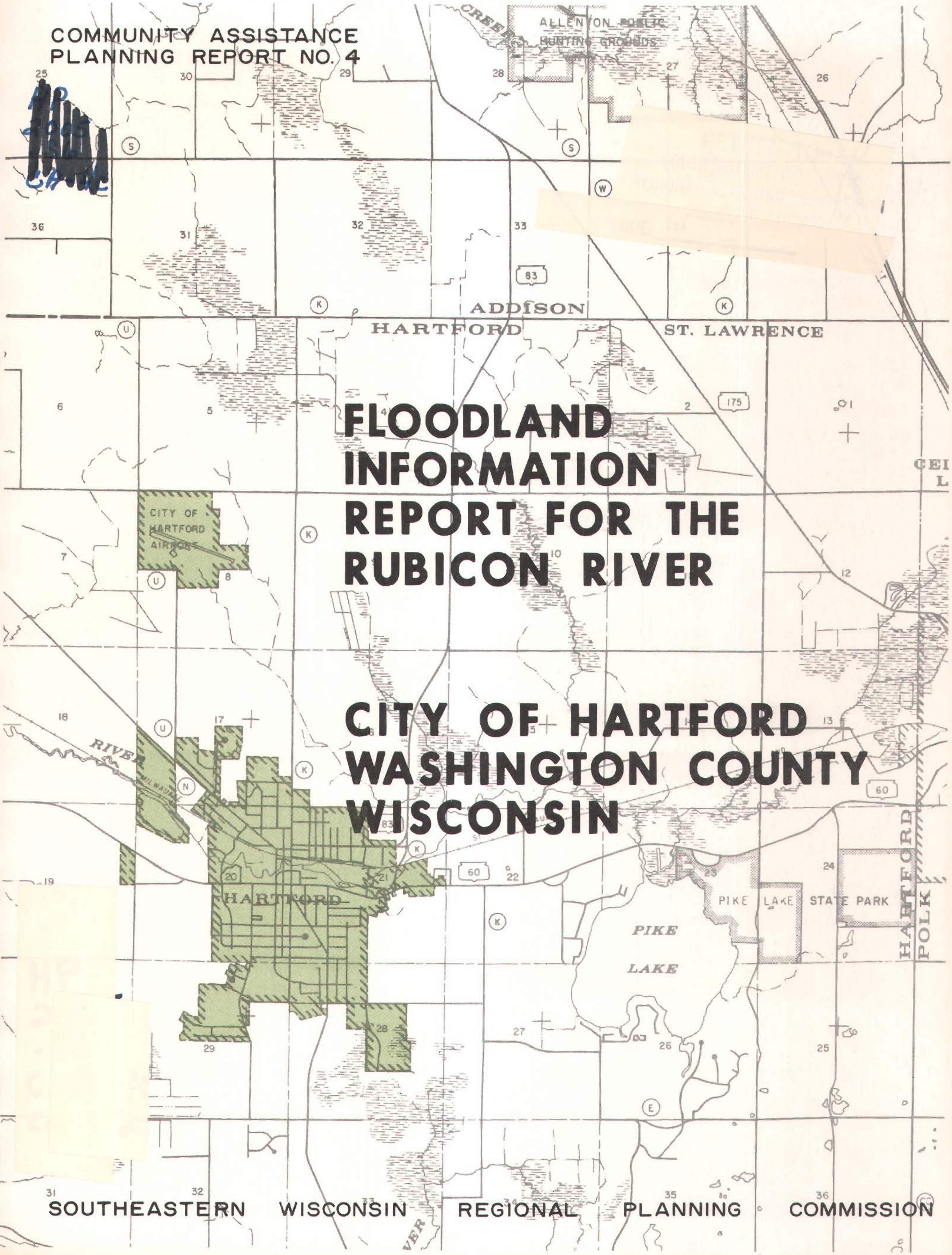
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 4

FLOODLAND INFORMATION REPORT FOR THE RUBICON RIVER

CITY OF HARTFORD WASHINGTON COUNTY WISCONSIN



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NUMBER 4

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FOR THE

RUBICON RIVER

CITY OF HARTFORD
WASHINGTON COUNTY, WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
P. O. Box 769
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INTRODUCTION

The purpose of this report, and the supporting inventory and analyses, is to develop and present floodland information for the Rubicon River within and near the City of Hartford, Washington County, Wisconsin. More specifically, this floodland information report presents flood discharges and stages, delineation of a floodway and floodplain fringe, and draft floodland regulations in order to provide the City of Hartford with the information necessary for the preparation and adoption of sound floodland use regulations in accordance with the requirements of Wisconsin's Flood Plain Management Program, the acquisition of flood insurance under the program administered by the U. S. Department of Housing and Urban Development, and the conduct of sound community planning and development programs.

This report was prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) in response to a formal request on December 27, 1973, from the City of Hartford. The study was conducted by the Commission from May through September, 1974. Commission data and information on the natural resource base and man-made features of the Hartford area were used in the conduct of this study. This data base was supplemented with information provided by the City of Hartford, the Hartford Times-Press, and private citizens of the city, as well as published U. S. Geological Survey and National Weather Service data.

In addition to the introductory section, this report contains the following seven major sections which describe the inventory and analyses phases of the project or present study results:

- The Study Area: An Overview
- Historic Flood Events
- The Hydrologic-Hydraulic System
- The Hydrologic-Hydraulic Model
- Flood Discharges, Stages, and the Natural Floodlands

- The Regulatory Floodlands
- Floodland Regulations

The text of this report concludes with a summary section that begins on page 32 and contains the principal study findings. All exhibits referred to in this report are included after the summary section.

Inasmuch as some users of this report may not be completely familiar with the technical terminology used in the field of floodland management, a glossary of selected terms is attached as Exhibit A.

THE STUDY AREA: AN OVERVIEW

Rock River Watershed

The Rubicon River originates in Section 7 of the Town of Polk in western Washington County, and flows in a westerly direction through Washington County and into Dodge County where it joins the Rock River. The Rubicon River is, as shown on the map attached as Exhibit B, a small headwater tributary of the Rock River which drains a 3,600 square mile area in Wisconsin.

The U. S. Geological Survey (USGS) stream gaging station (No. 05-425500) on the Rock River at Watertown, which was operated from 1931 to 1970, is the streamflow recordation station site closest to the Rubicon River. It had a tributary area of 971 square miles and was located approximately 45 miles downstream from the City of Hartford. The average discharge recorded at that location was 412 cubic feet per second (cfs), and the 10-, 25-, 50-, and 100-year recurrence interval flood discharges were estimated by the USGS to be 3,660 cfs, 4,390 cfs, 4,890 cfs, and 5,350 cfs, respectively, based on the period of record of 1932 through 1968.

Rubicon River Watershed

For purposes of this report, the Rubicon River watershed, as shown on the map attached as Exhibit C, is defined as that 30.6 square mile drainage area tributary to the Rubicon River at the point where it crosses the Dodge-Washington County line about 2.5 miles downstream of the center of the City of Hartford. Rural land uses dominate the Rubicon River watershed, with almost 93 percent of the watershed area being devoted in 1970 to agricultural and agricultural related uses, water, wetlands, woodlands, and other open lands. In addition to the City of Hartford, most of which is located within the watershed, the Rubicon River watershed contains a portion of one other incorporated area--the Village of Slinger. Detailed data and information pertaining to the natural resource base and man-made features of the Rubicon River watershed are presented in the section of this report titled "The Hydrologic-Hydraulic System."

City of Hartford

The City of Hartford was named after Hartford, Connecticut, since many of the early settlers emigrated from the State of Connecticut. Hartford developed around what is now known as the Hartford Mill Dam, a facility originally constructed to provide water power for a grist mill and a saw mill.

As of 1970, the city encompassed about 2.5 square miles, 80 percent of which lie within the watershed, and contained a population of 6,500 people. The 1970 population was about 15 percent above the 1960 population of 5,625 people. Commission projections indicate that by the year 2000, the population of Hartford may be expected to increase to about 11,000 people--almost 70 percent over the 1970 level. Industrial activity in Hartford includes the manufacture or production of machine parts, leather goods, canned foods, ventilating equipment, mufflers, chain saws, and outboard motors.

HISTORIC FLOOD EVENTS

The collection, collation, and analysis of historical flood information, which includes measurements or observations of flood flows, stages, areas of inundation, and flood damage, is an important work element in the preparation of a floodland information report. Such historic flood event data and information are important primarily for the following two reasons.

First, inasmuch as flood flows, stages, and areas of inundation developed for this report are primarily the result of the application of hydrologic-hydraulic simulation techniques, sound engineering practice requires comparison between the results obtained with these techniques and available, reliable observations of actual floodland hydrologic-hydraulic behavior. Such comparisons permit adjustments to and refinements in the analytic work, and therefore result in a more accurate representation of floodland hydrology and hydraulics.

Second, experience indicates that public memory of, and concern over, flood problems tends to diminish rapidly with the passage of time after a major flood event. Consequently, both public and private development decisions tend to be made without sound, definitive knowledge of actual flood events. An effective way to bring the seriousness of flood problems into proper perspective is to inventory and document historic flood information.

Procedure

The inventory of historic flood events was initiated by examining annual instantaneous peak streamflows as measured by the USGS at the Rock River gaging station (No. 05-425500) at Watertown in Jefferson County. Although this gaging station is 45 miles downstream from Hartford and monitors flow from a 971 square mile drainage area, which is large compared to the 30.6 square mile Rubicon River watershed, streamflow at the gaging station serves as an index to the time of occurrence of flood events in the Hartford area. National Weather Service 24-hour precipitation records for Hartford for the period 1951 through mid-1974 were also examined for the purpose of identifying probable periods of high water.

After completing this initial reconnaissance, the Commission staff contacted Hartford municipal officials, personnel at the public library, Hartford Times-Press staff members, and business people and private citizens. These sources provided a variety of flood and flood-related data and information, including recorded flood stages, identification of riverine areas that have been flooded, photographs of flooding, and newspaper accounts of flood events. This information was used to construct a comprehensive description of major and minor flood events and associated flood problems in and near the City of Hartford. Although the city has a history of numerous minor flood events, the records indicate the occurrence of two major flood events in the recent past--the March 1929 and the April 1959 floods.

March 1929 Flood: This late winter flood was attributed to the simultaneous occurrence of snowmelt and a light rainfall. The river rose very rapidly, and just east of the city washed out much of the area that is now Wilson Street. Floodwaters attained a peak stage of two feet above the top of the footbridge--no longer in existence--at the Hartford Mill Dam. Floodwaters overtopped the Rural Street Bridge which is located about 1,000 feet downstream of the dam. Flood stages dropped rapidly, and the river returned to its banks on the following day.

Major flooding was probably widespread throughout the Wisconsin portion of the Rock River watershed during March of 1929. An instantaneous peak discharge of 13,000 cfs was recorded by the USGS stream gaging station (No. 05-430500) on the Rock River at Afton in Rock County--about 100 miles downstream of Hartford--which had a recurrence interval of 29 years. That flow still stands as the largest flow ever recorded in the 59-year (1914-1972) operation of that gaging station.

April 1959 Flood: A rainfall-snowmelt combination caused flooding the night of April 2, 1959. This flood was not as severe as the 1929 event in that the floodwaters were, with a few exceptions, contained within river banks. The floodwaters, however, surrounded and entered the Jordan Engineering Company--located immediately downstream of Rural Street on the north bank of the Rubicon River--so that the first floor of the building was under two feet of water. Some flooding of city parklands was also reported.

As was the case with the March 1929 flood, major flooding appears to have been widespread throughout the Wisconsin portion of the Rock River watershed during April of 1959. The USGS stream gaging station (No. 05-430500) on the Rock River at Afton in Rock County recorded an instantaneous peak flow of 12,100 cfs, which has a recurrence interval of 18 years. That flow was the third largest flow recorded in the 59-year (1914-1972) period of record for that monitoring station. An instantaneous peak discharge of 4,970 cfs was recorded by the USGS gaging station (No. 05-425500) on the Rock River at Watertown in Jefferson County--about 45 miles downstream of Hartford. This flood flow, which had a recurrence interval of 56 years, was the largest recorded in the 39-year (1932-1970) operation of the station. The USGS stream gaging station (No. 05-426000) on the Crawfish River--a Rock River tributary--at Milford in Jefferson County, which is located about 28 miles southwest of Hartford, recorded a peak flow of 6,130 cfs on April 6, 1959, which has an estimated recurrence interval in excess of 100 years and was the greatest discharge observed in the 41-year (1932-1972) period of record.

Minor Flooding: Several instances of minor flooding of the Rubicon River, in some cases in conjunction with scattered storm water drainage and sewer backup problems in areas far removed from the riverine area, have occurred in the City of Hartford in recent years. For example, melting snow in the Rubicon River watershed caused minor flooding in March 1965, with floodwaters covering parts of the playground area in Hartford's Willowbrook Park on the east side of the city. About 2.38 inches of rainfall were recorded within a 24-hour period at Hartford on September 21, 1972, and while scattered instances of sewer backup and flooded basements occurred, no problems directly attributable to overland flooding of the Rubicon River were reported.

Widespread flooding--some of it quite serious--occurred at numerous locations throughout southeastern Wisconsin on April 21 and 22, 1973, as a result of intense rainfall. Only 1.52 inches of rainfall were recorded on April 21 in Hartford, however, with another 0.23 inch on the following day. As a result, only a few instances of minor sewer backup were reported in the city.

Hartford's Willowbrook Park was partially flooded in early March 1974 as a result of light rain and melting snow. West Side Park was partially flooded in late May of 1974 as a result of a moderate storm--a total of 2.76 inches of rain were recorded at Hartford on May 16 and 17. During the May 1974 high water, storm water entered and damaged the West Side Dairy. This flood damage was not directly related to high water on the Rubicon River, however, since the dairy is far removed, both horizontally and vertically, from the riverine area.

Summary

Based on the historic flood data and information presented above, the City of Hartford has not over the past half century experienced major flood problems resulting from the Rubicon River. This rather unusaul--relative to the experience of many other communities in southeastern Wisconsin--absence of major flooding in Hartford is probably attributable to a combination of three factors, each of which is briefly discussed below.

First, the absence of major floods may be due to the fact that much of the riverine area in general, and the natural floodlands in particular, are in public ownership and have been retained in open space for public recreational use. For example, public open space lands consisting primarily of West Side and Willowbrook Parks lie on at least one side of the Rubicon River for 27 percent of its 2.25-mile length within the City of Hartford. Other riverine area lands in the business district are used for parking purposes. Open space uses of natural floodlands such as is evident in Hartford are compatible with the flood-prone nature of those lands and they prevent urban development which is subject to flood damage.

The absence of major flood problems in the City of Hartford may also be attributable to the presence of Pike Lake on the Rubicon River upstream of the City of Hartford. As described later in this report, floodwater storage provided by the lake significantly reduces flood discharges and stages in the City of Hartford.

Chance is the third factor to which the absence of major floods in the City of Hartford may be attributed. Major floods, or more specifically the meteorological events and other conditions that cause such floods, are random events, and it is possible for those events to occur in such a manner that major flooding does not occur in a particular geographic area for a long period of time.

THE HYDROLOGIC-HYDRAULIC SYSTEM

Inasmuch as this report, and the inventory and analyses supporting it, focus on the flood characteristics of the Rubicon River watershed, it follows that hydrologic-hydraulic data constitute a key input to the study. While watershed hydrology and hydraulics may be inventoried and discussed separately, as is done in this report, they must be analyzed together, since they function in an interrelated manner within the watershed hydrologic-hydraulic system. The computer modeling techniques used to conduct the integrated analysis of watershed behavior are discussed in the subsequent section of this report titled "The Hydrologic-Hydraulic Model."

Hydrology of the Rubicon River Watershed

Precipitation: Precipitation within the watershed takes the form of rain, sleet, hail, and snow, and ranges from gentle showers of trace quantities to brief but intense and potentially destructive thunderstorms to major rainfall-snowmelt events causing property damage. Monthly and annual total precipitation and snowfall data for Hartford are presented in tabular form in Exhibit D. The average annual total precipitation in the watershed based on the Hartford data is 30.3 inches, expressed as water equivalent, while the average annual snowfall and sleet measured as snow and sleet is 33.7 inches. Assuming that 10 inches of measured snowfall and sleet are equivalent to one inch of water, the average annual snowfall of 33.7 inches is equivalent to 3.7 inches of water, and therefore only about 10 percent of the average annual total precipitation occurs as snowfall and sleet. Average total monthly precipitation for the watershed ranges from 0.87 inch in February to 4.02 inches in September. The principal snowfall months are December, January, February, and March, during which 93 percent of the average annual snowfall may be expected to occur.

Precipitation volume-duration-recurrence interval information for the watershed is presented in graphic form in Exhibit E. While the above referenced monthly and annual rainfall and snowfall data provide an overview of the precipitation characteristics of the watershed, the volume-duration-recurrence interval information is of value because it facilitates computation of the 10-, 25-, 50-, and 100-year recurrence interval flood flows at Hartford as discussed in subsequent sections of this report.

Runoff: Streamflow data are not available for the Rubicon River watershed. The nearest gaging station was the USGS installation (No. 05-425500) located on the Rock River at Watertown, 45 miles downstream of Hartford. In order to obtain some measure of the runoff from the watershed, average annual runoff was estimated at 7.5 inches per year, or an average discharge of 17 cfs based on the fact that, on an annual water year basis--October 1 to September 30--about 25 percent of the precipitation in southeastern Wisconsin appears as streamflow.

Hydrologic Soil Groups: The nature of soils in the Rubicon River watershed has been determined primarily by the interaction of parent glacial deposits covering the area and the topography, climate, plants, and animals over time. The U. S. Soil Conservation Service (SCS), under a 1963 cooperative agreement with the Commission, has completed a detailed soil survey for the seven-county Southeastern Wisconsin Region including the Rubicon River watershed.

With respect to watershed hydrology, the most significant soil interpretation completed by SCS is the categorization of soils into hydrologic soil groups A, B, C, and D. In terms of runoff characteristics, these four soil groups vary from Group A soils, which generate relatively little runoff because of high infiltration capacity, high permeability, and good drainage, to Group D soils, which generate relatively large amounts of runoff because of very low infiltration capacity, low permeability, and poor drainage.

The spatial distribution of the four hydrologic soil groups within the Rubicon River watershed is shown on the map attached as Exhibit F. Hydrologic Soil Groups B, C, and D comprise 64 percent, 11 percent, and 21 percent, respectively, of the watershed area, with the remaining 4 percent covered with man-made land or with water features and with Group A soils, the last of which covers less than 0.1 percent of the watershed. It is important to note that almost two-thirds of the watershed is covered by Group B soils which, relative to the other soil groups, generate only moderate runoff.

The impact of soil type on runoff characteristics is illustrated by the fact that if 4.0 inches of rainfall occur on grassland or meadow underlain by Hydrologic Soil Group B soils under average antecedent soil moisture conditions, only about 0.7 inch would be expected to run off directly to the surface drainage system; whereas, if the pasture were underlain by Hydrologic Soil Group D soils, about 1.9 inches--over twice as much--could be expected to appear as direct runoff. Hydrologic soils group data, therefore, constituted an important input to the computer model used to simulate the hydrologic response of the watershed.

Land Use: The nature and distribution of land uses--both existing and projected or planned--within a watershed constitute an important element in a hydrologic inventory, since both the volume and timing of direct runoff to the stream system is influenced by land uses and land use changes. While the underlying hydrologic soil groups are generally the primary determinant of hydrologic response, the type of land uses superimposed on the soil group can significantly modify that response. This is particularly true when lands are converted from rural to urban uses, since such a conversion results in a large increase in impervious surface and, therefore, an increase in runoff volume and a decrease in runoff time.

Inasmuch as the Rubicon River watershed is covered primarily by hydrologic soil Group B, which exhibits moderate runoff volume, it follows that the watershed or portions of it may be significantly and adversely affected by improperly planned urbanization. Consider, for example, grassland or meadow underlain by soils in hydrologic soils Group B for which a 4.0-inch rainfall would, as noted above, produce only 0.7 inch of runoff. If the pasture were converted to a medium density residential subdivision with a conventional storm sewer system, the 4.0-inch rainfall would result in approximately 1.4 inches of direct runoff volume--twice as much--and the peak discharge rate would probably increase by several multiples because of the added effect of reduced runoff times.

Existing land use within the watershed, based on the Regional Planning Commission's 1970 land use inventory, is shown in graphic summary in Exhibit G. Urban land uses--such as residential, commercial, industrial, and transportation--cover only 2.37 square miles, or 7.4 percent, of the watershed area, with such uses concentrated in the City of Hartford, the Village of Slinger, and the Pike Lake area.

A year 2000 land use plan map for the Rubicon River watershed is attached as Exhibit H. This map was developed to facilitate determination of the probable impact of incremental urbanization on flood discharges and stages. Inasmuch as the Regional Planning Commission has not yet completed the year 2000 land use plan for the Region, which is an update of the 1990 land use plan, the year 2000 plan for the Rubicon River watershed is an interim plan. Factors considered in developing this interim plan include the 1990 land use plan, urban development that has occurred in conflict with that plan, detailed neighborhood plans being prepared by the Commission for the City of Hartford, and sewer service areas as recommended in the recently completed regional sanitary sewerage system plan for southeastern Wisconsin.

Under year 2000 conditions, about 4.65 square miles, or about 15 percent, of the Rubicon River watershed may be expected to be devoted to urban land uses if the plan recommendations are followed, or about twice the present amount. The approximately 2.28 square miles of rural land may be expected to be converted from rural to urban uses within the watershed from 1970 to 2000.

Subbasins: The Rubicon River watershed was subdivided into smaller hydrologic units called subbasins to permit an adequate representation of the watershed hydrology in the computer model used to compute flood discharges and stations. The subbasin is, in effect, the framework within which watershed hydrologic characteristics are quantified prior to hydrologic modeling.

The watershed was subdivided into 15 subbasins--ranging from 0.10 square mile to 4.40 square miles--as shown on Exhibit I. Numerous factors in addition to topographic considerations entered into the delineation of subbasins. The subbasins were delineated, for example, so as to define areas tributary to intermittent streams and drainageways, and so as to have their discharge points located at or near corporate limits and at hydraulic structures such as dams and bridges.

Times of concentration were computed for each subbasin under existing 1970 and year 2000 plan conditions, and are also shown on the map attached as Exhibit I. This hydrologic parameter constitutes an important input to the computer model used to compute flood discharges and stages.

Runoff curve numbers--so named because they relate to rainfall-runoff curves or graphs--were determined for each subbasin under existing 1970 and year 2000 plan land use conditions using procedures established by the SCS. This hydrologic parameter, which is shown for each subbasin in Exhibit I, is a measure of the proportion of rainfall that may be expected to be discharged as direct runoff from any given subbasin. The proportion of runoff that will occur increases with the runoff curve number, although the relationship is not necessarily linear. Hydrologic soil group characteristics and land use are the primary factors used to determine the runoff curve numbers, and the resulting numbers were entered directly into the watershed hydrologic-hydraulic model.

Hydraulics of the Rubicon River watershed

The Rubicon River: The Rubicon River originates in a wetland area at the extreme eastern limits of the watershed and directly north of the Village of Slinger. From its point of origin, the river flows as a perennial stream in a southerly and westerly direction for about 3.69 miles to the Pike Lake outlet. The river flows northerly from Pike Lake and then westerly to the eastern limits of the City of Hartford--a total distance of 2.25 miles. A 2.41-mile-long segment of the river is contained between the eastern and western limits of the city. The river then follows a 1.45-mile-long route from the western limits of Hartford, past the city's sewage treatment plant--which is located outside of and west of the city limits--to the Washington-Dodge County line. The total length of the Rubicon River within the watershed is about 9.80 miles, and the average fall of the channel bottom is about 8.4 feet per mile.

While flood flows were determined for selected points along the entire length of the Rubicon River as well as for some of the tributary streams, flood stage information suitable for detailed flood hazard mapping was developed only for that 3.60-mile-long reach of the Rubicon River extending from River Mile 4.39, about

0.53 mile upstream of the east limits of the City of Hartford, to River Mile 0.79, about 0.66 mile downstream of the west limits of the city. The channel bottom falls about 35 feet in this distance at an average slope of 9.7 feet per mile. The study was restricted to this river reach because photogrammetrically compiled large-scale (1" = 100', 2 foot contour interval) topographic maps meeting National Map Accuracy standards and based on aerial photography taken in May 1968 were available for this reach from the City of Hartford, and because the development of detailed flood hazard information for riverine areas outside of the City of Hartford was beyond the scope of this project.

Floodland Cross Sections: The width, slope, and flow resistance of the channel and its floodplains, particularly the latter, are important hydraulic elements of a river inasmuch as they are the primary determinant of the stage at which a given flood discharge will occur. Channel-floodplain cross sections were developed by combining information from topographic maps--Hartford large-scale maps where available and 1" = 2000' scale standard USGS quadrangle maps elsewhere--with channel bottom data obtained from a hydraulic structure inventory conducted by field survey. About 50 channel-floodplain cross sections were constructed at an average spacing of 380 feet within the detailed study reach for which the large-scale topographic maps were available. These cross sections, along with channel and floodplain Manning roughness coefficients determined by field inspection, were used as input to the flood flow simulation computer program.

Bridges and Culverts: Depending on the size of the waterway opening and the characteristics of the approaches, bridges and culverts can be important elements in determining the hydraulics of a watershed. Constrictions caused by inadequately designed bridges and culverts can, under flood discharge conditions, result in large backwater effects and thereby create a floodland area upstream of the structure that is significantly larger than that which would exist in the absence of the bridge or culvert.

The Rubicon River is, as shown in Exhibit J, crossed 28 times by existing pedestrian ways, roadways and railroads in the 7.50-mile reach extending from the Washington-Dodge County line upstream to Kettle Moraine Drive. In addition, one crossing--Wacker Drive--is under construction and another crossing--Mill Pond Bridge--is in the planning stages. Existing, under construction, and proposed bridges and culverts were examined in this reach which begins 0.79 mile below and extends 3.11 miles above the detailed study reach, in order to include all bridges and culverts that might affect flood discharges or stages within the reach. Based on that examination, certain bridges and culverts were judged to be hydraulically insignificant, that is, were of such size and elevation as not to influence flood stages by more than 0.5 foot during 10- through 100-year recurrence interval flood events. A bridge or culvert is likely to be hydraulically insignificant if it simply spans the stream from bank to bank, has approach roads with little or no fill on the floodplain, and has a relatively small superstructure. Data and information such as waterway opening size, roadway profile, and channel bottom elevation were obtained for the hydraulically significant bridges and culverts and were used as input to the hydrologic-hydraulic computer model used to compute flood discharges and stages.

Dams: There are two dams located on the Rubicon River that permit some control over upstream water levels and downstream flood discharges and stages, at least during periods of low to moderate flow. These dams are the Hartford Mill Dam and the Pike Lake Dam. The position of these dams relative to the aforementioned bridges and culverts is shown on Exhibit J. Data such as spillway width and crest elevation and sluiceway position were obtained for these two hydraulically significant structures and used as input to the computer model used to simulate watershed hydrology and hydraulics.

The Hartford Mill Dam located within the city is equipped with a sluice gate that, under low flow conditions, facilitates drawing down the level of the pond a distance of about 6 feet below the dam crest. Wisconsin Department of Natural Resources operating regulations for the Mill Dam specify that, within the capability of the sluice gate, the dam be operated so as to maintain the Mill Pond levels within 0.3 foot range between 978.6 and 978.9 feet above mean sea level. The Mill Pond level is, however, normally maintained coincident with the dam crest. The Mill Pond level was presumed to be at the dam crest elevation of about 977.0 feet above mean sea level datum at the start of the storm event used to compute flood discharges and stages for the study by application of the hydrologic-hydraulic model.

The Pike Lake outlet structure, which is part of the STH 60 crossing of the Rubicon River immediately downstream of the lake, is the second of the two dams. Two sluice gates are provided in this structure to facilitate control of the level of Pike Lake. Based on Wisconsin Department of Natural Resources operating regulations, this dam is to be operated so as to maintain the level of Pike Lake between a minimum of 993.41 feet above Mean Sea Level datum--or 1.5 feet above the invert of the outlet control structure--to a maximum of 993.88 feet above Mean Sea Level datum. Thus the lake level is to be maintained within a very narrow range of only 0.5 foot. When the level of Pike Lake is in fact within the prescribed range, at least 1 cfs of flow must be discharged from the lake to the Rubicon River in order to maintain at least a minimal streamflow. When Pike Lake levels fall below the established minimum--for example, as a result of an extended drought--or rise above the established maximum--for example, during a major flood event--a "water in-water out" policy is to be followed with the gates operated so as to pass all incoming streamflow through the lake. For purposes of hydrologic-hydraulic modeling, it was assumed that Pike Lake was at its maximum elevation at the outset of a storm event.

THE HYDROLOGIC-HYDRAULIC MODEL

In order to accomplish the objective of this floodland information report, that is, the delineation of a regulatory floodplain and floodway for the Rubicon River in and near the City of Hartford, it was necessary to apply a suitable analytical technique to supplement the meager amount of available data. A digital computer model capable of simulating the watershed hydrologic-hydraulic system was selected as that analytic technique.

Description of the Model

The hydrologic-hydraulic system of the Rubicon River watershed consisted of two submodels, that is, two computer programs operated in sequence as illustrated in Exhibit K. The first, or hydraulic, submodel[1] was used to determine the hydraulic characteristics of the Rubicon River channel and floodplain. These characteristics, along with hydrologic data describing the land surface and the rainfall event to be modeled, provided the input for the second, or hydrologic, submodel,[2] the primary function of which was to convert design rainfall events into 10-, 25-, 50-, and 100-year recurrence interval Rubicon River discharges. The hydraulic submodel was applied a second time, using peak discharges obtained from the hydrologic submodel to obtain 10-, 25-, 50-, and 100-year flood stages and to determine the hydraulic effect of alternative floodway configurations.

In order to meet the data needs of the federal flood insurance program, which requires an estimate of 500-year recurrence interval flood stages and areas of inundation, the 10- through 100-year recurrence interval discharge-frequency relationships for selected points along the Rubicon River in and near Hartford

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[1] U. S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-2, Water Surface Profiles," Computer Program 723-X6-L202A, February 1972.

[2] U. S. Department of Agriculture, Soil Conservation Service, Engineering Division, "Computer Program for Project Formulation-Hydrology," Technical Release No. 20, May 1965.

were extrapolated to obtain the 500-year recurrence interval discharge for each location, that is, the discharge that has a 0.2 percent probability of being reached or exceeded in any year. The extrapolation was done on logarithmic-probability paper, since discharge-frequency relationships generally plot in a linear manner in that coordinate system. The 500-year recurrence interval discharge estimates obtained by this method were then input to the backwater submodel to compute the corresponding flood stages.

All the inputs to the two submodels developed under and taken from the inventory of the watershed hydrologic-hydraulic system are described in the preceding section of this report. One item of input, the design rainfall event, is discussed in Exhibit L.

Uses of the Model

The hydrologic-hydraulic model was primarily used in the computation of Rubicon River discharges and stages in and near the City of Hartford for 10-, 25-, 50-, and 100-year recurrence interval flood events under existing (1970) and year 2000 planned land use conditions. After completion of that portion of the simulation work, the hydraulic submodel was used to compute 500-year recurrence interval flood stages in and near the City of Hartford under year 2000 planned land use, and was also used in the floodway delineation process.

Flood discharges and stages were computed for 100-year recurrence interval flood conditions because the State of Wisconsin specifies use of that event for regulatory purposes, while 10-, 25-, 50-, and 500-year recurrence interval events were simulated so as to yield a full spectrum of flood discharges, stages, and areas of inundation to be used for federal flood insurance purposes and for detailed local land use planning and engineering applications.

Sound land and water resources decision making requires consideration of future as well as existing land uses which affect water resources in general, and flood problems in particular. Flood events were first simulated under existing land use conditions in order to determine the existing flood characteristics of the Rubicon River in and near Hartford, and to establish a point of reference for the results of simulation runs based on the Commission's interim planned year 2000 land use conditions. The hydrologic-hydraulic response of the planned year 2000 land use conditions was modeled in order to test the sensitivity of the flow regimen of the Rubicon River to the urbanization that is likely to occur, and to produce 100-year recurrence interval flood discharges and stages for regulatory purposes.

It should be noted that year 2000 land use conditions apply to areas within the floodlands of the Rubicon River and its major tributaries as well as to areas outside of those floodlands. The plan assumes that floodlands not yet occupied by urban uses will be retained in a natural or seminatural condition and used for recreation, agricultural, and other open space uses. This aspect of the year 2000 plan is critical inasmuch as widespread floodland filling and development upstream of the City of Hartford may, because of the loss of floodwater conveyance and storage capacity, be expected to increase flood discharges and stages within the city.

Existing and year 2000 flood discharges and stages as well as year 2000 floodplain delineations resulting from application of the hydrologic-hydraulic model are presented in tabular and graphical form and discussed in the "Flood Discharges, Stages, and the Natural Floodlands" section of this report. The year 2000 flood hazard information presented there is intended for use in developing floodland regulations.

The hydrologic-hydraulic effect of Pike Lake on the regulatory flood in Hartford under planned year 2000 land use conditions was determined with the hydrologic-hydraulic model. Pike Lake is relatively large--it encompasses 0.73

square mile at its maximum regulatory stage--and intercepts runoff from 10.60 square miles of the Rubicon River watershed headwater area, or about 40 percent of the portion of the watershed tributary to the center of the City of Hartford. Simulation runs were conducted to determine the potential effect of the operation of the Pike Lake outlet structure on flood flows and stages in Hartford, and to provide insight into the relative absence of major flood problems along the Rubicon River in the City of Hartford based on the hypothesis that the flood water storage provided by Pike Lake reduces flood discharges and stages at Hartford to levels significantly below those which would exist in the absence of the lake. Two supplemental simulation runs were conducted. Each was identical to that for the planned year 2000 land use conditions except that, in the case of the first run, input data were changed to reflect the assumption that Pike Lake was at the minimum permitted elevation of 993.4 feet above mean sea level datum at the outset of the storm event; and in the case of the second run, the input data were altered to correspond to the conditions that would prevail if Pike Lake did not exist. The results of modeling the hydrologic-hydraulic effect of Pike Lake are discussed in the next section of this report.

After completion of these simulation efforts, the hydraulic submodel was used to delineate a regulatory floodway along the Rubicon River through the City of Hartford using the 100-year recurrence interval discharge under year 2000 planned land use conditions. Hydraulic and nonhydraulic factors incorporated in that floodway delineation process, as well as the resulting floodway stages and lateral limits, are presented and discussed in "The Regulatory Floodlands" section of this report.

FLOOD DISCHARGES, STAGES, AND THE NATURAL FLOODLANDS

The purpose of this section is to present in tabular and graphic form the 10-, 25-, 50-, 100-, and 500-year recurrence interval flood discharges and stages under planned year 2000 land use conditions. The natural floodplain commensurate with year 2000 land use conditions is also described, as is the hydrologic-hydraulic effect of Pike Lake on flood flow characteristics in Hartford and the hydraulic adequacy of river crossings. All of this flood discharge, stage, and inundation information was developed using the hydrologic-hydraulic model as described in the preceding section of this report.

Discharges and Stages

Peak flood discharge and peak flood stage information for 10-, 25-, 50-, 100-, and 500-year recurrence interval flood events under planned year 2000 land use conditions are presented in a tabular format in Exhibit M. Discharge data are presented for the Rubicon River reach extending from River Mile 0.0 at the Washington-Dodge County Line upstream to Kettle Moraine Drive at River Mile 7.50. Flood stages are shown only for the 3.60-mile-long Rubicon River reach--River Mile 0.79 to River Mile 4.39--for which large-scale topographic maps are available for accurately defining the channel-floodplain cross section.

The table also includes left and right floodplain overbank depths and left floodplain, channel, and right floodplain average velocities for that 3.60-mile-long reach. Overbank depths and velocities are particularly useful for assessing potential flood hazards to existing and proposed floodland structures and facilities.

A comparison of flood characteristics under existing and planned year 2000 land use conditions indicates that there was no significant difference between discharge and stages under the planned year 2000 land use conditions and those under existing (1970) land use conditions. For that reason, existing condition flood discharges and stages are not included in the tabular summary attached as Exhibit M. The relative insensitivity of flood discharge and stages in and near Hartford to planned incremental urban development is due to the fact that the watershed is expected to continue to remain primarily rural in character. As discussed earlier, only about 7 percent of the watershed is currently devoted to urban land use, and a total of only about 15 percent is to be urbanized under the year 2000 land use plan.

An independent analysis of Rubicon River watershed flood discharges was conducted using an empirical method developed by the USGS.[3] The method, which is based on an analysis of regional streamflow records, permits the calculation of flood discharges as a function of measurable or otherwise quantifiable watershed parameters such as tributary area, channel slope, percent of lake and wetland area, and an areal factor that reflects the soils, geology, and physiography of a watershed. Although the technique is intended for use in estimating flood discharges of specified recurrence intervals on larger, rural watersheds in situations where more sophisticated methodology--such as the hydrologic-hydraulic model used in the Rubicon River watershed--is not readily available, it does provide an independent means of examining the validity of results obtained by the more sophisticated approaches.

The USGS regional method was used to compute 10-, 25-, and 50-year recurrence interval flood discharges at the Washington-Dodge County line, the discharge point of the Rubicon River watershed. The method could not be used to calculate flows for floods more severe than the 50-year recurrence interval flood, since the 30.6 square mile area of the Rubicon River is below the minimum size required for application of the method to more infrequent flood discharge.

Using an areal factor of 0.85, the USGS method yielded 10-, 25-, and 50-year recurrence interval flood discharges under planned year 2000 land use conditions

[3]Duane H. Conger, "Estimating Magnitude and Frequency of Floods in Wisconsin," USGS, Madison, 1971.

of 500, 700, and 855 cfs. The 10-year discharge value is 88 percent of the value obtained with the hydrologic-hydraulic model, the 25-year discharge is 91 percent of the model value, and the 50-year discharge is essentially identical to the model value. Refer to Exhibit N for further discussion of the USGS regional method as applied to the Rubicon River watershed with emphasis on the sensitivity of the results to the areal factor.

Flood Stage Profiles

Exhibit O presents 10- and 100-year recurrence interval flood stage profiles for planned year 2000 land use conditions. These profiles, which encompass the 3.60-mile-long Rubicon River reach for which large-scale topographic maps are available, constitute a graphic representation of the tabular flood stage data presented in Exhibit M. In addition to providing an overall representation of flood stages relative to familiar points of reference such as the channel bottom, bridge deck surfaces, and dam crests, the profiles, because they are continuous, permit the determination of flood stages at any point along the stream channel.

Natural Floodplain

The natural floodplain as it would exist under planned year 2000 land use conditions is shown on the large-scale maps (1" = 100', 2 foot contour interval) attached as Exhibit P. These maps were prepared using the tabular flood stage data of Exhibit M and the flood stage profiles of Exhibit O, and encompass 3.60 miles of the Rubicon River extending from River Mile 0.79 (0.66 mile downstream of the west corporate limits of Hartford) to River Mile 4.39 (0.53 mile upstream of the east corporate limits of Hartford).

Review of the flood hazard maps indicates that relatively few structures and facilities within or near Hartford would be affected by overland flooding of the Rubicon River during the 100-year recurrence interval event. Exceptions to this general observation are the commercial areas located north and south of the river along the 700-foot-long reach that extends from about 300 feet downstream of Rural Street upstream to Johnson Street. Another exception is the W. B. Place and Company property located just upstream of West Park, which may be expected to incur some damages during a 100-year recurrence interval flood. These findings are consistent with the results of the historic flood survey which, as discussed earlier in this report, revealed a rather unusual absence of major flooding in Hartford over the past half century.

Hydraulic Adequacy of River Crossings

Examination of the flood stage profiles attached as Exhibit O and the large-scale riverine area topographic maps attached as Exhibit P reveals that a 100-year recurrence interval flood would overtop the deck or approach roads of six of the 16 bridges and culverts that cross the 3.60-mile-long reach of the Rubicon River in the City of Hartford. With respect to traffic movement and the conduct of business within Hartford during a flood, the most troublesome bridge closings would be at Rural Street and Johnson Street.

The constricted waterway opening of the Rural Street bridge produces a backwater of about three feet, that is, the regulatory flood stage immediately upstream of the bridge is approximately three feet higher than it would be in the absence of the bridge. Although Rural Street lies only 400 feet downstream of Johnson Street, backwater computations indicate that the backwater effect of the Rural Street bridge does not extend upstream to the Johnson Street bridge. Therefore, if the large backwater effect of the Rural Street bridge waterway opening were eliminated, the 100-year flood stage at the downstream side of the Johnson Street bridge would not be significantly reduced, and that bridge would remain impassable under regulatory flood conditions.

Although not causing overtopping of Johnson Street, the Rural Street bridge appears to be the principal cause of overland flooding in the short reach between Rural Street and Johnson Street. Enlargement of the waterway opening of this bridge would markedly reduce the lateral extent of that overland flooding.

Effect of Pike Lake on Downstream Flood Flows

As discussed earlier, the model was used to investigate the hydrologic-hydraulic effect of Pike Lake on the regulatory flood in Hartford under year 2000 planned land use conditions. These simulation runs were conducted to provide insight into the relative absence of major flood problems along the Rubicon River in the City of Hartford, and to determine the potential effect of the operation of the Pike Lake outlet structure on flood flows and stages in Hartford. The results of these analyses are presented in tabular form in Exhibit Q.

Pike Lake has a very significant impact on downstream regulatory discharges, with that effect being greatest at the lake outlet structure and diminishing with increasing distance downstream from the lake. A significant effect persists at Hartford, however, in that the absence of Pike Lake would produce a 68 percent increase in the regulatory flood discharge at the Chicago, Milwaukee, St. Paul and Pacific Railroad bridge at the upstream limits of the city relative to that which would occur at that location with the lake at its maximum permitted stage of 993.0 feet above mean sea level datum at the outset of the critical storm event. The regulatory flood stages would be increased 2.1 feet at the eastern edge of Hartford.

While the presence of Pike Lake has a marked effect on Rubicon River 100-year flood discharges at the City of Hartford, the manner in which the outlet structure is operated has no significant influence on flood flows at Hartford. For example, if the Pike Lake stage is at the minimum permitted elevation of 993.4 feet above mean sea level datum at the outset of the critical storm event, the additional lake storage available during the ensuing flood will produce a peak 100-year recurrence interval discharge and stage at the upstream city limits that is essentially identical to that which would occur if Pike Lake were at its maximum permitted stage at the outset of the storm event. In summary, then, the presence of Pike Lake, and not the manner in which it is operated within the permitted maximum and minimum elevations, has a marked influence on the 100-year recurrence interval flood flows and stages of the Rubicon River in Hartford.

THE REGULATORY FLOODLANDS

Floodland regulations in urban and urbanizing areas such as the City of Hartford are normally based on a two-district floodway-floodplain fringe approach because the two-district concept recognizes the quite different hydraulic function of, as well as the different flood hazard in, the floodway as opposed to the fringes or outer areas of the regulatory floodlands. The rational nature of the two-district approach enhances the likelihood of public acceptance, generally severely affecting a smaller number of existing structures.

The Floodway and Floodplain Fringe

A floodway was delineated for the Rubicon River in and near the City of Hartford in order to satisfy one of the stated objectives of this report, that is, the determination of a floodway which, in combination with the delineated floodplain fringe, can form the basis for preparation and adoption of floodland regulations that will meet minimum State of Wisconsin requirements. The floodway, which is shown on the large-scale maps attached as Exhibit P, was delineated for that 3.60-mile-long reach of the Rubicon River (River Mile 0.79 to River Mile 4.39) for which large-scale topographic maps (1" = 100', 2 foot contour interval) were available. The floodplain fringe, which lies adjacent to the floodway, is also shown on the large-scale maps attached as Exhibit P.

Floodway Determination Factors

The floodplain of a river is essentially a natural feature, the identification of which is accomplished by hydrologic-hydraulic analysis. Thus, the natural floodplain in and near the City of Hartford is a unique feature of the riverine area determined by the flow regimen of the river and the adjacent topography. Its limits were determined by the technical methods described in earlier sections of this report.

In contrast, the floodway for a given reach of a river is neither a natural nor unique feature. There are many possible floodways that could be delineated to convey the regulatory, or 100-year recurrence interval, flood discharge, with small, acceptable stage increases relative to the stages that would exist when the flood flow occupies the entire natural floodlands. The determination of floodway limits, therefore, involves a judicious blend of hydraulic and nonhydraulic factors, the net effect of which is to provide for the safe passage of major floods, while recognizing the problems and plans of the community in general, and riverine property owners and land users in particular. Some of the hydraulic and nonhydraulic factors considered in the delineation of the City of Hartford floodway are discussed below.

Hydraulic Considerations: Floodway limits were made smooth and continuous to reflect the expected flow pattern of the deeper, more rapidly moving portions of the Rubicon River for floods up to and including the 100-year recurrence interval event. Smooth hydraulic transitions are provided wherever the floodway width undergoes large changes over short distances, such as in the vicinity of the Wilson Avenue bridge where the river, during flood stage, is constricted as it passes through the bridge waterway opening and then abruptly expands to occupy the wide natural floodplain downstream of the bridge.

The floodway determination procedure included computation of stage increases that would occur as a result of laterally constricting the regulatory flood discharge so as to confine it within the floodway limits rather than allowing the flood flow to utilize the entire width of the natural floodplain. Floodland regulations based on the two-district floodway-floodplain fringe approach must incorporate the higher flood stages, since completion of the filling and urbanization of the floodplain fringe would mean that essentially all conveyance potential would be removed from that area so that the regulatory flood discharge would, in effect, be forced to pass within the floodway limits. Chapter NR 116 of the Wisconsin Administrative Code specifies, as a general rule, a maximum allowable 100-year recurrence interval flood stage increase in urban areas of 0.5 foot attributable to a floodway delineation. The hydraulic submodel was used to obtain regulatory flood stages under floodway conditions and to assure that the stage increase limitation would be satisfied by the Hartford floodway. Tabular flood stage data presented in Exhibit R indicate that the maximum stage increase associated with the recommended Hartford floodway is 0.3 foot, which occurs at Rural Street (River Mile 2.80), and further upstream at the Chicago, Milwaukee, St. Paul and Pacific Railroad Bridge, (River Mile 3.86), which is also the eastern limits of Hartford.

Floodwater depth and velocity are two hydraulic characteristics that exhibit significant variation across the floodlands during major flood events. Depths and velocities are generally greatest in and near the channel area, while they decrease across the natural floodplains with increased distance from the channel. The floodway is intended to encompass those floodland areas that may be expected to exhibit floodwater depths and velocities of such magnitude as to constitute a threat not only to floodland structures and facilities but, more importantly, to the safety and well-being of floodland inhabitants. If structures, primarily private residences, exist or are allowed to be placed in areas having large floodwater depths and high velocities, the potential danger to human safety and life is greatly increased, since structure inhabitants or users may be swept off their feet when they attempt to move to or from those structures during flood events. Velocities of four feet per second in combination with floodwater depths of three or more feet, for example, develop dynamic forces sufficient to sweep persons off their feet. An attempt was made to identify the probable location of such danger zones so that they could be included within the confines of the floodway.

Due cognizance must be given during and after the floodway selection process to the maintenance of lateral drainageways so as to prevent the development of storm water drainage problems along those drainage courses. Any development that is to be permitted in the floodplain fringe must be executed in such a manner so as not to diminish the carrying capacity of the drainage courses lying within or passing through those areas.

Nonhydraulic Considerations: An attempt was made to minimize the number and value of existing structures located within the Rubicon River floodway. Recommended floodland regulations would make such structures nonconforming uses, with the intent that they be eventually removed from the floodway. For example, and as shown on Exhibit P, to minimize the number of nonconforming uses to be created, the floodway was designed to exclude structures located on both sides of the Rubicon River in the vicinity of Rural Street and Johnson Street.

Existing land uses in the regulatory floodplain constitute another nonhydraulic factor incorporated into the Rubicon River floodway determination. The floodway was delineated to incorporate to the maximum extent practicable riverine areas already in open space uses, such as parks, certain outdoor storage areas, and parking lots inasmuch as such uses are compatible with periodic inundation. Examples of the application of this factor, as shown on Exhibit P, are inclusions of large portions of Hartford's Willowbrook Park and West Side Park in the floodway, thus facilitating the exclusion of other, more developed areas.

Another nonhydraulic factor considered in the floodway selection process was the equal degree of encroachment concept. Whenever hydraulically acceptable and otherwise feasible, the floodway was positioned within the natural floodplain so as to encroach an approximately equal amount on both sides of the natural floodplain. In this way, the land use restrictions associated with the floodway more equitably impact the landowners on both sides of the river.

FLOODLAND REGULATIONS

The floodway and floodplain data developed under this study have been incorporated into suggested draft floodland zoning regulations for the City of Hartford. These regulations are set forth in full in Exhibit S. The regulations not only embody sound land use planning and regulatory concepts, but have also been designed to ensure that the City of Hartford meets all minimum floodplain management requirements set forth by the Wisconsin Department of Natural Resources in Chapter NR 116 of the Wisconsin Administrative Code. In addition, the regulations should ensure that the City of Hartford will ultimately meet all floodplain management requirements of the U. S. Department of Housing and Urban Development at such time as the City of Hartford may choose to participate in the federal flood insurance program. The draft regulations set forth in Exhibit S should be reviewed and approved by the City Attorney.

The suggested draft floodland zoning regulations for the City of Hartford divide the delineated 100-year recurrence interval floodlands of the Rubicon River through the city into three distinct regulatory areas:

1. The floodway, which has been placed into a suggested F Floodway District.
2. The undeveloped floodplain fringe, which has been placed into a suggested FC Floodplain-Conservancy Regulatory "Overlay" Area.

3. The developed floodplain fringe, which has been placed into a suggested UF Urban Floodplain Regulatory "Overlay" Area.

The boundaries of the proposed Floodway District and the two floodplain fringe regulatory areas are identified on a proposed Supplementary Floodland Zoning Map set forth in Exhibit P.

If adopted, the proposed regulations would place all lands within the Rubicon River floodway into the Floodway District, and thus would change the basic zoning of these lands from the current zoning--either residential, commercial, or industrial--to the proposed Floodway District zoning. The proposed regulations for the Floodway District seek to preserve the essentially open character of the lands in the floodway, and thus prohibit filling and building within the District. Exceptions to the filling and building prohibition are listed, including essential utilities, water measuring and control devices, and bridges.

The floodplain fringe lands designated for the proposed CF Conservancy-Floodplain Regulatory Area generally lie adjacent to the Rubicon River floodway upstream of the Hartford Mill Dam. Conservancy-Floodplain Regulatory Area designation is also suggested for a floodplain fringe area located in West Park. The proposed overlay regulations for this regulatory area prohibit filling and building except for structures relating to utilities, highways and bridges, and outdoor recreational uses.

The remaining floodplain fringe lands have been suggested to be placed in the UF Urban Floodplain Regulatory Area. These lands are located largely downstream of the Hartford Mill Dam and lie within an intensive commercial-industrial area of the city. As such, these lands have already been largely developed for urban use, including in some cases the placement of major buildings. The proposed regulations for this area provide that, with respect to any future development, the lands in question be filled to an elevation at least two feet above the elevation of the 100-year recurrence interval flood, or that appropriate floodproofing measures be taken to eliminate major flood damage.

As noted above, the enactment of the proposed floodland zoning regulations by the City of Hartford will serve to assure that the City will meet all applicable federal and state floodplain management standards. More importantly, however, enactment of the proposed zoning regulations will represent an important step toward the development of a sound riverine area land use policy by the city, and will thus serve as an important input to the subsequent preparation of detailed neighborhood land use plans.

SUMMARY

The purpose of this report is to present floodland information for the Rubicon River within and near the City of Hartford, Washington County, Wisconsin so that city officials and concerned citizens can better make decisions concerning sound floodland uses. The data are designed to permit the city to adopt sound floodland zoning regulations, to become eligible for federal flood insurance, and to facilitate various local planning and engineering efforts. This report was prepared by the Southeastern Wisconsin Regional Planning Commission at the request of the City of Hartford.

The Rubicon River, which is one of many headwater tributaries of the Rock River watershed, originates east of the City of Hartford, and flows in a generally westerly direction through Hartford to join the Rock River in Dodge County. The Rubicon River watershed is defined as that 30.6 square mile area tributary to the Rubicon River at the point where it crosses the Washington-Dodge County line about 2.5 miles downstream of Hartford. Rural land uses are dominant in the Rubicon River watershed, accounting for about 93 percent of the watershed area in 1970. As of 1970, the City of Hartford encompassed about 3.5 square miles and had a population of 6,500 people. Hartford is expected to grow to a population of almost

11,000 by the year 2000. An inventory of historical flood data and information revealed that the City of Hartford has not over the past half century experienced any truly major flood problems. This unusual situation--relative to many other communities in southeastern Wisconsin--appears to be attributable to the generally compatible open space uses to which the natural floodlands have been put, the floodwater storage capacity of Pike Lake which lies upstream of the city, and the fortuitous effect to date of the random nature of flood events on the Rubicon River.

Inasmuch as Rubicon River flood characteristics were the principal concern of this report, a detailed inventory was conducted of the Rubicon River watershed hydrologic-hydraulic system. The inventory of hydrologic elements of the system included the collection and collation of definitive data on precipitation, runoff, soils, and land use data, and the delineation of subbasins. Hydraulic data collected and collated under the inventory phase of the project included stream channel profiles, floodland cross sections and roughness coefficients, and bridge, culvert, and dam descriptions.

The above hydrologic-hydraulic system data provided input to the hydrologic-hydraulic model, a digital computer program that was used to simulate the flow regimen of the river system. This model consists of a hydrologic submodel that converts a design rainfall event on the land surface to direct runoff into the streams, resulting in the determination of prescribed recurrence interval flood discharges throughout the length of the river and a hydraulic submodel that computes the flood stages commensurate with those flood discharges.

The hydrologic-hydraulic model was used to determine flood discharges and stages for 10-, 25-, 50-, and 100-year recurrence intervals under existing (1970) and planned year 2000 land use conditions and 500-year discharges and stages under planned year 2000 land use conditions. This detailed flood hazard information was developed for the 3.60 mile reach of the Rubicon River in and near Hartford for which large-scale topographic maps were available as of late 1974. The hydrologic-hydraulic inventory and analyses were conducted to readily permit extension of the detailed flood hazard information upstream and downstream of Hartford as new riverine area large-scale topographic maps become available.

Model applications indicated that the small amount of incremental urbanization anticipated between now and the year 2000 if the regional land use plan is implemented may be expected to have an insignificant effect on flood flow and stage characteristics in the City of Hartford. The model was also used to evaluate the effect of Pike Lake on Rubicon River flood discharges in Hartford, and to delineate a floodway and corresponding floodplain fringe area for the Rubicon River in and near Hartford. Delineation of the floodway involved the consideration of hydraulic factors, such as smooth transitions and allowable stage increases, as well as nonhydraulic factors, such as existing land use and the number of structures in the floodway.

The hydrologic-hydraulic model indicates that the City of Hartford would experience some modest inconvenience associated with the disruption of traffic movements during a major flood event, because Rural street and Johnson Street could be expected to be rendered impassable and because structures along the river in the immediate area of those two bridges could be expected to be inundated. The principal cause of the overland flooding in this area is the hydraulic constriction imposed by the inadequate waterway opening of the Rural Street bridge.

Floodway-floodplain fringe data which, in effect, define the areas subject to floodland zoning regulations as required by the State of Wisconsin were used to prepare draft floodland regulations for the City of Hartford. These floodland regulations meet the minimum requirements established by the Wisconsin Department of Natural Resources and also reflect sound riverine area land use planning concepts. The publication in this report of 10- through 500-year recurrence interval flood discharge, stage, and area of inundation information will enable the City of Hartford to become eligible for the regular flood insurance program administered by the U. S. Department of Housing and Urban Development.

APPENDICES

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Exhibit A

GLOSSARY OF TERMS

CHANNEL - The linear, continuous, low-lying area normally occupied by a river or stream.

FLOODLANDS, NATURAL - The area encompassed by the channel plus the natural floodplain.

FLOODLANDS, REGULATORY - The area encompassed by the floodway, including the channel and the floodplain fringe. In the absence of a floodway, the regulatory floodlands are identical to the natural floodlands.

FLOODPLAIN FRINGE - That portion of the regulatory floodplain lying outside of the floodway. Floodwater depths and velocities are small in this regulatory area relative to the floodway, and therefore in a developed urban area further development may be permitted although restricted and regulated to minimize flood damage. Because the regulatory floodway may result in increases in the stage of the regulatory flood relative to that which would occur under natural conditions, the floodplain fringe may include at its edges areas that would not be subject to inundation under natural conditions, but would be subject to inundation under regulatory floodway conditions.

FLOODPLAIN, NATURAL - Wide, flat to gently sloping area contiguous with and usually lying on both sides of the channel. The floodplain, which is normally bounded on its outer edges by higher topography, is formed over a long period of time by the river. A river may be expected to overflow its channel banks and occupy some portion of its floodplains on the average of once every two years. How much of the natural floodplain will be occupied by any given flood will depend upon the severity of that flood and, more particularly, upon its elevation or stage. Thus, an infinite number of outer limits of the natural floodplain may be delineated, each related to a specified flood recurrence interval. The Southeastern Wisconsin Regional Planning Commission recommends, therefore, that the natural floodplains of a river or stream be more specifically defined as those corresponding to a flood having a recurrence interval of 100 years.

FLOOD STAGE PROFILE - A graph of peak water surface elevation as a function of position along a river or stream. The profile usually corresponds either to a flood event of specified recurrence interval or to a historic flood event. The channel bottom, as well as bridges, culverts, and dams, are also normally depicted on the flood stage profile.

FLOODWAY - A designated portion of the regulatory floodlands that will safely convey the regulatory flood discharge with small, acceptable upstream and downstream stage increases, generally limited in Wisconsin to 0.5 foot. The floodway, which includes the channel, is that portion of the floodlands not suited for human habitation. All fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities, or would itself be subject to flood damage, should be prohibited in the floodway.

HYDRAULICS - Study of the physical behavior of water as it flows within stream channels and associated natural floodlands; under and over bridges, culverts, and dams; and through lakes and other impoundments.

HYDROLOGY - Study of the physical behavior and amount of water from its occurrence as precipitation to its entry into streams, lakes, and other impoundments or its return to the atmosphere via evapotranspiration.

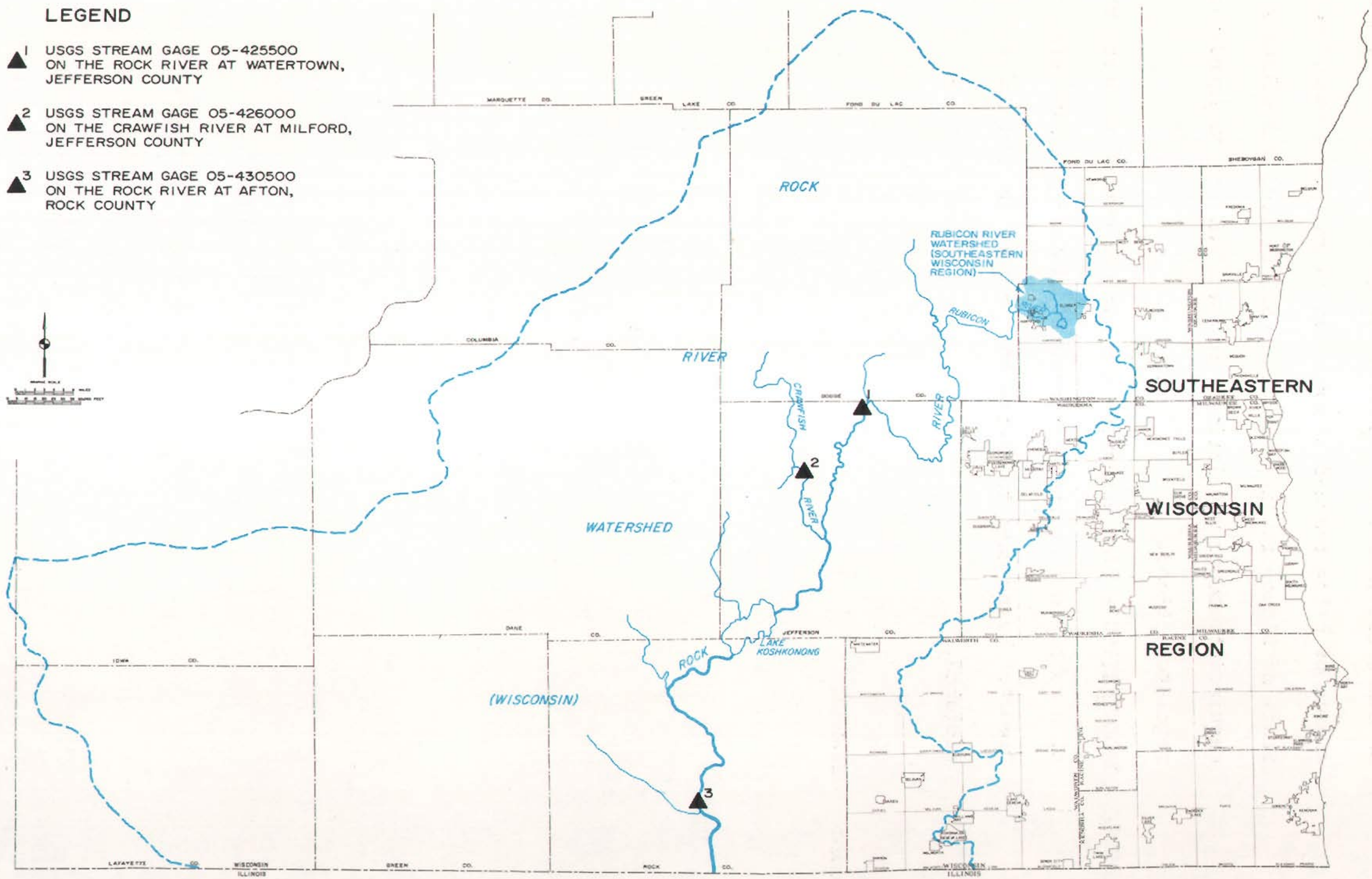
REGULATORY (100-YEAR) FLOOD - The 100-year recurrence interval flood event, that is, the flood event that would be reached or exceeded once on the average of every 100 years, or stated differently, would have a 1 percent chance of being reached or exceeded in any given year. According to State of Wisconsin law, all counties, cities, and villages are required to adopt regulations for land subject to inundation by the regulatory flood.

TIME OF CONCENTRATION - Time necessary for surface runoff to reach the outlet of a subbasin from the most remote point in the subbasin, the term "remote" being used to denote most remote in time and not necessarily distance.

Source: SEWRPC.

Exhibit B

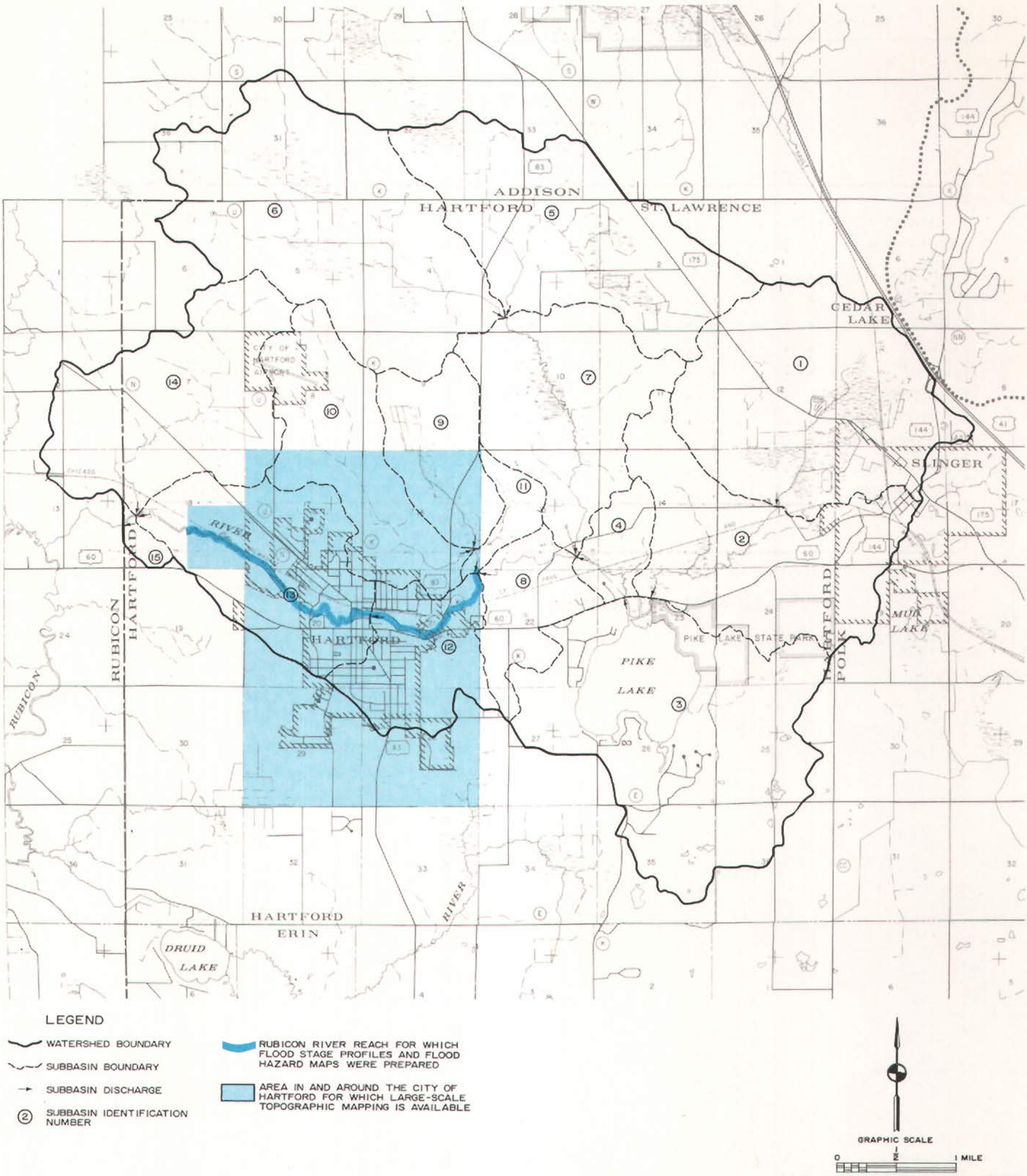
LOCATION OF THE STUDY AREA WITH RESPECT TO THE SOUTHEASTERN WISCONSIN REGION AND THE ROCK RIVER WATERSHED



Source: SEWRPC.

Exhibit C

THE RUBICON RIVER WATERSHED



Source: SEWRPC.

Exhibit D

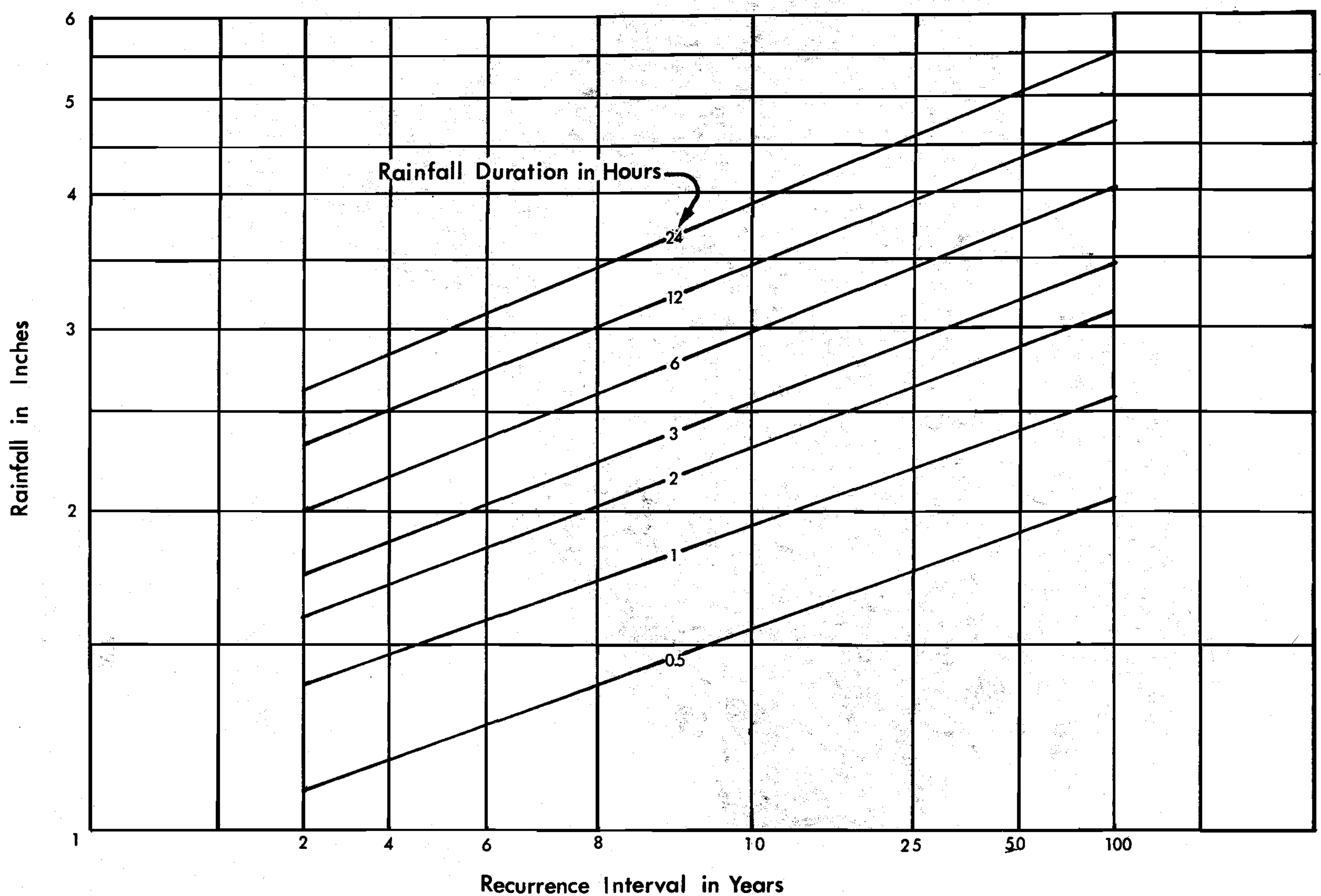
MONTHLY PRECIPITATION CHARACTERISTICS FOR THE CITY OF HARTFORD

Month	Average Total Precipitation (1954-1970) (Inches)	Average Snow and Sleet (1961-1970) (Inches)
January.	1.06	8.8
February	0.87	5.3
March.	1.79	8.8
April.	2.83	1.2
May.	3.23	Trace
June	3.96	0.0
July	3.79	0.0
August	2.75	0.0
September.	4.02	0.0
October.	2.68	0.1
November	1.88	0.9
December	1.46	8.6
Year	**30.32**	**33.7**

Source: National Weather Service.

Exhibit E

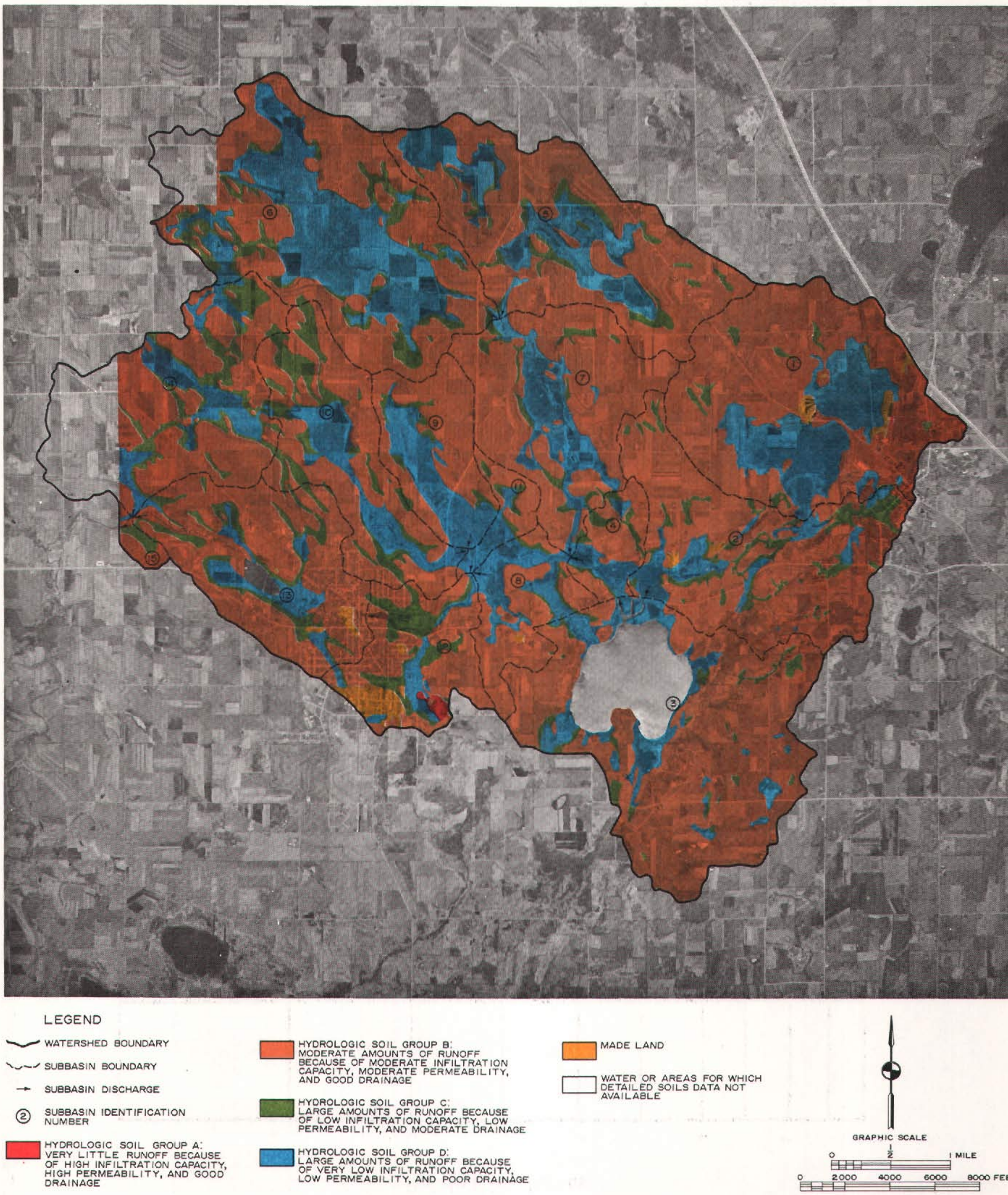
POINT RAINFALL DEPTH-DURATION-FREQUENCY RELATIONSHIPS
FOR THE
RUBICON RIVER WATERSHED



Source: National Weather Service and SEWRPC.

Exhibit F

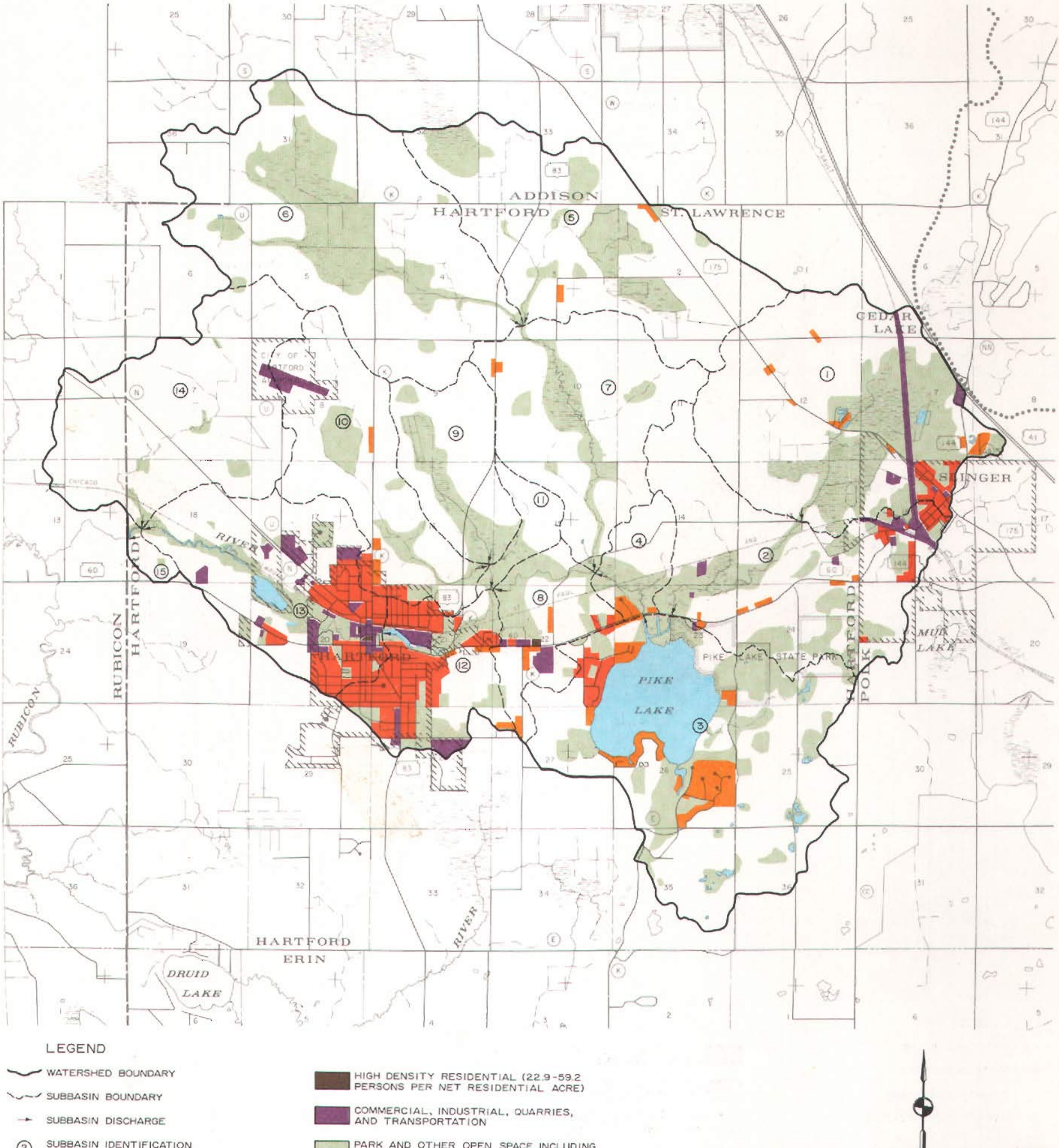
HYDROLOGIC SOIL GROUPS IN THE RUBICON RIVER WATERSHED



Source: U. S. Soil Conservation Service and SEWRPC.

Exhibit G

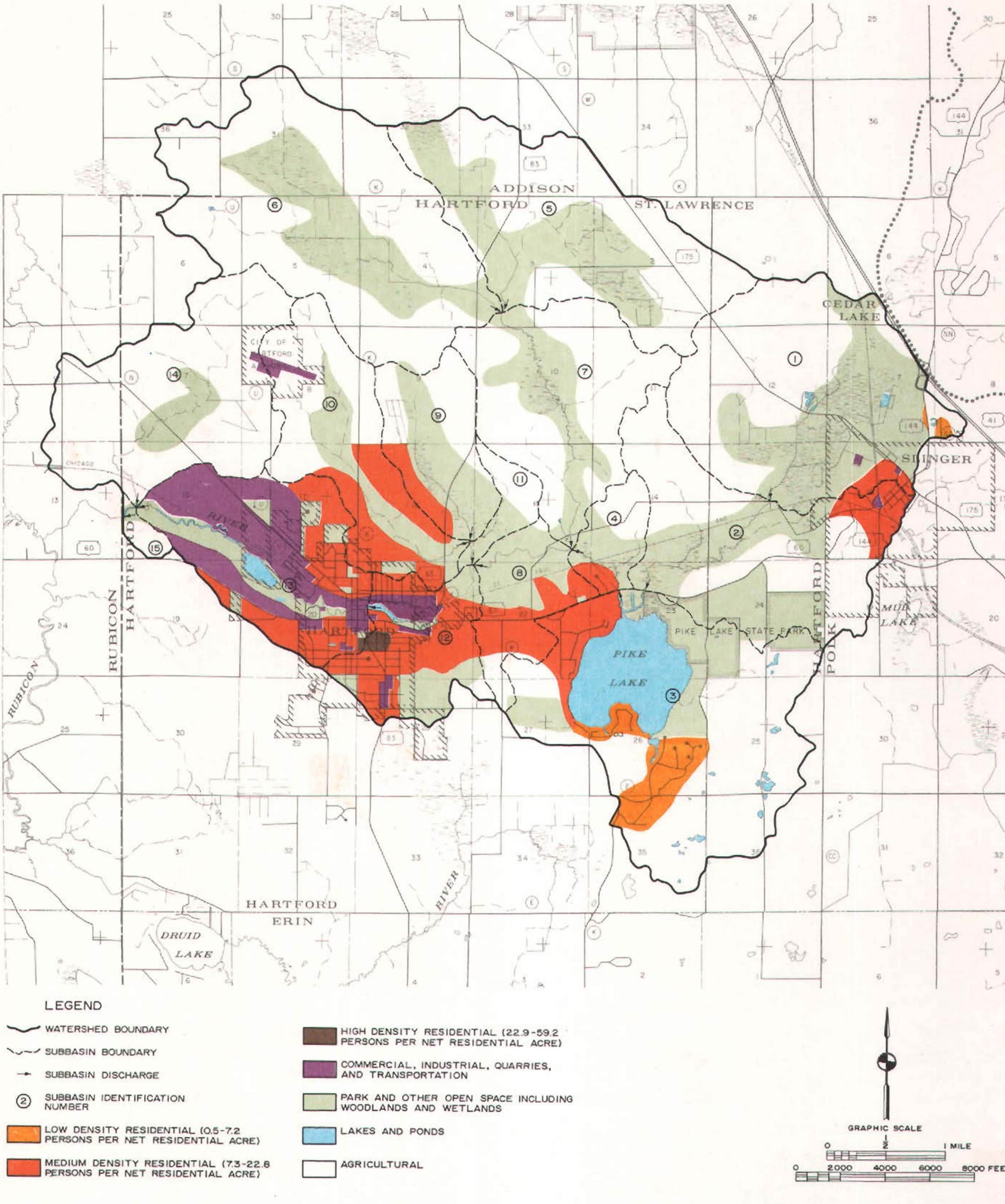
EXISTING (1970) LAND USE IN THE RUBICON RIVER WATERSHED



Source: SEWRPC.

Exhibit H

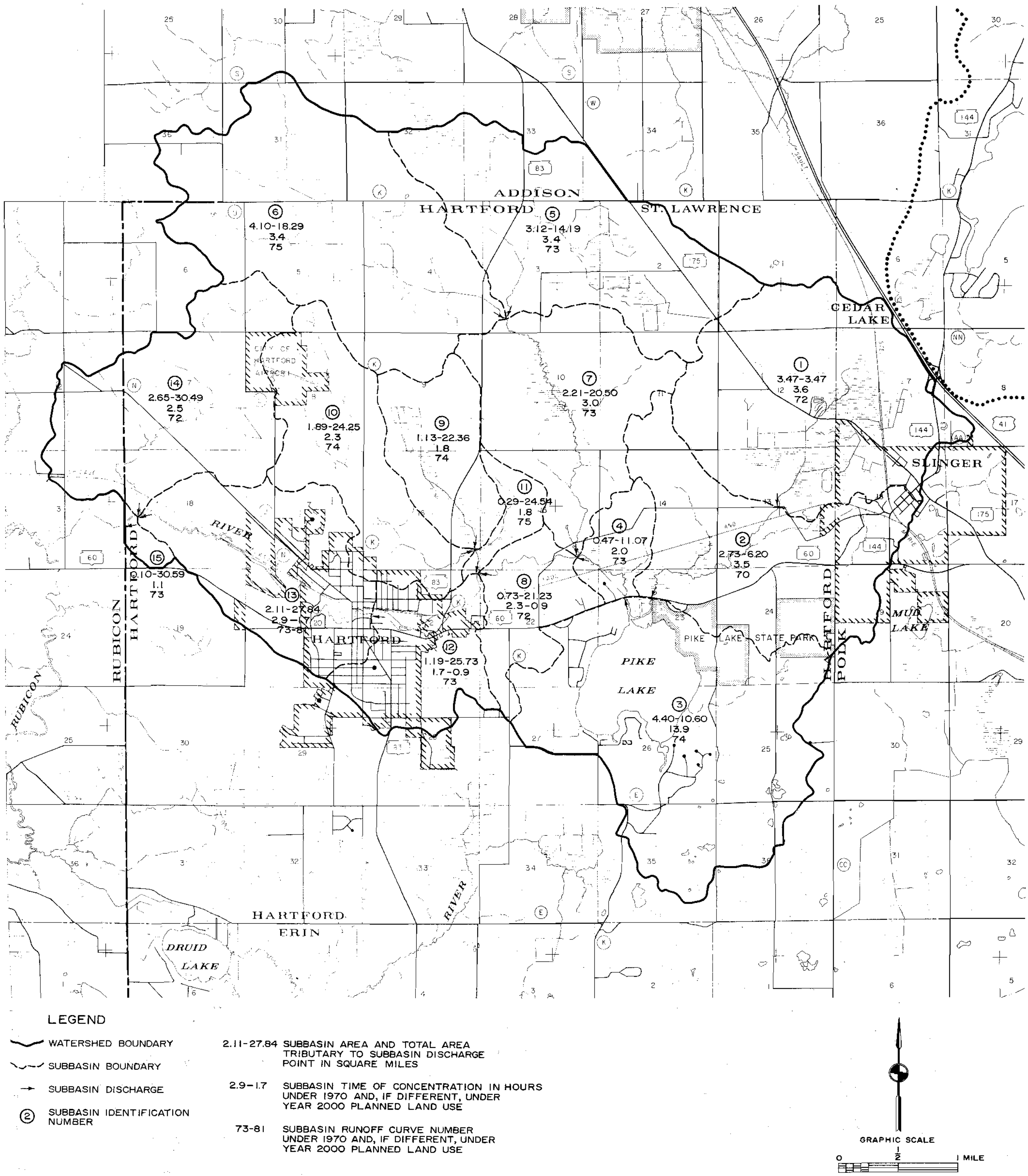
PLANNED (2000) LAND USE IN THE RUBICON RIVER WATERSHED



Source: SEWRPC.

Exhibit I

SUBBASINS IN THE RUBICON RIVER WATERSHED



Source: SEWRPC.

Exhibit J

HYDRAULIC STRUCTURE INDEX FOR THE RUBICON RIVER IN AND NEAR THE CITY OF HARTFORD

Structure Identification			Status			Structure Type		Hydraulically Significant	
Number	River Mile Station[a]	Name	Existing	Under Construction	Proposed	Bridge/Culvert	Dam	Yes	No
1	0.17	Private Bridge	x	--	--	x	--	--	x
2	0.64	STP Bridge	x	--	--	x	--	x	--
3	0.66	Private Bridge	x	--	--	x	--	--	x
4	0.91	Private Bridge	x	--	--	x	--	--	x
5	1.73	Libby's Lagoon Bridge	x	--	--	x	--	--	x
6	2.06	Wacker Drive	--	x	--	x	--	x	--
7	2.23	Grant Street	x	--	--	x	--	x	--
8	2.32	Park Bridge	x	--	--	x	--	--	x
9	2.80	Rural Street	x	--	--	x	--	x	--
10	2.84	Municipal Garage Bridge	x	--	--	x	--	x	--
11	2.85	Pedestrian Bridge	x	--	--	x	--	x	--
12	2.88	Johnson Street	x	--	--	x	--	x	--
13	2.95	Main Street	x	--	--	x	--	x	--
14	3.02	Hartford Mill Dam	x	--	--	--	x	x	--
15	3.19	Mill Pond Bridge	--	--	x	x	--	x	--
16	3.32	Pedestrian Bridge	x	--	--	x	--	--	x
17	3.48	Michigan Street	x	--	--	x	--	x	--
18	3.61	Ewing Street	x	--	--	x	--	x	--
19	3.66	Pedestrian Bridge	x	--	--	x	--	--	x
20	3.70	Pedestrian Bridge	x	--	--	x	--	--	x
21	3.72	Wilson Street	x	--	--	x	--	x	--
22	3.86	Chicago, Milwaukee, St. Paul and Pacific Railroad	x	--	--	x	--	x	--
23	4.17	Private Bridge	x	--	--	x	--	--	x
24	5.26	Hilldale Drive	x	--	--	x	--	x	--
25	5.75	Chicago, Milwaukee, St. Paul and Pacific Railroad	x	--	--	x	--	x	--
26	6.08	Pedestrian Bridge	x	--	--	x	--	--	x
27	6.08	STH 60	x	--	--	x	--	x	--
28	6.08	Outlet to Pike Lake	x	--	--	--	x	x	--
29	6.55	STH 60	x	--	--	x	--	x	--
30	7.01	Hartford Sand and Gravel	x	--	--	x	--	--	x
31	7.10	Hartford Sand and Gravel	x	--	--	x	--	--	x
32	7.50	Kettle Moraine Drive	x	--	--	x	--	x	--

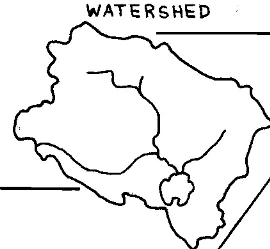
[a] River Mile stationing begins at the Washington-Dodge County line.

Source: SEWRPC.

Exhibit K

HYDROLOGIC-HYDRAULIC MODEL OF THE RUBICON RIVER WATERSHED

WATERSHED



INPUT TO HYDROLOGIC SUBMODEL

1. Land Data (by Subbasin): Area, Runoff Curve Number, Time of Concentration
2. Channel-Floodplain Data: Stage-Discharge-Area and Stage-Discharge-Volume Relations
3. Design Rainfall Data: Volume and Temporal Distribution

Operate Flood Routing Submodel For Design Events

OUTPUT FROM HYDROLOGIC SUBMODEL

1. 10-, 25-, 50-, and 100-Year Recurrence Interval Discharges
2. Miscellaneous: Hydrographs and Runoff Volumes

INPUT TO HYDRAULIC SUBMODEL

1. Bridge and Culvert Descriptions
2. Channel-Floodplain Cross Sections and Roughness Coefficients
3. Stage-Discharge Relations at Starting Points

Operate Hydraulic Submodel For a Range of Discharges

OUTPUT FROM HYDRAULIC SUBMODEL

1. For Channel Reaches: Stage-Discharge-Area Relations
2. For Impoundments: Stage-Discharge-Volume Relations

INPUT TO HYDRAULIC SUBMODEL

1. Bridge and Culvert Descriptions
2. Channel-Floodplain Cross Sections and Roughness Coefficients
3. Stage-Discharge Relations at Starting Points

Operate Hydraulic Submodel For 10-, 25-, 50-, and 100-Year Recurrence Interval Discharges

OUTPUT FROM HYDRAULIC SUBMODEL

10-, 25-, 50-, and 100-Year Recurrence Interval Flood State Profiles

Source: SEWRPC.

Exhibit L

SELECTION OF DESIGN RAINFALL EVENTS

The mathematical model used to simulate the hydrologic-hydraulic regimen of the Rubicon River system during major flood events requires, as one item of input, a design rainfall event. Inasmuch as the magnitude of the resulting flood discharges and stages may be highly dependent on the characteristics of the design rainfall event, and inasmuch as questions may arise concerning the design rainfall concept, the process used to select the design rainfall event and the underlying rationale behind that selection process are described herein.

Equivalence of Rainfall and Flood Event Recurrence Intervals

Implicit in the use of the design rainfall event is the assumption that the recurrence interval of peak discharges during a flood event is approximately equal to the recurrence interval of the causative rainfall event. That is, for any given point along the Rubicon River for which peak flood discharges and stages of a prescribed recurrence interval are desired, a rainfall event of identical recurrence interval will produce the desired peak discharges and stages.

This approach is subject to the shortcoming that the recurrence interval of a rainfall event cannot necessarily be equated to the recurrence interval of the ensuing flood because the subwatershed rainfall-runoff relationship may be influenced by several conditions or characteristics, each of which may change from time to time. These factors include antecedent moisture conditions, lake levels, presence of snow cover or frozen ground, and maturity of vegetation.

Experience indicates that for tributary areas as small as the Rubicon River watershed (30.6 square miles), major floods tend to be the result of high intensity, short duration thunderstorms. While snowmelt in combination with light rainfall may cause nuisance, minor flooding in small basins and certainly is the cause of most major floods on large watersheds in this geographic area, snowmelt and the type of rainfall normally accompanying it do not usually produce discharges as large as those resulting from high intensity, short duration rainfall events in small watersheds. In this geographic area, such severe rainfall events are most likely to occur in the warmer period extending from late spring to early fall, and therefore they are not likely to occur under conditions of snow cover and frozen ground. The hydrologic-hydraulic model applied to the Rubicon River watershed was operated under average antecedent moisture conditions, which are defined by the U. S. Soil Conservation Service as 1.4 to 2.1 inches of rainfall during the preceding five days under growing season conditions.

Thus, while there certainly are valid reasons to question the equivalence of rainfall event recurrence intervals and flood event recurrence intervals on large basins, errors introduced by that assumption probably become insignificant for smaller basins in general and for the Rubicon River watershed in particular.

RAINFALL EVENT PARAMETERS

As noted above, for any given point along the Rubicon River for which peak flood discharges and stages of a prescribed recurrence interval are desired, it is necessary to select a rainfall event of similar recurrence interval that will, by means of the hydrologic-hydraulic model, produce the desired peak discharges and stages. Six critical parameters--geographic location, recurrence interval, duration, volume, area, and depth sequence--are needed to completely prescribe such a rainfall event. Each of these parameters is discussed below.

Geographic Location

This parameter is important because rainfall characteristics exhibit significant spatial variations. Rainfall data representative of southeastern Wisconsin were used to prescribe the design rainfall events for the Rubicon River watershed.

Recurrence Interval

The severity of a design rainfall event is defined by its recurrence interval in years. In addition to the 100-year recurrence interval event, which was selected because the State of Wisconsin requires use of the 100-year recurrence interval flood event for regulatory purposes, 10-, 25-, and 50-year recurrence interval design rainfall events were also used to yield a full spectrum of flood discharges, stages, and areas of inundation for federal flood insurance purposes and for detailed land use planning applications.

Duration

For a given point on the Rubicon River and for a specified recurrence interval, the maximum discharge will occur if the duration of the design rainfall event used to compute flood discharges at that point is equal to the time of concentration of the entire tributary area. A duration less than the time of concentration will produce a more intense storm--that is, a greater rainfall rate in inches per hour relative to a storm of duration equal to the time of concentration--but the event will terminate before the full effect of runoff from the entire tributary will be realized at the location in question. If the duration exceeds the time of concentration, the entire tributary area will contribute to the location in question, but rainfall intensity will be less than the case where duration equals time of concentration and, as a result, the resulting peak discharge will be less than the maximum possible for the indicated recurrence interval.

Several locations were selected along the Rubicon River in, upstream of, and downstream of the City of Hartford, and the hydrologic-hydraulic model operated for the entire area tributary to each of these points. This procedure was intended to approximate the condition that storm duration be equal to time of concentration for all points along the river in and near Hartford. Subbasin times of concentration were used to compute the cumulative time of concentration for each of the selected locations along the Rubicon River.

Volume

The combination of recurrence interval and duration were used to select the volume of rainfall, in inches, over the tributary area that would occur during the design rainfall event. This volume was obtained from the depth-duration-recurrence interval relationships discussed in "The Hydrologic-Hydraulic System" section of this report.

Area

The depth-duration-recurrence interval relationships referred to above are, strictly speaking, applicable to point rainfall. These values decrease as the area over which the rainfall is to occur increases. From a practical perspective, rainfall depth adjustments are needed only when the area tributary to a point--and therefore the area over which the design rainfall is to be applied--exceeds five to ten square miles. National Weather Service depth-area curves were used to reduce rainfall depths in the Rubicon River watershed for tributary areas in excess of five square miles.

Depth Sequence

Having determined the depth and duration of the design rainfall event for a given point on the Rubicon River, it was necessary to select the depth-sequence relationship, that is, the temporal distribution of the rainfall during the duration of the event. Research[1] on discrete major rainfall events, which are not portions of larger events, indicates that such events exhibit a wide variation

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[1] Huff, F. A., "Time Distribution of Rainfall in Heavy Storms," Water Resources Research, Volume 3, No. 4, pp. 1,007-1,019, Fourth Quarter, 1967.

in depth-sequence relationships, although the tendency is for most of the rain to occur in the first half of the storm. That research is not directly applicable here, since the design rainfall event applied to the Rubicon River watershed is not necessarily a discrete event, that is, it may be part of a larger event.

Findings of the referenced research are, however, relevant to the project in the sense that those findings suggest that widely varying temporal distributions of rainfall exist even within portions of major rainfall events, and that such variations may significantly affect the peak flow of the resulting flood flow hydrograph. The Commission used the hydrologic-hydraulic model to determine the sensitivity of peak discharges to rainfall event depth-sequence relationships. A major rainfall event of given volume and duration was entered into the model with widely varying depth-sequence relationships representative of the types reported in the referenced research. While the resulting simulated hydrographs differed somewhat in shape, their peaks were relatively insensitive to the variable depth-sequence relationships. As a result of these model tests, which indicated the relative insensitivity of the Rubicon River subwatershed hydrology to the depth sequence of the rainfall event, design rainfall events were input into the hydrologic-hydraulic model with a linear depth-sequence relationship.

Exhibit M-1

FLOOD DISCHARGES AND STAGES FOR THE RUBICON RIVER IN AND NEAR THE CITY OF HARTFORD
FOR YEAR 2000 PLANNED LAND USE CONDITIONS

Location			10-Year Recurrence Interval Flood Event		25-Year Recurrence Interval Flood Event		50-Year Recurrence Interval Flood Event		100-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)
0.00	Washington-Dodge County Line	--	571	--	769	--	859	--	982	--
0.14	--	--	571	--	769	--	859	--	982	--
0.32	--	--	571	--	769	--	859	--	982	--
0.53	--	--	571	--	769	--	859	--	982	--
0.64	Sewage Treatment Plant Bridge	2	402	--	546	--	616	--	717	--
0.65	--	--	402	--	546	--	616	--	717	--
0.79	Downstream Limit of Large-Scale Mapping	--	402	953.2	546	953.7	616	953.9	717	954.1
0.93	--	--	402	953.6	546	954.1	616	954.3	717	954.6
1.01	--	--	402	954.1	546	954.7	616	954.9	717	955.2
1.07	--	--	402	954.8	546	955.4	616	955.6	717	955.9
1.12	--	--	402	954.9	546	955.5	616	955.7	717	956.0
1.20	--	--	402	955.3	546	956.0	616	956.2	717	956.5
1.27	--	--	402	955.4	546	956.0	616	956.3	717	956.6
1.37	--	--	402	955.6	546	956.3	616	956.5	717	956.8
1.45	Downstream Hartford City Limits	--	402	955.7	546	956.3	616	956.6	717	956.9
1.53	--	--	402	955.9	546	956.5	616	956.7	717	957.0
1.65	--	--	402	956.3	546	956.9	616	957.2	717	957.5
1.88	--	--	402	957.0	546	957.7	616	958.0	717	958.3
2.00	--	--	402	957.4	546	958.0	616	958.2	717	958.5
2.05	--	--	402	957.4	546	958.0	616	958.3	717	958.6
2.06	Wacker Drive	6	366	957.4	491	958.0	580	958.2	735	958.5
2.08	--	--	366	957.5	491	958.1	580	958.4	735	958.7
2.14	--	--	366	957.4	491	958.0	580	958.3	735	958.6
2.22	--	--	366	957.9	491	958.5	580	958.9	735	959.3
2.23	Grant Street	7	366	958.1	491	958.7	580	959.1	735	959.6
2.25	--	--	366	958.5	491	959.2	580	959.6	735	960.2
2.33	--	--	366	959.3	491	959.6	580	959.9	735	960.3
2.40	--	--	366	959.6	491	960.0	580	960.3	735	960.6
2.52	--	--	366	960.5	491	960.8	580	961.0	735	961.2
2.62	--	--	366	960.7	491	961.0	580	961.1	735	961.3
2.70	--	--	366	960.8	491	961.0	580	961.1	735	961.3

Exhibit M-1 (Continued)

Location			100-Year Recurrence Interval Flood Event						500-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Left Floodplain Depth (feet)	Channel Depth (feet)	Right Floodplain Depth (feet)	Left Floodplain Velocity (feet/second)	Channel Velocity (feet/second)	Right Floodplain Velocity (feet/second)	Discharge (cubic feet/second)	Stage (feet above Mean Sea Level)
0.00	Washington-Dodge County line	--	--	--	--	--	--	--	1,330	--
0.14	--	--	--	--	--	--	--	--	1,330	--
0.32	--	--	--	--	--	--	--	--	1,330	--
0.53	--	--	--	--	--	--	--	--	1,330	--
0.64	Sewage Treatment Plant Bridge	2	--	--	--	--	--	--	980	--
0.65	--	--	--	--	--	--	--	--	980	--
0.79	Downstream Limit of Large-Scale Mapping	--	1.6	4.73	1.6	0.51	2.95	0.51	980	954.8
0.93	--	--	2.0	5.27	2.0	0.83	4.88	0.90	980	955.2
1.01	--	--	2.6	5.58	2.6	1.07	5.87	1.16	980	955.8
1.07	--	--	3.3	6.08	3.3	0.71	3.71	0.87	980	956.4
1.12	--	--	3.5	6.00	3.5	1.00	5.09	1.26	980	956.5
1.20	--	--	4.0	6.29	4.0	0.54	2.55	0.75	980	957.0
1.27	--	--	4.0	6.09	4.0	0.74	3.23	0.80	980	957.2
1.37	--	--	4.8	6.00	4.3	0.45	1.89	0.56	980	957.4
1.45	Downstream Hartford City Limits	--	4.3	5.79	4.3	0.73	2.29	0.60	980	957.5
1.53	--	--	4.5	5.71	4.5	1.38	3.70	1.19	980	957.6
1.65	--	--	4.9	5.66	4.9	1.68	3.56	1.38	980	958.1
1.88	--	--	5.8	5.79	5.8	1.48	3.02	0.78	980	959.0
2.00	--	--	6.0	6.04	6.0	0.69	1.80	0.42	980	959.2
2.05	--	--	6.0	6.08	6.0	0.34	0.91	0.32	980	959.3
2.06	Wacker Drive	6	0.0	6.02	0.0	0.00	3.05	0.00	1,070	959.1
2.08	--	--	6.2	6.21	6.2	0.29	0.71	0.27	1,070	969.5
2.14	--	--	6.0	6.05	6.0	2.34	5.67	2.91	1,070	959.4
2.22	--	--	4.9	4.91	4.9	3.57	6.64	3.18	1,070	960.4
2.23	Grant Street	7	0.0	3.77	0.0	0.00	5.41	0.00	1,070	960.4
2.25	--	--	4.3	4.28	4.3	0.62	1.55	1.10	1,070	961.3
2.33	--	--	4.4	4.44	4.4	1.38	2.71	2.35	1,070	961.3
2.40	--	--	4.7	4.75	4.7	1.31	3.86	3.34	1,070	961.5
2.52	--	--	3.1	3.08	3.1	0.76	1.64	1.12	1,070	961.7
2.62	--	--	2.1	2.71	2.1	0.50	0.85	0.82	1,070	961.8
2.70	--	--	1.6	2.32	1.6	1.45	3.64	4.31	1,070	961.8

Exhibit M-2

FLOOD DISCHARGES AND STAGES FOR THE RUBICON RIVER IN AND NEAR THE CITY OF HARTFORD
FOR YEAR 2000 PLANNED LAND USE CONDITIONS

Location			10-Year Recurrence Interval Flood Event		25-Year Recurrence Interval Flood Event		50-Year Recurrence Interval Flood Event		100-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)
2.75	--	--	366	961.9	491	962.2	580	962.3	735	962.4
2.78	--	--	366	962.8	491	962.9	580	962.9	735	963.0
2.80	Rural Street	9	366	962.9	491	963.0	580	963.0	735	963.1
2.805	--	--	366	962.7	491	964.0	580	964.6	735	966.3
2.81	--	--	366	963.5	491	964.1	580	964.7	735	966.2
2.84	Municipal Garage Bridge	10	366	963.8	491	964.4	580	965.0	735	966.2
2.85	Pedestrian Bridge	11	366	963.9	491	964.6	580	965.1	735	966.4
2.87	--	--	366	964.5	491	965.2	580	965.7	735	967.2
2.88	Johnson Street	12	366	964.7	491	965.5	580	966.0	735	967.1
2.89	--	--	366	964.8	491	966.8	580	967.1	735	967.4
2.93	--	--	366	965.1	491	966.9	580	967.1	735	967.6
2.95	Main Street(STH 83)	13	366	965.3	491	967.1	580	967.3	735	967.8
2.96	--	--	366	966.2	491	967.5	580	967.9	735	968.6
2.99	--	--	366	966.8	491	968.0	580	968.5	735	969.2
3.01	Downstream of the Hartford Mill Dam	--	366	967.5	491	968.5	580	969.0	735	969.8
3.03	Upstream of the Hartford Mill Dam	--	840	978.2	1,076	978.7	1,241	979.0	1,451	979.4
3.10	--	--	840	978.2	1,076	978.7	1,241	979.0	1,451	979.4
3.20	--	--	840	978.2	1,076	978.7	1,241	979.0	1,451	979.4
3.29	--	--	840	978.2	1,076	978.7	1,241	979.0	1,451	979.4
3.40	--	--	840	978.3	1,076	978.8	1,241	979.2	1,451	979.5
3.47	--	--	840	978.8	1,076	979.3	1,241	979.7	1,451	980.0
3.48	Michigan Street	17	840	978.9	1,076	979.4	1,241	979.7	1,451	980.0
3.49	--	--	840	980.1	1,076	980.8	1,241	981.2	1,451	981.7
3.60	--	--	840	980.8	1,076	981.4	1,241	981.8	1,451	982.2
3.61	Ewing Street	18	792	980.6	1,015	980.9	1,185	981.9	1,361	982.4
3.62	--	--	792	982.4	1,015	983.6	1,185	984.4	1,361	984.8
3.71	--	--	792	982.6	1,015	983.6	1,185	984.5	1,361	984.8
3.72	Wilson Street	21	792	982.2	1,015	983.3	1,185	984.1	1,361	984.3
3.73	--	--	792	983.7	1,015	984.6	1,185	985.4	1,361	985.8
3.80	--	--	792	985.0	1,015	985.5	1,185	985.7	1,361	986.2
3.85	--	--	792	986.8	1,015	987.2	1,185	987.5	1,361	987.7
3.86	Chicago, Milwaukee, St. Paul and Pacific Railroad Upstream City Limits	22	879	986.8	1,104	987.2	1,288	987.4	1,518	987.4

Exhibit M-2 (Continued)

Location			100-Year Recurrence Interval Flood Event						500-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Left Floodplain Depth (feet)	Channel Depth (feet)	Right Floodplain Depth (feet)	Left Floodplain Velocity (feet/second)	Channel Velocity (feet/second)	Right Floodplain Velocity (feet/second)	Discharge (cubic feet/second)	Stage (feet above Mean Sea Level)
2.75	--	--	2.6	3.14	2.6	4.23	4.29	1.79	1,070	962.7
2.78	--	--	3.1	3.50	3.1	3.01	5.88	2.36	1,070	964.1
2.80	Rural Street	9	0.0	3.53	0.0	0.00	7.43	0.00	1,070	964.2
2.805	--	--	6.6	6.66	6.6	0.53	0.45	0.53	1,070	966.4
2.81	--	--	6.3	6.54	6.3	1.26	2.10	1.29	1,070	966.3
2.84	Municipal Garage Bridge	10	0.0	6.28	0.1	0.00	3.90	0.33	1,070	966.2
2.85	Pedestrian Bridge	11	6.4	6.41	6.4	1.21	3.79	1.21	1,070	966.7
2.87	--	--	6.7	7.05	6.7	1.01	2.04	0.94	1,070	968.0
2.88	Johnson Street	12	6.9	6.94	6.9	1.04	3.01	0.59	1,070	968.0
2.89	--	--	5.6	6.94	5.6	0.94	2.87	1.10	1,070	968.1
2.93	--	--	0.0	6.23	6.2	0.00	6.54	1.03	1,070	968.3
2.95	Main Street (STH 83)	13	0.0	5.99	6.0	0.00	6.81	1.07	1,070	968.6
2.96	--	--	0.0	6.80	6.8	0.00	6.00	0.97	1,070	969.8
2.99	--	--	6.1	6.14	6.1	6.47	4.47	1.48	1,070	970.7
3.01	Downstream of the Hartford Mill Dam	--	3.8	3.81	3.8	4.09	2.84	1.16	1,070	971.4
3.03	Upstream of the Hartford Mill Dam	--	3.2	11.88	3.2	0.32	0.78	0.23	1,960	980.2
3.10	--	--	3.0	10.49	3.0	0.15	0.45	0.13	1,960	980.3
3.20	--	--	2.8	8.39	2.8	0.32	0.75	0.23	1,960	980.3
3.29	--	--	2.7	6.38	2.7	1.26	2.16	1.07	1,960	980.3
3.40	--	--	2.7	4.73	2.7	2.66	3.78	1.93	1,960	980.4
3.47	--	--	3.1	4.20	3.1	5.95	7.28	4.69	1,960	980.8
3.48	Michigan Street	17	0.0	3.98	0.0	0.00	9.73	0.00	1,960	980.8
3.49	--	--	4.5	5.70	4.5	3.80	4.16	2.04	1,960	983.3
3.60	--	--	4.6	5.85	4.6	2.33	3.91	1.95	1,960	983.5
3.61	Ewing Street	18	7.8	5.84	7.8	2.30	3.66	2.32	1,810	983.6
3.62	--	--	8.1	8.17	8.1	1.34	1.59	1.07	1,810	985.4
3.71	--	--	6.7	6.71	6.7	1.50	1.79	1.02	1,810	985.5
3.72	Wilson Street	21	0.0	5.52	0.0	0.00	8.22	0.00	1,810	985.5
3.73	--	--	6.8	6.84	6.8	1.62	2.72	1.35	1,810	987.9
3.80	--	--	5.3	5.28	5.3	2.59	6.60	3.04	1,810	988.0
3.85	--	--	5.5	5.55	5.5	2.67	6.29	3.30	1,810	988.5
3.86	Chicago, Milwaukee, St. Paul and Pacific Railroad Upstream City Limits	22	0.0	5.01	0.0	0.00	7.96	0.00	2,000	988.3

Exhibit M-3

FLOOD DISCHARGES AND STAGES FOR THE RUBICON RIVER IN AND NEAR THE CITY OF HARTFORD
FOR YEAR 2000 PLANNED LAND USE CONDITIONS

Location			10-Year Recurrence Interval Flood Event		25-Year Recurrence Interval Flood Event		50-Year Recurrence Interval Flood Event		100-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)	Discharge (Cubic feet per second)	Stage (Feet above Mean Sea Level)
3.87	--	--	879	987.0	1,104	987.5	1,288	987.9	1,518	988.2
3.95	--	--	879	987.9	1,104	988.5	1,288	988.9	1,518	989.3
4.05	--	--	879	988.7	1,104	989.1	1,288	989.4	1,518	989.8
4.15	--	--	879	989.5	1,104	990.0	1,288	990.3	1,518	990.6
4.20	--	--	879	989.6	1,104	990.1	1,288	990.4	1,518	990.7
4.39	Upstream Limit of Large-Scale Mapping	--	--	--	--	--	--	--	--	--
4.81	--	--	637	--	802	--	936	--	1,105	--
4.85	--	--	637	--	802	--	936	--	1,105	--
4.96	--	--	637	--	802	--	936	--	1,105	--
5.06	--	--	637	--	802	--	936	--	1,105	--
5.17	--	--	637	--	802	--	936	--	1,105	--
5.26	Hilldale Drive	24	637	--	802	--	936	--	1,105	--
5.33	--	--	637	--	802	--	936	--	1,105	--
5.44	--	--	637	--	802	--	936	--	1,105	--
5.53	--	--	51	--	74	--	90	--	113	--
5.67	--	--	51	--	74	--	90	--	113	--
5.75	Chicago, Milwaukee, St. Paul and Pacific Railroad	25	51	--	74	--	90	--	113	--
5.78	--	--	51	--	74	--	90	--	113	--
5.96	--	--	51	--	74	--	90	--	113	--
6.06	Downstream of Pike Lake	--	51	--	74	--	90	--	113	--
6.66	Upstream of Pike Lake	--	373	--	450	--	509	--	580	--
6.99	--	--	373	--	450	--	509	--	580	--
7.12	--	--	373	--	450	--	509	--	580	--
7.43	--	--	373	--	450	--	509	--	580	--
7.50	Kettle Moraine Drive	32	375	--	471	--	573	--	644	--
7.505	--	--	375	--	471	--	573	--	644	--

Exhibit M-3 (Continued)

Location			100-Year Recurrence Interval Flood Event						500-Year Recurrence Interval Flood Event	
River Mile Station	Structure Name or Other Location Identification	Structure Number	Left Floodplain Depth (feet)	Channel Depth (feet)	Right Floodplain Depth (feet)	Left Floodplain Velocity (feet/second)	Channel Velocity (feet/second)	Right Floodplain Velocity (feet/second)	Discharge (cubic feet/second)	Stage (feet above Mean Sea Level)
3.87	--	--	5.7	5.75	5.7	4.54	6.65	3.66	2,000	989.4
3.95	--	--	6.5	6.57	6.5	2.35	3.93	2.00	2,000	990.3
4.05	--	--	3.7	6.68	3.7	3.16	6.43	2.36	2,000	990.7
4.15	--	--	4.1	7.11	4.1	1.08	3.18	1.47	2,000	991.2
4.20	--	--	4.0	7.02	4.0	2.83	6.18	2.54	2,000	991.4
4.39	Upstream Limit of Large-Scale Mapping	--	--	--	--	--	--	--	--	--
4.81	--	--	--	--	--	--	--	--	1,480	--
4.85	--	--	--	--	--	--	--	--	1,480	--
4.96	--	--	--	--	--	--	--	--	1,480	--
5.06	--	--	--	--	--	--	--	--	1,480	--
5.17	--	--	--	--	--	--	--	--	1,480	--
5.26	Hilldale Drive	24	--	--	--	--	--	--	1,480	--
5.33	--	--	--	--	--	--	--	--	1,480	--
5.44	--	--	--	--	--	--	--	--	1,480	--
5.53	--	--	--	--	--	--	--	--	173	--
5.67	--	--	--	--	--	--	--	--	173	--
5.75	Chicago, Milwaukee, St. Paul and Pacific Railroad	25	--	--	--	--	--	--	173	--
5.78	--	--	--	--	--	--	--	--	173	--
5.96	--	--	--	--	--	--	--	--	173	--
6.06	Downstream of Pike Lake	--	--	--	--	--	--	--	173	--
6.66	Upstream of Pike Lake	--	--	--	--	--	--	--	725	--
6.99	--	--	--	--	--	--	--	--	725	--
7.12	--	--	--	--	--	--	--	--	725	--
7.43	--	--	--	--	--	--	--	--	725	--
7.50	Kettle Moraine Drive	32	--	--	--	--	--	--	905	--
7.505	--	--	--	--	--	--	--	--	905	--

Source: SEWRPC.

Exhibit N

APPLICATION OF THE USGS REGIONAL METHOD TO THE RUBICON RIVER WATERSHED

As indicated in the "Flood Discharges, Stages, and Natural Floodlands" section of this report, an independent analysis of Rubicon River waterhsed flood discharges was conducted using an empirical method developed by the USGS[1]. The method, which is based on an analysis of regional streamflow records, facilitates the calculation of flood discharges of specified recurrence intervals as a function of measurable or otherwise quantifiable watershed parameters such as tributary area, channel slope, percent of lake and wetland area, and an areal factor that reflects the soils, geology, and physiography of a watershed. Although the technique is intended for use in estimating flood discharges on larger, rural watersheds in situations where more sophisticated methodology specifically tailored to the watershed--such as the hydrologic-hydraulic model used in the Rubicon River watershed--is not readily available, it does provide an independent means of examining the validity of results obtained by the more sophisticated approaches.

The USGS regional method was used to compute 10-, 25-, and 50-year recurrence interval flood discharges at the Washington-Dodge County line, the discharge point of the Rubicon River watershed. The method could not be used to calculate flows for floods more severe than the 50-year recurrence interval flood, since the 30.6 square mile area of the Rubicon River is below the minimum size required for application of the method to more infrequent flood discharges. The initial application of the USGS method yielded 10-, 25-, and 50-year recurrence interval flood discharges under planned year 2000 land use conditions of 412, 570, and 700 cfs, which were 72, 74, and 81 percent, respectively, of the corresponding values developed with the hydrologic-hydraulic model.

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[1]Duane H. Conger, "Estimating Magnitude and Frequency of Floods in Wisconsin," USGS, Madison, 1971.

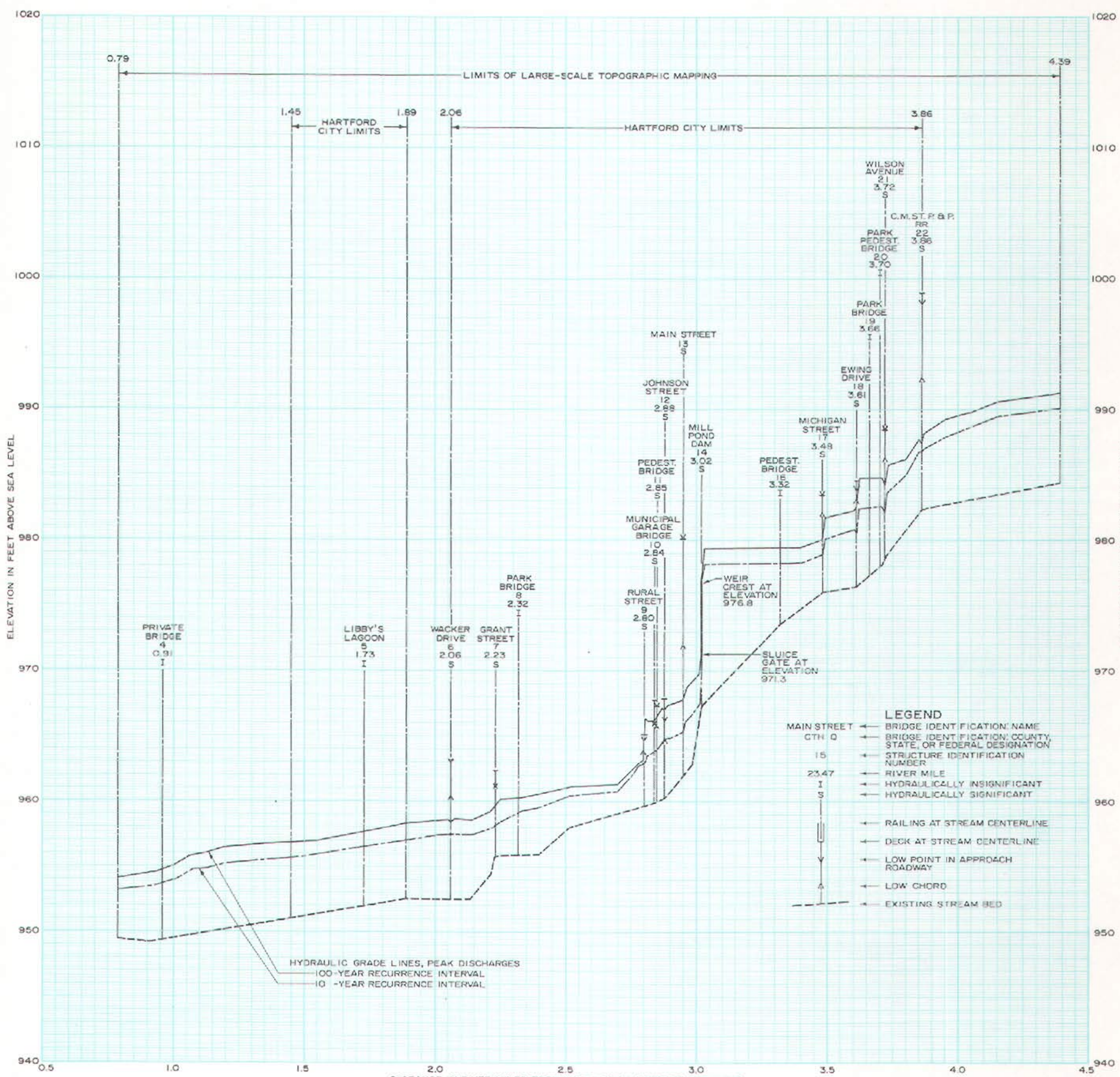
In weighing the discharge differences obtained with the hydrologic-hydraulic model and a strict application of the USGS regional method, it was noted that the Rubicon River watershed lies within, but at the edge of, a geographic area for which the assigned dimensionless areal factor as used in the empirical USGS equation is 0.70. Because of the watershed's location on the edge of a geographic area, computed flood discharges are likely to be sensitive to the areal factor that is used.

The area immediately north of the watershed has a larger areal factor of 1.00, while that to the east an even larger areal factor of 1.20. Inasmuch as the areal factor probably changes gradually from one geographic zone to another, rather than in an abrupt or discontinuous fashion, it may very well be that the Rubicon River watershed, because of its location on the edge of one such geographic zone, has an areal factor that is larger than 0.70, partly reflecting the higher values assigned to adjacent zones. If, for example, the true areal factor for the Rubicon River watershed were 0.85, the average for the geographic area containing the watershed and that geographic area immediately to the north, the 10-, 25-, and 50-year recurrence interval flood discharges computed with the USGS regional method would be 500, 700, and 855 cfs, respectively. These discharges would be very close to those obtained with the hydrologic-hydraulic model. The 10-year discharge would be 88 percent of the model value, the 25-year discharge would be 91 percent of the model value, and the 50-year discharge would be essentially identical to the model value.

In summary, then, there is reasonably good agreement between Rubicon River watershed discharges obtained from the hydrologic-hydraulic model and those computed using the USGS regional method. If allowance is made for the likely change in the areal factor as used in the USGS method to reflect the location of the Rubicon River watershed, there is very close agreement between the flood discharges developed with the hydrologic-hydraulic model used in the preparation of this report and those calculated with the USGS regional method.

Exhibit O

FLOOD STAGE PROFILES FOR THE RUBICON RIVER IN AND NEAR THE CITY OF HARTFORD
FOR YEAR 2000 PLANNED LAND USE CONDITIONS



Source: City of Hartford and SEWRPC.

EXHIBIT P

PROPOSED SUPPLEMENTARY FLOODLAND ZONING MAP
CITY OF HARTFORD, WASHINGTON COUNTY, WISCONSIN

This exhibit has been placed in the pocket attached to the inside back cover of the report.

Exhibit Q

EFFECT OF PIKE LAKE ON DOWNSTREAM FLOOD FLOWS AND STAGES
(100-Year Recurrence Interval Flood Under Year 2000 Planned Land Use Conditions)

Location		Condition 1 Pike Lake At Maximum Permitted Elevation (993.9 Feet Mean Sea Level Datum) At Outset Of Critical Storm Event		Condition 2 Pike Lake At Minimum Permitted Elevation (993.4 Feet Mean Sea Level Datum) At Outset Of Critical Storm Event		Condition 3 Pike Lake Removed From System			
Mile River Station	Name	Discharge (Cubic feet per second)	Stage (Feet Mean Sea Level)	Discharge (Cubic feet per second)	Percent Change In Discharge Relative To Condition 1	Discharge (Cubic feet per second)	Percent Change In Discharge Relative To Condition 1	Stage (Feet Mean Sea Level)	Change In Stage Relative To Condition 1 (Feet)
6.08	Outlet to Pike Lake	113	--	113	0	1,233	990	--	--
4.81	0.95 Mile Upstream of Hartford	1,105	990.7	1,104	0	2,299	108	992.3	1.6
3.86	City Limits and Chicago, Milwaukee, St. Paul and Pacific Railroad	1,518	987.4	1,511	-1	2,546	68	989.5	2.1
3.02	Hartford Mill Dam	735	979.4	731	-1	1,308	78	980.5	0.9
0.00	Washington-Dodge County Line	982	--	977	0	1,306	33	--	--

Source: SEWRPC.

Exhibit R

HYDRAULIC EFFECT OF THE RUBICON RIVER FLOODWAY IN AND NEAR THE CITY OF HARTFORD UNDER YEAR 2000 PLANNED LAND USE CONDITIONS

Location			Regulatory Flood Discharge (Cubic feet per second)	Flood Stages Under Natural Floodplain Conditions (Feet above Mean Sea Level)[a]	Flood Stages Under Floodway Conditions (Feet above Mean Sea Level)[a]	Stage Increase Attributable to Floodway (Feet)
River Mile Station	Structure Name or Other Identification	Structure Number				
0.79	Downstream Limit of Large-Scale Mapping	--	717	954.1	954.1	0.0
0.93	--	--	717	954.6	954.6	0.0
1.01	--	--	717	955.2	955.2	0.0
1.07	--	--	717	955.9	955.9	0.0
1.12	--	--	717	956.0	956.0	0.0
1.20	--	--	717	956.5	956.5	0.0
1.27	--	--	717	956.6	956.6	0.0
1.37	--	--	717	956.8	956.8	0.0
1.45	Downstream Hartford City Limits	--	717	956.9	956.9	0.0
1.53	--	--	717	957.0	957.0	0.0
1.65	--	--	717	957.5	957.5	0.0
1.88	--	--	717	958.3	958.3	0.0
2.00	--	--	717	958.5	958.6	0.1
2.05	--	--	717	958.6	958.6	0.0
2.06	Wacker Drive	6	735	958.5	958.5	0.0
2.08	--	--	735	958.7	958.7	0.0
2.14	--	--	735	958.6	958.7	0.1
2.22	--	--	735	959.3	959.4	0.1
2.23	Grant Street	7	735	959.6	959.7	0.1
2.25	--	--	735	960.2	960.2	0.0
2.33	--	--	735	960.3	960.5	0.2
2.40	--	--	735	960.6	960.7	0.1
2.52	--	--	735	961.2	961.2	0.0
2.62	--	--	735	961.3	961.4	0.1
2.70	--	--	735	961.3	961.4	0.1
2.75	--	--	735	962.4	962.5	0.1
2.78	--	--	735	963.0	963.3	0.3
2.80	Rural Street	9	735	963.1	963.4	0.3
2.805	--	--	735	966.3	966.3	0.0
2.81	--	--	735	966.2	966.2	0.0
2.84	Municipal Garage Bridge	10	735	966.2	966.2	0.0
2.85	Pedestrian Bridge	11	735	966.4	966.4	0.0
2.87	--	--	735	967.2	967.2	0.0
2.88	Johnson Street	12	735	967.1	967.2	0.1
2.89	--	--	735	967.6	967.4	0.2
2.93	--	--	735	967.6	967.5	0.1
2.95	Main Street (STH 83)	13	735	967.8	967.7	-0.1
2.96	--	--	735	968.6	968.5	0.1
2.99	--	--	735	969.2	969.2	0.0
3.01	Downstream of the Hartford Mill Dam	--	735	969.8	969.8	0.0
3.03	Upstream of the Hartford Mill Dam	--	1,451	979.4	979.4	0.0
3.10	--	--	1,451	979.4	979.4	0.0
3.20	--	--	1,451	979.4	979.4	0.0
3.29	--	--	1,451	979.4	979.4	0.0
3.40	--	--	1,451	979.5	979.5	0.0
3.47	--	--	1,451	980.0	980.0	0.0
3.48	Michigan Street	17	1,451	980.0	979.9	0.1

Exhibit R (Continued)

Location			Regulatory Flood Discharge (Cubic feet per second)	Flood Stages Under Natural Floodplain Conditions (feet above Mean Sea Level)[a]	Flood Stages Under Floodway Conditions (Feet above Mean Sea Level)[a]	Stage Increase Attributable to Floodway (Feet)
River Mile Station	Structure Name or Other Identification	Structure Number				
3.49	--	--	1,451	981.7	981.7	0.0
3.60	--	--	1,451	982.2	982.3	0.1
3.61	Ewing Street	18	1,361	982.4	982.4	0.0
3.62	--	--	1,361	984.8	984.8	0.0
3.71	--	--	1,361	984.8	984.8	0.0
3.72	Wilson Street	21	1,361	984.3	984.3	0.0
3.73	--	--	1,361	985.8	985.9	0.1
3.80	--	--	1,361	986.2	986.4	0.2
3.85	--	--	1,361	987.7	987.7	0.0
3.86	Chicago, Milwaukee, St. Paul & Pacific Railroad Upstream City Limits	22	1,518	987.4	987.7	0.3
3.87	--	--	1,518	988.2	988.2	0.0
3.95	--	--	1,518	989.3	989.4	0.1
4.05	--	--	1,518	989.8	989.8	0.0
4.15	--	--	1,518	990.6	990.6	0.0
4.20	--	--	1,518	990.7	990.7	0.0
4.39	Upstream Limit of Large-Scale Mapping	--	--	--	--	--

[a] Flood stages listed opposite of each river crossing actually occur immediately upstream of the river crossing.

Source: SEWRPC.

EXHIBIT S

PROPOSED FLOODLAND ZONING REGULATIONS FOR THE CITY OF HARTFORD

(Draft for Legal Review--All references are to the Hartford Municipal Code dated August 3, 1971)

1. Add the following paragraph to Section 13.01:

In addition, the floodland zoning regulations set forth in this Chapter have been adopted to promote the public health, safety, and general welfare; to prevent and control erosion, sedimentation, and other pollution of the surface waters; to further the maintenance of safe and healthful water conditions; and to prevent flood damage to persons and property and minimize expenditures for flood relief and flood control projects.

2. Add the following definitions in appropriate alphabetical order to Section 13.02:

Channel. Those floodlands normally occupied by a stream of water under average annual high-water flow conditions while confined within generally well-established banks.

Flood. A temporary rise in streamflow or stage in lake level that results in water overtopping the banks and inundating areas adjacent to the stream channel or lake bed.

Flood Profile. A graph showing the relationship of the floodwater surface elevation of a flood event of a specified recurrence interval to the stream bed and other significant natural and man-made features along a stream.

Flood Stage. The elevation of the floodwater surface above an officially established datum plane, which is Mean Sea Level, 1929 Adjustment, on the Supplementary Floodland Zoning Map.

Floodlands. Those lands included within the floodplain fringe and floodway.

Floodplain Fringe. Those floodlands, excluding the floodway, subject to inundation by the one hundred- (100-) year recurrence interval flood.

Floodproofing. Measures designed to prevent and reduce flood damage for those uses which cannot be removed from, or which, of necessity, must be erected on floodlands, ranging from structural modifications through installation of special equipment or materials to operation and management safeguards, such as the following: reenforcing of basement walls; underpinning of floors; permanent sealing of all exterior openings; use of masonry construction; erection of permanent watertight bulkheads, shutters, and doors; treatment of exposed timbers; elevation of flood vulnerable utilities; use of waterproof cement; adequate fuse protection; anchoring of buoyant tanks; sealing of basement walls; installation of sump pumps; placement of automatic swing check valves; installation of seal-tight windows and doors; installation of wire reenforced glass; location and elevation of valuable items; waterproofing, disconnecting, elevation, or removal of all eletrical equipment; avoidance of the use of flood vulnerable areas; temporary removal or waterproofing of merchandise; postponement of orders or rescheduling of freight shipments; operation of emergency pump equipment; closing of backwater sewer valve; placement of plugs and floor drain pipes; placement of moveable watertight bulkheads; counter flooding; erection of sand bag levees; and the shoring of weak walls or other structures. Floodproofing of structures shall be extended at least to a point two (2) feet above the elevation of the one hundred- (100-) year recurrence interval flood.

Floodway. Those floodlands, including the channel, required to carry and discharge the one hundred- (100-) year recurrence interval flood.

High Water Elevation. The average annual high water level of a pond, stream, lake, flowage, or wetland referred to an established datum plane or, where such information is not available, the elevation of the line up to which the presence of the water is so continuous as to leave a distinct mark by erosion, change in, or destruction of, vegetation or other easily recognized topographic, geologic, or vegetative characteristics.

Reach. A longitudinal segment of a stream generally including those floodlands wherein flood stages are primarily and commonly controlled by the same man-made or natural obstructions to flow.

Storage Capacity. The volume of space available above an area of floodplain fringe land for the temporary storage of flood water.

3. Repeal and recreate Section 13.03 to read as follows:

13.03 DISTRICTS AND REGULATORY AREAS. (1) In order to regulate and restrict the location of trades, industries, residences, and other uses, and the location of buildings designed, erected, altered, or occupied for specified purposes; to regulate and limit the height and size of buildings hereafter erected or altered; to regulate and determine the area of yards and other open spaces; and to regulate and limit the density of population, the City of Hartford is hereby divided into districts of which there shall be 9 known as:

A1 Residence District

A2 Residence District

A3 Residence District

B Residence District

C Residence District

Business District

A Industrial District

B Industrial District

F Floodway District

(2) In addition, there is hereby established within the City of Hartford two overlay regulatory areas which shall be known as:

FC Floodplain-Conservancy Regulatory Area

UF Urban Floodplain Regulatory Area

(3) The City of Hartford is hereby divided into the 9 districts aforesaid, and the boundaries of such districts as well as the two overlay regulatory areas are shown upon the Zoning Map and the Supplementary Floodland Zoning Map hereto attached and made a part of this chapter, or which is on file in the office of the City Clerk. Said maps and all the notations, references, and other information shown thereon shall be as much a part of this chapter as if the matters and information set forth by said maps were all fully desribed herein.

4. Create a new section following Section 13.06 to read as follows:

13.__ FLOODWAY DISTRICT AND FLOODPLAIN FRINGE OVERLAY REGULATORY AREAS.

(1) F Floodway District. This District is intended to preserve in essentially open space land uses the floodway of the Rubicon River, such lands being found necessary to safely carry and discharge the one hundred- (100-) year recurrence interval flood.

(a) District Boundaries: The boundaries of this District are as shown on the Supplementary Floodland Zoning Map.

(b) Permitted Uses: The following uses are permitted as a matter of right:

1. Drainage and movement of water
2. Navigation
3. Stream bank protection
4. Flood overflows
5. Wild crop harvesting
6. Hunting and fishing unless prohibited by other laws

7. Farming and related agricultural activities, not including the erection of structures
8. Impoundments
9. Sustained yield forestry
10. Fish hatcheries
11. Wildlife preserves
12. Utility transmission and distribution facilities

(c) Conditional Uses: The Board of Zoning Appeals may authorize the Building Inspector to issue a conditional use permit for the following uses after review and public hearing, provided that such conditional uses and structures are found to be in accordance with the purpose and intent of this District and Chapter NR 116 of the Wisconsin Administrative Code. The applicant must show that such use or improvement will not impede drainage, will not cause ponding, will not obstruct the floodway, will not increase flood flow velocities, will not increase the flood stage, and will not retard the movement of floodwaters. When permitted, all structures shall be floodproofed and constructed so as not to catch or collect debris nor be damaged by floodwaters. Certification of floodproofing shall be made to the Building Inspector and shall consist of a plan or document certified by a registered professional engineer that the floodproofing measures are consistent with the flood velocities, forces, depths, and other factors associated with the one hundred- (100-) year recurrence interval flood level for the particular area.

1. Navigational structures
2. Public water measuring and control facilities
3. Bridges and approaches
4. Marinas

5. Park and recreational areas, not including structures.

6. Parking lots accessory to permitted uses in adjacent districts, not including new or used vehicle sales or storage areas.

7. Filling as authorized by the Wisconsin Department of Natural Resources to permit establishment of approved bulkhead lines.

8. Other open space uses consistent with the purpose and intent of the district and compatible with uses in adjacent districts, not including structures.

(d) Specifically Prohibited Uses. The following uses are specifically prohibited:

1. Dumping

2. Filling, except as authorized to permit establishment of approved bulkhead lines or to accommodate bridge approaches.

3. Structures, except those necessary as a conditional use for navigation, water measurement and control, bridges, and utilities.

4. Storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, or plant life.

(2) FC Floodplain-Conservancy Regulatory Area. The following regulations shall apply to the floodplain fringe portion of the Rubicon River floodlands designated as the Floodplain-Conservancy Regulatory Area on the Supplementary Floodland Zoning Map, and shall be in addition to any regulations imposed by the underlying basic use district.

(a) Land Uses-Conditional Only. The underlying basic use district shall determine the use of land in the Floodplain-Conservancy Regulatory Area. Uses may be permitted, however, only on a conditional basis by the Board of Zoning Appeals after review and public hearing, provided that such uses are found to be in accordance with the purpose and intent of this section and Chapter NR 116 of the Wisconsin Administrative Code.

(b) Dumping and Filling Prohibited. Lands lying within the Floodplain-Conservancy Regulatory Area shall not be used for dumping or be filled, except as authorized to permit establishment of approved bulkhead lines or to accommodate bridge approaches. Normal earth grading activities to permit utilization of the lands for open space, outdoor recreation, yard, parking, and similar uses are permitted.

(c) Structures Prohibited. Lands lying within the Floodplain-Conservancy Regulatory Area shall not be used as building sites for structures, except those necessary for navigation, water measurement and control, bridges, utilities, and outdoor recreation. When permitted, all structures shall be floodproofed and constructed so as not to catch or collect debris nor be damaged by floodwaters. Certification of floodproofing shall be made to the Building Inspector and shall consist of a plan or document certified by a registered professional engineer that the floodproofing measures are consistent with the flood velocities, forces, depths, and other factors associated with the one hundred- (100-) year recurrence interval flood level for the particular area.

(d) Dangerous Materials Storage Prohibited. Lands lying within the Floodplain-Conservancy Regulatory Area shall not be used for the storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, or plant life.

(3) UF Urban Floodplain Regulatory Area. The following regulations shall apply to the floodplain fringe portion of the Rubicon River floodlands designated as the Urban Floodplain Regulatory Area on the Supplementary Floodland Zoning Map, and shall be in addition to any regulations imposed by the underlying basic use district.

(a) Land Uses - Conditional Only. The underlying basic use district shall determine the use of land in the Urban Floodplain Regulatory Area. Uses may be permitted, however, only on a conditional basis by the Board of Zoning Appeals after review and public hearing, provided that such uses and structures are found to be in accordance with the purpose and intent of this section and Chapter NR 116 of the Wisconsin Administrative Code.

(b) Land Elevation. Undeveloped floodplain fringe land lying contiguous to lands outside of the floodlands shall be filled to an elevation at least two (2) feet above the elevation of the one hundred- (100-) year recurrence interval flood as shown on the Supplementary Floodland Zoning Map if such land is to be utilized for building and development. However, such land need not be filled if the area involved is to be utilized for open space purposes as an integral part of a larger development located on contiguous non-floodlands. Undeveloped floodplain fringe land not contiguous to lands outside the floodlands shall be filled to an elevation at least two (2) feet above the elevation of the one hundred- (100-) year recurrence interval flood. Such fill shall extend for at least fifteen (15) feet beyond the limits of the structure developed thereon. Filling may be carried out only after issuance of a conditional use permit by the Building Inspector upon authorization of the Board of Zoning Appeals.

(c) Floodproofing. When the intent and purpose of this Ordinance cannot be fulfilled by filling the urban floodplain fringe due to existing and committed development, and when the Board of Zoning Appeals has made a finding to this effect, all new structures and all additions to existing structures in the Urban Floodplain Regulatory Area shall be floodproofed.

Certification of floodproofing shall be made to the Building Inspector and shall consist of a plan or document certified by a registered professional engineer that the floodproofing measures are consistent with the flood velocities, forces, depths, and other factors associated with the one hundred- (100-) year recurrence interval flood level for the particular area.

(d) Maintenance of Drainageways, No filling or development in the Urban Floodplain Regulatory Area shall adversely affect the channels or floodways of any tributary of the Rubicon River, drainage ditches, or other drainage facilities or systems.

(e) Certificate of Compliance. No undeveloped land in the Urban Floodplain Regulatory Area shall be occupied or used, and no building hereafter erected, altered, or moved shall be occupied until the applicant submits to the Building Inspector a certification by a registered professional engineer or land surveyor that the floodplain regulations set forth in this section have been fully compiled with.

(f) Removal of Lands From the Urban Floodplain Regulatory Area. The Urban Floodplain Regulatory Area designation on the Supplementary Floodland Zoning Map shall not be removed from any area unless it can be shown that the area is filled at least to an elevation two (2) feet above the elevation of the one hundred- (100-) year recurrence interval flood and is contiguous to other lands lying outside the floodlands.

5. Create Section 13.07(7) to read as follows:

13.07(7) Floodway Lands Eligible for Meeting Area Requirement. Where a lot is located partially within the F Floodway District and partially within any other adjoining use district, that portion of the lot in the F Floodway District may be utilized to meet the area requirements of the adjoining use district.

6. Add the following paragraph to Section 13.09:

Repairs and alterations permitted under the provisions of this Ordinance to nonconforming buildings and structures located on floodlands shall include floodproofing to those portions of the building or structure involved in such repairs or alterations. Certification of floodproofing shall be made to the Building Inspector and shall consist of a plan or document certified by a registered professional engineer that the floodproofing measures are consistent with the flood velocities, forces, depths, and other factors associated with the one hundred- (100-) year recurrence internal flood level for the particular area.

7. Add the following paragraphs to Section 13.10:

(1) The Board of Appeals shall not grant a variance or issue any order where:

(a) Filling and development contrary to the purpose and intent of the F Floodway District and FC Floodplain-Conservancy Regulatory Area would result.

(b) A change in the boundaries of the F Floodway District, FC Floodplain-Conservancy Regulatory Area, or the UF Urban Floodplain Regulatory Area would result.

(c) A lower degree of flood protection than a point two (2) feet above the one hundred- (100-) year recurrence interval flood for the particular area would result.

(d) Any action contrary to the provisions of the Wisconsin Statutes or the Wisconsin Administrative Code would result.

(2) Notice to DNR. A copy of all notices of applications for conditional uses in the floodland areas and variances or special exceptions to floodland regulations shall be transmitted to the Wisconsin Department of Natural Resources within ten (10) days of filing of the application. A

copy of all decisions relating to conditional uses in floodland areas and variances or special exceptions to floodland regulations shall be transmitted to the Wisconsin Department of Natural Resources within ten (10) days of the effective date of such decision.

8. Repeal and Recreate Section 13.11(1) to read as follows:

13.11 ANNEXED TERRITORY. (1) All new territory annexed to the City of Hartford shall automatically be placed in zoning districts and/or zoning overlay regulatory areas in the following manner:

(a) All floodways shall be placed in the F Floodway District.

(b) All other lands shall be placed in the A-1 Residence District.

(c) All floodplain fringe areas shall become subject to the regulations of the FC Floodplain-Conservancy Regulatory Area.

All the provisions of this chapter applicable to lands in the F Floodway District, the A1 Residence District, and the FC Floodplain-Conservancy Regulatory Area shall apply to all such annexed territory until definite district boundaries and regulations for such annexed territory shall be adopted by the Common Council; provided, however, that definite district boundaries and regulations for any classification other than F Floodway District, A1 Residence District, and FC Floodplain-Conservancy Regulatory Area shall be adopted by the Common Council within 90 days from the date of annexation to the City.

9. Add the following paragraph to Section 13.15:

The boundaries of the F Floodway District shall be determined by use of the scale contained on the Supplementary Floodland Zoning Map. The boundaries of the FC Floodplain-Conservancy Regulatory Area and the UF Urban Floodplain Regulatory Area shall be determined by the floodland limits shown on the Supplementary Floodland Zoning Map. Where a conflict exists between the floodland limits as shown on the map and actual field conditions, the elevations from the 100-year recurrence interval flood profile shall be the governing factor in locating the regulatory floodland limits.

10. Add the following paragraph to Section 13.17:

Due notice of all public hearings on petitions for changes to the F Floodway District, the FC Floodplain-Conservancy Regulatory Area, or the UF Urban Floodplain Regulatory Area, or amendments to regulations affecting floodlands, shall be transmitted to the Wisconsin Department of Natural Resources. No amendments to such district or regulatory area boundaries or regulations shall become effective until approved by the Wisconsin Department of Natural Resources.

11. Create Section 13.20 to read as follows:

13.20 NON-LIABILITY OF CITY. The City does not guarantee, warrant, or represent that only those areas designated by this Ordinance as floodlands will be subject to periodic inundation and hereby asserts that there is no liability on the part of the City, its officers, agents, or employees for any flood damage, sanitation problems, or structural damages that may occur as a result of reliance upon and conformance with this Ordinance.

CITY OF HARTFORD STAFF

Majed Abu-Lughod.	Director of Public Works
Lawrence Nightingale.	Former Director of Public Works
Donald Roecker.	City Engineer

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Kurt W. Bauer, P.E.	Executive Director
Philip C. Evenson.	Chief Community Assistance Planner
Lois A. Kawatski	Planner
Leland H. Kreblin.	Chief Planning Illustrator
William D. McElwee, P.E.	Chief Environmental Planner
Randolph M. Videkovich	Senior Engineer
Stuart G. Walesh, P.E.	Water Resources Engineer

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LEGEND

- FLOODWAY DISTRICT
- FLOODPLAIN–CONSERVANCY REGULATORY AREA
- URBAN FLOODPLAIN REGULATORY AREA
- AREAS WHERE TOPOGRAPHY HAS BEEN ALTERED SINCE THE DATE OF MAPPING
- 100-YEAR RECURRENCE INTERVAL FLOOD HAZARD LINE
- 100-YEAR RECURRENCE INTERVAL FLOODWAY
- 900.0 ELEVATION IN FEET ABOVE MEAN SEA LEVEL–100-YEAR RECURRENCE INTERVAL FLOOD UNDER FLOODWAY CONDITIONS
- CITY OF HARTFORD CORPORATE LIMITS

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION	BASE MAP COMPILED FROM CITY OF HARTFORD MAPS DATE OF PHOTOGRAPHY 1968, DATE OF MAPPING 1968 & 1969.	PROPOSED SUPPLEMENTARY FLOODLAND ZONING MAP CITY OF HARTFORD WASHINGTON COUNTY WISCONSIN	DRAWN: RONALD H. HEINEN — DATE: FEBRUARY 1975 REVISED: — DATE: SCALE: 1" = 200' (Compilation Scale 1" = 200')