FLOODPLAIN MANAGEMENT

Use of Experienced Flood Data in Flood Plain Regulation

TECHNICAL REPORT 4

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES
Division of Waters, Soils and Minerals

PREFACE

This report is one in a series developed by the Department of Natural Resources to assist local governmental officials to understand and implement flood plain management measures. It may also create a better understanding of the relationship between the procedures outlined herein and the stated flood loss control objectives on the part of other officials and the general public. The report discusses methods for defining flood hazard areas and administrative procedures that are particularly applicable to rural areas.

The assistance of the U. S. Department of Agriculture, Soil Conservation Service, in preparing that portion of the report dealing with the use of detailed soil maps for delineating flood plain areas is gratefully acknowledged.

I. WHY DO WE NEED FLOOD PLAIN MANAGEMENT

Floods have always occurred along Minnesota's rivers and streams, resulting from excess amounts of snowmelt and/or rainfall. Prior to the construction of man-made works on the flood plain, few flood problems existed. However, as development of flood plain areas has increased, flood damages have also increased. Generally, a flood problem arises when a single structure located on a flood plain is constructed at either too low an elevation or without regard to the resultant increase in flood stages upstream. This initial development encourages additional construction of the flood plain which further reduces the waterway capacity and increases flood levels. Subsequently, the general public is affected by the installation of streets and other public services and utilities in these areas which, when damaged by floods, are repaired at public expense. The public is also required to bear the costs of flood fighting, and rehabilitation. Ultimately, flood control works constructed at public expense may be required to protect flood plain occupants.

During the period 1965 - 1969 flood losses in Minnesota exceeded 170 million dollars. Flood control works and protective measures reduced the level of flood losses that could have occurred during the above period. However, despite the public investment in protective works, flood fighting and rehabilitation, annual flood damages are *increasing* because we are occupying flood hazard areas at a faster rate than we are protecting these areas from flooding. Present (1971) estimated average annual flood losses of 25 million dollars in Minnesota will rise to projected average annual losses of 80 million dollars within 50 years unless development in flood prone areas is controlled or protected.

A considerable portion of these flood losses occur in urban areas. But damage to scattered recreational development along Minnesota's lakes and streams

is also serious. Rural areas adjacent to cities are under intense development pressure. Uncontrolled flood plain development in recreational and urban fringe areas will result in tomorrow's flood problems.

II. MINNESOTA'S FLOOD PLAIN MANAGEMENT PROGRAM

To promote sound management of flood plain lands and reduce flood losses, the Minnesota Legislature in 1969 adopted the Flood Plain Management Act (Minnesota Statutes, Chapter 104). Local units of government (counties, cities, villages and boroughs) are required to adopt, enforce and administer sound flood plain management ordinances within their respective jurisdictions whenever the Commissioner of the Department of Natural Resources notifies said units that sufficient technical information is available for delineation of flood plains and floodways on their watercourses. All proposed flood plain management ordinances must be approved by the Commissioner before adoption by the local unit.

The Commissioner has adopted administrative regulations[1] which establish standards for local regulations. Sample ordinances[2,3,4] which meet these minimum standards were developed by the Department of Natural Resources, in cooperation

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[1] Statewide Standards and Criteria for Management of Flood Plain Areas of Minnesota. 1970.

[2] Sample Flood Plain Zoning Ordinance for Local Units of Government (Using Available Flood Information in the Absence of Detailed Engineering Studies). December 1970.

[3] Sample Flood Plain Management Ordinance for Local Units of Government (Using Detailed Engineering Studies). February 1971.

[4] Sample Subdivision Control Ordinance for Flood Hazard Areas. September 1971.

with the Association of Minnesota Counties and the League of Minnesota Municipalities, to serve as *guidelines* in drafting local flood plain regulations. (Copies of these ordinances may be secured from the Association or League.) The "Sample Flood Plain Zoning Ordinance for Local Units of Government (Using Available Flood Information in the Absence of Detailed Engineering Studies)" is particularly applicable in rural areas.

In addition, the Commissioner will provide assistance to local units of government, upon request, in gathering information, drafting ordinances and administering regulations.

III. FLOOD PLAIN REGULATION GOALS

The basic goals of flood plain regulations are *not to prohibit* but *to guide* flood plain development consistent with the needs of nature and the needs of man. Flood plain regulations can:

1. Restrict or prohibit uses which are dangerous to health, safety or property in times of flood or cause increases in flood heights or velocities.
2. Require that uses vulnerable to floods, including public facilities which serve such uses, be protected against flood damage at the time of initial construction.
3. Protect individuals from buying lands which are unsuited for intended purposes because of flood hazard.

IV. FLOOD PLAINS AND FLOODWAYS

To achieve these objectives flood plain regulations often divide flood plain areas into floodway and flood fringe areas and apply reasonable regulations to both areas.

Channels are sufficient to confine and carry the normal flow of rivers and streams. But at periodic intervals melting snows and/or heavy rains produce flood flows which rise above channel banks and flood adjacent areas. These areas, which are subject to periodic inundation, are called *flood plains* (Figure 1) and have a natural function in conveying flood flows in a manner similar to that of river channels in conveying normal flows.

The portion of the flood plain adjacent to a river or stream is normally subject to deep, frequent, and high velocity flood flows. This area serves the primary function of conveying flood waters from upstream to downstream areas and is termed the *floodway* (Figure 1). Outer flood plain areas are flooded less frequently and at lower depths and velocities. These *flood fringe* (Figure 1) areas are not as essential to the passage of flood flows. But unprotected dwellings and other uses placed in these areas are subject to flood damage.

To meet flood plain management goals as well as nature's needs to convey flood waters, flood plain regulations tightly control development in floodway areas. Debris, fills, houses, bridges, roads, and other uses which would individually or collectively increase flood heights or would be seriously damaged by floods, are prohibited. To meet the needs of man, regulations control, but permit, most development in outer fringe areas. Dwellings and essential services must be placed on fill or otherwise protected to the regulatory flood elevation (Figure 2). This prevents flotation of houses into channel areas or onto other lands where they are nuisances. It also prevents the blighting,

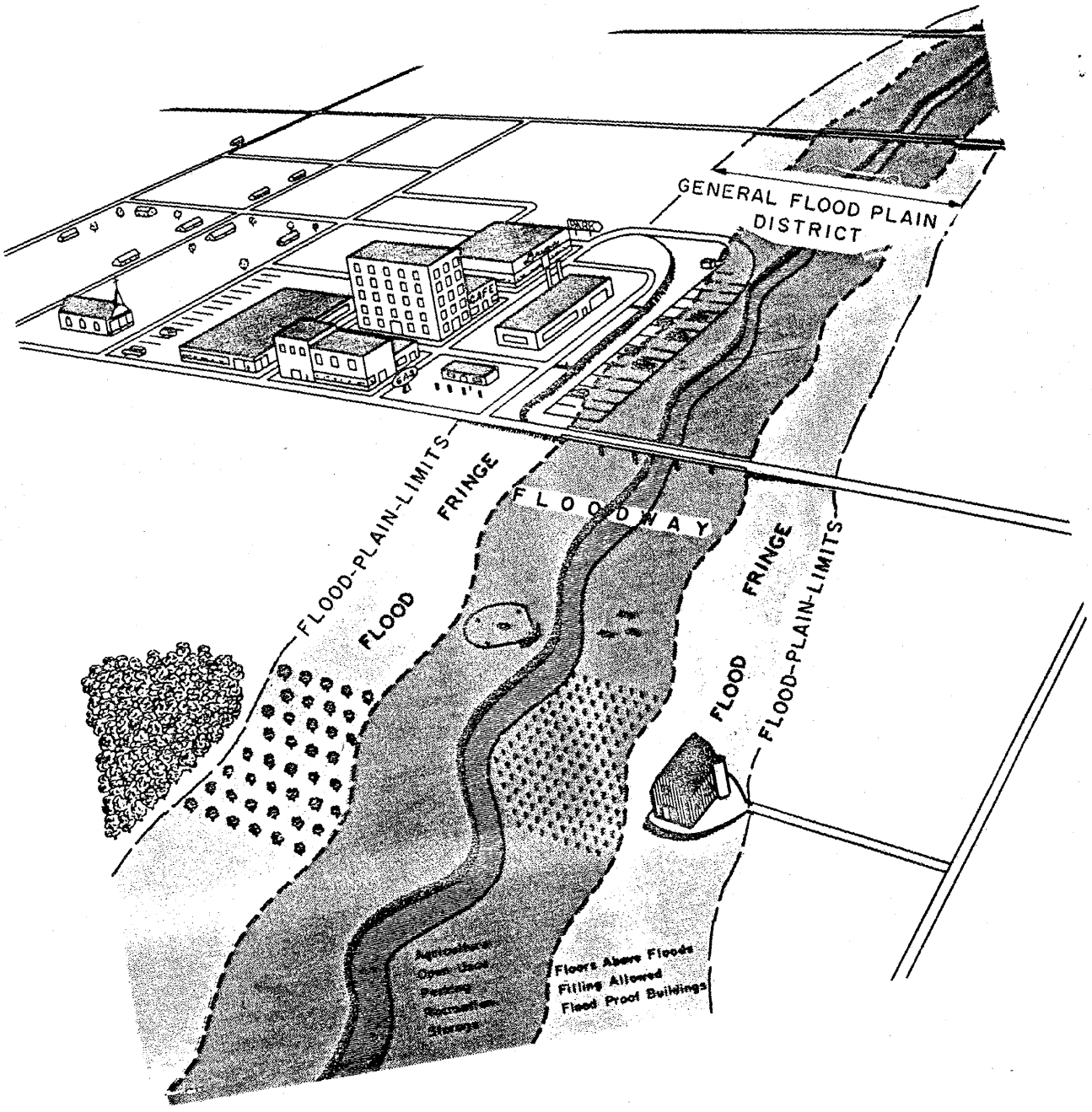
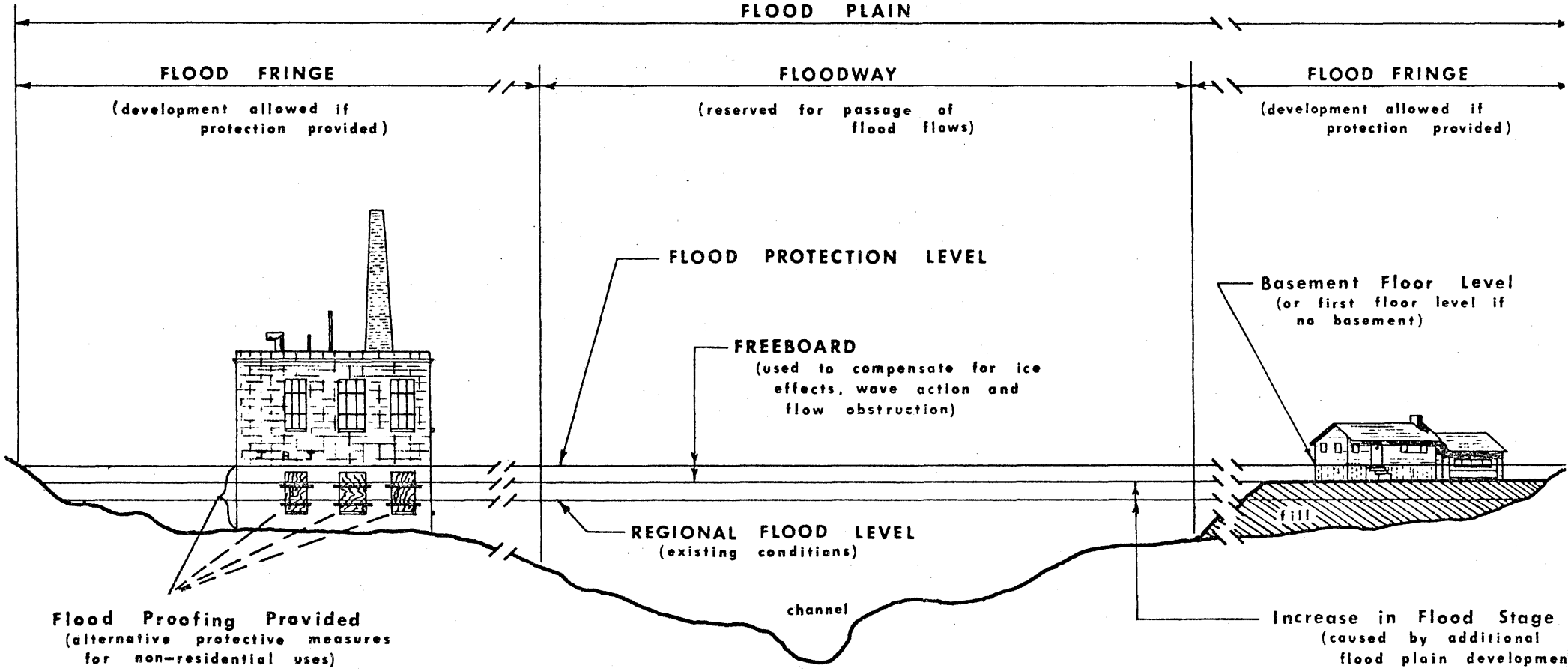

GENERAL FLOOD PLAIN DISTRICT
FLOOD-PLAIN-LIMITS
FRINGE
FLOODWAY
FRINGE
FLOOD-PLAIN-LIMITS
FLOOD
FLOOD
Agriculture
Open Uses
Parking
Recreation
Storage
Floors Above Floods
Filling Allowed
Flood Proof Buildings

Figure 1



Valley Cross Section

Figure 2

unsanitary conditions, loss of life, economic losses and social disruptions that accompany uncontrolled flood fringe uses.

V. WHAT FLOOD DATA ARE NEEDED FOR FLOOD PLAIN REGULATIONS?

A determination that particular lands are subject to flooding provides little information in determining the appropriateness of land uses. What kind of flooding? How often? How deep? At what velocity? For what period of time? The hazard for one location adjacent to a stream may be quite different from those at nearby locations. Distance from the river bed is in itself little indication of the flooding threat. Elevation of the site and the hydraulic characteristics of the stream play more important roles in determining the hazard. Streams which appear similar in size often have widely varied flood characteristics.

A very slight chance of flooding (perhaps only on an average of once each 100 years to a depth of a few feet) would not logically or legally justify prohibition of all development. Such regulations would be particularly vulnerable to constitutional attack if based upon poor flood data. Reasonable flood plain regulations must be related to the frequency and depth of flooding and the possible effects of development in blocking flood flows. Engineering studies are usually needed to determine the frequency and extent of flooding and the floodway area required to convey flood flow at a particular point.

However, detailed engineering studies are expensive, time-consuming and may not be justified or available for many rural streams. Here, less accurate flood hazard data may suffice for initial flood plain regulation.

The accuracy of flood data initially required to define flood hazard areas depends upon the expected use of the data. Generalized flood data may be adequate to define general flood plain limits and define the area of regulatory jurisdiction for a flood plain zone if more specific flood data can be generated later on a case-by-case basis as development is proposed. For example, soil maps, aerial photographs of floods, historic flood maps prepared by talking to local residents and gathering physical signs of flooding, and other similar sources of information can be used to prepare rural flood plain zoning maps if technical expertise is available during administration of a program to analyze more specifically flood hazards on a case-by-case basis as landowners propose development. This more technical evaluation can determine flood frequencies, flood protection elevations for proposed uses, and the floodway needed at any given point along a stream. Case-by-case technical evaluations may be carried out by county or city engineers, consultants, or, upon request, by the Department of Natural Resources.

The "Sample Flood Plain Zoning Ordinance for Local Units of Government (Using Available Flood Information in the Absence of Detailed Engineering Studies)", previously referred to, is designed for use with a variety of types of initial data which define the outer limit of regulatory jurisdiction. More specific analysis of flood hazards is done on a case-by-case basis. An important feature of this approach is to be noted: <u>although the flood plain zone as mapped is not related to a particular frequency or depth of flooding, the regulatory standards are linked to the regional flood which is defined on a case-by-case basis</u>. The mapped area only establishes a reasonable assumption of flooding. The "meat" of the regulations is in the case-by-case analysis of specific proposed development. The mapped flood often does not coincide with the regulatory flood hazard defined in the case-by-case evaluation. It may be larger or smaller.

The Department of Natural Resources rules for flood plain regulation[5] require that uses be regulated with reference to the "regional flood". NR 85 of these regulations defines regional flood as "representative of large floods known to have occurred generally in Minnesota and reasonably characteristic of what can be expected to occur on an average frequency in the magnitude of the 100 year recurrence interval." Ideally the boundaries of the *General Flood Plain District* (Figure 1) delineated on the basis of generalized flood data would closely approximate the boundaries of the area which would be inundated by the regional flood. If they do not, areas free of flooding may be regulated or areas with serious flooding threats may not be regulated.

The sample ordinance approach suggested by the Department does not prohibit development within delineated General Flood Plain Districts but only requires that landowners proposing development cooperate with the county or other regulatory unit in evaluating the specific flooding threat affecting their development. Therefore, some degree of over-inclusiveness in the General Flood Plain District may be justified. A serious problem arises if the mapped flood area is smaller than that of the regional flood determined on a case-by-case basis. Landowners within the mapped area may be required to elevate or protect their structures to a regulatory flood elevation but adjacent landowners outside the district and also below the regional flood elevation may escape regulation.

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[5] (See reference 1 on page 2)

VI. TYPES OF FLOOD DATA FOR FLOOD PLAIN DELINEATION

Apart from detailed engineering studies, several types of flood information may be used to define boundaries of an initial flood plain district. The Minnesota Department of Natural Resources Code (NR 87) provides that

> ". . . in special instances and upon approval of the Commissioner, the use of other techniques such as maps indicating limits of past flooding, detailed soil maps and/or aerial photographic interpretation may initially serve as a basis for the delineation of flood plains for regulatory purposes provided that:
>
> (aa) The affected flood plains are generally undeveloped.
>
> (bb) The associated text of the zoning ordinance provides for a special permit use procedure to determine the effects of proposed construction upon flood stages and flood flows and to establish the flood protection elevation.
>
> (cc) The local unit of government has initiated a program to ultimately obtain regional flood data.
>
> (4) Where a conflict exists between the flood plain limits illustrated on the official zoning map and actual field conditions, the flood elevations shall be the governing factor in locating the regulatory flood plain limits.

Administration of a single district ordinance based upon generalized flood data will be discussed at greater length later in this report. First, the types of data and some of their uses and limitations will be described.

Historic Flood Events

A variety of maps may be available or prepared delineating past flood events. These include actual aerial photos taken during times of flooding.

Flood photos of the 1965 and 1969 flood events are available for many of the streams in the Mississippi River drainage basin. Contact prints, at a scale of approximately 1" = 1667', are available with possible enlargements of up to 1" = 400'. Contact prints or enlargements may be ordered from:

Mark Hurd Aerial Surveys, Inc.
345 Pennsylvania Avenue S.
Minneapolis, Minnesota 55426

Flood photos of the 1969 flood are available for the Red River of the North drainage basin at approximately the same contact print and enlargement scale as described above from:

K. B. MacKichan & Associates, Inc.
1604 South Washington St.
Grand Forks, North Dakota 58201

Other historic flood maps may be prepared from highwater marks, photos, personal interviews, etc. The U. S. Army Corps of Engineers has prepared flood profiles wherever highwater marks and stream gage records are available. These profiles define the estimated water surface elevation for the particular flood event at any point within the stream reach.

Using available historic flood data the U. S. Geological Survey (USGS) has delineated on USGS quadrangles the approximate limits of flood-prone areas. The scale and contour interval of these maps are often insufficient to allow their use in local flood plain regulations. However, they may serve as a basis for a more precise determination of flood hazard areas needed for adoption of local flood plain regulations if used in conjunction with available flood profiles and detailed field inspections or surveys. The maps that have been prepared to date by the USGS have been distributed by the Department of Natural Resources to affected local governmental units. Additional copies of these maps are available upon request from the Department.

Often affected landowners readily understand historic flood maps since the maps are based upon tangible evidence of flooding. However, the maps often do not reflect an identified frequency of flooding and boundaries are often difficult to locate with precision.

Aerial Photo Interpretation

Flood plains are sometimes delineated on air photos based upon stereo interpretations. A stereo scope permits a three-dimensional view of lands by combining the images of two photographs taken at slightly different angles. Stereo pairs of photographs are available from several sources including the Agricultural Stabilization and Conservation Service (ASCS). This method is particularly useful for hilly topography and steep slopes. Where stereo photo coverage is not available, aerial photos like those available from area ASCS offices or private aerial survey firms can provide a basis for rough delineation by visual inspection of topography in the field.

Detailed Soil Maps

In many rural areas the most useful available technique for initially delineating flood plain areas is the use of detailed soil maps. The present Soil Survey Program is conducted by the U. S. Department of Agriculture - Soil Conservation Service (SCS) in cooperation with the Minnesota Agricultural Experiment Station (MAES). The use of detailed soil maps for locating flood plain areas is rapid and economical. Detailed soil maps are prepared by soil scientists who carefully determine soil types in the field based upon physical characteristics. Field examination is supplemented with air photo interpretation.

The boundaries of soil units are drawn on aerial photographs, usually at a scale of 4" = 1 mile. The completed soil maps show the location of each soil unit and an accompanying text describes the soil characteristics.

Flood plains are distinct geomorphic units of landscape that contain unique kinds of soils. The flood plain is an area of active erosion and deposition, and the evidence of these activities are clues that guide the soil scientist in his designation of alluvial soil. Alluvial soil, as defined in the USDA Soil Survey Manual, Agricultural Handbook No. 18, is a soil consisting of recently deposited unconsolidated alluvium generally stratified and exhibiting essentially no development or modification of the materials. These kinds of soils are recognizeably different from those soils that are not flooded.

The soil scientist can accurately delineate the area of alluvial soil, however, this may and often does not correspond exactly with the area inundated by the infrequent occurring flood. These types of floods do not occur often enough to leave well defined permanent evidence on the land. However, non-alluvial soils subject to flooding can also be recognized by one familiar with the soils, geology and hydrology of the area.

Figure 3 shows an area along the Zumbro River in Wabasha County with the flood plain outlined according to the interpretation of the published soil survey.

One practical use of soil survey data is in conjunction with engineering studies and historical flood records. A soil survey can rapidly and economically provide a view of river valley characteristics. Based on the perspective provided by the soil survey, areas needing more intensive study can be identified. Valley cross sections can then be run where they will provide the most information. After key elevations are established by an engineering study at these points, a soil map can be further interpolated to extend data and delineate the areal extent of flood plains at other points.


N
20
31
Indian Creek
(Joins sheet 24)
(Joins sheet 31)
Scale 1: 20 000
0
5000 Feet

Figure 3

In urban or highly developed areas, the use of the soil survey for flood plain delineation is not practical. The works of man materially alter the extent and area of flooding and consequently the flood plain.

In areas where works of man do not appreciably alter the stream regime and where extensive flood plain areas must be delineated immediately and at low cost, an accurate soil map, properly interpreted, will provide a good first estimate of areas subject to flooding. However, such soil maps will not furnish information on flood frequency, flood elevation, stream velocity or other specific flood information.

Studies conducted to date by the Department of Natural Resources and the Soil Conservation Service in Minnesota and supplemented by investigations of others (see "List of Selected References" in this report) indicate good correlation between the use of soil maps and engineering studies to delineate flood hazard areas where the streams are deeply cut into the landscapes and the valleys have steep sides. This condition generally occurs in the southeastern part of the state. (Figure 4). Within this area, the use of detailed soil maps for initial flood plain delineation will be acceptable to the Department of Natural Resources. Counties within this area that are interested in having the SCS prepare an inventory of the extent of the flood plains in their county can do so by routing a formal request through their Soil and Water Conservation District to the Department of Natural Resources. Priorities for completing the task are set by the Soil Conservation Service and the Department of Natural Resources. Reimbursement to the SCS for completing the work varies according to the amount, accuracy and recency of available soil survey data.

The Department will not approve flood plain management ordinances based solely upon the use of detailed soil maps in the unshaded area of Figure 4 until additional studies are completed to establish the relationship

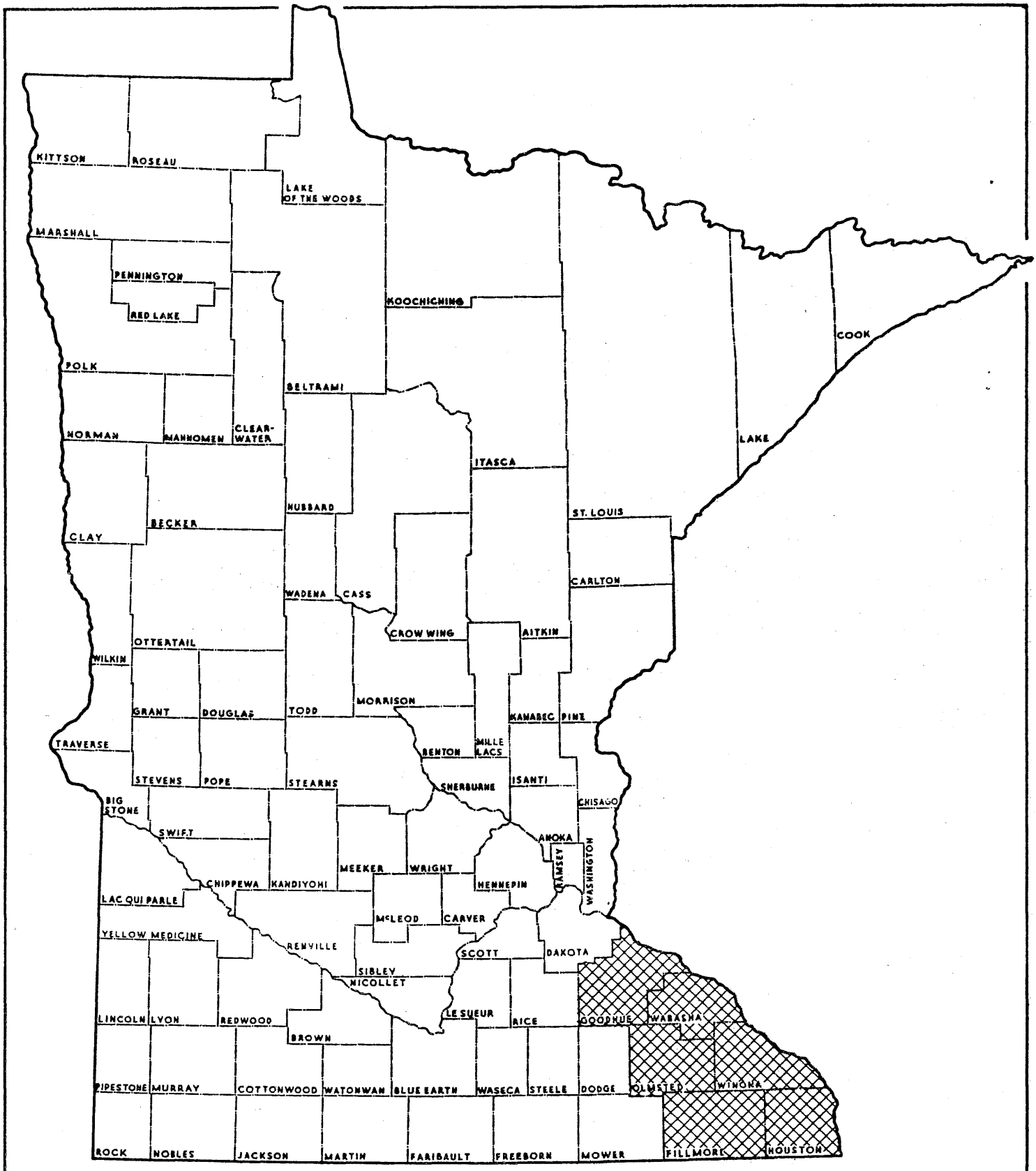
KITTSON
ROSEAU
LAKE OF THE WOODS
MARSHALL
PENNINGTON
RED LAKE
KOOCHICHING
COOK
POLK
BELTRAMI
NORMAN
MAHNOMEN
CLEAR-WATER
LAKE
ITASCA
HUBBARD
ST. LOUIS
BECKER
CLAY
CARLTON
WADENA
CASS
CROW WING
AITKIN
OTTERTAIL
WILKIN
GRANT
DOUGLAS
TODD
MORRISON
KANABEC
PINE
TRAVERSE
BENTON
MILLE LACS
STEVENS
POPE
STEARNS
SHERBURNE
ISANTI
BIG STONE
CHISAGO
SWIFT
ANOKA
RAMSEY
WASHINGTON
MEEKER
WRIGHT
CHIPPEWA
KANDIYOHI
HENNEPIN
LAC QUI PARLE
McLEOD
CARVER
YELLOW MEDICINE
RENVILLE
SCOTT
DAKOTA
SIBLEY
NICOLLET
LINCOLN
LYON
REDWOOD
LE SUEUR
RICE
GOODHUE
WABASHA
BROWN
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

Figure 4

between soils and flooding. These additional studies can be readily conducted within those areas where detailed soil surveys have been completed and engineering data are available.

When soil maps are used to delineate flood plains, additional factors for controlling development can be included. Soil maps indicate areas undesirable for septic tank use due to high ground water or low soil permeability, soils with low bearing strength which will not support heavy structures, soils with high erosion potential, and other development limitations.

If soil maps are to be used as a basis for developing a flood plain ordinance, the Department of Natural Resources should be contacted for more detailed technical assistance concerning flood plain soil types, preparation of maps and ordinance drafting. In addition, the local Soil and Water Conservation District should be contacted for up-to-date information on soil maps and their interpretation. If soil maps are not available, the District should be contacted for further mapping services.

It is often desirable to combine the use of historic flood records, air photos and soil maps for a single reach of stream or several reaches. The goal of providing a relatively accurate picture of flooding can best be met by comparing and judiciously selecting among data sources.

VII. ADMINISTRATION

Ordinances utilizing general flood plain districts derived from historic flood maps, aerial photo interpretation, and soil maps must provide a procedure for developing detailed flood hazard data on a case-by-case basis. The sample

ordinance[6] developed by the Department of Natural Resources contains such a procedure.

If a landowner wishes to substantially change an existing building or construct a new structure in a General Flood Plain District:

(1) He submits a permit to the zoning administrator. If the use is a permitted use (most open space uses, see Section 4.1 of the sample ordinance) the administrator issues the permit. If it is a conditional use (see Section 4.2 of the sample ordinance), the administrator submits the application to the Board of Adjustment.

(2) The Board of Adjustment, following procedures set out in Sections 4.2, 7.52 (1), (2), and (3), requires the applicant to submit detailed plans of the lot and area, a valley cross - section, a stream profile for at least 500 feet in both directions from the proposed development, and plans for the proposed use including flood protection measures. The Board may transmit this information to a designated engineer, agency or other qualified individual for technical assistance.

(3) The qualified agency or individual calculates the regional flood discharge at the proposed development site, determines the regulatory flood elevation, calculates the required floodway, evaluates the effect of the proposed use in blocking flood flows or otherwise damaging other lands, and evaluates the adequacy of the flood protection plans. Procedures are specified in 7.52 and

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[6] (See reference 2 on page 2)

Section 1.22 (1) and (2) of the sample ordinance. In calculating floodway areas, the expert assumes a reasonable equal degree of encroachment as set out in Section 1.22 (2) of the sample ordinance. This information is then submitted to the Board of Adjustment.

(4) Based upon these technical determinations, the Board determines whether the proposed use is located in the floodway or flood fringe area of the General Flood Plain District. It then applies the regulatory standards set out in the ordinance as applying to each of these areas. It determines whether the proposed use meets all ordinance standards. It denies, permits or conditionally permits the proposed use.

For the use of a single district approach, a county or other local unit must have technical assistance to evaluate individual uses on a case-by-case basis during administrative phases of the program. Careful and systematic policies must be followed in evaluating the regional flood, establishing flood protection elevations, and defining the floodway to prevent arbitrary and discriminary regulation.

VIII. SUMMARY

Detailed engineering studies initially defining the regional flood, establishing flood protection elevations, and delineating floodways are necessary for urban areas and other areas with high intensity development. For rural areas, the use of a general flood hazard district delineated on the

basis of historic flood maps, aerial photo interpretation, or detailed soil survey maps may be appropriate if more detailed flood hazard information is developed on a case-by-case basis.

The use of a general flood hazard district approach based upon available or easily developed data provides a mechanism for immediate regulation of hazard areas. Historic flood maps are readily understood by local landowners. The initial delineation discourages land speculation and protects unwary purchasers. Since much rural recreational and urban fringe development is initiated by subdividers, the special information requirements of the single district approach will not usually pose a burden upon individual landowners. Rural sanitary codes, subdivision regulations, and zoning regulations for flood plain areas can shape future land uses and prevent increased flood damages.

LIST OF SELECTED REFERENCES

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APPENDIX

Appendix Note A: Ordinance Modifications for Use in Conjunction with Detailed Soil Maps

The Sample Flood Plain Zoning Ordinance for Local Units of Government (Using Available Flood Information in the Absence of Detailed Engineering Studies) can be used, with very little modification, in conjunction with a detailed soil survey to delineate flood plain areas. Suggested changes and additions to that ordinance include:

Section 1.22. should make reference to the specific soil surveys. For example, it might provide: "Sheets 1- __ inclusive of the Soil Survey of _____ County, Minnesota, (U.S.D.A. SCS Series ____, No. ____".

Section 2.1. could designate detailed soil survey sheets with mapped flood plains as the Official Flood Plain Zoning Map. References should be specific as suggested for Section 1.22 above.

Section 3.0. should also make reference to the specific soil maps used for delineating flood plain areas. For example, it might provide that the "General Flood Plain District shall include all lands on map sheets 1 through __ inclusive of the Soil Survey of _____ County, Minnesota included as part of the Official Zoning Map, designated by the following letter symbols and mapped as lying in flood plain areas."

A Fillmore County, Minnesota ordinance designates the following soil mapping units: Aa, Alluvial land, medium textured, poorly drained; Ab, Alluvial land, medium textured, well drained; Ac, Alluvial land, coarse textured, well drained; Ca, Chaseburg and Judson silt loams,

0 - 1 percent slopes; Cb, Chaseburg and Judson silt loams, 2 - 6 percent slopes; Cg, Clyde silty clay loam; Ch, Clyde silty clay loam, overwash; Fn, Floyd and Clyde silty clay loams, overwash, 0 - 3 percent slopes; Ma, Marshan silty clay loam; Md, Mixed alluvial land, 0 - 6 percent slopes; Pc, Peat and muck.

It is important, however, that in addition to designating the soil mapping units which comprise the majority of the flood plain, the outer limits of the flood plain must be drawn on the map. Otherwise, minor patches of designated soils wherever they are located throughout a county will be designated flood plain areas although they bear no relationship in fact to the flood plain. Also, soil units which generally lie outside the flood plain but which are occasionally within the flood plain will not be included. In the location of the outer limits, the construction of flood control works, floodway obstructions and effects of other man-made alterations in the flood plain can be taken into account.