school district should carefully evaluate this damage reduction opportunity, and the Corps should evaluate this damage reduction opportunity, and the Corps should probably fund most of the construction costs of this action is found to be economically justified.

Other Damage Categories

This region straddles the towns of North Bend and Snoqualmie. Other damage reduction programs for the small existing damages should be articulated in coordination with programs for the adjacent, much more populous and strongly damaged municipalities.

2. Future Damages

Our estimate of future land use did not call for the types of land use conversion discussed earlier in this section with regard to this reach. These developing possibilities are real, however, and if they occurred there is reason to believe that increased damages could be induced, even if new structures were "floodproofed". Infrastructure and emergency aid damages could be significantly higher than shown in Tables 6-12 and 6-13, and residual damages could be anticipated in "floodproofed" structures. We recommend that the following strategies be pursued to avoid these potential increases in damage levels.

Subdivision Regulations

Land owners in this area might be induced either financially or otherwise, to plan development on their land using a floating density or average density for the whole property. What they would do is develop the full amount allowed by the existing zoning (one inducement might be to increase that amount) with the provisio that all development occur a) out of the floodplain completely, or b) outside of the floodway and parts of the floodfringe determined to affect downstream damages or to have values to the public of some other sort. Development rights or full title of the undeveloped land in the flood hazard area could go to the local, county or state government to be used for some flood compatible use.

Land Acquisition

Methods for the achievement of other floodplain management objectives, particularly as they relate to the proposed Three Forks Park, include:

1. Use of transferable development rights to allow development of areas in the reach without serious flood problems or environmental sensitivity while protecting open space, floodway wetlands and other wildlife habitat, and possibly to provide dispersed recreation opportunities.

2. Public purchase or purchase and leaseback of floodplain lands to prevent fringe or other development damaging to downstream development, agricultural, recreational or environmental values.

3. Strengthening of existing open space and other taxation measures to prevent forced development due to taxes or other reasons.

These actions could have the effect of reducing flood damages, if these purchase programs could be shown to lead to less development than would otherwise occur. This reach clearly could be annexed by either Snoqualmie or North Bend for urban development related purposes, even if these communities had a "regular" flood hazard insurance program in effect. Recent northward expansion of the boundary of North Bend for just this reason is indicative of the long-run probability that such annexations would occur unless urban land-use opportunities foreclosed. It is also clear that part of the lands in this reach have significant multiple-use water resource values, particularly in the vicinity of the confluence of the various reaches of the Snoqualmie River. The State of Washington and King County should develop a long-run multiple purpose land use management plan for this area, which may result in a basis for federal participation in the acquisition of development rights or fee simple acquisition in this reach.

Information and Education

Two actions in this area are recommended:

1. Provision of location and severity of flood hazard information to all those affected by changes in the floodplain level of development or type of land use. The objectives would include influencing location decisions, design decisions and making all concerned aware of their stake in floodplain development and use.

2. Continuous monitoring of floodplain development and land use changes to determine the effects of proposed projects on flood levels, velocities, routes and resultant damages. In addition, research on the importance of natural valley storage would be worthwhile.

King County could be responsible for implementation of recommendation number 1, while recommendation number 2 should be implemented jointly by The Corps, and the County.

REACH 5: WEYERHAEUSER MILL

A. Overview

Reach 5 is unique in this study, as the majority of development is industrial. Approximately 80% of the developed acreage in the area is industrial, occupied by Weyerhaeuser's Snoqualmie Falls wood processing operations. Included in that facility are: a large sawmill built in 1917, a silvicell plant built in 1951 and a plywood mill built in 1959, as well as planing and drying facilities, shops, finished products warehouses, at least 20 acres of open finished products storage, large areas of log storage yards and a log storage pond.

Most of the rest of the reach is second growth timber with small interspersed areas of residential and agricultural development. There is no commercial development within this reach.

Expected annual damage in this reach are over $.25 million, almost exclusively industrial damages to the Weyerhaeuser facility.

B. Opportunities for Reducing Damages

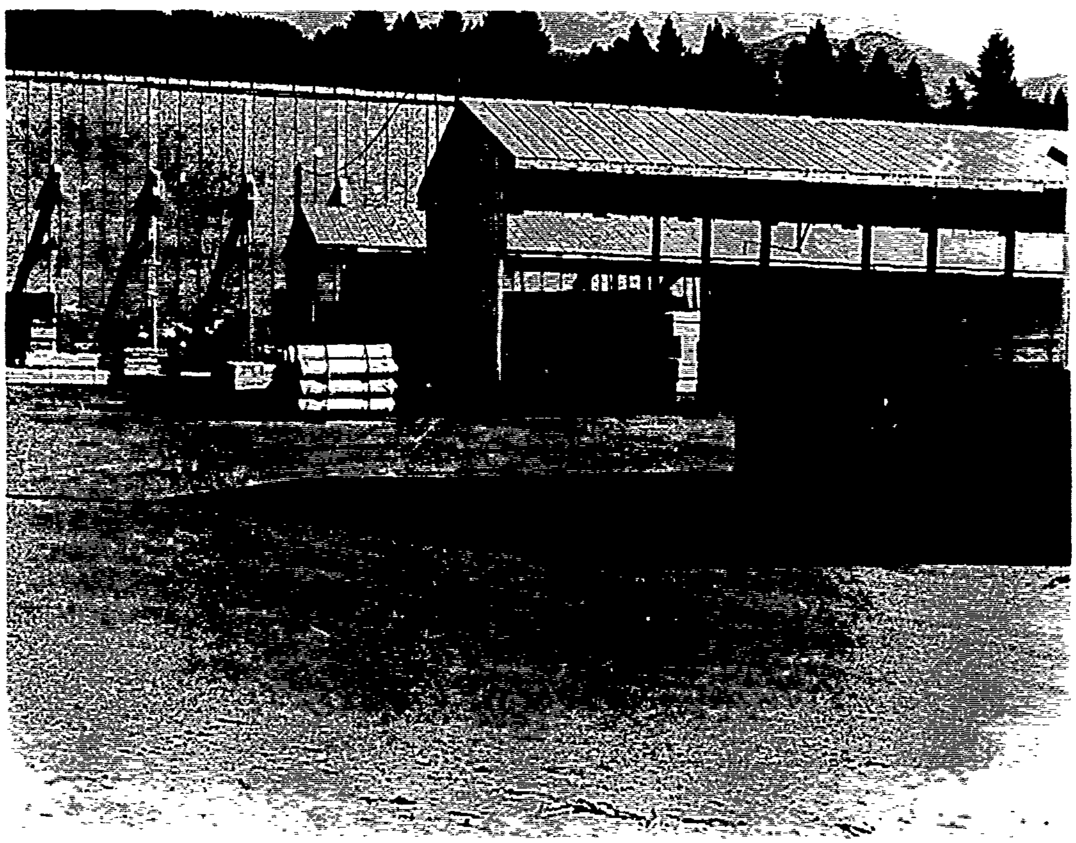
Existing Damages and Future Damages

The damage reduction strategies outlined in Chapter III of this report are more relevant for small structures such as houses or farm buildings than they are for the types of property subject to damages in this reach. Since there are no current projections for major changes in land use in this reach (except for a possible shut-down of the facility), present damage problems can be anticipated to be essentially similar to future damage problems. Therefore, both will be treated simultaneously.

Opportunities for reducing flood-related damages within this reach seem to be concentrated in the area of log and finished product inventory losses. See Photographs 7-6 and 7-7. Possible alternatives include:

PHOTOGRAPH 7-6. LOG STORAGE PILE, WEYERHAEUSER MILL

PHOTOGRAPH 7-7. FINISHED PRODUCTS STORAGE YARD, WEYERHAEUSER MILL



1. Anchoring all or part of log stacks to prevent unravelling of the stacks and movement of logs from the storage site.

2. Protection of finished product storage yards through site grading or raising.

3. Storage of logs outside the floodplain in flood season.

4. Minimization of log pond inventory during flood season.

Opportunities can be found for reducing the level of damages in other areas as well. Mechanical and equipment damage and some inventory damage at the Weyerhaeuser Mill could be reduced through the preparation of a flood contingency plan. The plan would start from a detailed inventory of flood damages at different expected intervals of return and would then evaluate the cost effectiveness of specific measures based upon the possible damages and their probability of occurrence. Residential structure in this reach should be evaluated to determine the applicability of measures suggested for Reach 3. Agricultural damages are so slight that they can be neglected. Public and emergency aid damages would need to be looked at on a more specific basis to find opportunities for reduction. The limited amounts involved may not merit detailed analysis.

C. Recommendations, Data Required, Institutional Opportunities

Knowledge of flood flows and depths around a given arrangement and amount of logs or finished products in storage piles is crucial to the determination of the feasibility of alternative ways of reducing raw material and product inventory losses in this reach. The Company and the Corps need to coordinate the development of such knowledge. Storage areas most susceptible to losses should be evacuated seasonally, and log stacks should be anchored. Anchoring might be done through the use of large chains or some sort of rigid metal rack similar to a log truck preload rack. Tests need to be done to determine the size of bundles of logs that would not be moved from the end of a log stack in a 100-year flood level. The company needs to develop log storage procedures which continually minimize the risk of damage during the flood season. Corps involvement could be justified as part of a basin-wide nonstructural program, coordinated by King County or an inter-local governmental body.

The key to a nonstructural damage reduction program in this reach is the application of damage reduction programs such as those just described by the Weyerhaeuser Company. The company must work with hydraulic engineers (probably the Corps) to define which measures should be implemented, given the present and anticipated future use of this facility.

One possibility for damage reduction in this reach is the removal of the log storage or product storage area from the floodplain. Another possibility is the closure of the mill, which is old, and which is periodically closed. If it were closed in the long-run, then industrial damages in this reach would be minimal, especially if closure were associated with the removal of inventories of logs from damage prone locations. If the company were to restructure this facility, as part of its ongoing modernization program in Western Washington, it might possibly relocate some of its manufacturing facilities and storage areas out of the floodplain, and this area currently occupied by logs and products could then possibly revert to a quasi-natural condition and serve as a natural valley storage area.

REACH 6: NORTH BEND-MIDDLE FORK SNOQUALMIE RIVER

A. Overview

Reach 6 is the lower ten miles 'f the Middle Fork of the Snoqualmie River. The reach includes the town of North Bend and related suburban development to the northeast and southeast. Flood damages are expected to be $.4 million annually, primarily for damages to residential structures and for emergency aid, including levee repair. Smaller amounts of damages occur to commercial activities and to public property. Development pressure is currently higher in reach 6 than in other floodplain areas in unincorporated King County, based on an analysis of flood control zone permits issued since 1972 (see Table 5-3). New construction is occurring on the west side of the Middle Fork, below the west face of Mt. Si.

B. Opportunities for Flood Damage Reduction

Nonstructural approaches in Reach 6 would de .ith reducing flood damages to existing residential structures, reducing emergency aid expenditures, limiting future residential development in flood prone areas, and providing lands for recreation and open space uses.

1. Existing Damages

Modifications to Existing Structures

Damage data for this reach suggest a great difference between the 10-year flood and the average expected damages in terms of residential damages. Earlier work by the Corps at the Hydrologic Engineering Center and our trial work which is reported in Appendix I suggests that for many structures the break-even point for the cost effectiveness of measures leading to the modification of existing structures was a situation where the expected annual damages were about equal to those incurred in a seven or eight year flood event. All structures in Reach 6 may not be economically modified, given these flood damage data, but specific data are not currently available for homes in this reach to make such a determination. It seems likely that homes immediately adjacent to the river, and those on the floodplain to the northeast of the town of North Bend would be promising candidates for structural modification, or for relocation. Ring levees for some isolated houses in this reach may also be feasible.

Emergency Preparedness and Management of Existing Flood Control Measures

Levee repair and restoration was the major cost of the 1975 flood in this reach. Consideration should be given to a program of levee management and coordination, to minimize the probability of levee breaching during flood events. In addition, an improved program of emergency preparedness, including seasonal inspections of residential and commercial properties subject to flood damage could help to reduce the probability of flood damages.

2. Future Damages

Zoning Measures and/or Land Acquisition

North Bend is subject to considerable future development pressure due to its location on Interstate 90 at the fringe of the Seattle metropolitan area. Future floodplain development may be restricted through a mix of measures including purchase of development rights and strong enforcement of existing zoning and regulations, and preferential open space taxation. Fee simple acquisition should be considered for selected lands such as parcels located along the Middle Fork adjacent to the Mount Si preserve. There is an almost continuous two-mile long block of riparian forest here, which may ultimately form Three Forks Park.

Flood Hazard Insurance

The town of North Bend has not yet implemented a regular federal flood hazard insurance program. Future damages could be averted if a program of this type were implemented soon, with definitions of the floodway and flood fringe compatible with those of King County. Strict zoning ordinances and building codes could be adopted to help implement a program of this type.

Watershed Management

Land use upstream affects flooding in downstream areas. Since forestry is the dominant land use in the Middle Fork drainage area above North Bend, watershed management should be studied as a nonstructural approach which may reduce flooding through alteration of upstream forestry practices.

The Middle Fork upstream from North Bend, and especially upstream from Tanner, becomes increasingly undeveloped, as shown in Photograph 7-6. Measures to maintain the environmental qualities of this area include purchase of development rights for nonforestry uses, zoning for forestry, open space taxation, river corridor management, and riparian vegetation management. However, existing flood damages to these upstream lands are less well documented.

In summary, nonstructural measures meriting further consideration for application in reach 6 are:

- Floodproofing of residential structures (especially raising and ring levees)
- Relocation of contents and equipment
- Improved emergency preparedness and flood warning program
- Management of existing flood control levees
- Purchase of development rights
- Strong enforcement of existing zoning and regulations
- Fee simple purchase of selected parcels
- Preferential open space taxation
- Watershed management

Further nonstructural possibilities for the Middle Fork upstream from Tanner are:

- Purchase of development rights for nonforestry uses
- Zoning for forestry
- Open space taxation
- River corridor management
- Riparian vegetation management

Photo 7-8 Middle Fork Snoqualmie River Valley Above Tanner.

C. Recommended Actions, Data Requirements, Institutional Opportunities

1. Existing Damages

Residential

A detailed study needs to be undertaken of residences on the floodplain in Reach 6, in much the same way as recommended for Reach 3, to ascertain which particular structures are subject to the most frequent flood damages, and which are only affected by floods more severe than a ten-year flood. For those affected by these frequent floods, actions such as the relocation of household contents and equipment so as to be damage-free in the 100-year flood event, or the construction of ring levees or raising of structures are likely to be cost effective.

The Corps of Engineers should take the leadership in the development of this inventory, and be primarily responsible for the evaluation of the measures which can help individual residences or groups of residences. If actions such as those recommended here are cost effective, the COE should work with local government (King County and the town of North Bend) to form special improvement districts to implement these measures.

Emergency Aid

While the 1975 flood had high emergency aid costs due to levee repairs, other emergency aid is necessary for individuals affected by floods in this reach. Therefore, a program of inspections and maintenance of existing flood control programs should be undertaken, to minimize the risk of damages such as those occurring in the 1975 flood. The actions suggested above for residences would help to reduce individual emergency aid costs. In addition, a program of information and education, and a program of inspection of residences and commercial buildings to ensure that property has not been left in locations subject to flood damage should be undertaken. King County and the town of North Bend could implement such a program.

Commercial

The same type of evaluation as suggested for residential structures suggested above should be undertaken for affected commercial facilities. The same institutional arrangement is suggested to help reduce these damages.

2. Future Incremental Damages

Future damages will increase in this reach without the application of stringent measures, as has been discussed in Chapter V and VI. To prevent such damages we suggest:

(1) development of a "regular" flood hazard insurance program, with definitions of floodway and flood fringe consistent with King County definitions.

(2) Strong enforcement of existing floodplain zoning, shoreline zoning, and subdivision regulation programs, and stringent implementation of zoning ordinances resulting from recommendation (1) above.

(3) Institutionalize a watershed management program on forest lands in the drainage basin above North Bend so as to minimize negative flooding impacts of forestry practices. The need and effectiveness of such a program is uncertain and requires further study.

These actions would help to reduce future increases in damages in the residential, commercial, emergency aid, and infrastructure categories. In the area of Reach 6 above Tanner, we recommend that the river corridor management concept be instituted with the intent of keeping the river and its environs in its existing largely undeveloped state. Specific measures would include strong enforcement of the existing shoreline management designation for the Middle Fork, purchase of development rights for non-forestry uses, and change in zoning to allow forestry uses only.

Responsibility for implementing these suggestions would be shared between the county, the Department of Natural Resources, the Forest Service, the Corps of Engineers, and the town of North Bend.

The Department of Natural Resources and the Forest Service are responsible for evaluation of downstream impacts of upstream logging practices. The county and the town of North Bend are responsible for minimization of the future damage potential within their respective jurisdictions, and this will undoubtedly involve the question of annexations. Future flood damage prevention in the near term in this reach will be much related to development on already platted land in the town of North Bend, and on land which might be annexed by this town in the near future. This town does not now have in force a "regular" federal flood hazard insurance program, and appears to be far from development of such a program in comparison to other jurisdictions in this floodplain. The obvious solution to this problem is a strategy which minimizes the flood damage potential of the inevitable growth of this town, but which also provides development opportunities.

A joint state-local-federal approach is clearly called for in Reach 6 as the basis for the reduction of existing and future flood damage problems. The annexation question is an obvious variable, with the recent movement northward of the North Bend boundary onto the floodplain. Lands between North Bend and Snoqualmie are obvious turf for the expansion of municipal boundaries in a few years. If these municipalities adopt more permissive zoning than King County now has for this area, such that greater development might occur on the floodplain (even within the framework of a federally funded flood damage insurance program), it may be in the public interest for the county to acquire some of these lands as part of a regional open space and flood damage reduction program.

Other recommended nonstructural approaches suggested by the preliminary analysis have been judged to be of lower priority for Reach 6 in the downstream North Bend area. These should not be entirely eliminated from consideration as many may be applicable in specific cases or be compatible and complementary with higher priority measures:

1. Management and coordination of existing levee systems. This option requires new technical information and institutional arrangements.
2. Purchase of development rights on lands especially subject to future development.
3. Fee simple purchase of selected sites having natural environmental values.
4. Natural valley storage seems to be rather inapplicable in Reach 6, but further technical studies are needed.

In the portion of Reach 6 upstream from Tanner, less promising nonstructural measures of some potential value are:

1. Riparian vegetation management
2. Expansion of preferential open space taxation program

REACH 7: NORTH FORK SNOQUALMIE RIVER

A. Overview

This reach is presently relatively undeveloped, and has a minimal level of expected current annual flood damage ($.026 million). Much of the land in this branch of the Snoqualmie River system is devoted to forestry, and a substantial amount of this land has already been logged by clearcut techniques. Some flood damage does occur near the confluence of the North Fork and Middle Forks, and the potential exists for greater damage if development were to occur on the floodplain in this reach.

B. Opportunities to Reduce Present and Future Damages

Nonstructural approaches to reduce flood damages could include a combination of measures such as designation of the North Fork as a wild and scenic river under a State or Federal program adjustment of open space taxation to encourage forestry on small parcels, purchase of development rights, or policing of logging practices according to the Forestry Practices Act (useful here to reduce amounts of logging wastes from heretofore extensively forested lands), riparian vegetation management, and floodplain zoning. An evaluation of these measures is determined as follows.

Since there are limited funds for designation as a wild and scenic river at both the State and Federal level and since there are several other rivers in this State and country with a higher priority for such designation it seems unfeasible that this measure could be implemented.

There are few small parcel owners along the North Fork and field checking shows that these lands are already in forest use so that adjustment of open space taxation would be unnecessary at this time but may be necessary after the first twenty years of nonstructural measure implementation.

This area is presently in the jurisdiction of King County, and is covered by the County floodplain zoning regulations and "regular" flood hazard insurance program. This zoning program has the potential to assure minimal future increases in structures and infrastructure subject to flood damage in this reach.

C. Recommended Program

The County must aggressively implement the zoning regulations currently in effect to prevent future increases in damage potential. Careful consideration needs to be given to a program of watershed management, including an evaluation of the effects of logging practices and programs in this reach upon downstream reaches. The Corps and the State of Washington Department of Natural Resources should collaborate on such a program, which should include consideration of logging debris management as it relates to downstream damages. Riparian vegetation management programs should already be in effect through the state Forest Practices Act. However, the state and county should review the application of these regulations from the standpoint of their effectiveness in reducing downstream flood damages.

REACH 8: Skykomish River

A. Overview

This reach is a mixture of pastoral and wooded landscapes, with a variety of types of existing flood damages (see Table 6-8) which total about one-half million dollars annually. Residential damages and related emergency aid expenditures are the largest category (34% and 12% respectively), followed by damages to public property (17%), agriculture (13%), and streambank erosion (21%). Snohomish County and the municipalities in this reach have not yet completed the development of a "regular" flood hazard insurance program, but such a program is in the process of development. Given the variety of flooding problems, a number of different nonstructural approaches may be applicable in this reach.

B. Opportunities for Damage Reduction

1. Existing Damages

A sample of homes located in Skyview River Tracts in this reach were used as a case study for the application of the efficiency of techniques tc reduce damages to existing structures in the Snohomish River Basin. Details of the computational process are described in Appendix I. The numerical example provided for this reach is exemplary; much more work is needed before it can be concluded that the statistical results obtained for this sample of homes is applicable broadly throughout this reach or throughout the basin. However, the results are sufficiently promising to suggest that it would be wise to make such an investment in analysis.

Floodproofing of Existing Residential Structures

Retrofitting existing structures for any modification is complicated and floodproofing is no exception. Each home must be examined in detail for value, structural components, state of repair and flood hazard factor.

Options include rearranging valuable contents within the home, raising, relocation, demolition and ring diking.

Some homes in reach 8, particularly in the Tualco Valley and in Sultan and Startup have basements susceptible to flooding. In such cases there may be damage to electrical or mechanical equipment housed in this part of the house. New locations for these and other basement contents can be either constructed or floodproofed at rather high cost or relocated in areas above the flood level at moderate cost to prevent flood damage to these items.

Any owners of two-story homes subject to inundation above the first floor should routinely house valuables subject to flood damage in the upper levels. If this is not possible, space should be allocated for temporary storage during a flood, assuming adequate forewarning time to relocate the items. Costs for this kind of pre-flood planning are low and benefits of content damage reduction may be high.

Raising is a possibility for structures whose owners wish to remain in existing locations and where the process is cost effective. Preliminary figures which we developed for a sample of 6 houses in the Sky View River Tracts indicate costs of $14,000 to $28,670 for raising the homes 5 feet. The benefits of flood damage reduction, however, are greater in each case, with cost benefit ratios ranging from 1.09 to 2.87.

Demolition of residences may be cost effective and desirable to owners who wish to leave their locations. In the sample of 6 houses referred to above, two showed cost benefit ratios of approximately 1.5 (others were less than 1) for demolition. Aside from damages prevented to structures and contents taken off from the floodplain, benefits accrue to residents who need no longer worry about inundation and to other local human beings and/or inhabitants who can then enjoy the space. After removal evacuation costs and damages to yards and outbuildings will also be reduced.

These benefits are also a function of removing homes from the floodplain intact and relocating them at higher elevations. This is possible in Reach 8 due to the availability of alternative sites, even to people who wish to remain living in the same locale. Moving is especially facilitated in the case of mobile homes, many of which are located in Reach 8 (although many appear to be considerably elevated). Moving (and relocation) costs and benefits of structure and content damage reduction were figured for the six sample Sky View River homes. Five of these six showed cost benefit ratios greater than 1, ranging from 1.04 to 2.25.

Ring dikes are another option for isolated homes at risk of flooding, when owners wish to remain on the floodplain. The sample group were analyzed for costs and benefits of 3 foot and 5 foot levees. All were cost effective with ratios ranging from 2.33 to 7.29 for 3 foot levees and 1.67 to 5.14 for 5 foot levees.

Emergency Preparedness, Flood Forecasting and Warning

These programs are already in place and improving them to the greatest degree of efficiency would probably have a high benefit cost ratio, since machinery, livestock and residential and commercial contents of structures can often be safely housed through a flood by removal--on shelves, in upper stories, or, if necessary, evacuated. Risk of loss of human health and life can also be minimized.

Information and Education

Relatively low cost programs could be implemented for dissemination of flood information. Benefits are indirect since improved flood hazard awareness supports all flood damage prevention measures. These programs could cut down on people locating on the floodplain who are unaware of the costs and dangers; motivate people to keep in touch with voluntary or official warning programs; motivating people to prepare flood contingency plans for their families and valuables.

2. Future Damage Reduction

The emergency flood control permit system, already in place is working to hold down growth in the floodway portion of the floodplain. But even development on the flood fringe is projected to cost $74,000 in average annual damages by 2012 and $196,000 by 2042.

Other damages are more difficult to quantify and are more dependent on where and how the development occurs. Costs of environmental losses are one such case. Reduction of forest habitat, projected to be several hundred acres by 2042 will surely signify forest obliteration, but may directly or indirectly cause a decline in quality of remaining habitat as well.* Water temperature and purity are particularly susceptible to damage, and this in turn affects fish. The May Creek/Wallace River/Skykomish River area, with its fish hatchery and high uses of natural fish population appear to be of critical importance. However, in discussing preservation of habitat for any species it is meaningless to limit concern to one geographic area frequented in the life cycle. Impacts of development on the environment, particularly the fishery and the eagles, needs more attention than can be given here.

Development can also lead to costs in terms of opportunities lost to enjoy the floodplain as it now exists. These include recreation, aesthetics, and spiritual relaxation. Concentrated housing or clearing of large parcels

*No specific projections have been supplied to us.

of forest would have high costs in this regard.

Loss of the natural floodplain function, the storing of floodwaters, is also incurred by development, even in the flood fringe. Again, quantifying this cost is technical and beyond the scope of this report.

Conversion of floodplain agricultural lands to more intensive use involve a whole different set of impacts. These include loss of agricultural employment and lifestyle opportunity, and reduction of fresh food supply.

Various measures are available to reduce the level of future damages on the floodplain, and many of these measures may also have environmental quality benefits related to the kinds of environmental values just discussed.

Fee Simple Purchase

This measure ensures the most effective control by government of future development occurring on the floodplain. Costs for wooded and pasture land in this area are in the range of $1.500 to $2,300 per acre, less in the wetlands. Additional costs are incurred by taking the land off the tax rolls, and necessitating public management costs.
Combining flood damage reduction benefits with recreation, environmental and aesthetic benefits would yield a relatively high cost-benefit ratio. Since preservation of agriculture is a county, state, and national goal and since agriculture, in this country, is in the private sector, the most likely parcels for fee purchase are in the eastern half of the reach where larger parcels of vacant land are located.

The stretch between Sultan and Gold Bar is the home of the highest concentration of bald eagles in Reach 8. It is also the location of the entrance of the Wallace River which is used for fish passage from the hatchery on May Creek.

The pattern of the river in this area is the so-called "braided channel" pattern. This provides visual and educational interest and also affords recreational opportunities, exceptional to the Skykomish of all the usual riverine variety at increased levels and with more opportunity for solitude.

Depending on the location of the lands for purchase, urban containment of Sultan and/or Gold Bar could be another benefit.

The Sultan-to-Gold Bar part of the reach, then, shows the highest promise for fee purchase, though flood damage reduction would only be one category of benefit. Further study is needed to determine:

1. Minimum size that would afford adequate environmental protection to the eagle, the fishery, and other ecological benefits, and that would provide the best recreation opportunity

2. Possible incompatibility of eagle preservation and recreation

3. Desirability of buying lands contiguous to growth centers

4. The trade-off of costs and benefits of buying expensive small and platted lots in the area where the densest growth is likely to occur.

Purchase of Development Rights

The purchase of development rights would be the next most effective tool to keep residential development off the floodplain. This tool was found to be politically acceptable for a program to preserve agriculture in King County. A background study for the King County program estimated costs of an acre of farmland in the Snoqualmie Valley (the only river valley analyzed) to be $2,210 and the costs of the development rights to be from $1,550 to $2,114 (1978 figures). The midpoint in this range is $1,832 or 83% of the price of full purchase. There are additional costs in loss of tax revenues, both for the value of the land in public ownership and the likelihood of increased participation of agricultural landowners in the open space program.

Justification for the King County program was primarily the economics of agriculture and the problem of urban sprawl. Preservation of the industry may well be equally important in the Skykomish, but given the stability of the agriculture on the floodplain and the level of agricultural flood damage, flood damage reduction is probably not a substantial benefit for the purchase of development rights of agricultural lands.

Purchase of development rights as a tool to preserve the riparian forest may be useful in place of fee purchase for some or all of the area discussed above.

Subdivision Regulations and Cluster Zoning

These measures may be useful on the May Creek and Wallace River floodplains where new growth could occur on large undeveloped tracts. Parcels which include some floodplain land and some uplands could be developed in such a way that the floodplain land remained as open space in these developments, and structures were located on adjacent uplands. If such planned unit developments occurred with a higher overall density than with sprawling development (incouding "floodproofed" structures on the floodplain with their attendant residual damages), then it could be argued that these regulations lead to flood damage reduction benefits in contrast to a "normal" scattered site development program.

Protection of Roads and Utilities

Assuming that floodplain development does materialize as projected, these services, especially roads, will represent the largest category of incremental flood damages in the future. For new installations the opportunity exists to plan for locations of main lines off the floodplain insofar as possible. Roads need to be planned so that inundation will not strand residents of the flood fringe.

C. Recommendations, Data Requirements, Institutional Responsibilities

The preceding discussion has identified a number of possible actions which could be taken in Reach 8 to reduce present flood damages, and to avoid future damage level increases. We recommend the following specific strategies in this reach.

1. Existing Damages

Residential

A number of alternative approaches to modification of existing structures appear to be cost effective in this reach. The trial application of (1) raising existing structures, (2) ring dikes, and (3) relocation of damageable contents within existing structures suggested that these approaches were cost effective for homes in Sky View Tracts. In this neighborhood, it was also found to be cost effective to relocate structures to the abundance of nearby home sites above the floodplain in this reach. In a few cases demolition was even found to be cost effective. The trial evaluation we undertook needs to be extended to the entire reach, particularly to homes in the Braided Channel and Tualco Valley. The Corps should undertake this evaluation, and could be the primary source of funds for implementing these actions, if such a program were articulated for the entire reach under the auspices of a local government damage reduction program. Information requirements for a program of this type are discussed later in this chapter.

Emergency Preparedness and Aid

If the program just outlined were implemented, emergency aid expenditures would fall, as there would be fewer cases of stranding, etc. However, the present program is very low profile, and it seems as though an enhanced emergency preparedness program would be cost effective. Regular inspections of property subject to damages would help to identify contents of residences who could be moved to avoid flood damage and types of property located around homes which would be subject to flood damage if not moved. Snohomish County could implement such a program, in coordination with the municipalities also located in this reach.

Utility

Damages might also be avoided through elevation of equipment; these opportunities have not been assessed.

Information and Education

At present there is only a minimal program to regularly inform people about past damages, to identify the location of the floodplain and flood fringe, and to provide communications between individuals at risk on the floodplain and with public agencies. These programs need enhancement, and Snohomish County could take the lead in providing support for such programs.

Agriculture

Most agricultural damage in this reach is to structures. A specific inventory of damage categories was not available, and should be compiled. It is likely that some of the techniques described for reduction of residential damages are also applicable to agricultural structures. The Corps is encouraged to undertake such a study as part of its broader study of the application of nonstructural measures to residential buildings in this reach.

Other (Streambank erosion)

Unfortunately, we did not obtain information on specific streambank erosion problems in this reach, so as to ascertain their causes and possible ways of reducing these damages.

2. Reduction of Future Incremental Damages: Urban-Related Damage Categories

Floodplain Building and Zoning Codes

The current "emergency" program of flood hazard insurance needs to be upgraded to a "regular" program, and then strictly enforced zoning and building codes need to be articulated by Snohomish County and the incorporated towns in this reach. The definitions of floodplain, floodway, and flood fringe should be consistent between these jurisdictions. The implementation of these programs will help to prevent new residential development in flood prone areas, such as the Tualco Valley, which we feel are subject to urbanization pressures. In addition, already platted areas which are shown on Map 5-5 must have these floodplain building codes applied to them.

Fee Simple Purchase and Acquisition of Development Rights

These actions would probably not lead to much reduction of future flood damages in the short run (assuming measure 1 above is in force), but as in Reach 2 could be effective in the long run in helping to minimize these damages and would probably contribute other multiple use benefits to the management of the reach. Snohomish County is in the process of developing programs for agricultural lands preservation, and as with King County if these programs were implemented they would help reduce flood damages in the long-run. After Snohomish County completes its program, some lands with significant environmental values (such as the braided channel) may be acquired, with some associated flood damage reduction values. At the confluence of the Skykomish and Snoqualmie Rivers between Monroe and Duvall, the same strategies may apply to the current acquisition of development rights or fee simple purchase as were discussed for Reach 2, as part of a long-run regional open space/park system. Snohomish County should take the lead in evaluating the use of these measures, but if they are found desirable federal involvement may become justified.

Subdivision Regulations

Snohomish County should be encouraged to develop regulations which relate floodplain lands as open space or recreational spaces with planned unit developments. Many sites appear to exist for the application of such a concept, such as May Creek or Wallace River, which would lead to flood damage reductions by co-opting the development of residences and structures on flood fringe or floodplain lands otherwise zoned for such uses. Residual damages to structures which were "floodproofed", damages to infrastructure, and emergency aid expenditures might be lowered in some subregions of this reach if an inventory of opportunities for development of this type were undertaken, and related to zoning programs for the parcels identified as suitable for this strategy.

Basin-Wide Approaches

The preceeding sections of this chapter have proposed ways for dealing with existing and future flood damage problems in the various reaches of the floodplain. Many strategies have been discussed, in both specific and general terms. In many cases these suggestions could have quantitative support via traditional benefit-cost calculations, and even stronger support from other accounts which are relevant in evaluating nonstructural approaches.

Table 7-3 and 7-4 catalog across reaches approaches which we feel are most promising in reducing present and future damages, respectively. Table 7-5 is a composite of the two tables, and also includes some other less strongly favored approaches. Inspection of these tables reveals that there are many options considered of high priority. Recognizing the differentiated nature of the problems of this floodplain among reaches, the rich array of seemingly useful strategies poses difficulties for the articulation of alternative strategies which might be implemented by the various governments involved in the flood hazard problem.

We must also be mindful of the multiple-use nature of water resources. Although this contract was directed to the specific problem of flood damage reduction, it is clear that other issues are related to the management of this floodplain from the perspective of the various governments involved in its management and development. These issues include: (1) open space and recreation: what should be on this floodplain over the next 100 years; (2) fisheries and wildlife habitats: what is the regional role of this floodplain; (3) assimilative capacity for surrounding human development: what is the role of this floodplain; and (4) agricultural lands preservation: what role should agriculture have in this region.

TABLE 7-3. RECOMMENDED MEASURES TO REDUCE EXISTING FLOOD DAMAGES

	REACH							
	1	2	3	4	5	6	7	8
1A Ring Levees Around Structure	3	3	2	1	4			1
1B Closure/Sealing of Structure Openings	3	3	1					
1C Raising of Structure	3	3	1			1		
1D Relocation in Structure of Contents/Equipment	3,1	1	1,1		1	1		1
2A Relocation of Structure	1,2	1,3	2					3
2B Demolition of Structure	1	3	3					3
2C Urban Redevelopment								
3 Protection/Relocation of Transport./Utilities	3	3						5
4A Change in Farming Methods	3	5						
4B Livestock Evacuation and Mounds (+Equipment)	1	1						
5A Public Purchase Fee/Fee & Leaseback								
5B Purchase Devel. Rights or Flooding Easement								
6A Floodplain and Shoreline Zoning								
6B Other Zoning								
6C Subdivision Regulations and Building Codes								
6D Other Regulations and Permits								
7 Preferential Open Space Taxation		3				5		
8A Emergency Preparedness and Flood Warning	1,1	1	1		1	1		1
8B Flood Insurance								
9 Natural Valley Storage								
10 Management of Existing Flood Control Measures	2,2	3				4		
11A Watershed Management								
11B Riparian Vegetation Management		5				5		
11C River Corridor Management								
12 Information and Education	1,1	1	1	1	1	1	1	2

1 = High 3 = Medium 5 = Low

TABLE 7-4. RECOMMENDED MEASURES TO REDUCE FUTURE FLOOD DAMAGES.

		REACH							
		1	2	3	4	5	6	7	8
1A	Ring Levees Around Structure								
1B	Closure/Sealing of Structure Openings								
1C	Raising of Structure								
1D	Relocation in Structure of Contents/Equipment								
2A	Relocation of Structure								
2B	Demolition of Structure								
2C	Urban Redevelopment								
3	Protection/Relocation of Transport./Utilities								
4A	Change in Farming Methods								
4B	Livestock Evacuation and Mounds								
5A	Public Purchase Fee/Fee & Leaseback	2	2	3	2		4		4
5B	Purchase Devel. Rights or Flooding Easement	2	1	3	3		3	3	4
6A	Floodplain and Shoreline Zoning	1	1	1	1		1	1	2
6B	Other Zoning								
6C	Subdivision Regulations and Building Codes				5				3
6D	Other Regulations and Permits								
7	Preferential Open Space Taxation								
8A	Emergency Preparedness and Flood Warning								
8B	Flood Insurance								
9	Natural Valley Storage	2	2	2	2		5		
10	Management of Existing Flood Control Measures								
11A	Watershed Management						2	2	
11B	Riparian Vegetation Management								
11C	River Corridor Management	2			4		1	2	2
12	Information and Education								

1 = High 3 = Medium 5 = Low

Tables 7-3 and 7-4 suggest approaches which seem most promising in each reach. However, IT SHOULD BE EMPHASIZED THAT NONSTRUCTURAL APPROACHES TO FLOODPLAIN MANAGEMENT INEVITABLY LEAD TO CUSTOM-TAILORED PARTICULARIZED STRATEGIES FOR THE PROBLEMS FOUND AT EACH LOCATION SUBJECT TO A FLOOD HAZARD. ADDITIONALLY, MULTIPLE PURPOSE NONSTRUCTURAL APPROACHES PROVIDE A BASIS FOR AN EVEN RICHER ARRAY OF POTENTIAL ACTIONS. WE CONCLUDE THAT IT IS DANGEROUS TO SUGGEST ANY PARTICULAR MIX OF ACTIONS TO THE EXCLUSION OF OTHER POSSIBLY PROMISING STRATEGIES IN PARTICULAR SUBREGIONS. THE FOLLOWING STRATEGIES SHOULD BE READ WITH THESE QUALIFICATIONS CONTINUOUSLY IN MIND.

Table 7-5 incorporates actions we found most promising in each reach for aversion of present and future damages, and identifies (in column 1) a set of actions which do appear to be basin-wide in their applicability. Actions which could help reduce the present flood hazard throughout the basin include: raising structures or relocating contents and equipment in structures, a more aggressive emergency preparedness and flood warning system, better management of existing flood control measures, and an improved and expanded system of information and education. Future flood damages may be averted through more aggressive programs of land acquisition, purchase of development rights, strict enforcement of floodplain zoning, and use of natural valley storage capabilities. In addition, we assume that existing flood insurance programs would continue, and possibly could be strengthened in terms of community eligibility to force even stronger local implementing mechanisms.

Table 7-5 also incorporates a number of other dimensions. Actions which private individuals could take are listed, levels of government which probably would have to accept either programmatic or financial responsibilities for actions are identified, the ease of implementing a particular strategy in this basin is assessed, magnitude of payoff in terms of flood damage

ABLE 7-5. STRATEGIES FOR FLOOD DAMAGE REDUCTION

			REACH									Level of Govt.					Other Benefits					STRATEGIES					
		Basin Wide	1	2	3	4	5	6	7	8	Private Action	Local	State	Federal	Ease of Implementation	Magnitude of Payoff	Envir. Res.	Recreation	Fisheries	Ag. Land Preserv.	Erosion & Sed.	IV High Level; Do Everything; Flood Dam. Emphasis	II Low Govt: Low Lev. Easy High Payoff (Flood Dam.)	III Emph. Mult. Purp. Lo Lev.; High Payoff	I No Specific Govt. Prog.	V High Level Mult. Purp.	VI Environ. Quality Emph.
1A	Ring Levees Around Structure	P	P3	P?	P2	P1	P4			P1	X			X	L	M						M	L	L	L	M	
1B	Closure/Sealing of Structure Openings		P3	P3	P3						X	X			H	L						L	L	L	L	L	
1C	Raising of Structure	P	P3	P3	P1			P1		P1	X			X	L							H				H	
1D	Relocation in Structure of Contents/Equipment	P	P2	P3	P1	P1	P1	P1		P1	X	X			H	H						H	H	H	L	H	
2A	Relocation of Structure	P?	P1	P2	P2					P3		X		X	L	M						L				L	M
2B	Demolition of Structure		P3	P3						P3		X		X	L	L						L				L	M
2C	Urban Redevelopment											X	X	X	-	-		(X)				-				-	M
3	Protection/Relocation of Transport./Utilities		P3	P3						P5		X	X		M	M						M				M	
4A	Change in Farming Methods		P3	P5							X	?	X ?	X ?	M	L	X			(X)	X	L				L	L
4B	Livestock Evacuation and Mounds		P1	P1							X			X	M or H	H				(X)		H			L	H	
5A	Public Purchase-- Fee/Fee & Leaseback	F	F2	F2	F3	F2		F4		F4		X	X	X	Sm-H Lg-L	H L	X	X	X	X		M		M		H	H
5B	Purchase Devel. Rights or Flooding Easement	F	F2	F1	F3	F3		F3	F3	F4		X	X	X	Exist-H New-M	H H	X	X	(X)	X		H	H	H		H	M
6A	Floodplain and Shoreline Zoning	F	F1	F1	F1	F1		F1	F1	F2		X	X	X	H	H+	X	(X)	(X)	X	X	H+	H	H		H	H
6B	Other Zoning											X			-?	-?	(X)	X		X		-		L		L	L
6C	Subdivision Regulations and Building Codes		?	?		F5				F3		X	X		H	M					(X)	M				M	M
6D	Other Regulations and Permits											X	X	X	M	M	(X)		(X)		(X)	-		L		L	M
7	Preferential Open Space Taxation			P3		?		P5		?			X		H	L	X	X		X		L	L	H		H	H
				P3		?		P5		?			X		H	L	X	X		X		L	L	H		H	H
8A	Emergency Preparedness and Flood Warning	P	P1	P1	P1		P1	P1		P1	X	X	X	X	H	H+				X		H+	M	H	L	H+	M
8B	Federal Flood Insurance Program	--------	--------	--------	--------	--------	--------	ASSUMED	ACROSS	ALL	REACHES	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
9	Natural Valley Storage	F	F2	F2	F2	F2		F5				X	X	X	L	M?	X	X	X	X	X	M?		M		M?	M
10	Management of Existing Flood Control Measures	P	P2	P3				P4			X	X		X	M	H				(X)	X	H	L	M	L	H	H
11A	Watershed Management							F2	F2		X	X	X	X	L	?	X	X	X	X	X	M?		M	L	M	H
11B	Riparian Vegetation Management			P5				P5			X	X	X	X	L	L	X		X		X	L		M	L	M	H
11C	River Corridor Management		F2			F4		F1	F2	F2		X	X	X	L	M?	X	X	X	X	X	L		L		M	M
12	Information and Education	P	P1	P1	P1	P1	P1	P1	P1	P1	X	X	X	X	M	H	(X)	(X)	(X)	(X)	X	H+	M	M	L	H+	M

P = Present F = Future

1 = High 3 = Medium 5 = Low

Hi (Easy Med Lo (Hard)

reduction is also assessed, and a variety of non-flood damage reduction benefit/impact categories are identified.

ALTERNATIVE STRATEGIES

Six alternative strategies were developed which represent varying intensities of governmental commitment to flood hazard reduction in the Snohomish River Basin. These are indicated on Table 7-5, with a scaling of effort by nonstructural approach for each alternative. These six strategies will now be described briefly. The specific nature of how elements in each strategy could work are discussed in Chapter 3, and the potential for application in each reach was discussed earlier in this chapter. These strategies must also be considered tentative, given the largely qualitative way in which they were derived; further research will probably lead to a better articulation of management strategies.

Strategy I

This approach could be characterized as the opportunities available to individuals and businesses for mitigation of flood damages by nonstructural approaches. No particular governmental program to reduce the existing flood hazard is implied here. The assumption is that people can do many things on their own to reduce the flood damage risk. In general, we feel that the level of effort associated with such a strategy would be low, and that it would not lead to much in the way of flood damage reduction.

Strategy II

This approach emphasizes tools available to local governments to help reduce present flood damages and avert future damages. The approaches involved are those which are relatively easy to implement, and which would appear to have a reasonably cost-effective payoff. Existing programs are included here, including the flood insurance program, floodplain zoning, preferential taxation for open space preservation, and the purchase of development rights to help minimize the increase in future damages. Present damages would be reduced through programs designed to relocate contents of structures, closure and sealing of structural openings, an enhanced emergency preparedness program and better information and education about flood hazards.

Strategy III

Strategy III is again a program based on the capabilities of local government, but emphasis is placed on the multiple-use management of water resources of the basin. This strategy encompasses all approaches included in Strategy II, but also embraces a more aggressive land acquisition program (for recreation and open space values and for fisheries and wildlife enhancement), and the use of complex strategies for basin-wide environmental management such as natural valley storage or river corridor management. These more complex approaches may help reduce future flood damage potential by avoiding future development to a greater extent than would be the case for a program focussing primarily on flood damage reduction (Strategy II).

It is possible that local governments could undertake other actions not identified in Table 7-5, but historically they have not absorbed the primary costs of programs such as raising structures or structural relocation. Local fiscal constraints have generally precluded local funding initiatives on programs of this type in our country, largely because the federal government has historically assumed much of the financial responsibility for "large" capital-intensive water projects. However, it is possible that local governments could move to support the more capital intensive nonstructural approaches, and do more than we have suggested here in Strategy III. We will assume that in the near future these funding responsibilities will rest more with the federal government, if authority and funding is available.

Strategy IV

Strategy IV is an aggressive approach to a nonstructural flood damage reduction program. It encompasses most of the recommended actions in each reach described earlier in this chapter. Unlike Strategies I, II, and III, this strategy clearly involves the federal government (primarily the Corps of Engineers). Almost all categories of nonstructural approaches identified in Table 3-2. and Chapter 3 are suggested here, but the emphasis is on flood damage reduction at the expense of multiple purpose water resource management. In addition to local government programs identified previously, this strategy would involve many complex federal-local programs for flood hazard reduction and prevention. Small-scale structural solutions such as raising structures, ring levees around structures, cattle and equipment mounds, participation in the purchase of development rights on selected parcels of land which might be subject to future development if they were not acquired, extensive programs of emergency preparedness and information and education, and aggressive pursuit of existing programs of flood control would be part of this strategy, with significant federal cost participation. Complex programs for basin management would be carefully assessed (Measures 9-11C).

This program would require significant amounts of information to be gathered if it were to be aggressively implemented. Damage reduction strategies for <u>each</u> existing house and structure would need to be developed. Each farm would need an evaluation of its needs for livestock and equipment mounds. Emergency preparedness and flood warning systems could be very labor intensive, involving <u>annual</u> seasonal inspections of each landowner's property to identify actions which should be taken to avoid flood damages. These illustrations of the intensity of such a program do not exhaust the list of actions which would be undertaken in a program of this type. Instead, they are illustrative of the level of intensity we are suggesting.

Strategy V

Strategy V is a multiple-purpose expansion of Strategy IV. In addition to the federal government helping to fund flood damage and prevention programs, all levels of government would also be involved in the management of other aspects of basin water resources. This would lead to shifts in emphasis in various program elements. For example, if recreational values of the various reaches of the river were capitalized upon through local-federal funding of a land acquisition program or development rights acquisition program, it is possible that public control of these lands could also reduce the likely level of development on them in the future, and thereby also help reduce future flood damage levels. This type of program, with greater emphasis on other water resource values such as fisheries, wildlife, preservation of riparian open space and floodplain agriculture would also emphasize complex basin wide approaches to land management. River corridor management, riparian vegetation management, watershed management, and natural valley storage would become tools with greater potential applicability than in a single-purpose flood hazard reduction program.

Strategy VI

This strategy emphasizes environmental quality. In this strategy, relocation or demolition of structures on the floodplain would be relatively more important, and would be replaced by open-space land uses. Land acquisition programs would be aggressive, primarily for preservation purposes. Emphasis would be on basin-wide approaches to natural landscape value preservation, including maintenance or enhancement of wildlife and fisheries, while retaining the open space values of the land. Recreational development might be less than in Alternative V.

Recommended Strategy

We feel that Strategy V probably has the greatest potential for maximizing public welfare through cooperation of all institutions--federal-state-local--in the Snohomish River Basin. However, resources involved in this study were insufficient to focus upon these multiple-use values. We believe that the detailed analyses of the reach-by-reach opportunities for flood damage reduction point to this conclusion. We are on stronger ground to embrace Strategy IV, but would like to suggest that Strategy V be pursued so that opportunities for the maximization of all land management values are not overlooked. This recommendation inevitably leads to the conclusion that more data on site specific flood damage is needed in the Snoqualmie River Basin, but it also does not mean that some significant actions cannot be taken in the short-run (next decade) to reduce the flood damage levels in this region. Therefore, our recommended strategy has two dimensions: short-run actions and long-run proposals for damage reduction.

Short-Run Actions

(1) Institutions. The preceding analysis suggests that flood damage reduction is a multifaced problem, involving many municipalities, two counties, numerous state and federal agencies, and an array of citizen groups and industrial interests. Any viable nonstructural approach to river basin management has to encompass all of these interests in its articulation and implementation.

The broadest existing institutional arrangement related to water resource management in this particular river basin is the Basin Coordinating Council. However, this Council has incomplete membership and little real authority to define solutions to existing or future problems. In our pluralistic society, it is foolish to think that we can create institutions which have such ultimate power. Instead, we will undoubtedly have to forge alliances which work to solve problems which we agree need solution. In this river basin, we encourage a broad-gauged and continuing look at this problem, to try to develop better and better institutional mechanisms for the implementation and development of nonstructural approaches to river basin management. Leadership in this matter would seem to rest with the counties and the Corps of Engineers. The local councils of government could also help foster intergovernmental approaches to problems of floodplain management in this river basin. Citizen groups and industrial interests need also to be involved, as they were critically involved in the articulation of the Mediated Agreement.

(2) Flood Hazard Insurance Programs

We urge the municipalities and Snohomish County to speed completion of "regular" flood hazard insurance programs. It appears clear that these programs offer significant opportunities for aversion of future flood damages, if they are articulated in a forceful manner. King County has exercised leadership in this matter, and its stringent standards should be reviewed by jurisdictions seeking to promulgate programs which will maximally avoid flood damages.

In the past, it may be that some jurisdictions felt that structural solutions would provide levels of protection which would allow them to adopt relatively weak flood hazard insurance programs and related zoning ordinances. However, in the event that most structural solutions proposed for this river basin are uneconomic, this historic assumption must be replaced with other standards which are in the public interest.

Federal agencies responsible for the arrangement of such programs should press for their consummation in areas presently covered by emergency programs. If this means that more federal funds are needed for studies, then the cost of these increased funds needs to be weighed against the possible stream of increased flood damages associated with delay in implementation of such programs.

(3) Annexations and Land Acquisition Programs

King and Snohomish Counties must begin to consider now the long-run prospects for annexations of lands on the floodplain in the Snohomish River Basin which could lead to increased levels of flood damages. We have touched upon a number of situations in particular reaches where this conditions strategies for future flood damage reductions. This is a sensitive political issue. However, if we have our eye on flood damage reduction, we have to consider the appropriate present policies of county governments with respect to land acquisition, recognizing that ultimately some parcels acquired by county governments may be transferred to municipalities for their management.

In the short-run, we feel that there are significant development pressures in Reach 1, 2, 4, and 8 which require the articulation of county long-range management plans. Typical planning horizons are only ten to twenty years in county government, while water resource management planning horizons stretch out a century. Reconciliation of these different planning horizons is absolutely necessary to focus on this problem. The Corps cannot abandon its mandate for long-run analyses, and the local governments have no prohibitions on their dreaming about the future.

The results of these evaluations as they relate to ultimate annexation programs of local governments cannot be underemphasized for their importance in determining the efficiency of nonstructural approaches to future flood damage reduction. The discussion concerning Reach 2 in this chapter most dramatically illustrates this situation.

We recommend that the two counties approach this question in a conditional manner, trying to develop approaches which are "conditional futures" where boundaries of jurisdictions are played down, and problems of floodplain management in a long-run floodplain growth scenario are played up. The results of such an exercise should help in the formulation of land purchase and development rights acquisition programs in the short-run. These evaluations should also help to identify the possible bases for federal financial participation in such programs.

(4) <u>Information and Education Programs; Emergency Aid</u>

Present local government support to emergency aid/flood hazard warning/ and information and education programs is not as aggressive as it could be. King County has been more aggressive in this matter than Snohomish County, but it has inherently more resources because of its larger population.

In the short-run a number of actions seem possible in this area which could have a significant effect on flood damages.

Bad flooding problems seem to occur in this river basin about every five years. Human nature, being what it is, tends to forget past damaging events. There is ample evidence to suggest that it is human nature to bet against the reoccurrence of natural disasters, and often individuals have not experienced flood damage problems in the location that they are now occupying in this highly mobile society of ours. In addition, we can have on the books the best of technical approaches to flood damage problems, but not have the enforcement capabilities to see that these strategies are implemented.

We strongly recommend an expanded program of information, education, and emergency preparedness. This is a very complex subject, and it is clear that research must be done on the best opportunities in this river basin. At present, these seem to be promising approaches:

(a) The floodway should be posted clearly and uniformly over all municipalities and counties in the region. Signs on utility poles with depths of flood waters in various frequencies of flood events could dramatically suggest risks to even casual recreational users of the basin.

(b) State laws regulating real estate transactions should require the conveyance of information to purchasers of floodplain property on historic flood damage levels on a uniform basin among jurisdictions.

(c) There should be an inspection program established for each parcel of property at risk. This program could be modelled on the periodic fire safety inspection program of municipalities. In this basin, the flooding is seasonal, and before each winter season, inspections could be made. These inspections should identify public and private property which is subject to probable damage from the 100-year flood if it were to occur within the next month. September and October seem like appropriate months for such inspections in this basin. This program needs to be considered for all structures, whether they are "flood-proofed" or not, including such diverse features as cattle mounds, houses, public roads, etc. Much of the emergency aid costs in this river basin have been from improperly maintained infrastructures, and there is evidence to suggest that the same problems exist with private property. Periodic inspection and maintenance of existing levees is especially critical.

The responsibility for such programs should probably be divided between the federal government and local governments. Federal support should probably be used to initiate such programs, and monitoring of its effectiveness through the next several flood events is obviously needed to establish a statistical basis for its effectiveness. County governments seem most appropriate for administration of such a program, but other institutional arrangements are certainly conceivable.

(5) Existing Damage Information

The most important current need is the development of site specific estimates of existing damage characteristics, so that the effectiveness of the relatively custom-tailored nature of a nonstructural approach can be determined.

Long Run Actions

Assuming that the problems just outlined can be resolved in the next few years, a number of actions can be taken to achieve the goal of flood damage reduction in this basin via nonstructural means. The short run actions just outlined are really conditional measures. They are necessary for any strategy to work. Without appropriate institutions, land management objectives, communications networks, and statistical bases for making public funds investment decisions, there is no political basis for actions recommended in this chapter.

Strategy 5 (or 4) is the closest collage possible at a basin-wide level of the programs suggested in the reach-by-reach treatments found earlier in this chapter. We simply suggest at this juncture that the Corps take the leadership in the evaluation process for these myriad suggestions. Specific governmental responsibilities were suggested in the reach-by-reach treatments earlier in this chapter. The preceding discussion of short-run actions underscored the common elements in each of these strategies (e.g. basin-wide strategies 4 or 5). Table 7-5 indicates the differentiated nature of these strategies by reach, and there is no point in trying to be reductionist here.

(1) Adjustments to Existing Structures

We did try to evaluate the opportunities for damage reduction on a sample of existing structures in the basin by nonstructural approaches. Appendix I presents a description of these calculations.

The results of the trial computations suggest that many small scale structural approaches may lead to significant aggregate reduction in damages in the Snohomish River Basin. The most important need is for the development of more detailed damages data, which should be the responsibility of the COE. After the COE has helped identify the damage reduction opportunities for the various individual structures, both residential and commercial, as well as related infrastructure elements, then the COE in cooperation with the various local governments could work towards the development of local improvement districts which would facilitate implementation of these measures. We consider this to be a long-run action, because it will take several years to gather the necessary site-specific data, some time to evolve an institutional framework within which such actions could be taken, and additional time to actually implement programs to modify or relocate existing structures.

(2) Land Use Regulations

These measures involve land use regulation, either by public "taking" or public design standards. It is evident that these measures hold great promise at a basin-wide level for amelioration or prevention of future flood damages. Their value is "long run", in that their effectiveness is not really tied to existing damages, but rather to prevention of the growth of the damage potential and systematic diminution of the existing damage potential.

In dealing with these management frameworks for the future now, we must recognize the uncertainty inherent in local government abilities to forecast the course of change. These uncertainties were emphasized in the latter parts of Chapters 5 and 6, and need not be repeated here. If we are conservative about future risks, then the discounted value of our expectations is clearly lower than if we are bullish with regard to development. To preserve our options in this regard probably argues for an aggressive public land acquisition program now for this floodplain. This strategy is strengthened if we think that development is imminent and if we are not sure that we have the power to regulate it away from areas with certain risks through the weaker power of zoning vis-a-vis acquisitions.

In the long run, it is absolutely imperative to assume that the short run measures continue to be implemented, and that the long run measures just discussed are also in force.

<u>The combination of all these strategies in the long run constitute a nonstructural approach to the management of the water resources of this river basin.</u>

CHAPTER VIII

CONCLUDING REMARKS

The preceding chapters have really been exploratory work, on an obviously complicated task. When we undertook this project we anticipated getting farther than we have in the evaluation of nonstructural approaches to the management of the Snohomish River Basin. The alternative strategies outlined in Chapter VII are only a few possibilities out of an infinite combination of possible alternatives. At this point, the recommended strategy may not be the most cost effective, the most feasible, or the most environmentally desirable; moreover it is likely that no single approach could simultaneously maximize all of these factors.

Traditional approaches to water resource development and management have often involved the use of "rules of thumb" to estimate site specific benefits of structural proposals. The structural proposals themselves have tended to be relatively easy to cost, and fairly easy to relate to summary measures of benefits derived by the application of standardized damage reduction functions. In contrast, nonstructural approaches are just that: approaches. In many cases they are concepts that need to be fleshed out precisely within the physical framework of the particular basin being analyzed, and more importantly within the institutional setting of that basin. In many cases these programs will be implemented by local governments and individuals, as opposed to the federal government taking the structural action which leads to damage reduction.

Because of the heavy role that local governments and affected parties play in the implementation of nonstructural approaches, and the significant power that has been delegated to these local governments to determine their own land-use futures, it seems to us as though they should be centrally involved in the articulation of a nonstructural program. At present no such policy direction has been articulated for this basin, and we strongly recommend that the Corps and local governments proceed cooperatively to define a nonstructural management strategy which encompasses the entire basin.

We cannot emphasize this point too strongly, for local government will critically affect the ability of nonstructural programs to function in this river basin. Annexations, existing plats, life cycles for existing structures and their statistical relationship to flood damage functions, and unanticipated new industrial developments are examples of factors which are partially beyond the control of those formulating policy for flood damage reduction in this region.

While this may seem to complicate matters from the standpoint of the articulation of a nonstructural flood damage prevention program, we feel that the opposite is the case in comparison to traditional approaches. The actions suggested here do not involve large structures with long payout periods and uncertain risks of damage reduction. The benefits and costs are much more contingently or associatively tied together because of the inherently localized nature of nonstructural approaches. This means that as goals and objectives change for the use of particular lands, that strategies may also change for flood damage prevention--but within the framework of a nonstructural approach.

The flood damage issues faced in this river basin which can be approached from a nonstructural perspective may be relatively unique. We have not made comparative evaluations, and that too is a need. As we have discussed our work with others, we have asked about the similarity of problems, without finding a good comparative model. Even so, the prospects for additional flood damage reduction through these strategies in the Snohomish River Basin are very promising, and we strongly recommend that the various governments responsible for management of the basin work actively towards the application of these measures in the region. We also strongly recommend that as research proceeds on the subject, that a balance be sought between measures to reduce existing damages, and actions which will prevent future damage.

The Snohomish Mediated Agreement has gained national recognition as a model process to attempt solutions proposed by people, groups, and institutions with many divergent objectives. The product of the Mediation, the Snohomish Mediated Plan, has gained attention at the highest levels in the federal government. Within the framework of the Mediated Plan, the emphasis on nonstructural approaches has been identified as a critical element, but also an innovate element (see letter from Senators Magnuson and Jackson to President Carter dated January 23, 1979, and the reply of the White House dated March 19, 1979 in Appendix II).

One possible approach to the implementation of a nonstructural approach would be a process similar to the development of the original Snohomish Mediated Agreement. After the Corps of Engineers and local governments gather the data we have initially identified as needed to consider such approaches in greater detail, public workshops could be held to discuss the possible application of these various nonstructural approaches in particular subregions, such as the reaches we have described in this report. The Basin Coordinating Committee or some successor organization could act as the facilitator for such workshops. Affected individuals, representatives from all levels of government, and interested groups could jointly develop an array of alternative nonstructural approaches to prevent flood damages and also attain other land use and water resource management objectives. Consideration would need to focus on the reduction of existing flood damage problems, but critical consideration would also have to be given to longer term land-use questions in this area.

Once an array of specific nonstructural programs had been articulated by these individuals, groups, and governmental entities, the COE could take the leadership in evaluating the magnitude of the beneficial aspects and costs of each alternative, within the framework of the various benefit-cost accounts currently in use by the federal government. These analyses would need to be supplemented by concurrent local government evaluations of their interests in the various alternatives. The number of alternatives could then be reduced through such an evaluation process to the most promising alternatives. Selection of specific recommended alternatives would be a joint decision of the people and property owners in the floodplain, citizens and governments affected regionally by floodplain management programs, and by the levels of government which have the authority to implement and fund selected approaches. The resulting plan (subject to change with variation in levels of funding, authorities of governments, and technology) would spell out where the specific nonstructural measures would be implemented, who would be affected, what agency would have responsibility for implementation, management and funding, and the time frame within which the plan would be implemented.

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APPENDIX I

The purpose of this section is to give highlights of data collected and calculations made in order to get a rough idea of the feasibility of costs and benefits of some nonstructural measures, as applied to residential structures and mobile homes. Data collection, computations, and lessons learned in the process will be discussed.

To determine the feasibility of implementing measures to reduce flood damages to residential structures, a sample of houses in Reaches 3 and 8 and mobile homes in Reach 1 were analyzed. An estimate of the value of each house was obtained from County Assessor's records, and the mobile homes' values were based on a recent study in New Hampshire. ("Formulation, Assessment and Evaluation of Flood Damage Reduction Techniques for Keene, New Hampshire," May 1980, Draft submitted to New England Division COE by CDM/Resource Analysis.)

Costs for relocation, raising, and replacement of foundations with floodproofed foundations were updated from a study done by the Baltimore District, U.S. Army Corps of Engineers ("Cost Report on Nonstructural Flood Damage Reduction Measures for Residential Buildings Within the Baltimore District," Institute for Water Resources, 1977) using the Engineering News-Record Building Cost Index and location multipliers from Stevens Valuation Quarterly. Costs of relocating mobile homes and building small berms and walls were corrected to Seattle costs from the Keene, New Hampshire study. Data on flood probability and flood hazard factors were obtained from Seattle District, COE maps and studies. Benefits were estimated in terms of expected annual damage reduced, based on the assessed valuation of the structure. The expected benefit curves were taken from "Physical and Economic Feasibility of Non-Structural Flood Damage Reduction Measures" by William K. Johnson of the Hydrologic Engineering Center.

DATA

The S' r .e District COE supplied information on flood and floor elevations for the Snoqualmie area. Flood elevations came from the Jones and Associates worksheets, and from Corps of Engineers computer printouts. The floor elevations came from Jones and Associates study. Flood elevations for the mobile home park in Reach 1 and the houses in Reach 8 were derived from the data being developed for the Skykomish River Flood Insurance Study by Seattle District, Flood Plain Management (FPM) section. These flood elevations should be regarded as tentative. Ground elevations for both areas were derived from the Skykomish Flood Insurance Study base maps provided by FPM. Floor elevations for houses in Reach 8 were collected in the field by Margie Palmer. Mobile home elevations were postulated by assuming heights of 1.15 and 2 feet above ground level.

Detailed information on the structures in both Snohomish and King Counties were collected in the respective assessor's offices. (Unfortunately, Washington law provides for the publication of only limited information about commercial structures, making their analysis more difficult. It might be noted that this information is machine retrievable, although with difficulty.)

COST INFORMATION

The main sources of cost information used for the detailed analyses were the Baltimore study, "Cost Report on Non-Structural Flood Damage Reduction Measures for Residential Buildings within the Baltimore District," and the Keene, New Hampshire study, "Formulation, Assessment and Evaluation of Flood Damage Reduction Techniques for Keene, New Hampshire," by CDM/Resource Analysis. Information on costs from the Baltimore study were regionally adjusted using the Valuation Quarterly, and the costs were updated using the more extreme of the two Engineering News-Record indexes. Mobile home costs and ring dike and levee costs were taken from the Keene study.

It is important to note that the work in the Baltimore study is based on detailed engineering analyses, probably a requirement for additional work of this type, and the range of validity of the engineering assumptions are a major impediment to the generalization of this work to other types of construction.

BENEFIT INFORMATION

Benefit data were derived from the 1970 HUD expected annual damage reduction tables in Appendix A of Johnson (1978). Flood Hazard Factors (FHF) were determined by subtracting the 100-year flood height from the 10-year flood height. The FIA table was used either by interpolating from the FHFs given or by using the more conservative of the two straddling the actual value. Expected interval of return was used in the same manner. The dollar value of expected annual damage reduced was derived by multiplying the percentage value derived from the table by the assessed value of the house. Slightly different results might have come from using the Jones and Associates valuations of the houses. That would have been difficult to do without a tag, tying the house in the Jones study to the houses in the Assessor's office data.

Expected interval of return was calculated by taking the flood heights provided by the Seattle District, computing the logarithm of their frequency and running a linear regression. The resultant r^2 value was uniformly high, although the sample size was so small that it might cast doubt on the statistical significance of the result. The resulting linear equation was used in a calculator program to determine the Expected Interval of Return for any given floor elevation within a group of houses having the same flood elevations in the Jones study.

Sources of Error

Possible sources of error in these calculations include errors in estimation of costs, errors in the degree of flood hazard, and errors in the amount of benefits received from a particular action. Costs are not likely to have been under-estimated for relocation or raising houses. A recent Seattle District estimate is much less than the updated Baltimore study estimates used here. It would be helpful, however, to get some estimates on houses by moving or construction companies or to look at the costs of some actual projects in this area.

Errors in the degree of flood hazard might arise from the precision of the data provided to us. Variation in this information is as likely to increase benefits as it is to decrease them, however.

The amount of benefits received from a particular action were calculated using a general flood frequency-stage distribution, not one specific to this basin, introducing the possibility of inaccuracy. Again, however, the error could be in either direction. In addition, the economic feasibility of some of the measures in some of their trial implementations is sufficiently positive that it would take errors of very large magnitude to change the outcome.

Sample Computational Results

A house in Snoqualmie. Table A-1 shows working notes for an evaluation of the effectiveness of raising a typical house in Snoqualmie. House No. 0250 was a 1250 square foot, one-story structure with a slab floor. In terms of total costs of raising the house, we estimated this to be $25,929 based on data presented for Baltimore for homes of a similar type, raised to a similar height, but updated to Seattle costs, by using a geographic correction factor

TABLE A-1

An Example of Calculating Costs and Benefits of Raising a House Three Feet

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Reach #4
House 0250

Type of House = 1-story w/slab floor
Size = 1250 ft^2

ANNUAL COSTS

Closest house in Baltimore = slab on grade #1, p. 6, Appendix A
Updated cost of Raising SOG #1 = $25,929

BOTH HOUSES ARE EXACTLY THE SAME SIZE, SO COSTS ARE NOT INTERPOLATED PER SQUARE FOOT

ANNUAL COST OF RAISING = $2090
(Assumes 30-year amortization, 7% interest rate)

ANNUAL BENEFITS

Information Required:

FHF = 1.6

EIR = <2 years

Assessed Valuation = $41,500

If EIR = 2 and FHF = 1 Annual Damage Reduced = 13.0% of assessed valuation

FHF = 2 Annual Damage Reduced = 15.6% of assessed valuation

15.6 - 13.0 = 2.6

.6x = 1.56

13 + 1.56 = annual damage reduced

14.56%

.1456 x 41,500 = $6042.4

$$C/C = \frac{6042.4}{2090} = 2.89$$

Source: Johnson, *Physical and Economic Feasibility of Nonstructural Floodplain Management Measures*. Davis, CA, 1978.

of 1.1 (Valuation Quarterly, July 1980) and a building cost correction factor of 1.42 (ENR, 1980). These computations yield an annual cost of raising of $2090, for a 30-year amortization period at a 7% interest rate.

To compute benefits we know in this case that the expected interval of return is less than two years, that the flood hazard factor is 1.6. The assessed valuation is $41,500. If the expected interval of return is 2, and the flood hazard factor is 1, annual damages would be reduced by 13% of the assessed value, while for a flood hazard factor of 2, annual damages would be reduced by 15.6%. (Source: Johnson). Interpolating, we find there with a flood hazard factor of 1.6 that annual expected damages reduced are 14.56% of the assessed value, or $6042.6. Therefore, the benefit-cost ratio is 6042/2090, or 2.89.

Computations were made for a number of homes in Snoqualmie using this same methodology; and results were reported in the text for Reach 3.

Sky River Tracts. Similar computations were made for a sample of homes in Sky River Tracts, in Reach 8. Table A-2 reports the findings of these computations, which include raising these homes, removing them from their sites and relocating them, removing their contents and demolishing them, or constructing various sized levees.

Mobile Home Court near S.R. 522--Snohomish River Bridge. Mobile homes in a 57-unit court, northwest of the State Route 522 bridge over the Snohomish River, were examined to determine the feasibility of raising or moving the structures out of the floodplain. The method used was the same as in the areas described above, with the following exceptions:

1. Mobile home values were assumed to be $6000 each.
2. Floor elevations were developed from map spot elevations and use of floor heights 1, 1.5 and 2 feet above the ground level.
3. Costs were annualized using 20 and 30 year amortization periods.

The costs of these computations are shown in Table A-3.

A.6

REACH 8 SKYVIEW RIVER TRACTS

LOT #	RAISE HOUSE (UPDATE BALTIMORE FIGURES)	COST	EAD REDUCED 5ft RAISE	PNV 30YRS @ 7%	REMOVE STR & CONTENTS COST	EAD REDUCED	PNV 30YRS @ 7%	REMOVE CONTENTS DEMOLISH STR COST	PNV EAD REDUCED	3' LEVEE COST	3' LEVEE PNV EAD REDUCED	5' LEVEE COST	5' LEVEE PNV EAD REDUCED
6	5ft	19,962	3,175/YR	40,975	39,410	3175/YR	40,975	52,170	40,975	8000	36,148	12,500	40,486
ROUGH BC			(2.05)			(1.04)			(.79)		(4.52)		(3.24)
19	7ft	19,306	1,635/YR	21,100	35,865	1635/YR	21,100	38,550	21,100	8000	18610	12,500	20842
			(1.09)			(.54)			(.55)		(2.33)		(1.67)
38	6ft	20,840	4,627/YR	59,715	30,675	4713/YR	60,823	43,560	60,824	8000	54,513	12,500	60,058
			(2.87)			(1.98)			(1.40)		(6.81)		(4.81)
41	6ft	18,525	4,950/YR	63,882	28,911	5044/YR	65,095	45580	65095	8000	58,346	12,500	64308
			(3.45)			(2.25)			(1.43)		(7.29)		(5.16)
49	7ft	28,670	4024/YR	51,951	47,330	4024/YR	51,932	62,160	51931	8000	45,418	12,500	51312
			(1.81)			(1.10)			(.84)		(5.68)		(4.16)
52	6ft	14,000	2,395/YR	30,908	25,384	2440/YR	31,489	37,200	31489	8000	28,224	12,500	31102
			(2.21)			(1.29)			(.85)		(3.53)		(2.49)

Note: Column (1) indicates heights which a sample of houses in Skyview River Tracts would have to be raised to be above the 100 year flood level. The cost of raising these homes are shown in column (2), and the present net value of this action (over a 30 year payback period at a 7% discount rate) is shown in column (4) (based on current assessed values for these structures). Benefit-cost ratios are shown in parenthese for these actions; they are the ratios of columns (4) and (2). Columns (5) through (13) show costs of other actions and present values of the expected annual damages reduced by these actions, and ratios of costs to benefits.

TABLE A-3

Floor Elevation	Expected Interval of Return (in years)	Annual Cost of Raising Three Feet		Expected Annual Damage Reduction	B/C		Annual Cost of Removing From Floodplain		Expected Annual Damage Reduction	B/C	
		20 year	30 year				20 year	30 year		20 year	30 year
32'	4.6	$133.00	$114.00	$360.00	2.7	3.2	$123.00	$105.00	$509.00	4.1	4.8
34.5	15.3			$120.00	.9	1.0			$167.00	1.4	1.6
35.0	19.5			$ 93.00	.7	.8			$123.00	1.0	1.2
35.5	24.7			$ 75.00	.6	.7			$ 98.00	.8	.9
36.0	31.4			$ 60.00	.4	.5			$ 78.00	.6	.7

Results of these analyses showed favorable benefit to cost ratios for raising houses and relocation of mobile homes. In a few cases, relocation of houses and foundation-replacement type floodproofing were found to be feasible, but only for high value houses in very high hazard areas. For example, either of the latter measures might be worthwhile for a relatively new $80,000 house with its floor below the 10-year flood level.

For the Seattle District to fully evaluate the potential for reduction of damage to existing structures, certain additional information about those structures is necessary, and other data, while not essential would make the analysis more effective. Information necessary for a basin-wide analysis would include the flood level for five or six different flood events with as much accuracy as possible, the ground elevation next to the house on an aerial photo or large scale map, and the difference between ground elevation and first floor level. It is imperative that these data be collected with the address or some other identifier for the structure so that information available from other sources, like the Assessor's office, can be utilized. In addition the building type and construction are necessary to determine the costs of measures and the structural feasibility (For example, frame walls will not stand water depths beyond two and a half or three feet, and masonry structures are not easily moved or raised). Enclosed is a form used by the Hydrologic Engineering Center on a nonstructural study in Santa Fe, New Mexico. This form would probably have to be modified for the Northwest, and some of the categories were confusing to the Santa Fe field crews.

The promising economics of modifications to existing structures to reduce flood damages and enhance other water resource values needs to be verified by much additional research. The Corps is urged to fund such analyses, and to work with local governments to implement programs of damage reduction to existing structures and infrastructures through these means.

A folio is included with this report which includes worksheets from these analyses; it is available at Seattle District COE offices for use by interested parties. Most of these computations were made by Mr. Thomas Robinson.

STRUCTURE + CONTENTS CHARACTERISTICS

STRUCTURE USE: RES COMM IND
PUBLIC UTILITY

STRUCTURE TYPE:
1 ONE STORY, NO BASEMENT
2 >1 STORY, NO BASEMENT
3 SPLIT LEVEL, NO BASEMENT
4 ONE STORY WITH BASEMENT
5 >1 STORY WITH BASEMENT
6 SPLIT LEVEL WITH BASEMENT
7 MOBILE HOME ON FOUNDATION

[illegible]ABILITY: HI MED LO

[illegible]. OPENINGS: BELOW FIRST FLOOR ______
AT FIRST FLOOR ______
WINDOWS ______

[illegible]UNDATION: FOOTING ON-GRADE SLAB
OTHER ______

[illegible]NSTRUCTION MATERIALS: FRAME ______
(SPECIFY) SIDING: ______

[illegible]ONDITION: GOOD QUESTIONABLE POOR

[illegible]AWN? YES NO

[illegible]LOCATION OF CONTENTS:
1 ALL ON FIRST FLOOR
2 ALL ON FLOORS 1 + 2
3 IN SPLIT LEVEL
4 ALL ON FLOOR 1 + BASEMENT
5 ALL ON FLOORS 1,2 + BASEMENT
6 IN SPLIT LEVEL + BASEMENT
7 IN MOBILE HOME
8 ALL ABOVE FLOOR 1
9 ALL IN BASEMENT

REFERENCE FLOOR:

[illegible]VENT	ELEVATION	EVENT	ELEVATION

SPECIAL SOCIAL, ENVIRONMENTAL INFO.

	YES	NO
PARK SITE?		
HISTORIC SITE?		
WILDLIFE HABITAT?		
TOXIC SUBSTANCES STORED ONSITE?		
FUELS STORED ONSITE?		
ZOO SITE?		

OTHER: ______

FIELD ASSESSMENT

	YES	NO	DON'T KNOW
TEMPORARY OR PERMANENT CLOSURES FEASIBLE?			
RAISING STRUCTURE FEASIBLE?			
WALL OR LEVEE FEASIBLE?			
RELOCATING STRUCTURE FEASIBLE?			
PONDING OF WATER LIKELY?			

COMMENTS:

Appendix II

United States Senate

WASHINGTON, D.C. 20510

January 23, 1979

The President
The White House
Washington, D.C.

Dear Mr. President:

We wish to bring to your attention a highly promising approach to the management of water and related land resources in the Snohomish River Basin, Washington State.

The Snohomish Basin drains the west slopes of the Cascade Mountains through fertile valleys to an ecologically valuable delta area. The basin supports a strong agricultural and forestry economy just east and north of the Seattle metropolitan area.

Frequent and serious flooding results in approximately $5 million annually in damages. Increasing pressures for growth and development have posed a dilemma for citizens and governmental bodies: how to provide needed flood protection and maintain or enhance the hydrologic, ecologic and economic character of the basin.

After more than a dozen years of federal structural flood control studies resulting in citizen disagreement over recommended solutions, a new approach was tried in 1974 - mediation. The Mediated Agreement developed by farmers, townspeople and environmentalists is a detailed blueprint for the management of the basin's floodplain and resources. A copy of the Agreement is attached for your information.

The Mediated Agreement provides for a mix of structural and non-structural approaches to flood control and floodplain management which we feel are inherent in the Administration's current policies. The Mediated Agreement

- o provides for a largely non-structural approach to flood damage prevention in the basin as recommended in EO 11988;
- o insures a sound balance between economic development and environmental quality;
- o requires close federal/state/local cooperation and a substantial state/local responsibility in implementation; and
- o is the first successful application of mediation to a large-scale environmental dispute. Its use is currently supported by the Council on Environmental Quality.

The Agreement has strong bipartisan citizen and state and local elected official support. During the past few months the local governments in the basin and Governor Dixy Lee Ray have formally reaffirmed their support with the creation of a Basin Coordinating Council charged with guiding the implementation of the Mediated Agreement.

An important component of this program is the completion of the Corps of Engineers' feasibility study of the Mediated Agreement. To facilitate this study and speed implementation, the 1979 Appropriations Act includes extra funds and directs that the study be completed as soon as possible. All of us desire that the study be accomplished fully within the letter and spirit of the Principles and Standards and your recent water and floodplain management policies. We believe that the Corps of Engineers' feasibility study would provide an opportunity for testing and further amplifying the Administration's new water policies. In this regard we suggest you consider the possibility of establishing the study as a pilot test similar to those currently being conducted in conjunction with Corps and SCS studies on the Connecticut River. We believe this could be accomplished under current study authorization.

In particular, we would like to see included in such a study a full evaluation of the federal interest in innovative non-structural limitations to ask important "what if" and "why not" questions. In our opinion, the results of such a study would further the development of policies and procedures incorporated in Section 73 of P.L. 93-251 and your recent water policy and floodplain management initiatives.

Staff from the Council on Environmental Quality, the Domestic Council, and the Water Resources Council have been briefed on the current Corps study and its potential implications.

We encourage your support for the pilot study. We and the involved state and local governments are ready to assist in any way we can.

Sincerely,

Henry M. Jackson

Henry M. Jackson, U.S.S.

Warren G. Magnuson

Warren G. Magnuson, U.S.S.

Attachment
cc: Governor Dixy Lee Ray
John Spellman, King County Executive

THE WHITE HOUSE

WASHINGTON

March 19, 1979

Dear Senator Jackson:

On behalf of the President, thank you for your letter of January 23 concerning the Snohomish River Basin. It prompted a great deal of discussion within the Administration, with David Aggerholm of King County and with Alice Shorett of the Office of Environmental Mediation in Seattle. As a result I think we are all in a position to pursue both the Snohomish Basin problem and the non-structural flood control aspects of the President's water policy in a more thorough fashion.

A number of important issues bearing on both the Snohomish mediated plan specifically and on non-structural flood control generally have been identified and are already being analyzed by the Water Resources Council and the Department of the Army.

As a next step, my staff is convening a meeting of the various Federal agencies and representatives of the local area to discuss these issues and their relationship to the Corps' Snohomish study. Members of your staff will also be invited, and I hope they will be able to participate.

Thank you for bringing this matter to my attention.

Sincerely,

Stuart E. Eizenstat
Assistant to the President
for Domestic Affairs and Policy

The Honorable Henry M. Jackson
United States Senate
Washington, D. C. 20510