USGS
science for a changing world

Prepared in cooperation with the
New Jersey Department of Environmental Protection

Flood-Inundation Maps for the Hohokus Brook in Waldwick Borough, Ho-Ho-Kus Borough, and the Village of Ridgewood, New Jersey, 2014

Scientific Investigations Report 2015–5064

U.S. Department of the Interior
U.S. Geological Survey

Flood-Inundation Maps for the Hohokus Brook in Waldwick Borough, Ho-Ho-Kus Borough, and the Village of Ridgewood, New Jersey, 2014

By Kara M. Watson and Michal J. Niemoczynski

Prepared in cooperation with the
New Jersey Department of Environmental Protection

Scientific Investigations Report 2015–5064

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit http://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod/.

Suggested citation:
Watson, K.M., and Niemoczynski, M.J., 2015, Flood-Inundation maps for the Hohokus Brook in Waldwick Borough, Ho-Ho-Kus Borough, and the Village of Ridgewood, New Jersey, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5064, xx p., http://dx.doi.org/10.3133/sir20155064.

ISSN 2328-0328 (online)

Acknowledgments

The authors wish to thank the New Jersey Department of Environmental Protection which has cooperated in the funding of this study. The New Jersey Department of Environmental Protection and the U.S. Army Corps of Engineers, New York District have provided the funding for the operation and maintenance of the streamgage used for this study. Special thanks are given to Natural and Technological Hazards Management Consulting, Inc., for providing the hydraulic model for this study and the National Weather Service for their continued support of the U.S. Geological Survey flood-inundation mapping program.

Contents

Figures

Tables

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.59	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)

Vertical coordinate information is referenced to either (1) stage, the height above an arbitrary datum established at a streamgage, or (2) elevation, the height above the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Flood-Inundation Maps for the Hohokus Brook in Waldwick Borough, Ho-Ho-Kus Borough, and the Village of Ridgewood, New Jersey, 2014

By Kara M. Watson and Michal J. Niemoczynski

Abstract

Digital flood-inundation maps for a 6-mile reach of the Hohokus Brook in New Jersey from White's Lake Dam in Waldwick Borough, through Ho-Ho-Kus Borough to Grove Street in the Village of Ridgewood were created by the U.S. Geological Survey (USGS) in cooperation with the New Jersey Department of Environmental Protection. The flood-inundation maps, which can be accessed through the USGS Flood Inundation Mapping Science Web site at http://water.usgs.gov/osw/flood_inundation/, depict estimates of the areal extent and depth of flooding corresponding to selected water levels (stages) at the USGS streamgage on the Hohokus Brook at Ho-Ho-Kus, New Jersey (station number 01391000). Stage data at this streamgage may be obtained on the Internet from the USGS National Water Information System at http://waterdata.usgs.gov/nwis/uv?site_no=01391000 or the National Weather Service (NWS) Advanced Hydrologic Prediction Service at http://water.weather.gov/ahps2/hydrograph.php?gage=hohn4&wfo=okx.

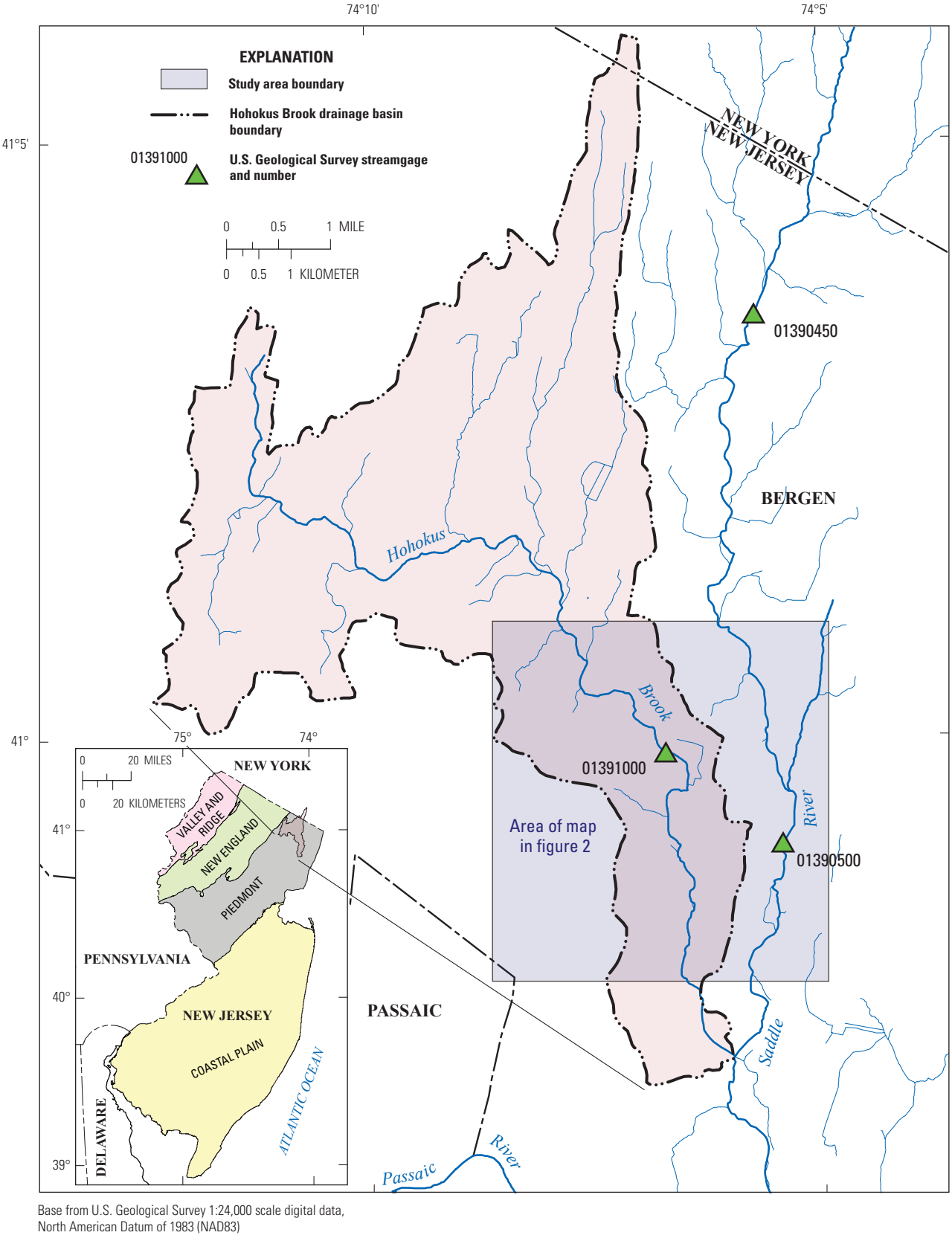
Flood profiles were simulated for the stream reach by means of a one-dimensional step-backwater model. The model was calibrated using the most current stage-discharge relation at the Hohokus Brook at Ho-Ho-Kus, New Jersey, streamgage (station number 01391000). The hydraulic model was then used to compute 12 water-surface profiles for flood stages at 0.5-foot (ft) intervals referenced to the streamgage datum and ranging from 2.5 ft, the NWS "action stage" or near bankfull, to 8.0 ft, which exceeds the stage that corresponds to the maximum recorded peak flow (7.32 ft) and is the extent of the current stage-discharge relation for the streamgage. The simulated water-surface profiles were then combined with a geographic information system 3-meter (9.84 ft) digital elevation model [derived from light detection and ranging (lidar) data] to delineate the area flooded at each water level.

The availability of these maps along with information on the Internet regarding current stage from the USGS streamgage will provide emergency management personnel and residents with information that is critical for flood response activities such as evacuations and road closures, as well as for post-flood recovery efforts.

Introduction

The Boroughs of Ho-Ho-Kus and Waldwick, and the Village of Ridgewood, are urban communities with estimated populations of 4,120, 9,840, and 25,350, respectively, and population densities of 2,360, 4,710, and 4,360 persons per square mile (U.S. Bureau of Census, 2014). These communities have experienced severe flooding numerous times, most notably in 2011 (Tropical Storm Irene), 1999 (Tropical Storm Floyd), and 1977. National Flood Insurance Program flood insurance claims for these communities were estimated to be $2,618,848 in 2011, $2,563,464 in 1999, and $53,605 in 1977 (New Jersey Department of Environmental Protection, State National Flood Insurance Program Coordinators Office, written commun., 2013). Most of the flood damages have occurred along the Hohokus Brook (fig.1), which flows through the Boroughs of Waldwick (Waldwick) and Ho-Ho-Kus (Ho-Ho-Kus), and the Village of Ridgewood (Ridgewood) (fig.2). Floodplains along the Hohokus Brook are highly developed and contain a mix of residential and commercial structures and recreational areas.

Prior to this study, emergency responders in Ho-Ho-Kus, Waldwick, and Ridgewood relied on several information sources (all of which are available on the Internet) to make decisions on how to best alert the public and mitigate flood damages. One source is the effective Federal Emergency Management Agency (FEMA) flood insurance study (FIS) for Bergen County dated September 30, 2005 (Federal Emergency Management Agency, 2005). A second source of information is the U.S. Geological Survey (USGS) streamgage, Hohokus Brook at Ho-Ho-Kus, New Jersey (station number 01391000), from which current (U.S. Geological Survey, 2014a) and historical (since 1954; U.S. Geological Survey, 2014b) water levels and discharges, including annual peak flows, can be obtained. A third source of flood-related information is the National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS; National Weather Service, 2014), which also displays the USGS stage data from the Ho-Ho-Kus streamgage. Although the NWS forecasts flood stage at many USGS streamgages, it does not provide forecasts of flood stages at streamgages with small drainage areas, such as



Base from U.S. Geological Survey 1:24,000 scale digital data, North American Datum of 1983 (NAD83)

Figure 1. Location of study reach for the Hohokus Brook and location of U.S. Geological Survey streamgages, in New Jersey.

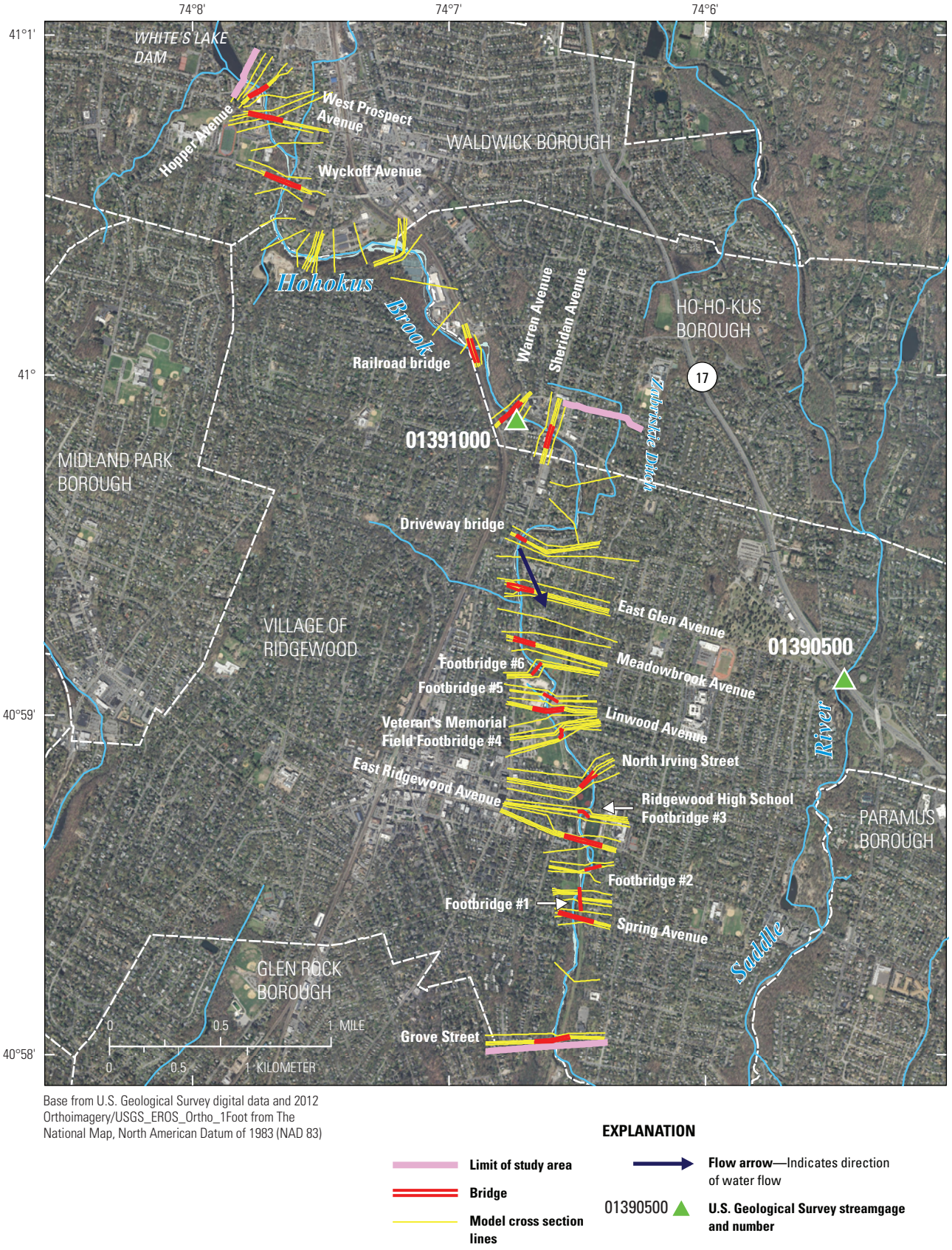


Figure 2. Location of study reach and direction of flow for the Hohokus Brook at Ho-Ho-Kus, New Jersey.

the Hohokus Brook at Ho-Ho-Kus. This is because the time between a precipitation-runoff event and peak streamflow in these small drainage areas is typically shorter in duration than the 6-hour time step used by the NWS for stage forecasts.

Although the current stage at a USGS streamgage is particularly useful for residents in the immediate vicinity of a streamgage, it is of limited use to residents farther upstream or downstream because the water-surface elevation is not constant along the entire stream reach. A water-level value at a streamgage is difficult to translate into depth and areal extent of flooding at points distant from the streamgage. One way to address these informational gaps is to produce a library of flood-inundation maps that are referenced to the stages recorded at the USGS streamgage. By referring to the appropriate map, emergency responders can discern the severity of flooding (depth of water and areal extent), identify roads that are or will soon be flooded, and make plans for notification or evacuation of residents in harm's way for some distance upstream and downstream from the streamgage. In addition, the capability to visualize the potential extent of flooding has been shown to motivate residents to take precautions and heed warnings that they previously might have disregarded. In 2014, the USGS, in cooperation with the New Jersey Department of Environmental Protection, conducted a project to produce a library of flood-inundation maps for the Hohokus Brook at Ho-Ho-Kus, New Jersey.

Table 1. U.S. Geological Survey streamgage information on Hohokus Brook at Ho-Ho-Kus, New Jersey.

[Station location is shown in figure 1. mi^2, square miles; ft^3/s, cubic feet per second; NAVD 88, North American Vertical Datum of 1988]

Station name	Hohokus Brook at Ho-Ho-Kus, New Jersey
Station number	01391000
Drainage area (mi^2)	16.4
Latitude	40° 59'52"
Longitude	74°06'43"
Period of peak-flow record (water years[1])	1954–present
Maximum recorded stage, in feet, gage datum (and elevation, in feet above NAVD 88) and date	7.32 -126.44 September 16, 1999
Maximum discharge, in ft^3/s, and date	4,670 September 16, 1999

[1]Water year is the 12-month period from October 1 of one year through September 30 of the following year and is designated by the calendar year in which it ends.

Purpose and Scope

This report describes the development of a series of estimated flood-inundation maps for the Hohokus Brook at Ho-Ho-Kus, New Jersey, and identifies where on the Internet the maps can be found and ancillary data [geographic information systems (GIS) flood polygons and depth grids] can be downloaded.

The flood-inundation maps cover a 6-mile reach of the Hohokus Brook in New Jersey from White's Lake Dam in Waldwick Borough, through Ho-Ho-Kus Borough to Grove Street in the Village of Ridgewood (figs. 1 and 2). The maps were produced for water levels referenced to the stage recorded at the USGS streamgage on the Hohokus Brook at Ho-Ho-Kus, New Jersey (table 1); the streamgage is in Ho-Ho-Kus Borough at Warren Avenue, 3.5 miles upstream from the downstream study extent and 4.9 miles upstream from the confluence of Hohokus Brook and the Saddle River.

The maps cover a range of stages from 2.5 to 8.0 feet (ft), gage datum, at 0.5-foot increments. The 2.5 ft stage is approximately bankfull and is defined by the National Weather Service (2013) as the "action stage" or the stage which, when reached by a rising stream, requires the NWS or a partner to take some type of mitigation action in preparation for possible significant hydrologic activity. The upper limit of inundation maps is the 8.0 ft stage, which is the maximum extent of the stage-discharge relation at the USGS streamgage and 0.68 ft higher than the maximum recorded water level at the streamgage. This exceeds the "major flood stage" as defined by the NWS by 1 ft.

Study Area Description

The Hohokus Brook is in northeastern New Jersey in the Piedmont Physiographic Province (fig. 1). The drainage areas are 14.9 square miles (mi^2) at White's Lake Dam in Waldrick, 16.4 mi^2 at the Hohokus Brook at Ho-Ho-Kus streamgage, and 19.3 mi^2 at the downstream extent of the study reach. The source of the Hohokus Brook is 10.5 miles upstream from the Hohokus Brook at Ho-Ho-Kus streamgage, in northern Bergen County in New Jersey. The stream flows generally southward through Waldwick, Ho-Ho-Kus, and Ridgewood. One minor tributary, Zabriskie Ditch, flows into the Hohokus Brook within the study reach (fig. 2). The Hohokus Brook drains into the Saddle River 4.9 miles downstream from the Hohokus Brook at Ho-Ho-Kus streamgage (fig. 1). The basin terrain is moderately hilly. The study reach is approximately 6-miles long, has an average top-of-bank channel width of about 70 ft, and has an average channel slope of 28.7 feet per mile. About 78 percent of the land contiguous to the study reach is classified as urban or developed, 13.2 percent as forest, 7.7 percent as wetland and water, and 1.1 percent agriculture and barren land (New Jersey Department of Environmental Protection,

2010). The basin is still under development, and population has increased 1.8 percent from 38,618 to 39,315 between 2000 and 2013 (U.S. Bureau of Census, 2014). Twelve major road bridges, 6 footbridges, 1 railroad bridge, and 1driveway bridge span the channel within the study reach (fig. 2).

Previous Studies

The current FIS for Ho-Ho-Kus, Waldwick, and Ridgewood in Bergen County (Federal Emergency Management Agency, 2005) was completed in 2004 by Natural and Technological Hazards Management Consulting, Inc. (NTHMC, 2004). The study provided information on the 10-, 2.0-, 1.0-, and 0.2-percent annual exceedance probability water-surface profiles and associated flood plain maps for the Hohokus Brook. Estimates of the peak discharges for these annual exceedance probability floods along the Hohokus Brook, as shown in table 2 for the study reach, were described by the Federal Emergency Management Agency (2005).

Table 2. Peak-discharge estimates at the 10-, 2-, 1-, and 0.2-percent annual exceedance probabilitie sand drainage areas for selected locations on the Hohokus Brook at Ho-Ho-Kus, New Jersey (from Federal Emergency Management Agency, 2005)

[mi^2, square miles; ft^3/s, cubic feet per second; USGS, U.S. Geological Survey]

Location on Hohokus Brook	Drainage area (mi^2)	Estimated peak discharges (ft^3/s) for indicated annual exceedance probabilities (in percent)			
		10	2	1	0.2
At downstream township boundary with Waldwick. At White's Lake Dam in Waldwick	14.9	1,980	3,550	4,430	7,200
At USGS streamgage number 01391000	16.4	2,270	4,050	5,050	8,090
At Grove Street	19.3	2,560	4,580	5,710	9,140

Creation of Flood-Inundation-Map Library

The USGS has standardized the procedures for creating flood-inundation maps for flood-prone communities (U.S. Geological Survey, 2014c) so that the process followed and products produced are similar regardless of which USGS office is responsible for the work. Tasks specific to development of the flood maps for Ho-Ho-Kus, New Jersey, were (1) attainment of the hydraulic model that was used for the most recent FEMA flood insurance study for Bergen County (Federal Emergency Management Agency, 2005), (2) analysis of peak streamflow data from USGS station 01391000 (table 1), (3) computation of water-surface profiles by use of the U.S. Army Corps of Engineers' HEC-RAS computer program (U.S. Army Corps of Engineers, 2010), (4) production of estimated flood-inundation maps at various stream stages by use of a GIS, and (5) preparation of the maps, both as shapefile polygons that depict the areal extent of flood inundation and as depth grids that provide the depth of floodwaters, for display on the USGS Flood Inundation Mapper Web site (U.S. Geological Survey, 2014d) and the NWS AHPS Web site (National Weather Service, 2014).

Computation of Water-Surface Profiles

The water-surface profiles used to produce the 12 flood-inundation maps in this study were computed with the hydraulic model that was developed for the effective FIS for Bergen County (Federal Emergency Management Agency, 2005). This model, which was developed using HEC–RAS, version 4.1.0 (U.S. Army Corps of Engineers, 2010), was created by NTHMC in 2004. HEC–RAS is a one-dimensional step-backwater model for simulation of water-surface profiles with steady-state (gradually varied) or unsteady-state flow computation options.

Hydrologic Data

The study reach includes one streamgage (01391000; fig. 1; table 1) that has been in operation since October 1954. The water level (stage) is measured every 15 minutes, transmitted hourly by a satellite radio in the streamgage, and made available on the Internet through the USGS National Water Information System (NWIS; U.S. Geological Survey, 2014b). Stage data from this streamgage are referenced to a local datum but can be converted to water-surface elevations referenced to the NAVD 88 by adding 119.12 ft. Continuous records of streamflow are computed from a stage-discharge relation that has been developed for the streamgage and are available through the USGS NWIS Web site (U.S. Geological Survey, 2014a).

The peak flows used in the model simulations (table 3) were taken from the stage-discharge relation rating number 15

Table 3. Estimated discharges for corresponding stages and water-surface elevations at selected locations used in the hydraulic model of the Hohokus Brook at Ho-Ho-Kus, New Jersey.

[ft, feet; NAVD 88, North American Vertical Datum of 1988]

Stage of water-surface profile (ft)[1]	Water-surface elevation (ft, NAVD 88)	Estimated discharge, in cubic feet per second
2.5	121.62	352
3.0	122.12	880
3.5	122.62	1,510
4.0	123.12	2,070
4.5	123.62	2,520
5.0	124.12	2,920
5.5	124.62	3,300
6.0	125.12	3,680
6.5	125.62	4,070
7.0	126.12	4,450
7.5	126.62	4,800
8.0	127.12	5,150

[1]Water-surface profiles are 0.5-foot increments of stage, referenced to the gage datum of the U.S. Geological Survey streamgage, Hohokus Brook at Ho-Ho-Kus, New Jersey (station number 01391000)

(effective September 20, 2012) and correspond to the target stages. No major tributaries join the Hohokus Brook within the 6-mi study reach; therefore, the gage-derived discharges were not adjusted for tributary inflows but were held constant throughout the study reach for a given profile.

Topographic and Bathymetric Data

All topographic data used in this study are referenced vertically to the North American Vertical Datum of 1988 (NAVD 88) and horizontally to the North American Datum of 1983 (NAD 83). Channel cross-section field surveys for hydraulic analyses were conducted by NTHMC in 2004 (Natural and Technological Hazards Management Consulting, Inc., 2004). These surveys provided detailed channel-elevation data from below the water surface. Channel elevations were collected using traditional field surveys or hydroacoustic instrumentation to measure depth along with Differential Global Positioning System instrumentation to determine horizontal position. Light Detection and Ranging (lidar) data were used to create 3-meter (9.84-ft) digital elevation data, from which elevations for the portions of the cross sections that were above the water surface at the time of the surveys were obtained. The lidar data were collected during 2006–07 by the National Geospatial-Intelligence Agency. Postprocessing of these data was completed by the National Geospatial-Intelligence Agency in 2007 (National Geospatial-Intelligence Agency, 2007).

For this hydraulic model, an additional cross section was created and added at the streamgage location (across the weir). The distance between existing cross sections in this area of the model combined with the gradient of the stream necessitated this additional cross section to facilitate model calibration. Elevation data obtained from the lidar were used for this cross section. Channel depths at the streamgage weir are very shallow (less than 2.0 ft), so bathymetric data were determined to be unnecessary for the cross section.

Hydraulic Structures

Twenty structures (12 road bridges, 6 foot bridges, 1 driveway bridge, and a railroad bridge) have the potential to affect water-surface elevations during floods along the stream. To properly account for the 20 bridges (fig. 2) in the model, the structural dimensions were measured and surveyed in the field concurrently with the stream-channel surveys conducted by NTHMC (2004). Structures in the study reach have not been modified or altered since the completion of these surveys.

Energy-Loss Factors

Hydraulic analyses require the estimation of energy losses that result from frictional resistance exerted by a channel on flow. These energy losses are quantified by the Manning's roughness coefficient ("*n*" value). Manning's roughness coefficients ("*n*" values) for energy (friction) loss calculations were included in the hydraulic model provided by NTHMC (Natural and Technological Hazards Management Consulting, Inc., 2004) and ranged from 0.023 to 0.040 for the main channel and 0.01 to 0.15 for the overbank areas modeled in this analysis. Channel conditions in the study reach are typified by bed material consisting of coarse gravel and cobbles with occasional scattered boulders and light brush on the banks. Overbank conditions throughout the study reach are variable. About 13 percent of the reach is still classified as forested, and 78 percent is classified as urban or developed (New Jersey Department of Environmental Protection, 2010). Dense vegetation and paved impervious surfaces are often present in the overbank within the same cross section. Roughness coefficients provided with the hydraulic model were not changed by the USGS.

Hydraulic Model

The HEC-RAS analysis for this study was done by using the steady-state flow computation option. Steady-state flow data consisted of flow regime, boundary conditions, and peak flows that produced water-surface elevations at the streamgage cross section that matched target water-surface elevations. These target elevations coincided with even 0.5 ft increments of stage, referenced to the local gage datum for Hohokus

Brook at Ho-Ho-Kus, New Jersey. Subcritical flow regime was assumed for the simulations. Normal depth was used as the reach's downstream boundary condition. The energy slope used for the normal depth boundary condition was 0.007, estimated by computing the slope of the channel bottom through the study reach. The peak flows that were used in the model are discussed in the section "Hydrologic Data."

The hydraulic model was calibrated to 12 points (table 4) representing the stage-discharge relation (rating number 15; effective September 20, 2012) at the USGS streamgage 01391000 Hohokus Brook at Ho-Ho-Kus, New Jersey. Additionally, the model was calibrated to two recent recorded peak discharges from the floods of September 16, 1999, and August 28, 2011, at the Hohokus Brook at Ho-Ho-Kus streamgage as shown in table 5. Model calibration is typically accomplished by adjusting Manning's *n* values and, in some cases, changing the channel cross section until the results of the hydraulic computations closely agree with the known flood discharge and stage values. It was unnecessary to adjust the Manning's *n* values for this particular model; however, an additional channel cross section was added at the streamgage. Differences between observed and simulated water-surface elevations for the 12 simulated flows at the USGS streamgage were 0.00 ft to 0.01 ft (table 4). Differences between recorded and simulated elevations of high-water marks in the study reach for the floods of September 16, 1999, and August 28, 2011, were 0.01 ft and 0.00 ft, respectively (table 6). The results demonstrate that the model is capable of simulating accurate water levels over a wide range of flows in the basin.

Table 4. Target and simulated water-surface elevations at U.S. Geological Survey streamgage on Hohokus Brook at Ho-Ho-Kus, New Jersey, (station number 01391000) used for calibration of the model.

[ft, feet; NAVD 88, North American Vertical Datum of 1988]

Stage of water-surface profile (ft)	Target (observed) water-surface elevation (ft, NAVD 88)	Simulated water-surface elevation (ft, NAVD 88)	Difference in elevations (ft)
2.5	121.62	121.62	0.00
3.0	122.12	122.12	0.00
3.5	122.62	122.62	0.00
4.0	123.12	123.12	0.00
4.5	123.62	123.62	0.00
5.0	124.12	124.12	0.00
5.5	124.62	124.62	0.00
6.0	125.12	125.12	0.00
6.5	125.62	125.63	0.01
7.0	126.12	126.12	0.00
7.5	126.62	126.62	0.00
8.0	127.12	127.12	0.00

Table 5. Recorded peak discharges and gage heights for selected peaks at the U.S. Geological Survey streamgage on Hohokus Brook at Ho-ho-kus, New Jersey (station number 01391000).

[ft^3/s, cubic feet per second; ft, feet]

Date of peak	Peak discharge (ft^3/s)	Peak gage height (ft, gage datum)
September 16, 1999	4,670	126.44
August 28, 2011	4,230	125.83

Development of Water-Surface Profiles

Profiles were developed for a total of 12 stages at 0.5-ft intervals from 2.5 ft to 8.0 ft as referenced to the local datum of the Hohokus Brook at Ho-Ho-Kus, New Jersey, streamgage. These stages correspond to elevations ranging from 121.62 ft to 127.12 ft, NAVD 88, respectively. Discharges corresponding to the various stages were obtained from the stage-discharge relation rating number 15, effective September 20, 2012, for the Hohokus Brook at Ho-Ho-Kus, New Jersey, streamgage.

Development of Flood-Inundation Maps

Flood-inundation maps were created for the USGS streamgage Hohokus Brook at Ho-Ho-Kus, New Jersey. Flood-inundation maps were created in a GIS for the 12 water-surface profiles by combining the profiles and digital elevation model (DEM) data. The DEM data were derived from the 3-meter (9.84-ft) digital elevation model lidar data obtained from the National Geospatial-Intelligence Agency (2007). Each HEC-RAS cross-section line used for the study area was attributed with a HEC-RAS-calculated water-surface elevation for each of the 12 profiles; then water-surface elevation contours were derived from these water-surface elevations. For each profile, a flood water-surface elevation raster layer was generated using an iterative finite-difference interpolation technique found in the ArcGIS Topo to Raster tool. Topo to Raster is an interpolation method specifically designed for the creation of hydrologically correct digital elevation models (Environmental Systems Research Institute, Inc., 2012). Inputs into the tool include the water-surface-elevation contours and the study-area polygon boundary. Finally, depth-of-water grids were generated by subtracting the lidar DEM ground elevation from the flood water-surface raster layer. Shapefile polygons and depth grids of the inundated areas for each profile were modified, using the NWS Flood Inundation Mapping Quality

Table 6. Recorded and simulated water-surface elevations at the U.S. Geological Survey streamgage on Hohokus Brook at Ho-Ho-Kus, New Jersey, (station number 01391000) for the floods of September 16, 1999, and August 28, 2011, used for calibration of the model, and differences between elevations.

[ft, feet; NAVD 88, North American Vertical Datum of 1988]

Date of flood	Recorded water-surface elevation 01391000 (ft, gage datum)	Recorded water-surface elevation 01391000 (ft, NAVD 88)	Simulated water-surface elevation 01391000 (ft, NAVD 88)	Difference in elevations (ft)
September 16, 1999	7.32	126.44	126.43	-0.01
August 28, 2011	6.71	125.83	125.83	0.00

Control Tools (National Weather Service, 2011), in the ArcMap application of ArcGIS (Environmental Systems Research Institute, Inc., 2010) to ensure a hydraulically reasonable transition of the flood boundaries between modeled cross sections. Any inundated areas that were detached from the main channel and, therefore, erroneously delineated as parts of the flood extent were removed from the mapped inundated areas. The mapped areas of inundation are overlaid on high-resolution, geo-referenced, aerial photographs of the study area. Estimates of water depth can be obtained from the depth-grid data that are included with the flood maps on the interactive online map-library Web site described in the following section, "Flood-Inundation Maps on the Internet." The flood map corresponding to the highest simulated water-surface profile, a stage of 8.0 ft, is presented in figure 3.

Flood-Inundation Maps on the Internet

The current study documentation is available online at the USGS Publications Warehouse (http://pubs.usgs.gov/sir/2015/5064). Also, a Flood Inundation Mapping Science Web site (U.S. Geological Survey, 2014c) has been established to provide a portal at http://water.usgs.gov/osw/flood_inundation/ to make USGS flood-inundation study information available to the public. That Web portal has a link to an interactive flood mapper Web site (U.S. Geological Survey, 2014d) at http://wim.usgs.gov/FIMI/FloodInundationMapper.html which presents map libraries that provide detailed information on flood extents and depths for selected sites. At this latter Web site, customized flood-inundation maps can be generated from the map library for Hohokus Brook at Ho-Ho-Kus, New Jersey. Also included on this Web site is a link to the USGS National Water Information System (http://waterdata.usgs.gov/nwis/uv?site_no=01391000), which presents graphs of the current stage and streamflow at the USGS streamgage 01391000 to which the inundation maps are referenced. The estimated flood-inundation maps are displayed in sufficient detail to note the extent of flooding with respect to individual structures so that preparations for flooding and decisions for emergency response can be performed efficiently. Depending on the flood magnitude, roadways are shown as shaded (inundated and likely impassable) or not shaded (dry and passable) to facilitate emergency planning and use. Bridge surfaces are shown shaded—that is, shown as inundated—when the water-surface-elevation for a stage is at the same elevation as the low chord of the bridge (table 7). Buildings that are shaded do not reflect inundation but denote that bare earth surfaces in the vicinity of the buildings are inundated. When the water depth (as indicated in the Web Mapping Application by holding the cursor over an inundated area) in the vicinity of the building of interest exceeds that building's height, the structure can be considered fully submerged.

Disclaimer for Flood-Inundation Maps

The flood-inundation maps should not be used for navigation, regulatory, permitting, or other legal purposes. The USGS provides these maps "as-is" for a quick reference, emergency planning tool but assumes no legal liability or responsibility resulting from the use of this information.

Uncertainties and Limitations Regarding Use of Flood-Inundation Maps

Although the flood-inundation maps represent the boundaries of inundated areas with a distinct line, some uncertainty is associated with these maps. The flood boundaries shown were estimated on the basis of water stages and streamflows at a selected USGS streamgage. Water-surface elevations along the stream reaches were estimated using steady-state hydraulic modeling, assuming unobstructed flow, and using streamflows and hydrologic conditions anticipated at the USGS streamgage. The hydraulic model reflects the land-cover characteristics and any bridge, dam, levee, or other hydraulic structures existing as of 2014. Unique meteorological factors

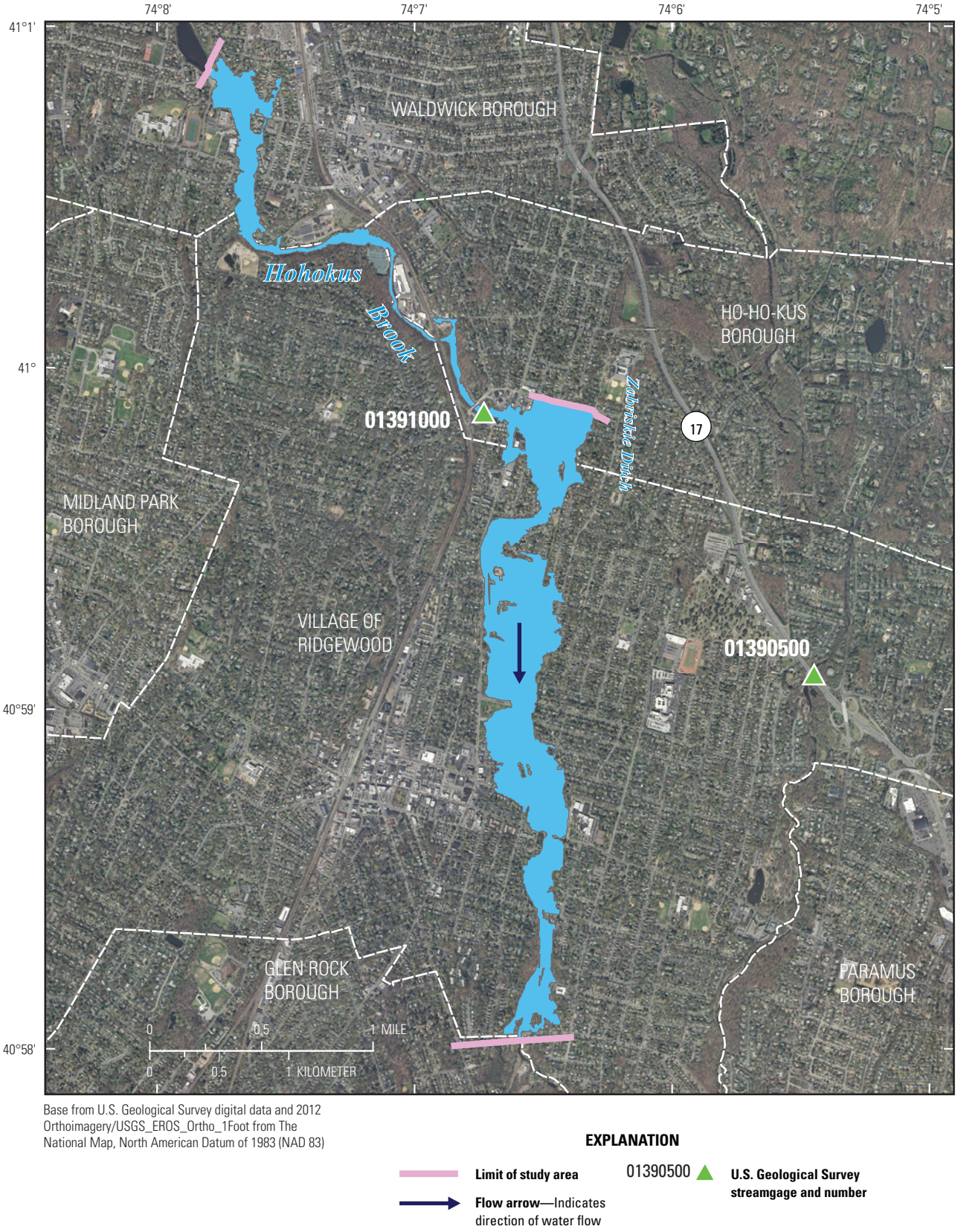


Figure 3. Flood-inundation map for the Hohokus Brook at Ho-Ho-Kus, New Jersey, corresponding to a stage of 8.0 feet at the U.S. Geological Survey streamgage (station number 01391000).

Table 7. Occurrence of bridge inundation determined from simulated water-surface profiles corresponding to a stage level for the Hohokus Brook at Ho-Ho-Kus, New Jersey, streamgage (station number 01391000).

[ft, feet]

Stage (ft)	Bridge inundated
2.5	None
3.0	Footbridge #1, Ridgewood High Footbridge #3
3.5	Footbridge #1, Footbridge #2, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4
4.0	Spring Avenue, Footbridge #1, Footbridge #2, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6
4.5	Spring Avenue, Footbridge #1, Footbridge #2, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
5.0	Spring Avenue, Footbridge #1, Footbridge #2, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
5.5	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
6.0	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
6.5	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
7.0	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Footbridge #6, Meadowbrook Avenue, East Glen Avenue, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
7.5	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Linwood Avenue, Footbridge #6, Meadowbrook Avenue, East Glen Avenue, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge
8.0	Grove Street, Spring Avenue, Footbridge #1, Footbridge #2, East Ridgewood Avenue, Ridgewood High Footbridge #3, North Irving Street, Veteran's Memorial Field Footbridge #4, Linwood Avenue, Footbridge #6, Meadowbrook Avenue, East Glen Avenue, Driveway bridge, Sheridan Avenue, Wyckoff Aveune, West Prospect Bridge

(timing and distribution of precipitation) may cause actual streamflows along the modeled reach to vary from those assumed during a flood, which may lead to deviations in the water-surface elevations and inundation boundaries shown. Additional areas may be flooded as a result of unanticipated conditions such as changes in the streambed elevation or roughness, backwater into major tributaries along a main stem river, or backwater from localized debris or ice jams. The accuracy of the floodwater extent portrayed on these maps will vary with the accuracy of the digital elevation model used to simulate the land surface.

If this series of flood-inundation maps will be used in conjunction with NWS river forecasts, the user needs to be aware of additional uncertainties that may be inherent or factored into NWS forecast procedures. The NWS uses forecast models to estimate the quantity and timing of water flowing through selected stream reaches in the United States. These forecast models (1) estimate the amount of runoff generated by precipitation and snowmelt, (2) simulate the movement of floodwater as it proceeds downstream, and (3) predict the flow and stage (and water-surface elevation) for the stream at a given location (AHPS forecast point) throughout the forecast period (every 6 hours and 3 to 5 days out in many locations). For more information on AHPS forecasts, please see: http://www.nws.noaa.gov/os/water/ahps/resources/BAMS_Article.pdf.

Summary

A series of 12 digital flood-inundation maps were developed in cooperation with New Jersey Department of Environmental Protection for the Hohokus Brook at Ho-Ho-Kus, New Jersey. The maps cover a reach about 6 miles long from White's Lake Dam in Waldwick Borough at the upstream end of Hohokus Brook, through Ho-Ho-Kus Borough to Grove Street in the Village of Ridgewood, New Jersey. The maps were developed by using the U.S. Army Corps of Engineers' HEC–RAS program to compute water-surface profiles and to delineate estimated flood-inundation areas and depths of flooding for selected stream stages. The HEC-RAS hydraulic model was calibrated to the most current stage-discharge relation at the Hohokus Brook streamgage. The model was used to compute 12 water-surface profiles for flood stages at 0.5-ft intervals referenced to the streamgage datum and ranging from 2.5 ft, or near bankfull, to 8.0 ft, which is the upper extent of the current stage-discharge relation and exceeds the stage of the maximum recorded peak flow. The simulated water-surface profiles were then combined with a geographic information system (GIS) digital elevation model [derived from light detection and ranging (lidar) data] to delineate estimated flood-inundation areas as shapefile polygons and depth grids for each profile. These flood-inundation polygons were overlaid on high-resolution, georeferenced aerial photographs of the study area. The flood maps are available at the USGS flood-inundation mapping Web portal at http://wim.usgs.gov/FIMI/FloodInundationMapper.html.

Interactive use of the maps at this portal can give users a general indication of depth of water at any point by using the mouse cursor to click within the shaded areas. These maps, in conjunction with the real-time stage data from the USGS streamgage, Hohokus Brook at Ho-Ho-Kus, New Jersey (station number 01391000) will help to guide the general public in taking individual safety precautions and will provide emergency management personnel with a tool to efficiently manage emergency flood operations and postflood recovery efforts.

References Cited

Environmental Systems Research Institute, Inc., 2010, Products—ArcGIS, accessed April 8, 2013, at http://www.esri.com/software/arcgis/.

Environmental Systems Research Institute, Inc., 2012, Using the Topo to Raster Tool, accessed April 3, 2014, at http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Using%20the%20Topo%20to%20Raster%20tool.

Federal Emergency Management Agency, 2005, Flood Insurance Study, Bergen County, New Jersey, and incorporated areas: Washington D.C., September 30, 2005, 4 p.

National Geospatial-Intelligence Agency, 2007, LiDAR-Metro New Jersey 2006-07: Springfield, Virginia.

National Weather Service, 2011, National Weather Service Flood Inundation Mapping Quality Control Tools v1.0, accessed June 23, 2014, at http://water.usgs.gov/osw/flood_inundation/toolbox/prepare.html.

National Weather Service, 2013, National Weather Service Glossary, accessed September 12, 2013, at http://w1.weather.gov/glossary/index.php?word=action+stage.

National Weather Service, 2014, Advanced Hydrologic Prediction Service, Hohokus Brook at Ho-Ho-Kus, accessed April 3, 2013, at http://water.weather.gov/ahps2/hydrograph.php?gage=hohn4&wfo=okx.

Natural and Technological Hazards Management Consulting, Inc. (NTHMC), 2004, Final hydrology: Riverine flood insurance studies in FEMA Region II New Jersey FY-01, Saddle River, New Jersey: Montvale, N.J., NTHMC. 107 p.

New Jersey Department of Environmental Protection, 2010, NJDEP 2007 Landuse/Landcover Update, State of New Jersey: Trenton, N.J.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2010, HEC–RAS River Analysis System, Hydraulic Reference Manual, version 4.1: Davis, Calif., [variously paged].

U.S. Bureau of Census, 2014, Census 2010 State and county quick facts, accessed September 12, 2014, at http://quickfacts.census.gov/qfd/states/34000.html.

U.S. Geological Survey, 2014a, USGS 01391000 Hohokus Brook at Ho-Ho-Kus, New Jersey: U.S. Geological Survey, accessed September 18, 2014, at http://waterdata.usgs.gov/nwis/uv?site_no=01391000.

U.S. Geological Survey, 2014b, USGS National Water Information System: U.S. Geological Survey, accessed October 20, 2014, at http://waterdata.usgs.gov/nwis/sw.

U.S. Geological Survey, 2014c, USGS Flood Inundation Mapping Science: U.S. Geological Survey, accessed October 20, 2014, at http://water.usgs.gov/osw/flood_inundation/toolbox/.

U.S. Geological Survey, 2014d, USGS Flood Inundation Mapper: U.S. Geological Survey, accessed October 20, 2014, at http://wim.usgs.gov/FIMI/FloodInundationMapper.html.

Prepared by the West Trenton Publishing Service Center

For more information, contact:
New Jersey Water Science Center
U.S. Geological Survey
3450 Princeton Pike, Suite 110
Lawrenceville, NJ 08648

http://nj.usgs.gov/

ISSN 2328-0328 (online)
http://dx.doi.org/10.3133/sir20155064