FLOOD INSURANCE STUDY

LEELANAU COUNTY, MICHIGAN

(ALL JURISDICTIONS)

Community Name	*Community Number*
BINGHAM, TOWNSHIP OF	260772
CENTERVILLE, TOWNSHIP OF	260625
CLEVELAND, TOWNSHIP OF	260302
ELMWOOD, TOWNSHIP OF	260113
EMPIRE, TOWNSHIP OF	260765
EMPIRE, VILLAGE OF	260605
GLEN ARBOR, TOWNSHIP OF	260604
GRAND TRAVERSE BAND OF OTTAWA AND CHIPPEWA INDIANS	261803
*KASSON, TOWNSHIP OF	261509
LEELANAU, TOWNSHIP OF	260114
LELAND, TOWNSHIP OF	260760
NORTHPORT, VILLAGE OF	260580
SOLON, TOWNSHIP OF	261510
SUTTONS BAY, TOWNSHIP OF	260770
SUTTONS BAY, VILLAGE OF	260283
TRAVERSE CITY, CITY OF	260082

*NO SPECIAL FLOOD HAZARD AREAS IDENTIFIED

Preliminary: February 18, 2011
Revised Preliminary: December 23, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
26089CV000A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) report may not contain all data available within the Community Map Repository. Please contact the Community Map Repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone(s)	New Zone
Al through A30	AE
B	X
C	X

Initial Countywide FIS Effective Date: To Be Determined

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FLOOD INSURANCE STUDY
LEELANAU COUNTY, MICHIGAN (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This FIS revises and updates information on the existence and severity of flood hazards in the geographic area of Leelanau County, including the City of Traverse City; the Townships of Bingham, Centreville, Cleveland, Elmwood, Empire, Glen Arbor, Kasson, Leelanau, Leland, Solon, and Suttons Bay; the Villages of Empire, Northport, and Suttons Bay; and the Grand Traverse Band of Ottawa and Chippewa Indians (referred to collectively herein as Leelanau County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the City of Traverse City is geographically located in Grand Traverse and Leelanau Counties. Only the Leelanau County portion of the City of Traverse City is included in this FIS report. See the separately published FIS report and Flood Insurance Rate Map (FIRM) for flood-hazard information.

Please note that the Township of Kasson has no mapped special flood hazard areas.

The Digital Flood Insurance Rate Map (DFIRM) and FIS report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the FEMA DFIRM database specifications and Geographic Information System (GIS) format requirements. The flood hazard information was created and is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Precountywide Analyses

Information on the authority and acknowledgements for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown below:

Elmwood, Township of:	The hydrologic and hydraulic analyses for West Arm-Grand Traverse Bay, Lake Leelanau, and Cedar Lake for the August 2, 1982, FIS report (FEMA, 1982) were performed by the U.S. Army Corps of Engineers (USACE), Detroit District, for FEMA, under Contract No. DACW-35-80-C-0025/Interagency Agreement IAA-H-9-79, Project Order No. 21. The work was completed in April 1981.
Northport, Village of:	The hydrologic and hydraulic analyses for Northport Creek and Grand Traverse Bay for the March 2, 1989, FIS report (FEMA, 1989) were performed by the U.S. Geological Survey (USGS), for FEMA, under Interagency Agreement EMW-E-1823, Project Order No.1. The work was completed in January 1987.
Suttons Bay, Village of:	The hydrologic and hydraulic analyses for Suttons Bay for the December 1976 FIS report (FIA, 1976) were performed by Johnson & Anderson, Inc., for Federal Insurance Administration (FIA), under Contract No. H-3816. The work was completed in February 1976.

The Townships of Bingham, Centreville, Cleveland, Empire, Glen Arbor, Kasson, Leelanau, Leland, and Solon; the Village of Empire; and the Grand Traverse Band of Ottawa and Chippewa Indians have no previously printed FIS reports.

This Countywide FIS Report

The hydrologic and hydraulic analyses for the streams studied by approximate analysis for this study was performed by Atkins North America for FEMA, under Contract No. HSFE05-05-D-0023, Project Order No. 30. The work was completed in July 2010.

Stillwater elevations for Lake Michigan from Leelanau County's southwestern boundary with Benzie County, to approximately Calhead Bay Road East, including the islands of Leelanau County, were incorporated from the Phase II Revised Report on Great Lakes Open-Coast Flood Levels (USACE, 1988). The

stillwater elevations for Grand Traverse Bay, including Northport Bay, Suttons Bay, and West Arm Grand Traverse Bay, were incorporated from the Grand Traverse Bay and Little Traverse Bay Food Levels Report (USACE, 1990). This flooding, studied by detailed methods, has been redelineated to updated topography.

Base map information shown on the FIRM was derived from 1 meter resolution digital ortho imagery from the National Agriculture Imagery Program dated 2009. The projection used in the preparation of this map is Universal Transverse Mercator (UTM) zone 16, and the horizontal datum used is North American Datum of 1983 (NAD 83), Geodetic Reference System 1980 (GRS80).

1.3 Coordination

An initial meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied or restudied. A final meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study.

Precountywide Analyses

The initial and final meeting dates for previous FIS reports for Leelanau County and its communities are listed in the following table:

Table 1: Precountywide Intial and Final Meeting Dates

Community	FIS Date	Initial Meeting	Final Meeting
Elmwood, Township of	August 2, 1982	November 14, 1978	March 22, 1982
Northport, Village of	March 2, 1989	*	June 28, 1988
Suttons Bay, Village of	December 1976	*	April 26, 1976

*Data unavailable

This Countywide FIS Report

The initial meeting was held on June 10, 2008, and attended by representatives of FEMA, Leelanau County Planning and Development department, Michigan Department of Environmental Quality, and Grand Traverse Band of Ottawa and Chippewa Indians, Leelanau Township, and Atkins North America.

The results of the study were reviewed at the final meeting held on _____ and attended by representatives of _____. All concerns and/or issues raised at that meeting have been addressed.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Leelanau County, Michigan, including the incorporated communities listed in Section 1.1. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction at the time of study.

Northport Creek, Cedar Lake, Grand Traverse Bay, Lake Leelanau, Lake Michigan, Northport Bay, Outflow from Cedar Lake, Suttons Bay, and West Arm Grand Traverse Bay were studied by detailed methods in this FIS report.

The limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

This Countywide FIS Report

For this countywide FIS, the FIS report and FIRM were converted to countywide format, and the flooding information for the entire county, including both incorporated and unincorporated areas, is shown. Also, the vertical datum was converted from the National Geodetic Vertical Datum of 1929 (NGVD) to the North American Vertical Datum of 1988 (NAVD). In addition, the Universal Transverse Mercator coordinates, previously referenced to the North American Datum of 1927, are now referenced to NAD83.

Stillwater elevations for Lake Michigan from Leelanau County's southwestern boundary with Benzie County, to approximately Calhead Bay Road East, including the islands of Leelanau County, were incorporated from the Phase II Revised Report on Great Lakes Open-Coast Flood Levels (USACE, 1988). The stillwater elevations for Grand Traverse Bay, including Northport Bay, Suttons Bay, and West Arm Grand Traverse Bay, were incorporated from the Grand Traverse Bay and Little Traverse Bay Food Levels Report (USACE, 1990). This flooding, studied by detailed methods, has been redelineated to updated topography.

Approximate analyses were used to study those areas having low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by FEMA and Leelanau County.

2.2 Community Description

Leelanau County is located in the northwestern portion of the Lower Peninsula of Michigan. It is bordered by Grand Traverse and Benzie Counties to the south, Lake Michigan to the north and west, and Grand Traverse Bay to the east. The total area of Leelanau County is 2,532 square miles, of which, 348 square miles is land and 2,184 square miles is water. The County Seat is in the Township of Suttons Bay. The population of Leelanau County was 21,119 at the 2000 census (U.S. Census Bureau, 2010).

The climate in Leelanau County is dependent upon wind direction. The prevailing westerly winds passing over Lake Michigan moderate annual temperatures. Cool lake water cools warm air reaching the township in the spring, and the warm lake warms the cold air in the fall. The climate during periods of prevailing westerly winds is quasi-maritime. When the wind shifts to the south or southeast and passes over a large land mass, the climate becomes modified continental with more abrupt variations in temperature. The average summer high temperature in July is 81 degrees Fahrenheit (˚F) and the average winter low temperature in January is 15˚F. The average annual precipitation is 34.74 inches per year with September being the wettest month (The Weather Channel, 2010). The county lies in Michigan's Lake Snow Belt region, which receives an average annual snowfall of 84.6 inches.

The topography in Leelanau County is varied. Rolling hills and terraced farmland areas are predominant throughout the county. The geomorphic characteristics of the region are a result of several periods of glaciations, with most recent being the Wisconsin stage which receded about 10,000-12,000 years ago. This results in a branching or dendritic drainage system which drains slowly and has a high potential for flood water storage.

2.3 Principal Flood Problems

The history of the flooding on the streams, lakes and bays being studied within the county indicate that flooding may occur during any season of the year, although the worst flooding conditions are normally the result of spring rains combined with snowmelt.

Lake-level gage data on Grand Traverse Bay is recorded seasonally, from approximately April to October. The highest lake levels occur during this period of time, although rises of a lesser magnitude can be expected to occur at various times during the year.

Shoreline erosion is due primarily to storm-induced waves. High water levels can cause acceleration of shore erosion by inundation of beaches and allowing wave action to reach the bluffs. High water levels occur over protracted periods of above-normal precipitation, when drainage into Lake Michigan exceeds the

outflow. High water levels can also occur in the downwind shore of the lake during severe windstorms.

Temporary seiche events, characterized by a sudden rise or drop of water levels, are common. Fluctuations of up to 6 inches can occur several times in a 24-hour period. The largest flood on record is the flood of the summer of 1986, when the floodwater elevation was nearly 582 feet NAVD.

Residents of the Village of Northport have indicated that occasional shallow flooding from the overflow of Northport Creek occurs across Rose Street; however, no flood damage has resulted. During the most severe flood, water from Northport Creek was reported to have overflowed the creek banks and flowed east along the northern side of Third Street south of Pond Street. The diverted flow caused some shallow flooding in low-lying areas within the village before rejoining the creek South of Mill Street.

2.4 Flood Protection Measures

Structural devices designed specifically for flood protection are not known to exist in Leelanau County. Nonstructural measures of flood protection are being utilized in the Township of Elmwood to aid in the prevention of future flood damage. These are in the form of land use regulations which control building within areas having a high risk of flooding.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent-annual-chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance (100-year) flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Precountywide Analyses

For the detailed study of Lake Leelanau, recorded discharge data from the USGS gaging station in Leland, Michigan, were used. The period of record used included water years 1942 through 1975, inclusive. There is no known established legal lake level on Lake Leelanau. The level of the lake is controlled by a dam at the northwest side of the lake at Leland (Miller and Thompson, 1970).

Various analytical and graphical methods were used to determine elevation-frequency relationships on Lake Leelanau. The results of all methods agreed closely. The elevation-frequency relationships selected for use in this study were computed by a graphical analysis frequency curves were developed by arranging the maximum annual peak elevations in order of magnitude and plotting of each item against its estimated exceedence frequency (Beard, 1962).

For the detailed study of Cedar Lake, the Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS), methodology, a regional analysis based on rainfall and basin characteristics (SCS, 1972 and Sorrell, 1977), was used to determine inflow volume of stormwater into the lake. Rainfall amounts were obtained from Technical Paper No. 40 published by the U.S. Weather Bureau (Hershfield, 1961). Basin characteristics were determined from existing USGS topographic mapping with a scale of 1:62,500 and contour interval of 20 feet (USGS, 1957). Aerial photography and field survey data compiled in 1980 (Abrams, 1980) were used to obtain existing outlet conditions. Groundwater effects on lake levels were considered and determined to be insignificant. At the time of the study, the outlet works were privately owned and no legal lake level had been established.

For the detailed study of the outflow from Cedar Lake, which is immediately downstream of Cedar Lake and empties directly into the West Arm of Grand Traverse Bay, the elevation-frequency relationships were determined to be the same as those on Grand Traverse Bay, primarily because any outflow from Cedar Lake will empty into a large body of water on which inflows from many sources will control lake levels, and secondly because the outflow from Cedar Lake, as determined in the elevation-frequency analysis on Cedar Lake, will be very small.

Elevation-frequency relationships used in the detailed study of the West Arm of Grand Traverse Bay were provided by the USACE, Detroit District. The flood

elevations for the bay at the Township of Elmwood were taken from "Report on Great Lakes Open Coast Flood Levels", prepared by the USACE (USACE, 1977).

Due to the physical connection of Grand Traverse Bay to Lake Michigan, an analysis was made to determine if further adjustment to open coast flood levels to include wind setup in the bay was needed. Two methods were used. The first method employed equation 3-97 of the U.S. Army Coastal Engineering Research Center's "Shore Protection Manual" Volume I (U.S. Army Coastal Engineering Research Center, 1977). The second method employed equation 5-12 from "Estuary and Coastline Hydrodynamics" (Ippen, 1966).

The results of the analysis indicated that additional wind setup in the bay would be insignificant based on an evaluation of wind speed, wind direction, length of fetch and depth of water. The analysis showed that the extreme depth of Grand Traverse Bay moderates the effects of wind setup. In addition, the orientation of the longer fetches of Lake Michigan to the mouth of the bay are such that significant compounding of wind setup effects would not occur. The open coast elevations presented in "Report on Great Lakes Open Coast Flood Levels" were adopted.

For the detailed portion of Northport Creek, discharge estimates were developed using USGS regional regression equations (Holtschlang and Croskey, 1984), and the SCS procedures for unit-hydrograph analysis (Sorrell, 1985). Basin characteristics for the computation were measured from topographic maps (USGS, 1983), SCS soil survey maps for Leelanau County (SCS, 1973), and Michigan quaternary geology maps (Farrand and Bell, 1984).

Monthly gaging records for the period 1900-1973 were taken from the Harbor Beach master gage. The Harbor Beach gage represents the Michigan-Huron lake basin. Partial gaging records for the months of May through October were obtained for Suttons Bay. Individual years of record included 1965, 1971, and 1972.

The Harbor Beach master gaging records (1900-1973) historically represent long-term lake cycles for the Michigan-Huron lake basin. From the Harbor Beach records, it was possible to establish the base, or mean, monthly lake elevation for Suttons Bay. Mean monthly lake levels were adjusted for present inlet and outlet diversions on the Great Lakes. A duration curve was generated for the data (Hjemfelt and Cassidy, 1975).

To determine the effect of seiching and other short-term lake level fluctuations, analysis of gaging records obtained for Suttons Bay was made.

From the gage record, a short period lake level fluctuation curve for Suttons Bay was generated. The procedure involved selecting the highest daily lake elevation for northern Lake Michigan. The mean daily lake elevation was found by

interpolating monthly mean lake levels for the Straits of Mackinac gage at Mackinaw City, Michigan (USDC, 1971). A partial duration series was generated on the net change in lake surface (Beard, 1962). Through curve fitting, changes in lake surface for Suttons Bay were established for recurrence intervals of from 1 to 500 years.

Predicted lake levels were then obtained for the 10-, 2-, 1-, and 0.2-percent-annual-chance flood events by combining the long-term levels with the local short-term fluctuations such that they equaled the desired frequency event. For example, one 1-percent-annual-chance event was found by matching the 10-percent-annual-chance mean lake level with the 10 percent short period lake level fluctuation. The greatest of all 1-percent-annual-chance combinations was then selected as the 1-percent-annual-chance event. The 10-, 2-, and 0.2-percent-annual-chance events were determined in a similar manner.

Manmade influences consisted of changes in the amount of diversion into and out of the Great Lakes basin, alterations in the configuration of the connecting channels, and the erection of control structures at the outlets of Lakes Superior and Ontario. The movement of the earth's crust also affects the level of the Great Lakes. This tilting of the earth's crust in the region has been attributed to rebound from Pleistocene glaciations.

The full period of record at the Harbor Beach gage (1860-1974) was originally considered important. It appeared that other studies failed to take into account the higher water levels experienced on Lakes Michigan and Huron in the years prior to 1900. From personal communication with the USACE (Shutze, 1975), it was established that, over a 10-year period beginning in the summer of 1886, a drastic change in lake elevation was experienced. this change was attributed to gravelling operations in the lower St. Clair River. Gravel removal changed the outflow characteristics of the river channel and gradually lowered Lakes Michigan and Huron approximately 2 feet. Changes in the St. Clair River Channel went unrecorded prior to 1900. Lake levels again stabilized after gravelling operations were abandoned around the turn of the century. Therefore, channel outflow adjustments could not be established and pre-1900 gaging records were dismissed from consideration.

Adjustment of monthly mean lake levels for Lakes Michigan and Huron were made for present diversions and inlet conditions using the International Great Lakes Levels Board Report (December 1973). Adjustment of recorded data was made for manmade and geological influences.

Peak discharge-drainage area relationships for each flooding source studied in detail are shown in Table 2.

Table 2 - Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA SQ MILES	PEAK DISCHARGE (CFS) 10% Annual Chance	PEAK DISCHARGE (CFS) 2% Annual Chance	PEAK DISCHARGE (CFS) 1% Annual Chance	PEAK DISCHARGE (CFS) 0.2% Annual Chance
NORTHPORT CREEK At confluence with Northport Bay	4.4	*	*	280	*

*Data not available

Stillwater elevations for each flooding source studied in detail are shown in Table 3.

Table 3 - Summary of Stillwater Elevations

Location	Water Surface Elevations (Feet NAVD[1]) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
CEDAR LAKE	594.0	594.5	594.6	594.9
GRAND TRAVERSE BAY and NORTHPORT BAY (From approximately 2,000 feet north of Michigan Avenue, to the northern tip of mainland Leelanau County at Calhead Bay Road East- Township of Leelanau and Village of Northport)	582.7	583.8	584.2	585.0
LAKE LEELANAU	589.3	589.6	589.7	589.8
LAKE MICHIGAN (From southwestern Leelanau/Benzie county boundary, to approximately Calhead Bay Road East, including islands of Leelanau County- Townships of Centerville, Cleveland, Empire, Glen Arbor, Leelanau and Leland, and Village of Empire)	582.6	583.7	584.1	585.0
OUTFLOW FROM CEDAR LAKE	582.4	583.4	583.7	584.4
SUTTONS BAY and WEST ARM GRAND TRAVERSE BAY (From approximately Sanders Road, to approximately 2,000 feet north of Michigan Avenue- Townships of Bingham, Leelanau, Suttons Bay, and Village of Suttons Bay)	582.9	583.9	584.3	585.0
WEST ARM GRAND TRAVERSE BAY (From southeastern Leelanau/Grand Traverse county boundary, to approximately Sanders Road- Townships of Bingham and Elmwood)	582.9	584.0	584.3	585.1

[1]North American Vertical Datum of 1988

This Countywide FIS Report

Analysis for Lake Michigan from Leelanau County's southwestern boundary with Benzie County, to approximately Calhead Bay Road East, including the islands of Leelanau County, were incorporated from the Phase II Report on Great Lakes Open-Coast Flood Levels (USACE, 1988).

For the approximate analyses streams, peak discharges were estimated using the published USGS regional regression equations (Holtschlang and Croskey, 1984). Regression equations estimate peak discharges for ungaged streams based on characteristics of nearby gaged streams. Drainage areas were developed from USGS 30-meter Digital Elevation Models (DEMs).

For streams with a drainage area of less than 1 square mile, the peak discharges were determined based on guidelines from the Michigan Department of Environmental Quality (Sorrell, 2008).

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data Table in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS report in conjunction with the data shown on the FIRM.

Precountywide Analyses

For the backwater analysis of Northport Creek, cross sections were obtained from field survey or were synthesized from adjacent surveyed sections. Structural geometry and elevations for culvert, bridges, and road sections were also obtained from the field survey.

Water-surface elevations for the 1-percent-annual-chance flood were computed using the Federal Highway Administration (FHWA) WSPRO, a step-backwater computer program (FHWA, 1986 and 1988). The starting water surface elevation for Northport Creek was based on the 1-percent-annual-chance flood levels for Grand Traverse Bay (USACE, 1981).

Channel roughness factors (Mannings "n") used in the hydraulic computations were chosen by engineering judgment. The Manning's "n" values for all detailed studied streams are listed in the following table:

Table 4: Manning's "n" Values

Manning's "n" Values

Stream	Channel "n"	Overbank "n"
Northport Creek	0.032	0.022-0.075

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

The profile baselines depicted on the FIRM represent the hydraulic modeling baselines that match the flood profiles on this FIS report. As a result of improved topographic data, the profile baseline, in some cases, may deviate significantly from the channel centerline or appear outside the Special Flood Hazard Area.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

This Countywide FIS Report

Analysis for Lake Michigan from Leelanau County's southwestern boundary with Benzie County, to approximately Calhead Bay Road East, including the islands of Leelanau County, were incorporated from the Phase II Report on Great Lakes Open-Coast Flood Levels (USACE, 1988).

For the approximate study streams, cross section data was obtained from topographic maps. Low flow channels were added to the cross section data, based on the estimated depth of the 2-percent-annual-chance flow. Roads appearing on the topographic maps were modeled as weirs; top of road elevations were estimated from the topography. The approximate studied streams were modeled using the USACE, Hydrologic Engineering Center's (HEC) computer program, HEC-RAS version 3.1.3 (HEC, 2005).

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FIS reports and FIRMs was NGVD. With the finalization of NAVD, many FIS reports and FIRMs are being prepared using NAVD as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD. Structure and ground elevations in the community must, therefore, be

referenced to NAVD. It is important to note that adjacent communities may be referenced to NGVD. This may result in differences in Base Flood Elevations (BFEs) across the corporate limits between the communities. Some of the data used in this study were taken from the prior effective FIS reports and adjusted to NAVD. The average conversion factor that was used to convert the data in this FIS report to NAVD was calculated using the National Geodetic Survey's (NGS) VERTCON online utility (NGS, 2010). The data points used to determine the conversion are listed in Table 5.

Table 5 - Vertical Datum Conversion

Quad Name	Corner	Latitude	Longitude	Conversion from NGVD29 to NAVD88 (feet)
Beulah	NE	44.750	-86.000	-0.302
Burdickville	NE	44.875	-85.875	-0.318
Empire	NE	44.875	-86.000	-0.328
Gills Pier	NE	45.125	-85.625	-0.338
Good Harbor Bay	NE	45.000	-85.750	-0.344
Grawn	NE	44.750	-85.625	-0.361
Lake Ann	NE	44.750	-85.750	-0.295
Maple City	NE	44.875	-85.750	-0.335
North Manitou Island	NE	45.125	-86.000	-0.256
Platte River	NE	44.750	-85.875	-0.292
South Fox Island	NE	45.500	-85.750	-0.171
Suttons Bay	NE	45.000	-85.625	-0.344
Traverse City SW	NE	44.875	-85.625	-0.331
South Manitou Island	SE	45.000	-86.125	-0.279
South Fox Island OE W	SE	45.375	-85.875	-0.203
Average:				**-0.300**

For additional information regarding conversion between NGVD and NAVD, visit the NGS website at www.ngs.noaa.gov, or contact the NGS at the following address:

Vertical Network Branch, N/CG13
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (500-year) floodplain boundaries and 1-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data Table, and Summary of Stillwater Elevations Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community.

For Northport Creek, the 1- and 0.2-percent-annual-chance floodplain boundaries were delineated using the flood elevations determined at each cross section. For lakes studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries were delineated using their respective water surface elevations. All boundaries were interpolated using digital topographic maps with a contour interval of 2 feet (Joint Airborne LiDAR Bathymetry Technical Center of Expertise, 2009).

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE) and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-

percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. In Michigan, however, under Michigan Act 245, Public Acts of 1929, as amended by Act 167, Public Acts of 1968 (State of Michigan, 1968), encroachment in the floodplain is limited to that which will cause only an insignificant increase in flood heights. Thus, at the recommendation of the Bureau of the Water Management, a floodway having no more than a 0.1 foot surcharge has been delineated for this study. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevation (WSEL) of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

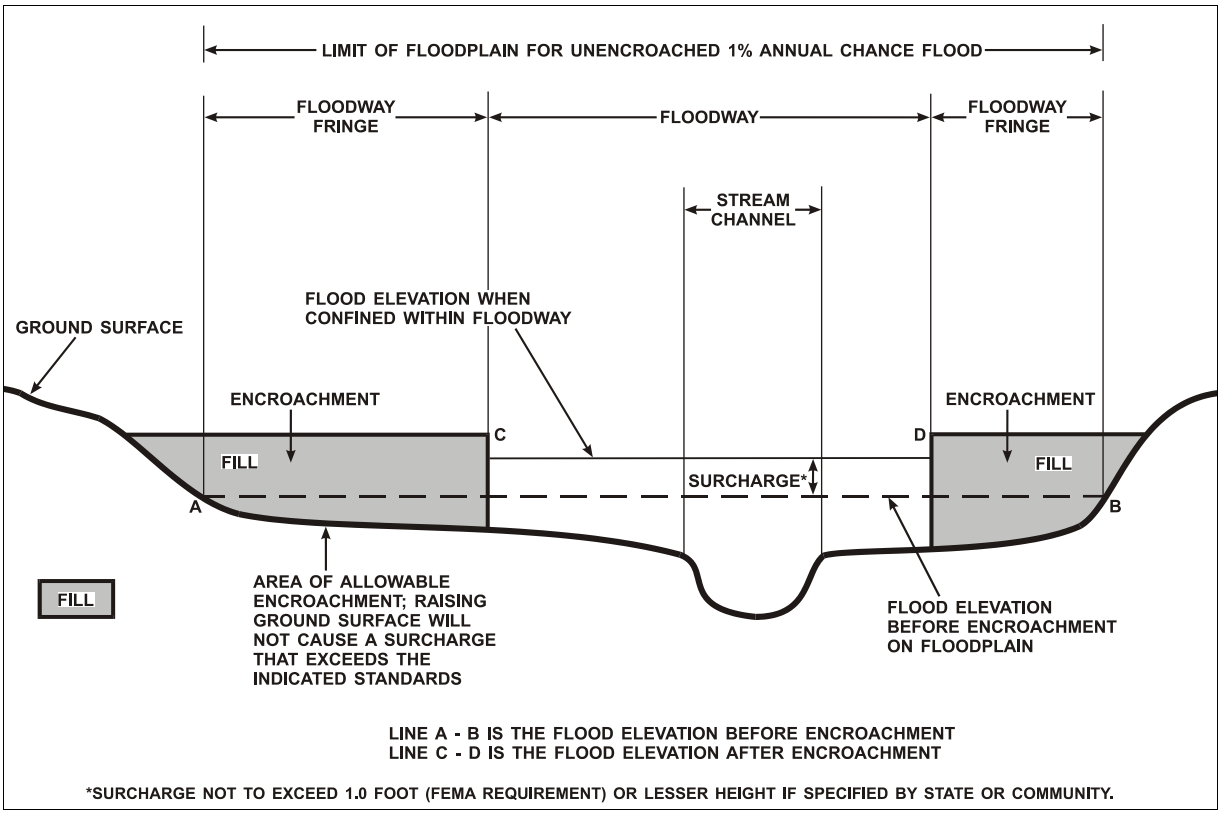

Figure 1 - Floodway Schematic

No floodways were computed for Northport Creek.

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or base flood depths are shown within this zone.

Zone AE

Zone AE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or base flood depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance risk zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Leelanau County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. This countywide FIRM also includes flood-hazard information that was presented separately on Flood Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community are presented in Table 6.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE	FIRM EFFECTIVE DATE	FIRM REVISION DATE
Bingham, Township of	To Be Determined	None	To Be Determined	None
Centerville, Township of	March 18, 1977	None	February 1, 1986	None
Cleveland, Township of	February 21, 1975	None	September 1, 1986	None
Elmwood, Township of	September 20, 1974	March 5, 1976 September 28, 1979	February 2, 1983	None
Empire, Township of	To Be Determined	None	To Be Determined	None
Empire, Village of	To Be Determined	None	To Be Determined	None
Glen Arbor, Township of	December 30, 1977	None	September 1, 1986	None
Grand Traverse Band of Ottawa And Chippewa Indians	To Be Determined	None	To Be Determined	None
*Kasson, Township of	N/A	None	N/A	None
Leelanau, Township of	December 6, 1974	November 26, 1976	April 2, 1986	None
Leland, Township of	To Be Determined	None	To Be Determined	None
Northport, Village of	October 28, 1977	None	March 2, 1989	None
Solon, Township of	To Be Determined	None	To Be Determined	None
Suttons Bay, Township of	To Be Determined	None	To Be Determined	None
Suttons Bay, Village of	June 28, 1974	None	June 1, 1977	None
Traverse City, City of	May 24, 1974	November 14, 1975	December 15, 1982	None

*No Special Flood Hazard Areas Identified

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

LEELANAU COUNTY, MI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

This report either supersedes or is compatible with all previous studies on streams studied in this report and should be considered authoritative for purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 536 South Clark Street, Sixth Floor, Chicago, Illinois 60605.

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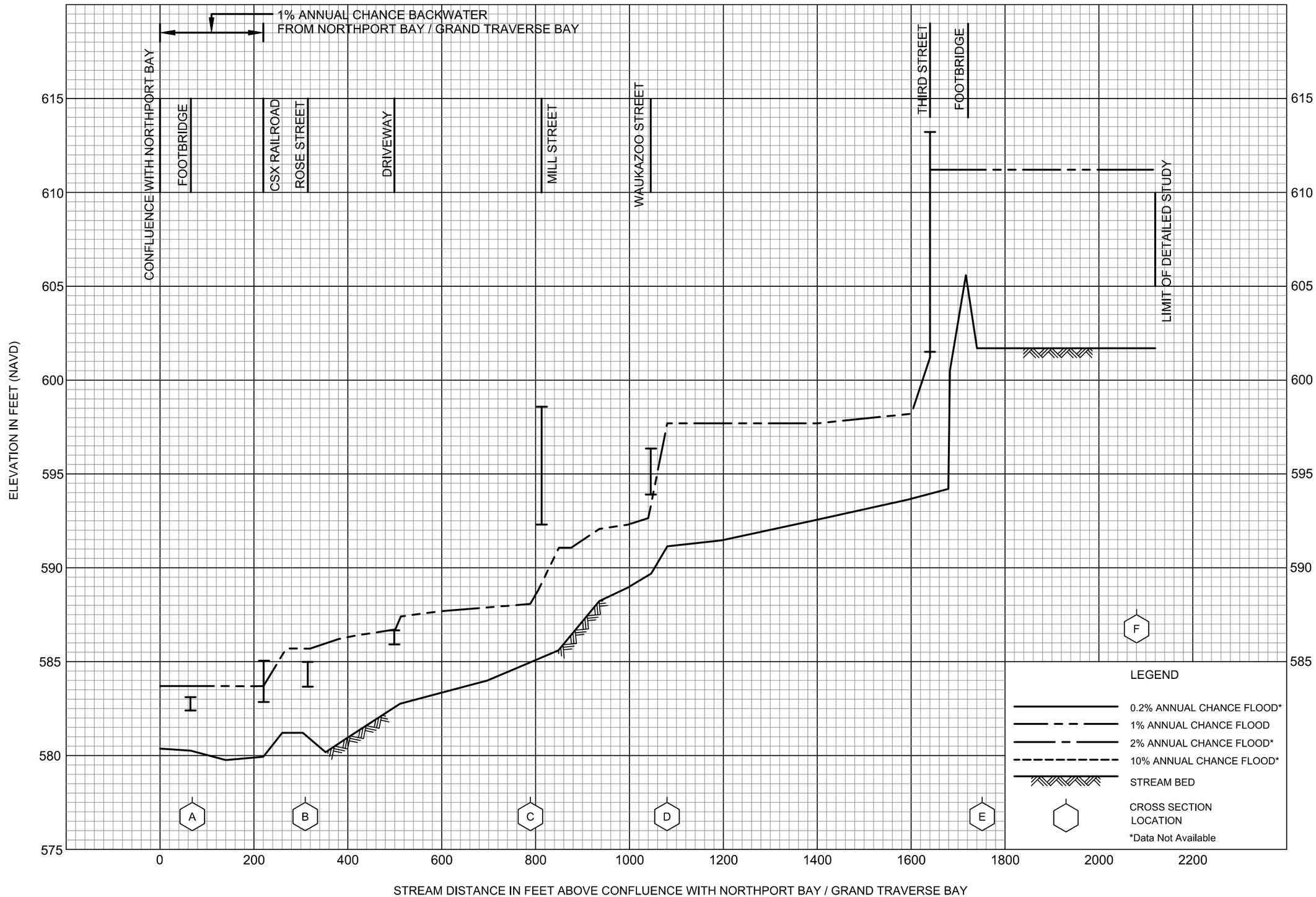

FLOOD PROFILES

NORTHPORT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

LEELANAU COUNTY, MI

(ALL JURISDICTIONS)

01P